H-Max™ Series Variable Frequency Drive

Installation Manual

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Powering Business Worldwide

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Cover Photo: H-Max Series Drives

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Safety

Warning!
Dangerous Electrical Voltage!

Before Commencing the Installation

- Disconnect the power supply of the device
- Ensure that devices cannot be accidentally restarted
- Verify isolation from the supply
- Earth and short circuit the device
- Cover or enclose any adjacent live components
- Follow the engineering instructions (IL04020001E) for the device concerned
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system
- Before installation and before touching the device ensure that you are free of electrostatic charge
- The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection
- Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automation functions
- Install automation devices and related operating elements in such a way that they are well protected against unintentional operation
- Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states in the automation devices
- Ensure a reliable electrical isolation of the extra-low voltage of the 24V supply. Only use power supply units complying with IEC 60364-4-41 (VDE 0100 Part 410) or HD384.4.41 S2
- Deviations of the input voltage from the rated value must not exceed the tolerance limits given in the specifications, otherwise this may cause malfunction and dangerous operation
- Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes of the automation devices. Unlatching the emergency-stop devices must not cause a restart
- Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been installed and with the housing closed. Desktop or portable units must only be operated and controlled in enclosed housings
- Measures should be taken to ensure the proper restart of programs interrupted after a voltage dip or failure. This should not cause dangerous operating states even for a short time. If necessary, emergency-stop devices should be implemented
- Wherever faults in the automation system may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (for example, by means of separate limit switches, mechanical interlocks, and so on)
- Depending on their degree of protection, variable frequency drives may contain live bright metal parts, moving or rotating components, or hot surfaces during and immediately after operation
- Removal of the required covers, improper installation, or incorrect operation of motor or variable frequency drive may cause the failure of the device and may lead to serious injury or damage
- The applicable national accident prevention and safety regulations apply to all work carried out on live variable frequency drives
- The electrical installation must be carried out in accordance with the relevant regulations (for example, with regard to cable cross sections, fuses, PE)
- Transport, installation, commissioning, and maintenance work must be carried out only by qualified personnel (IEC 60364, HD 384 and national occupational safety regulations)
- Installations containing variable frequency drives must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the variable frequency drives using the operating software are permitted
- All covers and doors must be kept closed during operation
- To reduce hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the drive (increased motor speed or sudden standstill of motor). These measures include:
  - Other independent devices for monitoring safety-related variables (speed, travel, end positions, and so on)
  - Electrical or non-electrical system-wide measures (electrical or mechanical interlocks)
  - Never touch live parts or cable connections of the variable frequency drive after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be live after disconnection. Fit appropriate warning signs

Safety

Definitions and Symbols

⚠ WARNING

This symbol indicates high voltage. It calls your attention to items or operations that could be dangerous to you and other persons operating this equipment. Read the message and follow the instructions carefully.

⚠

This symbol is the "Safety Alert Symbol." It occurs with either of two signal words: CAUTION or WARNING, as described below.

⚠ WARNING

Indicates a potentially hazardous situation which, if not avoided, can result in serious injury or death.

⚠ CAUTION

Indicates a potentially hazardous situation which, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the CAUTION may, if not avoided, lead to serious results. Important safety measures are described in CAUTION (as well as WARNING).

Hazardous High Voltage

⚠ WARNING

Motor control equipment and electronic controllers are connected to hazardous line voltages. When servicing drives and electronic controllers, there may be exposed components with housings or protrusions at or above line potential. Extreme care should be taken to protect against shock.

Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure equipment is properly grounded. Wear safety glasses whenever working on electronic controllers or rotating machinery.

Warnings and Cautions

⚠ CAUTION

When selecting the cable cross-section, take the voltage drop under load conditions into account.

The consideration of other standards (for example, VDE 0113 or VDE 0289) is the responsibility of the user.

⚠ CAUTION

The specified minimum PE conductor cross-sections (EN 50178, VDE 0160) must be maintained.

⚠ WARNING

With frequency inverters, only AC/DC sensitive residual current circuit breakers (RCD type B) are to be used (EN 50178, IEC 755).

⚠ CAUTION

Debounced inputs may not be used in the safety circuit diagram.

Residual current circuit breakers (RCD) are only to be installed between the AC power supply network and the frequency inverter.

⚠ CAUTION

Debounced inputs may not be used in the safety circuit diagram.

If you are connecting multiple motors on one frequency inverter, you must design the contactors for the individual motors according to utilization category AC-3.

Selecting the motor contactor is done according to the rated operational current of the motor to be connected.

⚠ CAUTION

Debounced inputs may not be used in the safety circuit diagram.

A changeover between the frequency inverter and the input supply must take place in a voltage-free state.

WARNING

The frequency inverter outputs (U, V, W) must not be connected to the input voltage (destruction of the device, risk of fire).

CAUTION

Debounced inputs may not be used in the safety circuit diagram.

Switch S1 must switch only when frequency inverter T1 is at zero current.

WARNING

Carry out wiring work only after the frequency inverter has been correctly mounted and secured.

WARNING

Electric shock hazard—risk of injuries!

Carry out wiring work only if the unit is de-energized.

CAUTION

Debounced inputs may not be used in the safety circuit diagram.

Fire hazard!

Only use cables, protective switches, and contactors that feature the indicated permissible nominal current value.

CAUTION

Debounced inputs may not be used in the safety circuit diagram.

Ground contact currents in frequency inverters are greater than 3.5 mA (AC). According to product standard IEC/EN 61800-5-1, an additional equipment grounding conductor must be connected, or the cross-section of the equipment grounding conductor must be at least 0.39 in^2 (10 mm^2).

WARNING

The components in the frequency inverter's power section remain energized up to five (5) minutes after the supply voltage has been switched off (intermediate circuit capacitor discharging time).

Pay attention to hazard warnings!

DANGER
5 MIN

WARNING

Do not perform any modifications on the AC drive when it is connected to mains.

CAUTION

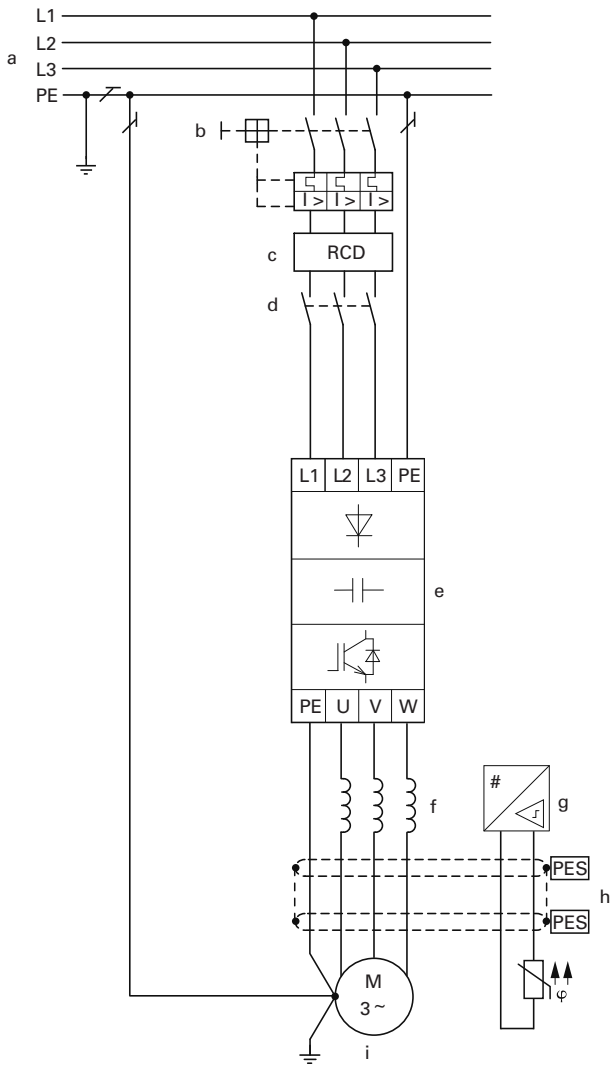
Before connecting the AC drive to mains make sure that the EMC protection class settings of the drive are appropriately made.

Engineering

Introduction

This chapter describes the most important features in the energy circuit of a drive system (PDS = Power Drive System) that you should take into consideration in your project planning.

Figure 1. Drive System (PDS)



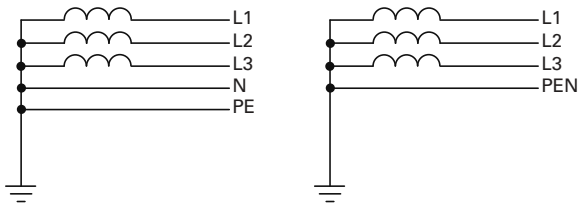
Item Number	Description
1	Network configuration, input voltage, input frequency, interaction with p.f. correction systems
2	Breakers, fuses, and cable cross-sections
3	Protection of persons and domestic animals with residual-current protective devices
4	Input contactor
5	Frequency inverter: mounting, installation; power connection; EMC measures; circuit examples
6	Motor reactor, dv/dt filter, sine-wave filter
7	Motor protection; thermistor
8	Cable lengths, motor cables, shielding (EMC)
9	Motor and application, parallel operation of multiple motors on a frequency inverter, bypass circuit; DC braking

Electrical Power Network

Input Connection and Configuration

The H-Max series frequency inverters can be connected and operated with all control-point grounded AC power networks (see IEC 60364 for more information).

Figure 2. AC Power Networks with Grounded Center Point (TN-/TT Networks)



While planning the project, consider a symmetrical distribution to the three external conductors, if multiple frequency inverters with single-phase supplies are to be connected. The total current of all single-phase consumers is not to cause an overload of the neutral conductor (N-conductor).

The connection and operation of frequency inverters to asymmetrically grounded TN networks (phase-grounded Delta network "Grounded Delta", USA) or non-grounded or high-resistance grounded (over 30 ohms) IT networks is only conditionally permissible.

If the H-Max frequency inverters are connected to an asymmetrically grounded network or to an IT network (non-grounded, insulated), the internal interference suppression filter must be disconnected (unscrew the screw marked EMC, see "Installation in IT System" on **Page 37**). The required filtering for electromagnetic compatibility (EMC) is then no longer present.

Measures for electromagnetic compatibility are mandatory in a drive system in order to meet the legal requirements for EMC and low voltage regulations.

Good grounding measures are a prerequisite for the effective insert of further measures such as shielding or filters. Without respective grounding measures, further steps are superfluous.

Input Voltage and Frequency

The standardized input voltages (IEC 60038, VDE017-1) for energy suppliers (EVU) guarantee the following conditions at the transition points:

- Deviation from the rated value of voltage: maximum ±10%
- Deviation in voltage phase balance: maximum ±3%
- Deviation from rated value of the frequency: maximum ±4%

The broad tolerance band of the H-Max frequency inverter considers the rated value for
European as (EU: U_{LN} = 230V/400V, 50 Hz) and
American as (USA: U_{LN} = 240V/480V, 60 Hz) standard voltages:

- 230V, 50 Hz (EU) and 240V, 60 Hz (USA) at HMX32
- 400V, 50 Hz (EU) and 480V, 60 Hz (USA) at HMX34_
- 600V, 60 Hz at HMX35

For the bottom voltage value, the permitted voltage drop of 4% in the consumer circuits is also taken into account, therefore a total of U_{LN} –14%.

- 200V device class (HMX32):
  208V –10% to 240V +10% (188V –0% to 264V +0%)
- 400V device class (HMX34):
  380V –10% to 480V +10% (342V –0% to 528V +0%)
- 600V device class (HMX35):
  525V –10% to 600V +10%

The permitted frequency range is 50/60 Hz (48 Hz –0% –66 Hz +0%).

Voltage Balance

Because of the uneven loading on the conductor, and with the direct connection of greater power ratings, deviations from the ideal voltage form and asymmetrical voltages can be caused in three-phase AC power networks. These asymmetric divergences in the input voltage can lead to different loading of the diodes in input rectifiers with three-phase supplied frequency inverters, and as a result, an advance failure of this diode.

In the project planning for the connection of three-phase supplied frequency inverters (HMX32, HMX34), consider only AC power networks that handle permitted asymmetric divergences in the input voltage ≦+3%.

If this condition is not fulfilled, or symmetry at the connection location is not known, the use of an assigned main choke is recommended.

Total Harmonic Distortion (THD)

The THD (Total Harmonic Distortion) is a measurement for the occurring harmonic distortion of the sinusoidal oscillation (input power side) input variables with the frequency inverter. It is given in percent of the total value.

$$K = \frac{\sqrt{U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2}}{\sqrt{U_1^2 + U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2}} \bullet 100\%$$

U_1 = fundamental component
THD k = 0.1 → K = 10% ~ –20 dB (THD suppression)

$$THD = \frac{\sqrt{U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2}}{U_1}$$

With H-Max series frequency inverters, the permitted value for the total harmonic distortion THD is >120%.

Idle Power Compensation Devices

Compensation on the power supply side is not required for H-Max series frequency inverters. From the AC power supply network, they take on very little reactive power of the fundamental harmonics (cos φ ~ 0.98).

In the AC power networks with non-choked idle current compensation devices, current deviations can enable parallel resonance and undefinable circumstances.

In the project planning for the connection of frequency inverters to AC power networks with undefined circumstances, consider using main chokes.

Safety and Switching

Fuses and Cable Cross-Sections

The fuses and wire cross-sections allocated for power-side connections depend on the rated input current I_{LN} of the frequency inverter (without input reactor).

CAUTION

When selecting the cable cross-section, take the voltage drop under load conditions into account.

The consideration of other standards (for example, VDE 0113 or VDE 0289) is the responsibility of the user.

The national and regional standards (for example VDE 0113, EN 60204) must be observed and the necessary approvals (for example UL) at the site of installation must be fulfilled.

When the device is operated in a UL-approved system, use only UL-approved breakers, fuses, fuse bases, and cables.

The leakage currents to ground (to EN 50178) are greater than 3.5 mA. The connection terminals marked PE and the housing must be connected with the ground circuit.

CAUTION

The specified minimum PE conductor cross-sections (EN 50178, VDE 0160) must be maintained.

Choose the cross-section of the PE conductor in the motor lines at least as large as the cross-section of the phase lines (U, V, W).

Cables and Fuses

The cross-sections of the cables and line protection fuses used must correspond with local standards.

For an installation in accordance with UL guidelines, the fuses and copper cable that are UL-approved and have a heat-resistance of 167° to 194°F (75° to 90°C) are to be used.

Use power cables with insulation according to the specified input voltages for the permanent installation. A shielded cable is not required on the input side.

A completely (360°) shielded low impedance cable is required on the motor side. The length of the motor cable depends on the RFI class and must not exceed 500 ft (153m) without additional filtering.

Residual-Current Device (RCD)

RCD (Residual Current Device): Residual current device, residual current circuit breaker (FI circuit breaker).

Residual current circuit breakers protect persons and animals from the existence (not the origination) of impermissibly high contact voltages. They prevent dangerous, and in some cases deadly injuries caused by electrical accidents, and also serve as fire prevention.

WARNING

With frequency inverters, only AC/DC sensitive residual current circuit breakers (RCD type B) are to be used (EN 50178, IEC 755).

Table 1. Identification on the Residual-Current Circuit-Breakers

AC/DC sensitive (RCD, type B)		

Frequency inverters work internally with rectified AC currents. If an error occurs, the DC currents can block a type A RCD circuit breaker from triggering and therefore disable the protective functionality.

CAUTION

Debounced inputs may not be used in the safety circuit diagram.

Residual current circuit breakers (RCD) are only to be installed between the AC power supply network and the frequency inverter.

Safety-relevant leakage currents can occur while handling and when operating the frequency inverter, if the frequency inverter is not grounded (because of a fault).

Leakage currents to ground are mainly caused by foreign capacities with frequency inverters; between the motor phases and the shielding of the motor cable and via the Y-capacitors of the noise filter. The size of the leakage current is mainly dependent upon the:

- length of the motor cable
- shielding of the motor cable
- height of the pulse frequency (switching frequency of the inverter)
- design of the noise filter
- grounding measures at the site of the motor

The leakage current to ground is greater than 3.5 mA with a frequency inverter. Based on the requirements of EN 50178, an increased ground (PE) has to be connected. The cable cross-section must be at least 10 mm^2 or consist of two separately connected ground cables.

Residual current circuit breakers must be suitable for:

- the protection of installations with DC current component in case of fault scenario (RCD type B)
- high leakage currents (300 mA)
- brief discharges of pulse current spikes

Input Contactor

The input contactor enables an operational switching on and off of the supply voltage for the frequency inverter, and switching off in case of a fault.

The input contactor is designed based on the input current (I_{LN}) of the frequency inverter and the utilization category AC-1 (IEC 60947). Input contactors and the assignment to H-Max frequency inverters are explained in the appendix.

While planning the project, make sure that inching operation is not done via the input contactor of the frequency inverter on frequency-controlled drives, but through a controller input of the frequency inverter.

The maximum permitted operating frequency of the input voltage with the H-Max frequency inverter is one time per minute (normal operation).

EMC Measures

Electrical components in a system (machine) have a reciprocal effect on each other. Each device not only emits interference but is also affected by it. The interference can be produced by galvanic, capacitive, and/or inductive sources, or by electromagnetic radiation. In practice, the limit between line-conducted interference and emitted interference is around 30 MHz. Above 30 MHz, cables and conductors act like antennas that radiate electromagnetic waves.

Electromagnetic compatibility (EMC) for frequency controlled drives (variable speed drives) is implemented in accordance with product standard IEC/EN 61800-3. This includes the complete power drive system (PDS), from the input supply to the motor, including all components, as well as cables (see figure on **Page 1**). This type of drive system can consist of several individual drives.

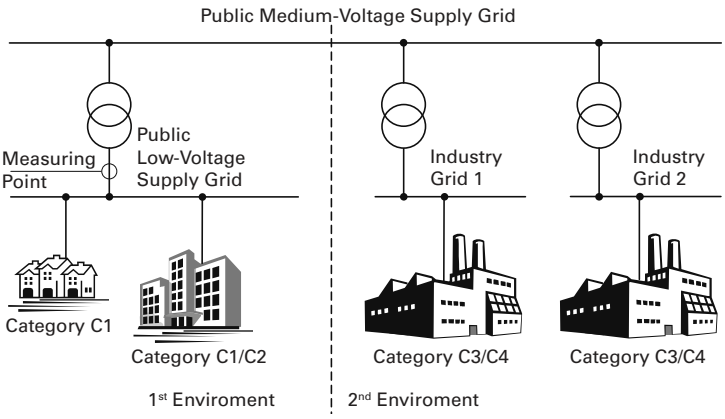
The generic standards of the individual components in a PDS compliant with IEC/EN 61800-3 do not apply. These component manufacturers, however, must offer solutions that ensure standards-compliant use.

In Europe, maintaining the EMC guidelines is mandatory.

A declaration of conformity (CE) always refers to a "typical" power drive system (PDS). The responsibility to comply with the legally stipulated limit values and thus the provision of electromagnetic compatibility is ultimately the responsibility of the end user or system operator. This operator must also take measures to minimize or remove emission in the environment concerned (see figure below). He must also use means to increase the interference immunity of the devices of the system.

With their high interference immunity up to category C2, H-Max frequency inverters are ideal for use in commercial networks (1st environment).

Figure 3. EMC Environment and Category



Motor and Application

Motor Selection

General recommendations for motor selection:

- Use three-phase powered asynchronous motors with short-circuit rotors and surface cooling, also called asynchronous motors or standard motors for the frequency-controlled drive system (PDS). Other specifications such as external rotor motors, slip-ring motors, reluctance motors, synchronous or servo motors can also be run with a frequency inverter, but normally require additional planning and discussion with the motor manufacturer
- Use only motors with at least heat class F (311°F [155°C] maximum steady state temperature)
- Four-pole motors are preferred (synchronous speed: 1500 min^{-1} at 50 Hz or 1800 min^{-1} at 60 Hz)
- Take the operating conditions into account for S1 operation (IEC 60034-1)
- When operating multiple motors in parallel on one frequency inverter, the motor output should not be more than three power classes apart
- Ensure that the motor is not overdimensioned. If a motor in speed control mode is underdimensioned, the motor rating must only be one rating level lower

Connecting Motors in Parallel

The H-Max frequency inverters allow parallel operation of several motors using multi-pump application control mode:

- Multi-pump application: several motors with the same or different rated operational data. The sum of all motor currents must be less than the frequency inverter's rated operational current
- Multi-pump application: parallel control of several motors. The sum of the motor currents plus the motors' inrush currents must be less than the frequency inverter's rated operational current

Parallel operation at different motor speeds can be implemented only by changing the number of pole pairs and/or changing the motor's transmission ratio.

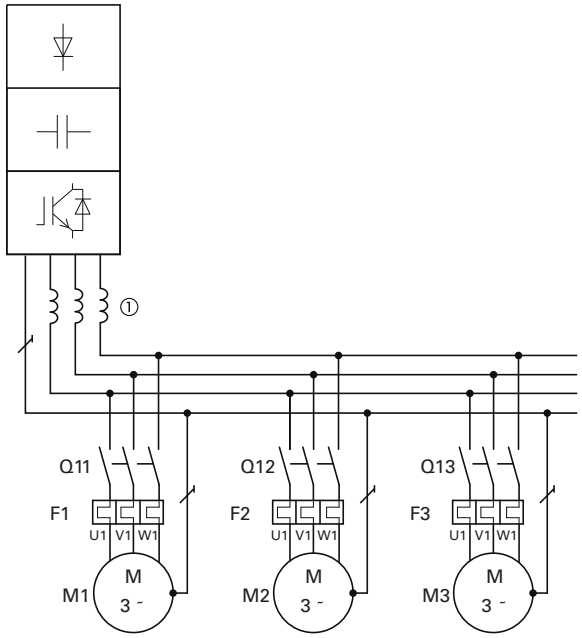
⚠ CAUTION

Debounced inputs may not be used in the safety circuit diagram.

If you are connecting multiple motors on one frequency inverter, you must design the contactors for the individual motors according to utilization category AC-3.

Selecting the motor contactor is done according to the rated operational current of the motor to be connected.

Figure 4. Parallel Connection of Several Motors to One Frequency Inverter



Connecting motors in parallel reduces the load resistance at the frequency inverter output. The total stator inductance is lower and the leakage capacity of the lines greater. As a result, the current distortion is greater than in a single-motor circuit. To reduce the current distortion, you should use motor reactors (see **[1]** in figure above) in the output of the frequency inverter.

The current consumption of all motors connected in parallel must not exceed the frequency inverter's rated output current I2N.

Electronic motor protection cannot be used when operating the frequency inverter with several parallel connected motors. You must, however, protect each motor with thermistors and/or overload relays.

The use of a motor protective circuit breaker at the frequency inverter's output can lead to nuisance tripping.

Motor and Circuit Type

The motor's stator winding can be connected in a star or delta configuration, in accordance with the rated operational data on the nameplate.

Figure 5. Example of a Motor Ratings Plate

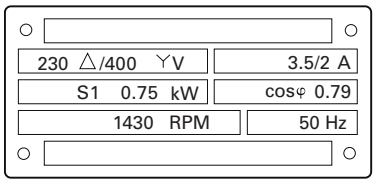
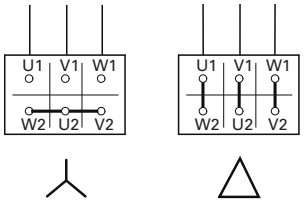


Figure 6. Star and Delta Circuit Types



The three-phase motor with the rating plate based on the figure shown above, can be run in a star or delta connection. The operational characteristic curve is determined by the ratio of motor voltage and motor frequency, in this case.

87-Hz Characteristic Curve

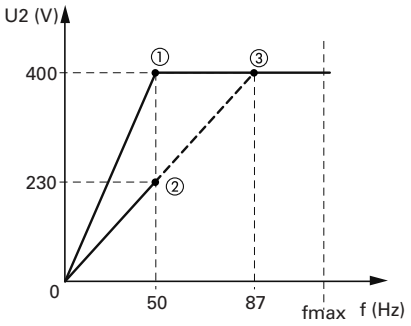
In the delta circuit with 400V and 87 Hz, the motor shown in the figure above was released with three times-fold output (~1.3 kW).

Because of the higher thermal loading, using only the next higher motor output according to the list (1.1 kW) is recommended. The motor (in this example) therefore still has 1.47-fold higher output compared with the listed output (0.75 kW).

With the 87-Hz characteristic curve, the motor also works in the range from 50 to 87 Hz with an unattenuated field. The pull-out torque remains at the same level as in input operation with 50 Hz.

The heat class of the motor must be at least F in 87-Hz operation.

Figure 7. V/Hz-Characteristic Curve



The following table shows the allocation of possible frequency inverters depending on the input voltage and the type of circuit.

Table 2. Assignment of Frequency Inverters to Example Motor Circuit (See Figure Above)

Frequency Inverters	HMX32AG3D7	HMX34AG3D4	HMX34AG4D8
Rated operational current	3.7A	3.4A	4.8A
Input voltage	3 AC 230V	3 AC 400V	3 AC 400V
Motor circuit	Delta	Star	Delta
V/Hz-characteristic curve	2	1	3
Motor current	3.5A	2.0A	3.5A
Motor voltage (ratings plate)	230V	400V	230V
Motor speed	1430 min^{-1}	1430 min^{-1}	2474 min^{-1} 4
Motor frequency	50 Hz	50 Hz	87 Hz 4

Notes

1 Star connection: 400V, 50 Hz.
2 Delta connection: 230V, 50 Hz.
3 Delta connection: 400V, 87 Hz.
4 Note the permitted limit values of the motor.

Bypass Operation

If you want to have the option of operating the motor with the frequency inverter or directly from the input supply, the input branches must be interlocked mechanically.

⚠ CAUTION

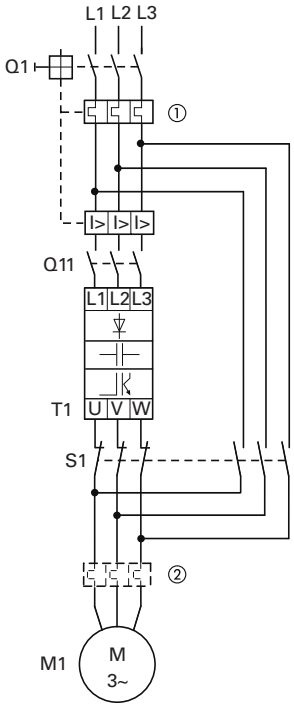
Debounced inputs may not be used in the safety circuit diagram.

A changeover between the frequency inverter and the input supply must take place in a voltage-free state.

⚠ WARNING

The frequency inverter outputs (U, V, W) must not be connected to the input voltage (destruction of the device, risk of fire).

Figure 8. Bypass Motor Control (Example)



Item Number	Description
1	Input/bypass contactor
2	Output contactor

⚠ CAUTION

Debounced inputs may not be used in the safety circuit diagram.

Switch S1 must switch only when frequency inverter T1 is at zero current.

Contactors and switches (S1) in the frequency inverter output and for the direct start must be designed based on utilization category AC-3 for the rated operational current of the motor.

Connecting EX Motors

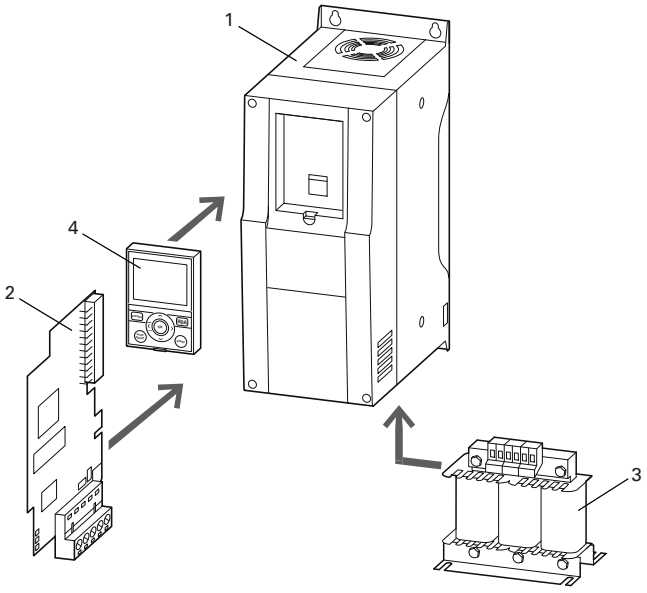
Note the following when connecting explosion-protected motors:

- The frequency inverter must be installed outside the EX area
- Note the branch- and country-specific standards for explosion-protected areas (ATEX 100a)
- Note the standards and information of the motor manufacturer regarding operation on frequency inverters—for example, if motor reactors (du/dt-limiting) or sinus filters are specified
- Temperature monitors in the motor windings (thermistor, thermo-Click) are not to be connected directly to frequency inverters but must be connected via an approved trigger apparatus for EX areas

System Overview

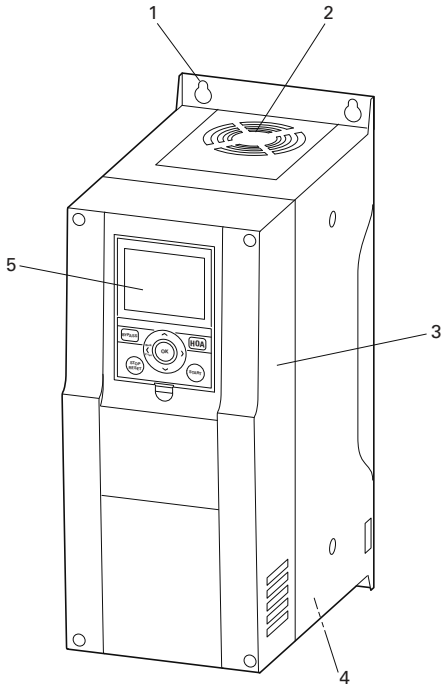
Component Identification

Figure 9. H-Max Series



Item Number	Description
1	Frequency inverter HMX-_
2	I/O option boards
3	Motor reactor DEX-LM3, sinusoidal filter SFB400
4	Keypad

Figure 10. Description of the H-Max

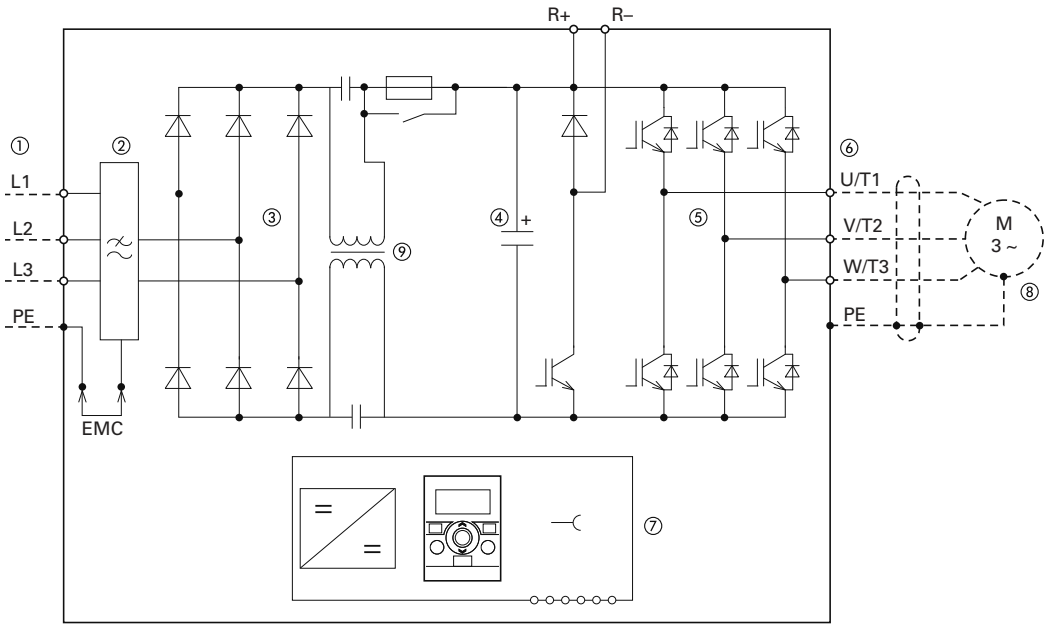


Item Number	Description
1	Mounting holes
2	Device fan
3	Front cover
4	Power terminals
5	Keypad with display

Features

The H-Max frequency inverter converts the voltage and frequency of an existing AC network into a DC voltage. This DC voltage is used to generate a three-phase AC voltage with variable frequency and assigned amplitude values for the variable speed control of three-phase asynchronous motors.

Figure 11. Block Diagram, Elements of H-Max Frequency Inverters

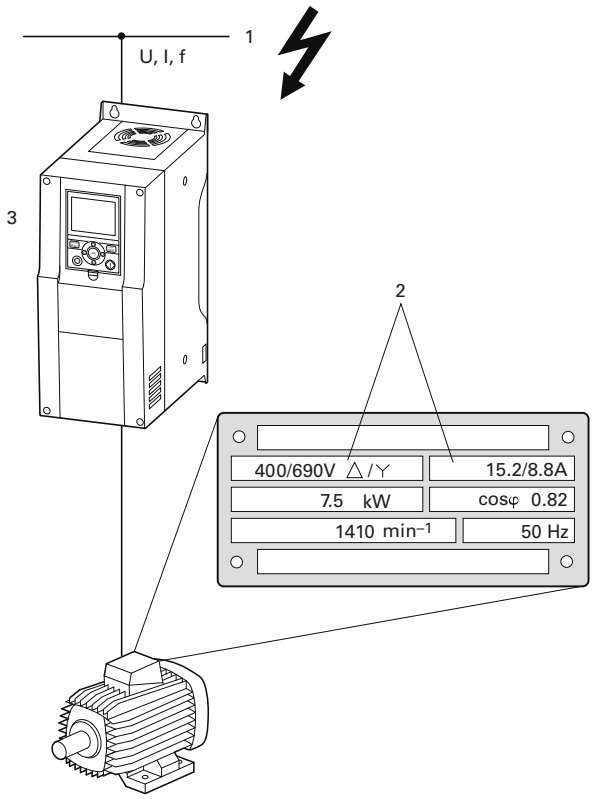


Item Number	Description
1	Supply L1, L2/N, L3, PE, input supply voltage $U_{LN} = U_e$ at 50/60 Hz: HMX32: 200V class, three-phase input connection (3 AC 230V/240V) HMX34: 400V class, three-phase input connection (3 AC 400V/480V) HMX35: 575V class, three-phase input connection (3 AC 575V/600V)
2	Internal interference suppression filter, category C2 to IEC/EN 61800-3 EMC-connection of internal interference suppression filter to PE
3	Rectifier bridge, converts the AC voltage of the electrical network into DC voltage
4	DC link with charging resistor, capacitor and switching mode power supply unit (SMPS = Switching Mode Power Supply): DC link voltage U_{DC} with three-phase input connection (3 AC): $U_{DC} = 1.41 \times U_{LN}$
5	Inverter. The IGBT based inverter converts the DC voltage of the DC link (U_{DC}) into a three-phase AC voltage (U_2) with variable amplitude and frequency (f_2). Sinusoidal pulse width modulation (PWM) with V/f control can be switched to speed control with slip compensation
6	Motor connection U/T1, V/T2, W/T3 with output voltage U_2 (0–100% U_e) and output frequency f_2 (0–320 Hz) output current (I_2): HMX32: 3.7–310A HMX34: 3.4–310A HMX35: 3.9–208A 100% at an ambient temperature of 104°F (40°C) with an overload capacity of 110% for 60s every 600s and a starting current of 200% for 2s every 20s
7	Keypad with control buttons, graphic display, control voltage, control signal terminals, microswitches, and interface for the PC interface module (option)
8	Three-phase asynchronous motor, variable speed control of three-phase asynchronous motor for assigned motor shaft power values (P_2): HMX32: 0.55–90 kW (230V, 50 Hz) or 0.75–125 hp (230V, 60 Hz) HMX34: 1.1–160 kW (400V, 50 Hz) or 1.5–250 hp (460V, 60 Hz) HMX35: 3–200 hp (600V, 60 Hz)
9	DC link—chokes, to minimize current harmonics

Selection Criteria

The frequency inverter **[3]** is selected according to the supply voltage U_{LN} of the input supply **[1]** and the rated current of the assigned motor **[2]**. The circuit type (△/Y) of the motor must be selected according to the supply voltage **[1]**. The rated output current I_e of the frequency inverter must be greater than/equal to the rated motor current.

Figure 12. Selection Criteria



When selecting the drive, the following criteria must be known:

- Type of motor (three-phase asynchronous motor)
- Input voltage = rated operating voltage of the motor (for example, 3 AC~400V)
- Rated motor current (guide value, dependent on the circuit type and the supply voltage)
- Load torque (quadratic, constant)
- Starting torque
- Ambient temperature (rated value 122°F [50°C])

When connecting multiple motors in parallel to the output of a frequency inverter, the motor currents are added geometrically—separated by effective and idle current components. When you select a frequency inverter, make sure that it can supply the total resulting current. If necessary, for dampening and compensating the deviating current values, motor reactors or sinusoidal filters must be connected between the frequency inverter and the motor.

The parallel connection of multiple motors in the output of the frequency inverter is only permitted with V/Hz-characteristic curve control.

If you connect a motor to an operational frequency inverter, the motor draws a multiple of its rated operational current. When you select a frequency inverter, make sure that the starting current plus the sum of the currents of the running motors will not exceed the rated output current of the frequency inverter.

Switching in the output of the frequency inverter is only permitted with V/Hz-characteristic curve control.

Proper Use

The H-Max frequency inverters are not domestic appliances. They are designed only for use as HVAC or pumping system components.

The H-Max frequency inverters are electrical apparatus for controlling variable speed drives with three-phase motors. They are designed for installation in machines or for use in combination with other components within a machine or system.

After installation in a machine, the frequency inverters must not be taken into operation until the associated machine has been confirmed to comply with the safety requirements of Machinery Safety Directive (MSD) 89/392/EEC (meets the requirements of EN 60204). The user of the equipment is responsible for ensuring that the machine use complies with the relevant EU Directives.

The CE markings on the H-Max frequency inverter confirm that, when used in a typical drive configuration, the apparatus complies with the European Low Voltage Directive (LVD) and the EMC Directives (Directive 73/23/EEC, as amended by 93/68/EEC and Directive 89/336/EEC, as amended by 93/68/EEC).

In the described system configurations, H-Max frequency inverters are suitable for use in public and non-public networks.

A connection to IT networks (networks without reference to earth potential) is permissible only to a limited extent, because the device's built-in filter capacitors connect the network with the earth potential (enclosure). On earth free networks, this can lead to dangerous situations or damage to the device (isolation monitoring required).

To the output of the frequency inverter (terminals U, V, W) you must not:

- connect a voltage or capacitive loads (for example, phase compensation capacitors)
- connect multiple frequency inverters in parallel
- make a direct connection to the input (bypass)

Observe the technical data and connection requirements. For additional information, refer to the equipment nameplate or label at the frequency inverter, and the documentation.

Any other usage constitutes improper use.

Maintenance and Inspection

H-Max frequency inverters are maintenance free. However, external influences may affect the function and the lifespan of the H-Max frequency inverter. We therefore recommend that the devices are checked regularly and the following maintenance measures are carried out at the specified intervals.

There are no plans for replacing or repairing individual components of H-Max frequency inverters.

If the H-Max frequency inverter is damaged by external influences, repair is not possible. Dispose of the device in accordance with the respectively applicable environmental laws and provisions for the disposal of electrical or electronic devices.

Table 3. Maintenance Measures and Intervals

Maintenance Measure	Maintenance Interval
Clean cooling vents (cooling slits)	If required
Check the fan function	6–24 months (depending on the environment)
Filter in the switching cabinet doors (see manufacturer specifications)	6–24 months (depending on the environment)
Check the tightening torques of the terminals (control signal terminals, power terminals)	Regularly
Check connection terminals and all metallic surfaces for corrosion	6–24 months (depending on the environment)

Storage

If the frequency inverter is stored before use, suitable ambient conditions must be ensured at the site of storage:

- Storage temperature: –40° to 158°F (–40° to 70°C)
- Relative average air humidity: <95%, noncondensing (EN 50178)
- Thin film capacitors are used to allow up to five years non-powered shelf life

Service and Warranty

In the unlikely event that you have a problem with your H-Max frequency inverter, please contact your local sales office.

When you call, have the following information ready:

- the exact frequency inverter part no. (see nameplate)
- the date of purchase
- a detailed description of the problem that has occurred with the frequency inverter

If some of the information printed on the nameplate is not legible, please state only the information that is clearly legible. This information can also be found on the cover of the control terminals.

Information concerning the guarantee can be found in the Eaton General Terms and Conditions of Sale.

H-Max Series Overview

This chapter describes the purpose and contents of this manual, the receiving inspection recommendations and the H-Max Series Open Drive catalog numbering system.

How to Use this Manual

The purpose of this manual is to provide you with information necessary to install, set and customize parameters, start up, troubleshoot and maintain the Eaton H-Max Series variable frequency drives (VFD). To provide for safe installation and operation of the equipment, read the safety guidelines at the beginning of this manual and follow the procedures outlined in the following chapters before connecting power to the H-Max Series VFD. Keep this operating manual handy and distribute to all users, technicians and maintenance personnel for reference.

Receiving and Inspection

The H-Max Series VFD has met a stringent series of factory quality requirements before shipment. It is possible that packaging or equipment damage may have occurred during shipment. After receiving your H-Max Series VFD, please check for the following:

Check to make sure that the package includes the Installation Manual (MN04008005E), Quick Start Guide (MN04008004E) and accessory packet. The accessory packet includes:

- Rubber grommets
- EMC grounding clamps for power cables
- Control cable grounding clamps
- EMC jumper locking clips
- M4 screw for EMC level change (FS7 only)
- Additional grounding screw
- Real time clock battery
- UL conduit plate

Inspect the unit to ensure it was not damaged during shipment.

Make sure that the part number indicated on the nameplate corresponds with the catalog number on your order.

If shipping damage has occurred, please contact and file a claim with the carrier involved immediately.

If the delivery does not correspond to your order, please contact your Eaton Electrical representative.

Note: Do not destroy the packing. The template printed on the protective cardboard can be used for marking the mounting points of the H-Max VFD on the wall or in a cabinet.

Figure 13. Rating Plate

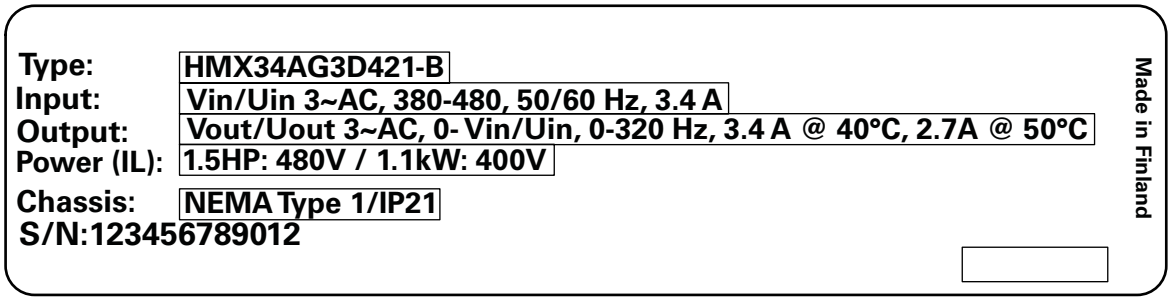


Figure 14. Approval Sticker

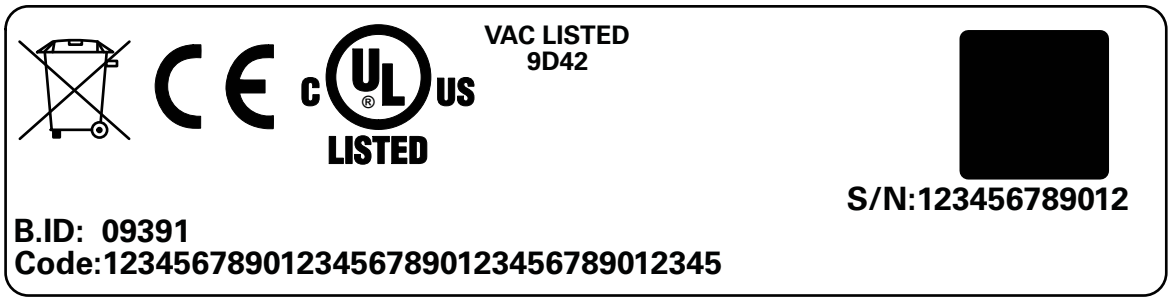
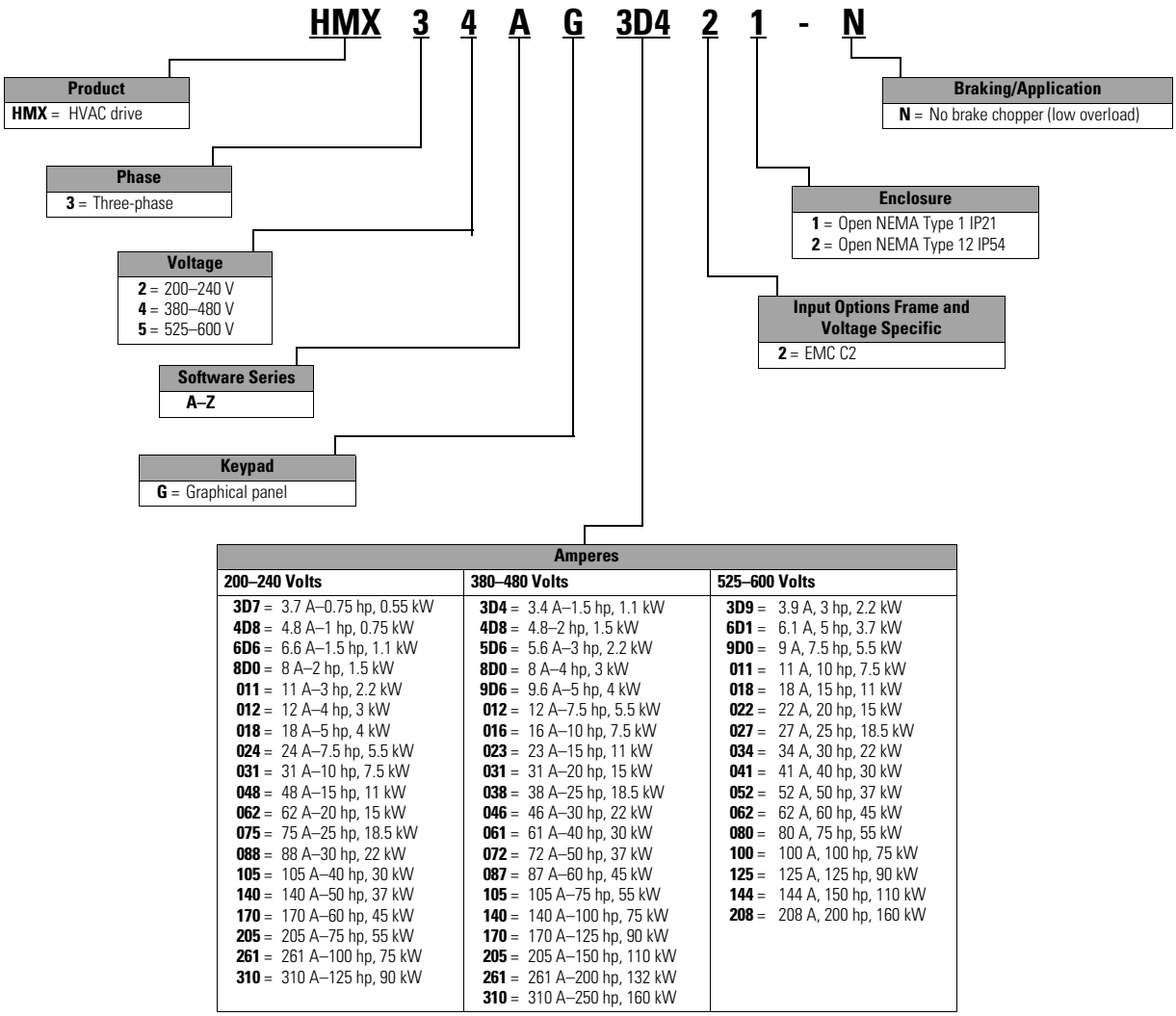


Figure 15. Carton Labels (U.S.)

U.S. Carton Label

Catalog Number Selection

Figure 16. H-Max Series Drives



Amperes		
200–240 Volts	**380–480 Volts**	**525–600 Volts**
3D7 = 3.7 A–0.75 hp, 0.55 kW	**3D4** = 3.4 A–1.5 hp, 1.1 kW	**3D9** = 3.9 A, 3 hp, 2.2 kW
4D8 = 4.8 A–1 hp, 0.75 kW	**4D8** = 4.8–2 hp, 1.5 kW	**6D1** = 6.1 A, 5 hp, 3.7 kW
6D6 = 6.6 A–1.5 hp, 1.1 kW	**5D6** = 5.6 A–3 hp, 2.2 kW	**9D0** = 9 A, 7.5 hp, 5.5 kW
8D0 = 8 A–2 hp, 1.5 kW	**8D0** = 8 A–4 hp, 3 kW	**011** = 11 A, 10 hp, 7.5 kW
011 = 11 A–3 hp, 2.2 kW	**9D6** = 9.6 A–5 hp, 4 kW	**018** = 18 A, 15 hp, 11 kW
012 = 12 A–4 hp, 3 kW	**012** = 12 A–7.5 hp, 5.5 kW	**022** = 22 A, 20 hp, 15 kW
018 = 18 A–5 hp, 4 kW	**016** = 16 A–10 hp, 7.5 kW	**027** = 27 A, 25 hp, 18.5 kW
024 = 24 A–7.5 hp, 5.5 kW	**023** = 23 A–15 hp, 11 kW	**034** = 34 A, 30 hp, 22 kW
031 = 31 A–10 hp, 7.5 kW	**031** = 31 A–20 hp, 15 kW	**041** = 41 A, 40 hp, 30 kW
048 = 48 A–15 hp, 11 kW	**038** = 38 A–25 hp, 18.5 kW	**052** = 52 A, 50 hp, 37 kW
062 = 62 A–20 hp, 15 kW	**046** = 46 A–30 hp, 22 kW	**062** = 62 A, 60 hp, 45 kW
075 = 75 A–25 hp, 18.5 kW	**061** = 61 A–40 hp, 30 kW	**080** = 80 A, 75 hp, 55 kW
088 = 88 A–30 hp, 22 kW	**072** = 72 A–50 hp, 37 kW	**100** = 100 A, 100 hp, 75 kW
105 = 105 A–40 hp, 30 kW	**087** = 87 A–60 hp, 45 kW	**125** = 125 A, 125 hp, 90 kW
140 = 140 A–50 hp, 37 kW	**105** = 105 A–75 hp, 55 kW	**144** = 144 A, 150 hp, 110 kW
170 = 170 A–60 hp, 45 kW	**140** = 140 A–100 hp, 75 kW	**208** = 208 A, 200 hp, 160 kW
205 = 205 A–75 hp, 55 kW	**170** = 170 A–125 hp, 90 kW	
261 = 261 A–100 hp, 75 kW	**205** = 205 A–150 hp, 110 kW	
310 = 310 A–125 hp, 90 kW	**261** = 261 A–200 hp, 132 kW	
	310 = 310 A–250 hp, 160 kW	

Notes

All boards are varnished (conformed coated). Corrosion resistant.

Battery included in all drives for real-time clock.

Keypad kit includes HOA bypass.

Keypad kit includes HOA, back reset for Europe application.

EMI/RFI filters included.

DC link choke included.

Notes

All boards are varnished (conformed coated). Corrosion resistant.
Battery included in all drives for real-time clock. Three year lifetime.
Keypad kit includes HOA bypass.
Keypad kit includes HOA, back reset for Europe application.
EMI/RFI filters included.
DC link choke included.

Power Ratings and Product Selection

H-Max Series Drives—208–230 Volt

Table 4. NEMA Type 1/IP21 or NEMA Type 12/IP54

	Drive Rated Current and hp				De-Rated	Assigned Motor Ratings	_ Can Be:
FS Frame Size	Drive Rating Low Overload Full Load Amps at 40°C	230V 60 Hz Horsepower	Drive Input Amps	NEC Motor 60 Hz 230V Amps [1]	Low Overload Full Load Amps at 50°C	Open Drive kW 230V 50 Hz	1 = N1 = IP21 2 = N12 = IP54 Catalog Number
FS4	3.7	0.75	3.2	3.2	2.6	0.55	**HMX32AG3D72_-N**
	4.8	1	4.3	4.2	3.7	0.75	**HMX32AG4D82_-N**
	6.6	1.5	6	6	4.6	1.1	**HMX32AG6D62_-N**
	8	2	7.2	6.8	6.6	1.5	**HMX32AG8D02_-N**
	11	3	9.7	9.6	8	2.2	**HMX32AG0112_-N**
	12.5	4	10.9	N/A	9	3	**HMX32AG0122_-N**
FS5	18	5	16.1	15.2	12.5	4	**HMX32AG0182_-N**
	24	7.5	21.7	22	18	5.5	**HMX32AG0242_-N**
	31	10	27.7	28	25	7.5	**HMX32AG0312_-N**
FS6	48	15	43.8	42	31	11	**HMX32AG0482_-N**
	62	20	57	54	48	15	**HMX32AG0622_-N**
FS7	75	25	69	68	62	18.5	**HMX32AG0752_-N**
	88	30	82.1	80	75	22	**HMX32AG0882_-N**
	105	40	99	104	88	30	**HMX32AG1052_-N**
FS8	140	50	133	130	114	37	**HMX32AG1402_-N**
	170	60	163	154	140	45	**HMX32AG1702_-N**
	205	75	198	192	170	55	**HMX32AG2052_-N**
FS9	261	100	256	248	211	75	**HMX32AG2612_-N**
	310	125	303	N/A	251	90	**HMX32AG3102_-N**

Note

[1] For sizing reference, full-load motor running currents—UL508C.

H-Max Series Drives—380–480 Volt

Table 5. NEMA Type 1/IP21 or NEMA Type 12/IP54

	Drive Input Rated Current and hp				De-Rated	Assigned Motor Ratings	_ Can Be:
FS Frame Size	Low Overload Full Load Amps at 40°C	460V 60 Hz Horsepower	Drive Input Amps	NEC Motor 60 Hz 460V Amps [1]	Low Overload Full Load Amps at 50°C	Open Drive kW 400V 50 Hz	1 = N1 = IP21 2 = N12 = IP54 Catalog Number
FS4	3.4	1.5	3.4	3	2.6	1.1	**HMX34AG3D42_-N**
	4.8	2	4.6	3.4	3.4	1.5	**HMX34AG4D82_-N**
	5.6	3	5.4	4.8	4.3	2.2	**HMX34AG5D62_-N**
	8.0	5	8.1	7.6	5.6	3.0	**HMX34AG8D02_-N**
	9.6	5	9.3	N/A	8	4	**HMX34AG9D62_-N**
	12	7.5	11.3	11	9.6	5.5	**HMX34AG0122_-N**
FS5	16	10	15.4	14	12	7.5	**HMX34AG0162_-N**
	23	15	21.3	21	16	11	**HMX34AG0232_-N**
	31	20	28.4	27	23	15	**HMX34AG0312_-N**
FS6	38	25	36.7	34	31	18.5	**HMX34AG0382_-N**
	46	30	43.6	40	38	22	**HMX34AG0462_-N**
	61	40	58.2	52	46	30	**HMX34AG0612_-N**
FS7	72	50	67.5	65	61	37	**HMX34AG0722_-N**
	87	60	85.3	77	72	45	**HMX34AG0872_-N**
	105	75	100.6	96	87	55	**HMX34AG1052_-N**
FS8	140	100	139.4	124	105	75	**HMX34AG1402_-N**
	170	125	166.5	156	140	90	**HMX34AG1702_-N**
	205	150	200	180	170	110	**HMX34AG2052_-N**
FS9	261	200	258	240	205	132	**HMX34AG2612_-N**
	310	250	303	302	251	160	**HMX34AG3102_-N**

Note

[1] For sizing reference, full-load motor running currents—UL508C.

H-Max Series Drives—600 Volt

Table 6. NEMA Type 1/IP21 or NEMA Type 12/IP54

	Drive Rated Current and hp			De-Rated	_ Can Be:
FS Frame Size	Drive Rating Low Overload Full Load Amps at 40°C	600V 60 Hz Horsepower	Drive Input Amps	Low Overload Full Load Amps at 50°C	1 = N1 = IP21 2 = N12 = IP54 Catalog Number
FR5	3.9	3	4.6	3.3	**HMX35AG3D92_-N**
	6.1	5	6.8	5.2	**HMX35AG6D12_-N**
	9	7.5	9	7.7	**HMX35AG9D02_-N**
	11	10	10.5	9.4	**HMX35AG0112_-N**
FR6	18	15	19.9	15	**HMX35AG0182_-N**
	22	20	23.3	18	**HMX35AG0222_-N**
	27	25	27.2	23	**HMX35AG0272_-N**
	34	30	32.8	28	**HMX35AG0342_-N**
FR7	41	40	45.3	34	**HMX35AG0412_-N**
	52	50	53.8	44	**HMX35AG0522_-N**
	62	60	62.2	52	**HMX35AG0622_-N**
FR8	80	75	90	68	**HMX35AG0802_-N**
	100	100	106	85	**HMX35AG1002_-N**
	125	125	127	106	**HMX35AG1252_-N**
FR9	144	150	156	122	**HMX35AG1442_-N**
	208	200	212	176	**HMX35AG2082_-N**

Table 7. H-Max Series Variable Frequency Drive Option Boards

Option Board Part Number	Assigned to Control Module Slot:	Description
XMX-IO-B1-A	D or E	Expanded 6 digital output—two outputs are programmable as digital inputs or outputs
XMX-IO-B2-A	D or E	Expanded relay outputs—two programmable relays (each with a NO and NC contact) and thermistor input
XMX-IO-B4-A	D or E	Expanded analog inputs and outputs—one analog input and two analog outputs (isolated)
XMX-IO-B5-A	D or E	Expanded relay outputs—contains three programmable relays (one NO contact each)
XMX-IO-B9-A	D or E	Accepts up to five AC inputs (42–240 Vac) and one relay output (NO)
XMX-IO-BF-A	D or E	Expanded analog and digital output—one analog, one digital, and one relay output (NO)
XMX-COM-C4-A	D or E	LonWorks® communication

Electrical Installation

WARNING

Carry out wiring work only after the frequency inverter has been correctly mounted and secured.

WARNING

Electric shock hazard—risk of injuries!

Carry out wiring work only if the unit is de-energized.

CAUTION

Debounced inputs may not be used in the safety circuit diagram.

Fire hazard!

Only use cables, protective switches, and contactors that feature the indicated permissible nominal current value.

CAUTION

Debounced inputs may not be used in the safety circuit diagram.

Ground contact currents in frequency inverters are greater than 3.5 mA (AC). According to product standard IEC/EN 61800-5-1, an additional equipment grounding conductor must be connected, or the cross-section of the equipment grounding conductor must be at least 0.39 in^2 (10 mm^2).

WARNING

The components in the frequency inverter's power section remain energized up to five (5) minutes after the supply voltage has been switched off (intermediate circuit capacitor discharging time).

Pay attention to hazard warnings!

DANGER
5 MIN

Note: Complete the following steps with the specified tools and without using force.

Installation Requirements

This chapter contains all of the information required to properly install and prepare the H-Max Series VFD for operation. The contents are listed to serve as a list of tasks needed to complete the installation. Included in this section are:

- Line (mains) and motor power wiring
- I/O control wiring

Standard Mounting Instructions

- Select the mounting location based on requirements listed in this chapter
- Mounting surface must be a vertical, flat, non-flammable surface
- H-Max Series open drives may be mounted side-by-side or stacked vertically, as outlined in this chapter
- Surface must be strong enough to support the drive and not subject to excessive motion or vibration
- Mark the location of the mounting holes on the mounting surface, using the template provided on the cover of the cardboard shipping package
- Using fasteners appropriate to your VFD and mounting surface, securely attach the VFD to the mounting surface using all four mounting hole locations

When mounting one unit above the other the lower unit air outlet must be directed away from the inlet air used by the upper one. The clearance between the upper and lower unit should equal C + D.

1. Measure the mounting space to ensure that it allows the minimum space surrounding the H-Max Series drive. Drive dimensions are on **Page 23**.
2. Make sure the mounting surface is flat and strong enough to support the drive, is not flammable, and is not subject to excessive motion or vibration.
3. Ensure that the minimum airflow requirements for your drive are met at the mounting location.
4. Mark the location of the mounting holes on the mounting surface, using the template provided on the cover of the cardboard shipping package.
5. Using fasteners appropriate to your drive and mounting surface, securely attached the drive to the mounting surface using all four screws or bolts.

Mounting dimensions:

- Refer to **Page 23** for drive dimensions

Figure 17. Mounting Space

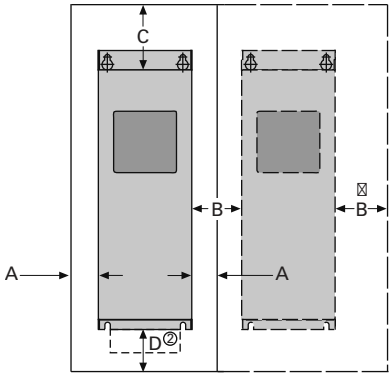


Table 8. Space Requirements for Mounting the H-Max Series VFD and Airflow

Frame Size	Line Voltage	hp (VT)	kW [1]	Amperes	A [2] in (mm)	B [2] in (mm)	C in (mm)	D in (mm)	Cooling Air Required
FS4	230V	0.75–4	0.55–3.0	3.7–12.5	0.8 (20)	0.8 (20)	3.9 (100)	3.0 (50)	27 CFM 45 m^3/h
	480V	1.5–7.5	1.1–5.5	3.4–12					
FS5	230V	5–10	4–7.5	18–31	0.8 (20)	0.8 (20)	4.7 (120)	2.4 (60)	45 CFM 75 m^3/h
	480V	10–20	7.5–15	16–31					
	600V	3–10	—	3.9–11					
FS6	230V	15–20	11–15	48–62	0.8 (20)	0.8 (20)	6.3 (160)	3.1 (80)	112 CFM 190 m^3/h
	480V	25–40	18.5–30	38–61					
	600V	15–30	—	18–34					
FS7	230V	25–40	18.5–30	75–105	0.8 (20)	0.8 (20)	9.8 (250)	3.9 (100)	109 CFM 185 m^3/h
	480V	50–75	37–55	72–105					
	600V	40–60	—	41–62					
FS8	230V	50–75	37–55	140–205	0.8 (20)	0.8 (20)	11.9 (300)	6.0 (150)	209 CFM 335 m^3/h
	480V	100–150	75–110	140–205					
	600V	75–125	—	80–125					
FS9	230V	100–125	75–90	261–310	0.8 (20)	0.8 (20)	13.8 (350)	7.9 (200)	366 CFM 621 m^3/h
	480V	200–250	132–160	261–310					
	600V	150–200	—	144–208					

Notes

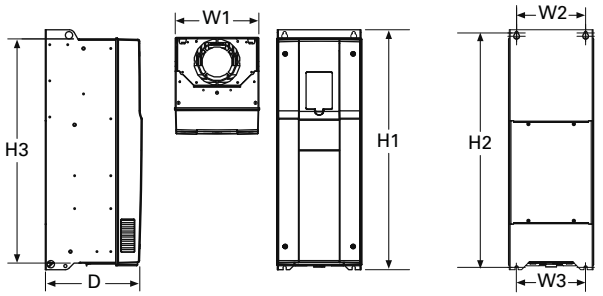
1 kW ratings are at 400V/50 Hz.

2 Minimum clearances A and B for drives with NEMA 12 (IP54) enclosure is 0 mm (in).

NEMA Type 1/12 Open Drives (1–250 hp)

Approximate Dimensions in Inches (mm)

Figure 18. Mounting Drive Dimensions—FS4–FS7



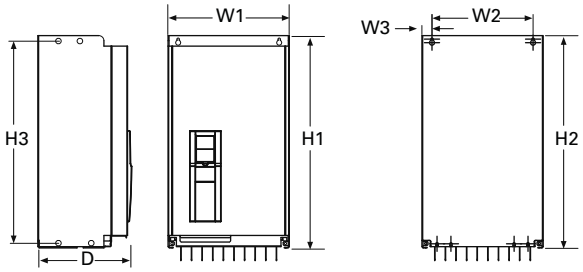
H-Max Series Frames FS4—FS7

Table 9. Mounting Drive Dimensions—FS4–FS7

Frame Size	Line Voltage	hp (VT)	kW	Amperes	D	H1	H2	H3	W1	W2	W3	Weight in Lbs (kg)
FS4	230V	0.75–4	0.55–3.0	3.7–12.5	7.77 (197.3)	12.89 (327.5)	12.32 (313)	11.22 (285)	5.04 (128)	3.94 (100)	3.94 (100)	13.2 (6.0)
	480V	1.5–7.5	1.1–5.5	3.4–12								
FS5	230V	5–10	4–7.5	18–31	8.73 (221.6)	16.50 (419)	15.98 (406)	15.04 (382)	5.67 (144)	4.53 (115)	3.94 (100)	22 (10.0)
	480V	10–20	7.5–15	16–31								
	600V	3–10	—	3.9–11								
FS6	230V	15–20	11–15	48–62	9.29 (236)	21.93 (557)	21.28 (540.5)	20.24 (514)	7.68 (195)	5.83 (148)	5.83 (148)	44.1 (20.0)
	480V	25–40	18.5–30	38–61								
	600V	15–30	—	18–34								
FS7	230V	25–40	18.5–30	75–105	10.49 (266.5)	25.98 (660)	25.39 (645)	24.29 (617)	9.06 (237)	7.48 (190)	7.48 (190)	82.6 (37.5)
	480V	50–75	37–55	72–105								
	600V	40–60	—	41–62								

Approximate Dimensions in Inches (mm)

Figure 19. Mounting Drive Dimensions—FS8 and FS9



H-Max Series Frames FS8 and FS9

Table 10. Mounting Drive Dimensions—FS8 and FS9

Frame Size	Line Voltage	hp (VT)	kW	Amperes	D	H1	H2	H3	W1	W2	W3	Weight in Lbs (kg)
FS8	230V	50–75	37–55	140–205	13.76 (350)	38.02 (965.7)	37.26 (946)	37.26 (946)	11.42 (290)	9.29 (236)	1.42 (36)	154.3 (70)
	480V	100–150	75–110	140–205								
	600V	75–125	—	80–125								
FS9	230V	100–125	75–90	261–310	14.63 (372)	33.09 (1150.4)	31.89 (810)	31.89 (810)	18.90 (480)	15.75 (400)	1.57 (40)	238.1 (108)
	480V	200–250	132–160	261–310								
	600V	150–200	—	144–208								

Power Wiring Selection

Line (Mains) and Motor Cable Installation

Motor cable connections are made to terminals U/T_1, V/T_2, and W/T_3.

Cable Selection: Power and Motor Leads

- Use UL approved heat-resistant copper cables only
- 75°C or higher for all units rated <480V
- 90°C or higher for all 480V units
- Line voltage/mains should be Class 1 wire only outside North America
- Refer to the following tables for cable sizing guidelines

North America 208–240V	**Page 47**
North America 380–480V	**Page 48**
All other International 380–600V	**Page 50**

The input line and motor cables must be sized in accordance with the rated H-Max VFD input current.

If motor temperature sensing is used for overload protection, the output cable size may be selected based on the motor specifications.

Maximum symmetrical supply current is 100,000A RMS for all size H-Max VFDs.

Input Fusing

Fuses are rated based on H-Max rated output current.

Use Class T (UL or CSA) or type gG/gL (IEC 60269-1).

Refer to **Pages 47**, **48**, and **50** for proper fuse size selection.

Fuses with an operating speed of less than 0.4 seconds may be used including the following types:

- High Speed J (UL and CSA)
- aR (UL recognized, IEC 60269-4)
- gS (IEC 60269-4)

Consult with Eaton Electrical for further information on fusing requirements.

Table 11. Power Connection Tightening Torque

Fame Size	Tightening Torque (in-lbs)	Tightening Torque (Nm)
FS4	4.5–5.3	0.5–0.6
FS5	10.6–13.3	1.2–1.5
FS6	88.5	10
FS7	70.8 [1]/49.6 [2]	8 [1]/5.6 [2]
FS8	266	30
FS9	354	40

Notes

[1] The tightening torque for a Torz screw.

[2] The tightening torque for an Allen screw.

Note: Strip the motor and power cables as shown in figure on next page.

Table 12. Spacing Between Parallel Motor Cables

Cable Length	Distance Between Cables
Less than 164 ft (50 m)	1 ft (0.3m)
Less than 657 ft (200 m)	3 ft (3.3m)

Table 13. Maximum Cable Length by Frame Size without DV/DT Protected C2 Ratings

Frame Size	Maximum Cable Length
FS4	328 ft (100m)
FS5	493 ft (150m)
FS6	
FS7	657 ft (200m)
FS8	657 ft (200m)
FS9	657 ft (200m)

Figure 20. Input Power and Motor Cable Stripping Lengths

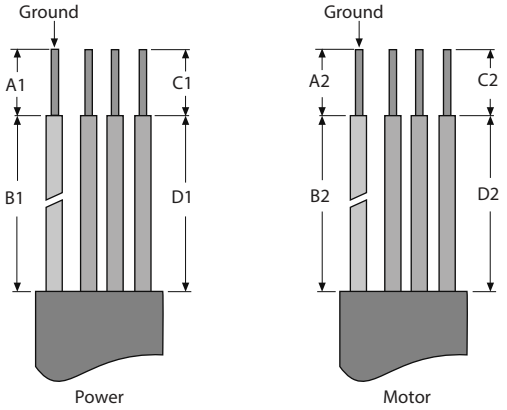


Table 14. Input Power and Motor Cable Stripping and Wire Lengths

Frame Size	Power Wiring in Inches (mm)				Motor Wiring in Inches (mm)			
	A1	**B1**	**C1**	**D1**	**A2**	**B2**	**C2**	**C4**
FS4	0.59 (15)	1.38 (35)	0.39 (10)	0.79 (20)	0.28 (7)	1.97 (50)	0.28 (7)	1.38 (35)
FS5	0.79 (20)	1.57 (40)	0.39 (10)	1.18 (30)	0.79 (20)	2.36 (60)	0.39 (10)	1.57 (40)
FS6	0.79 (20)	3.54 (90)	0.59 (15)	2.36 (60)	0.79 (20)	3.54 (90)	0.59 (15)	2.36 (60)
FS7	0.98 (25)	4.72 (120)	0.98 (25)	4.72 (120)	0.98 (25)	4.72 (120)	0.98 (25)	4.72 (120)
FS8	1.10 (28)	9.45 (240)	1.10 (28)	9.45 (240)	1.10 (28)	9.45 (240)	1.10 (28)	9.45 (240)
FS9	1.10 (28)	11.61 (295)	1.10 (28)	11.61 (295)	1.10 (28)	11.61 (295)	1.10 (28)	11.61 (295)

Cable Routing

If conduit is being used for wiring, use separate conduits for line voltage (mains), motor cables, and all interface/control wiring.

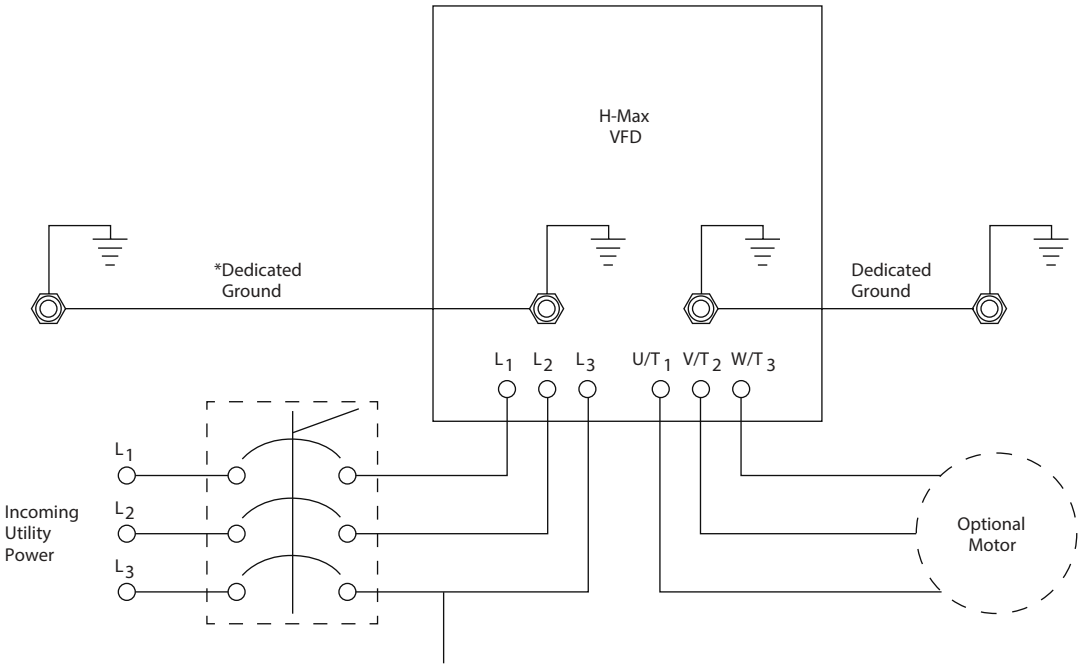
Avoid running motor cables alongside or parallel to any other wiring. If it is necessary to run motor cables with other wiring, then maintain spacing between motor cables and other wiring in accordance with the table on **Page 25**.

Refer to the table on **Page 25** for maximum cable lengths by frame size.

If three or more motor cables are used, each conductor must have its own overcurrent protection.

If three or more motor cables are used, each conductor must have its own overcurrent protection.

Figure 21. Wiring the VFD



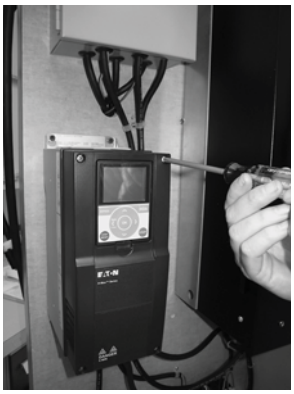
*Conduit Only Does Not Represent Ground.

Power Wiring

Notice

Do not discard the plastic bag containing the wiring hardware.

1. Remove the cover by removing (4) screws, then lifting the cover away from the base.

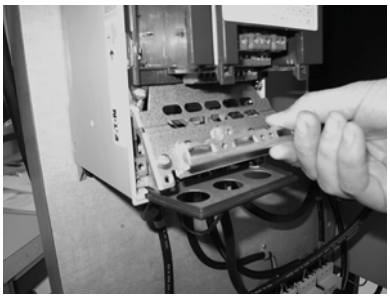


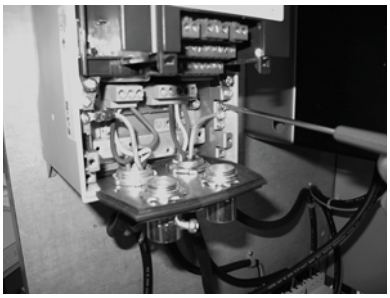
Wiring Hardware Contents

- European rubber grommet and flat rubber grommet (for IP54 integrity).
- Modification label
- Wire (grounding strap)
- Detachable cable clamp
- Attachable grounding clamps
- Ground lug mounting screw size M4

Power Wiring/Grounding

2. Remove power wiring protection plate. Use power/motor cable tables on **Pages 47**, **48**, and **50**.
3. Add attachable grounding clamps (qty 2), one on each side of drive.
4. Pass motor, input power wires/cables through base wiring plate.
5. If shielded cable is used, connect the shields of input power and motor cables shields to ground.

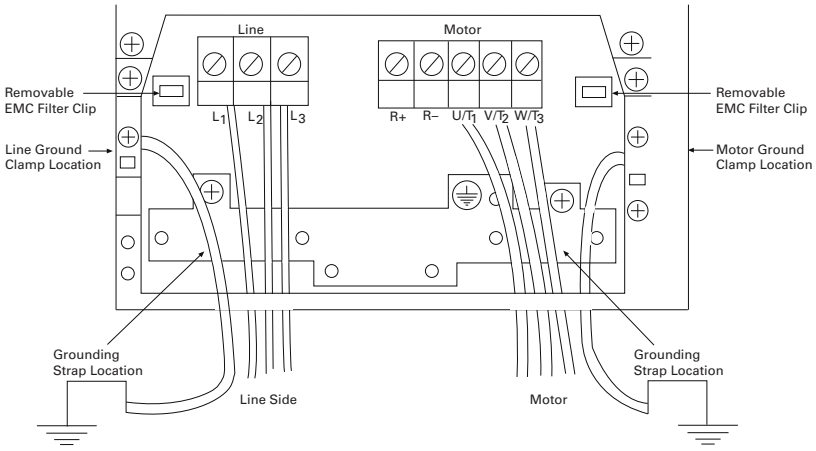




Power Wiring/Grounding, continued

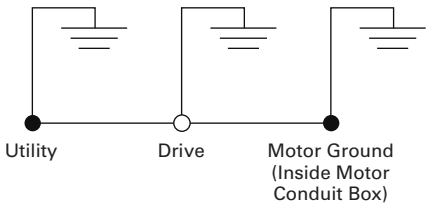
6. Wire power terminals (L1,L2,L3), motor terminal (U/T1, U/T2, U/T3), and grounding terminals per diagram below. Power and motor leads must be in separate conduit.

Note: Do not wire motor leads to R+, R–. This will cause damage to the drive.



GROUND WIRING

- Run motor cables in separate conduit
- DO NOT RUN CONTROL WIRES in same conduit
- Cables sized per NEC
- Provide **dedicated** wire for low impedance ground between drive and motor. DO NOT USE conduit as ground



IMPORTANT: Improper grounding could result in damage to the motor and/or drive and could void warranty.

Control Wiring

7. Wire the control terminals following the details for the specific option boards shown on the following pages.

Note: For ease of access, the board terminals blocks can be unplugged for wiring.

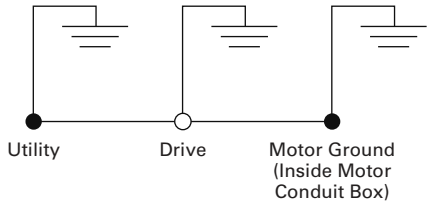
Control Wiring

8. Wire control to the control board.

Note: Drive default is programmed for external interlock.

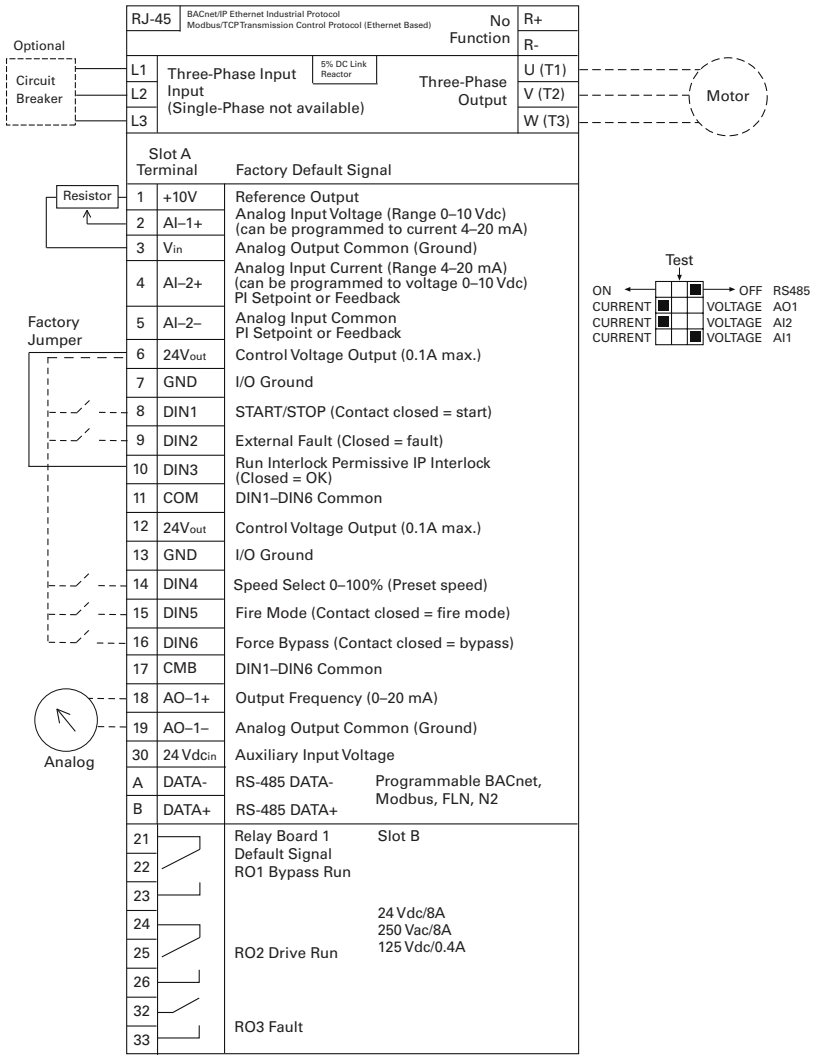
Mandatory Ground Wiring

Be sure to pull a dedicated low impendance ground wiring from customer power to drive and ground wire from drive to motor.



I/O Connection

- Run 110 Vac and 24 Vdc control wiring in separate conduit
- Communication wire to be shielded

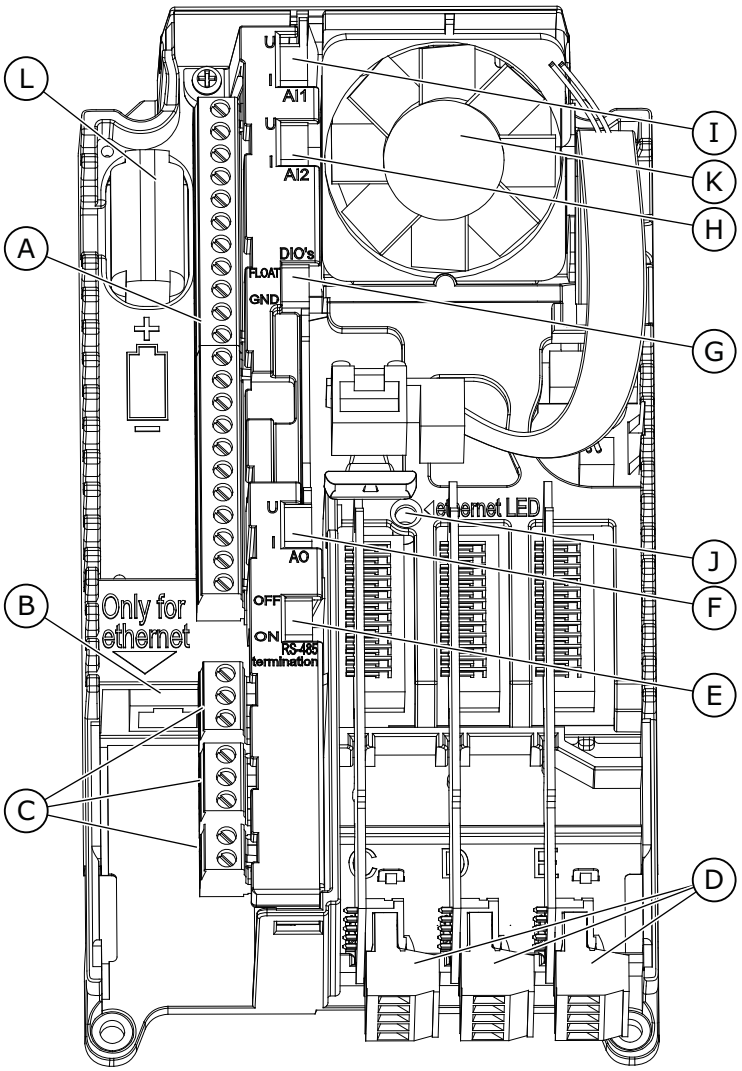


Control Board

The main H-Max Series VFD consists of a main control board, control I/O connections block and two slots for extra option boards.

This main control board launched March 2017. Serial Numbers after C171201265 were manufactured with this main control board. All units manufactured prior shipped with an old style control board. The new main control board contains backward compatibility.

Figure 22. H-Max Series Variable Frequency Drive



Legend

A. The control terminals for the standard I/O connections
B. The Ethernet connection
C. The relay board terminals for 3 relay outputs or 2 relay outputs and a thermistor
D. The option boards [1]
E. A DIP switch for the RS-485 bus termination
F. A DIP switch for the signal selection of analog output
G. A DIP switch for the isolation of the digital inputs from ground
H. A DIP switch for the signal selection of Analog Input 2
I. A DIP switch for the signal selection of Analog Input 1
J. The status indicator of the Ethernet connection
K. A fan (only in IP54 of FR4 and of FR5)
L. The battery for the RTC

Note

[1] Expansion slots D and E will accept option boards. Slot C is inactive and will not function with any option board.

Control Wiring

- All control I/O wiring must be segregated from line (mains) and motor cabling
- Control wiring shall be shielded twisted pairs. To meet EMC levels required by ENG1800-3 (2004). Control wiring must be Type 4 cable
- Run 120 Vac and +24 Vdc control I/O in separate conduit
- Control I/O terminals must be tightened to 4.5 lb (0.5 Nm)

LED Functionality

The status LED of the drive shows the status of the drive. The status LED is located in the control panel, below the keypad, and it can show 5 different statuses.

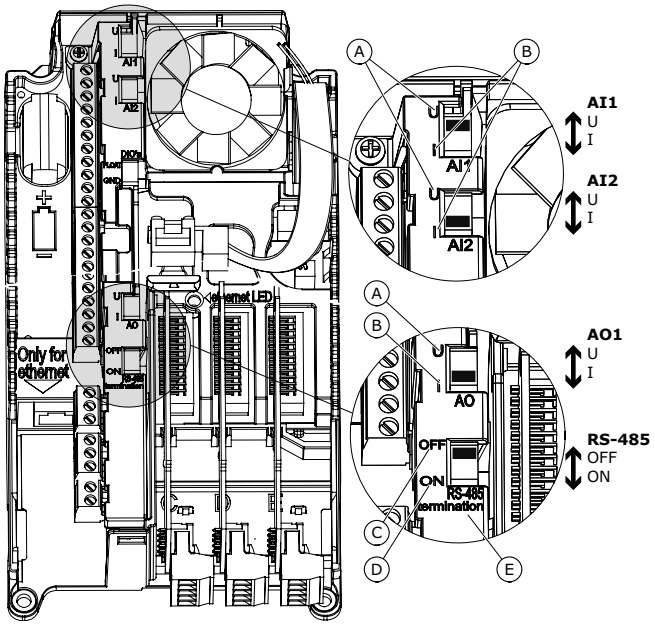
Table 15. LED Status

Color of the LED Light	Status of the Drive
Green—blinking slowly	Ready
Green—steady	Run
Red	Fault
Orange	Alarm
Green—blinking fast	Downloading software

DIP Switch Functionality

You can make 2 selections with the DIP switches for specified terminals. The switches have 2 positions: up and down. You can see the location of the DIP switches and the possible selections below.

Figure 23. DIP Switch Functionality



A. The voltage signal (U), 0–10 V input

B. The current signal (I), 0–20 mA input

C. OFF

D. ON

E. The RS-485 bus termination

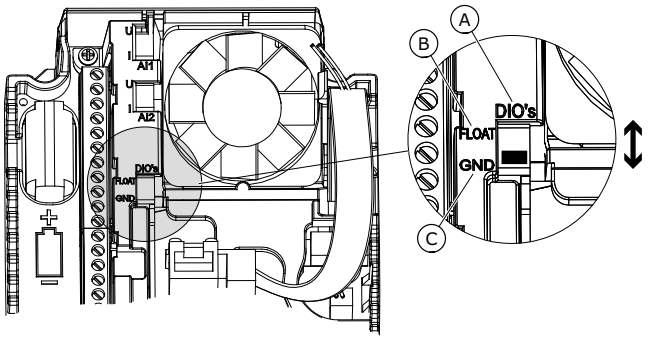
Table 16. DIP Switch

DIP Switch	Default Position
AI1	I
AI2	I
AO1	I
RS-485 bus termination	OFF

Digital Input Ground Isolation

It is possible to isolate from ground the digital inputs (terminals 8–10 and 14–16) on the standard I/O board. To do this, change the position of a DIP switch on the control board.

Figure 24. Digital Input Ground Isolation



A. The digital inputs

B. Floating

C. Connected to GND (default)

Battery for Real Time Clock

To use the Real Time Clock (RTC), you must install a battery in the drive.

1. Use a 1/2 AA battery with 3.6 V and a capacity of 1000–1200 mAh. You can use, for example, a Panasonic BR-1/2 AA or a Vitzrocell SB-AA02.
2. Install the battery on the left side of the control panel.

The battery will last approximately 10 years. See more about the functions of the RTC in the Application Manual.

EMC Installation

The responsibility to comply with the legally stipulated limit values and thus the provision of electromagnetic compatibility is the responsibility of the end user or system operator. This operator must also take measures to minimize or remove emissions in the environment concerned (see figure on **Page 5**). He must also use means to increase the interference immunity of the system devices.

In a drive system (PDS) with frequency inverters, you should take measures for electromagnetic compatibility (EMC) while doing your planning, because changes or improvements to the installation site, which are required in the installation or while mounting, are normally associated with additional higher costs.

The technology and system of a frequency inverter cause the flow of high frequency leakage current during operation. All grounding measures must therefore be implemented with low impedance connections over a large surface area.

With leakage currents greater than 3.5 mA, in accordance with VDE 0160 or EN 60335, either

- the protective conductor must have a cross-section ≧10 mm^2
- the protective conductor must be open-circuit monitored, or
- the second protective conductor must be fitted

For an EMC-compliant installation, we recommend the following measures:

- Installation of the frequency inverter in a metallic, electrically conducting enclosure with a good connection to earth
- Shielded motor cables (short cable lengths)

Ground all conductive components and housings in a drive system using as short a line as possible with the greatest possible cross-section (Cu-braid).

EMC Measures in the Control Panel

For EMC-compatible installation, connect all metallic parts of the device and the switching cabinet together over broad surfaces and so that high-frequencies will be conducted. Mounting plates and cabinet doors should make good contact and be connected with short HF-braided cables. Avoid using painted surfaces (anodized, chromized). An overview of all EMC measures is provided in the figure on **Page 35**.

Install the frequency inverter as directly as possible (without spacers) on a metal plate (mounting plate).

Route input and motor cables in the switch cabinet as close to the ground potential as possible. This is because free moving cables act as antennas.

When laying HF cables (for example, shielded motor cables) or suppressed cables (for example, input supply cables, control circuit and signal cables) in parallel, a minimum clearance of 11.81 in (300 mm) should be ensured in order to prevent the radiation of electromagnetic energy. Separate cable routing should also be ensured when large voltage potential differences are involved. Any necessary crossed cabling between the control signal and power cables should always be implemented at right angles (90 degrees).

Never lay control or signal cables in the same duct as power cables. Analog signal cables (measured, reference and correction values) must be shielded.

Earthing

The ground connection (PE) in the cabinet should be connected from the input supply to a central earth point (mounting plate). All protective conductors should be routed in star formation from this earth point and all conductive components of the PDS (frequency inverter, motor reactor, motor filter, main choke) are to be connected.

Avoid ground loops when installing multiple frequency inverters in one cabinet. Make sure that all metallic devices that are to be grounded have a broad area connection with the mounting plate.

Screen Earth Kit

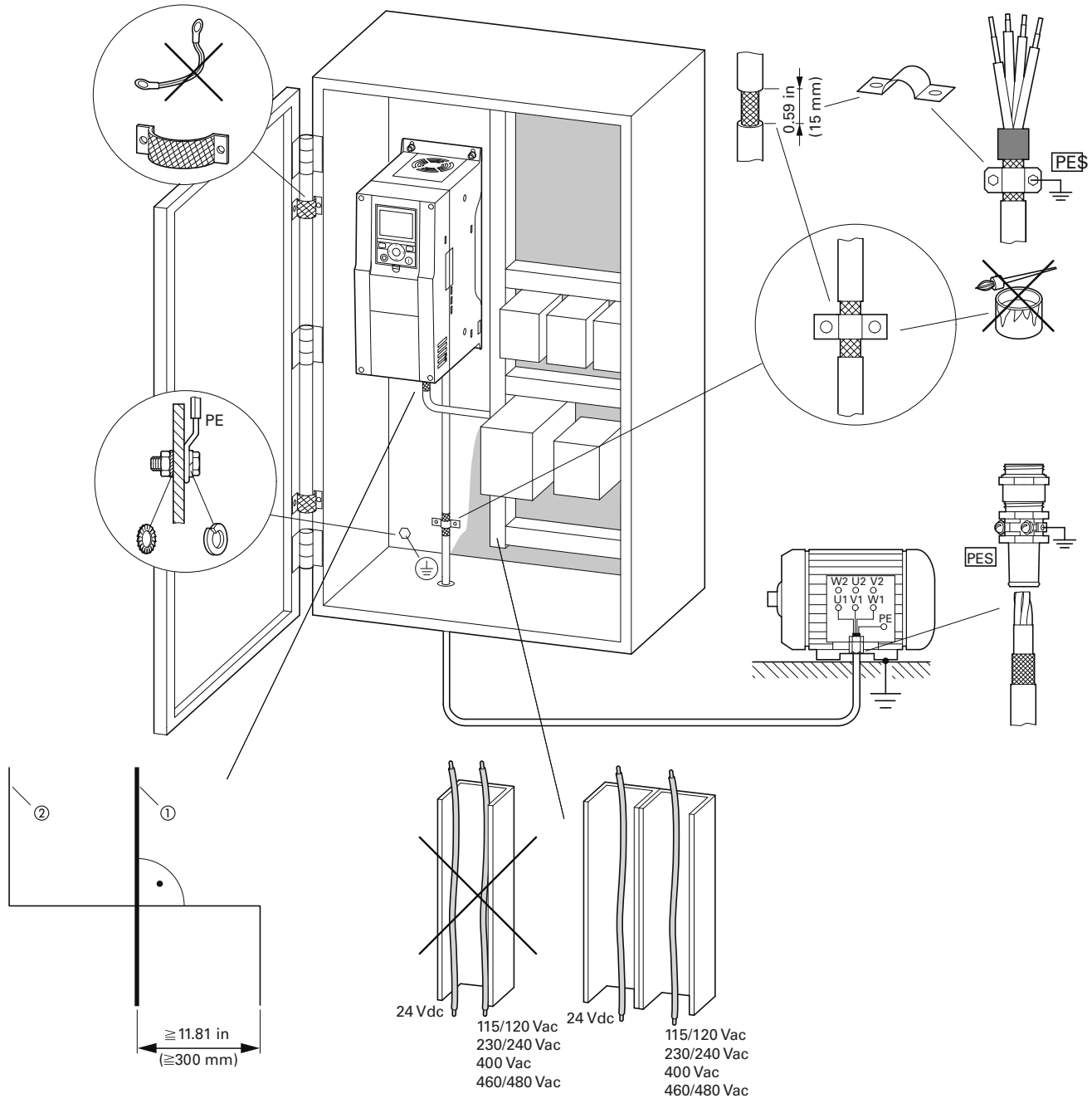
Cables that are not shielded work like antennas (sending, receiving). Make sure that any cables that may carry disruptive signals (for example, motor cables) and sensitive cables (analog signal and measurement values) are shielded apart from one another with EMC-compatible connections.

The effectiveness of the cable shield depends on a good shield connection and a low shield impedance.

Use only shields with tinned or nickel-plated copper braiding. Braided steel shields are unsuitable.

Control and signal lines (analog, digital) should always be grounded on one end, in the immediate vicinity of the supply voltage source (PES).

Figure 25. EMC-Compliant Setup (Example: H-Max)



Notes

1 Power cable: L1, L2, L3 and U/T1, V/T2, W/T3.

2 Control and signal lines: 1 to 30, A, B, fieldbus connection

Large-area connection of all metallic control panel components.

Mounting surfaces of frequency inverter and cable shielding must be free from paint.

Connect the cable shielding in the output of the frequency inverter with a large surface area contact to the ground potential (PES).

Large-area cable shield contacts with motor.

Large-area earth connection of all metallic parts.

Table 17. International EMC Protection Cable Requirements

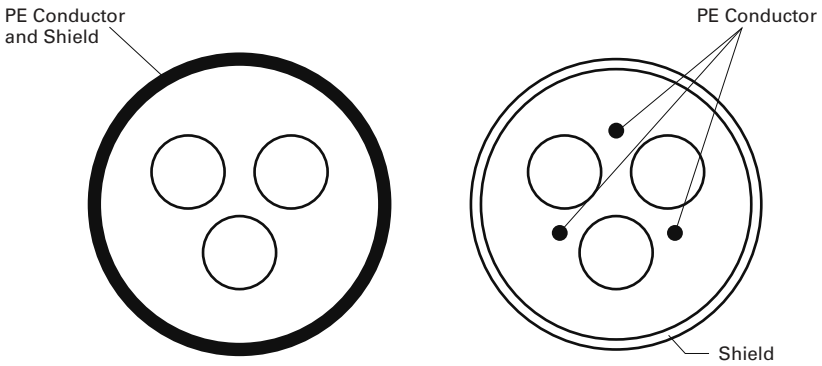
1st Environment 2nd Environment EMC Levels According to EN61800-3 (2004)

Cable Type	Category C2	Category C3	Level T
Line voltage/mains	1	1	1
Motor cable	3 [1]	2	2
Control cable	4	4	4

Cable Categories

Cable Category	Description (All cables are rated for the specific operating voltage)	Recommended Cable Types
1	Intended for fixed installation	MCMK or similar
2	Symmetrical power cable equipped with a concentric protection wire.	MCMK or similar
3	Symmetrical power cable with compact low-impedance shield. Recommended cable transfer impedance of 1–30 Mhz max. See figure below.	MCCMK, EMCMK, or similar
4	Screened cable equipped with compact low-impedance shield	JAMAK, SAB/ ÖCuY**23** -0 or similar

Figure 26. Cable Description



Note

[1] 360° earthing of the shield with cable glands in motor end needed for EMC Level C2.

Installation in Corner-Grounded Network

Corner grounding is allowed for the drive types rating from 72–310A at 380–480V supply and from 75–310A at 208–240V supply.

In these circumstances the EMC protection class must be changed to level C4 following the instructions below.

Corner grounding is not allowed for the drive types with rating from 3.4–6A at 380–480V supply and 3.7–62A with 208–240V supply.

Installation in High Leg Systems

High leg systems are not recommended with the H-Max series drives.

Installation in IT System

If your supply network is an IT (impedance-grounded) system but your AC drive is EMC-protected according to class C2 you need to modify the EMC protection of the AC drive to EMC level C4. This is done by removing the built-in EMC jumpers with a simple procedure described below:

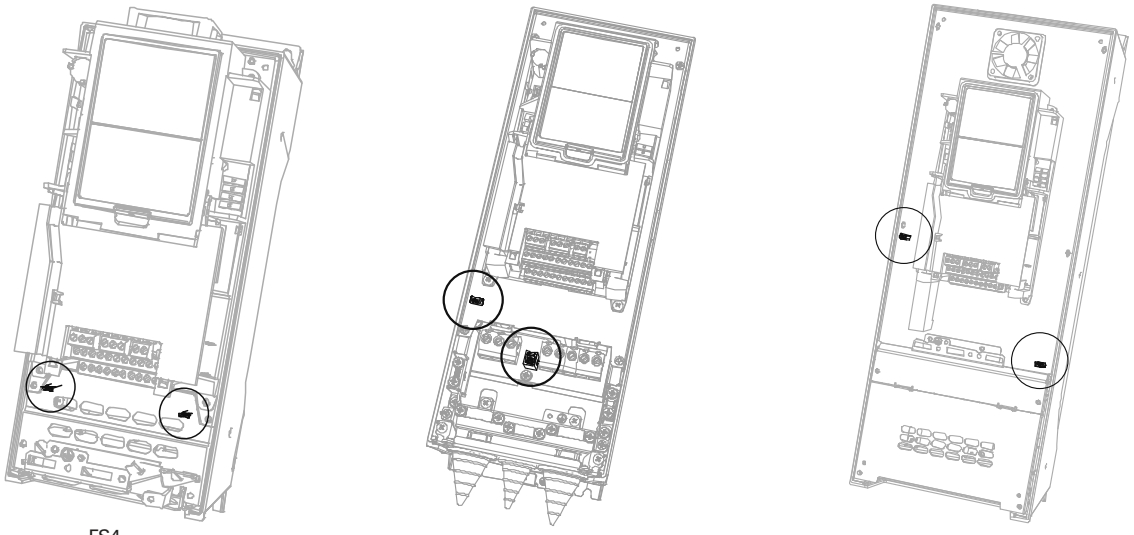
WARNING

Do not perform any modifications on the AC drive when it is connected to mains.

Frames FS4 to FS6

Remove the main cover of the AC drive (see figure below) and locate the jumpers connecting the built-in RFI-filters to ground. See figure below.

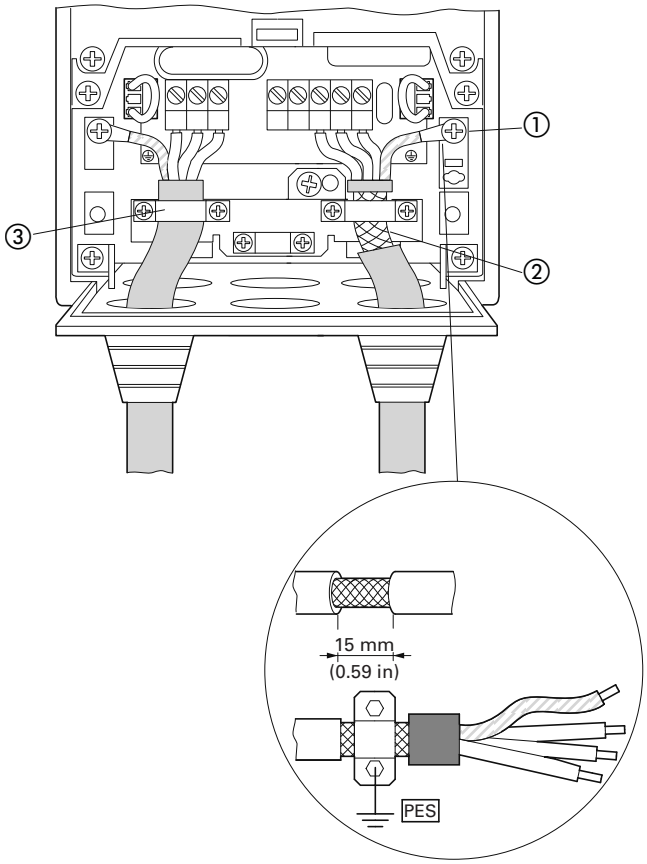
Figure 27. Locations of the EMC-Jumpers in Frames FS4 to FS6



Connection to Power Section

The following figure shows the general connections for the frequency inverter in the power section.

Figure 28. Three-Phase Input Connection



Terminal Designations in the Power Section

- L1, L2, L3: Connection terminals for the supply voltage (input, input voltage):
  - Three-phase AC voltage: Connection to: L1, L2, L3 with HMX3_
- U/T1, V/T2, W/T3: Connection terminals for the three-phase line to the AC motor (output, frequency inverter)
- ⏚ PE: connection for protective ground (reference potential). PES with mounted cable routing plate for shielded cables

Figure 29. Connection to Power Section

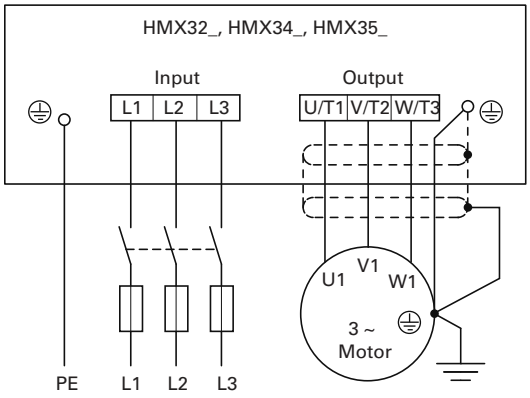
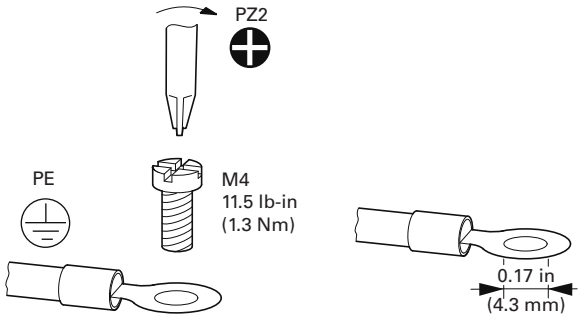


Figure 30. Ground Connection



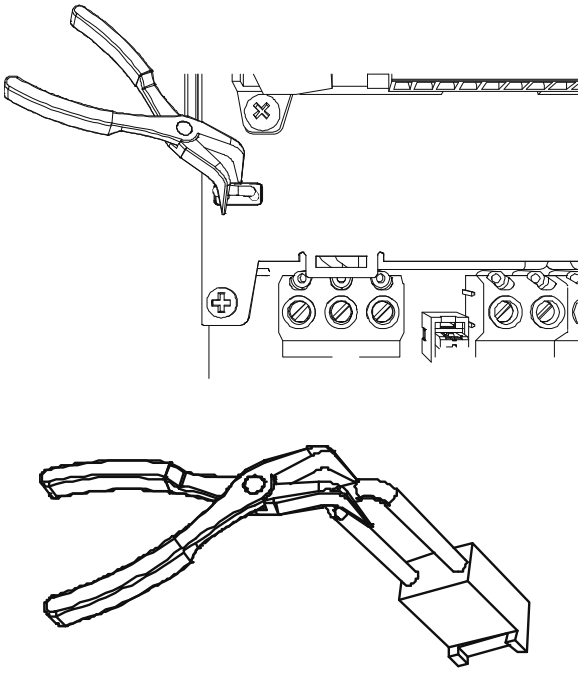
The ground connection is connected directly with the cable clamp plates.

The shielded cables between the frequency inverter and the motor should be as short as possible. Connect the shielding on both ends and over a large surface area with protective ground PES (Protective Earth Shielding). You can connect the shielding of the motor cable directly to the cable clamp plate (360 degrees coverage) with the protective ground.

The frequency inverter must always be connected to the ground potential via a grounding cable (PE).

Disconnect the RFI-filters from ground by removing the EMC-jumpers using long-nose pliers or similar. See figure below.

Figure 31. Removing the Jumper, FS5 as Example

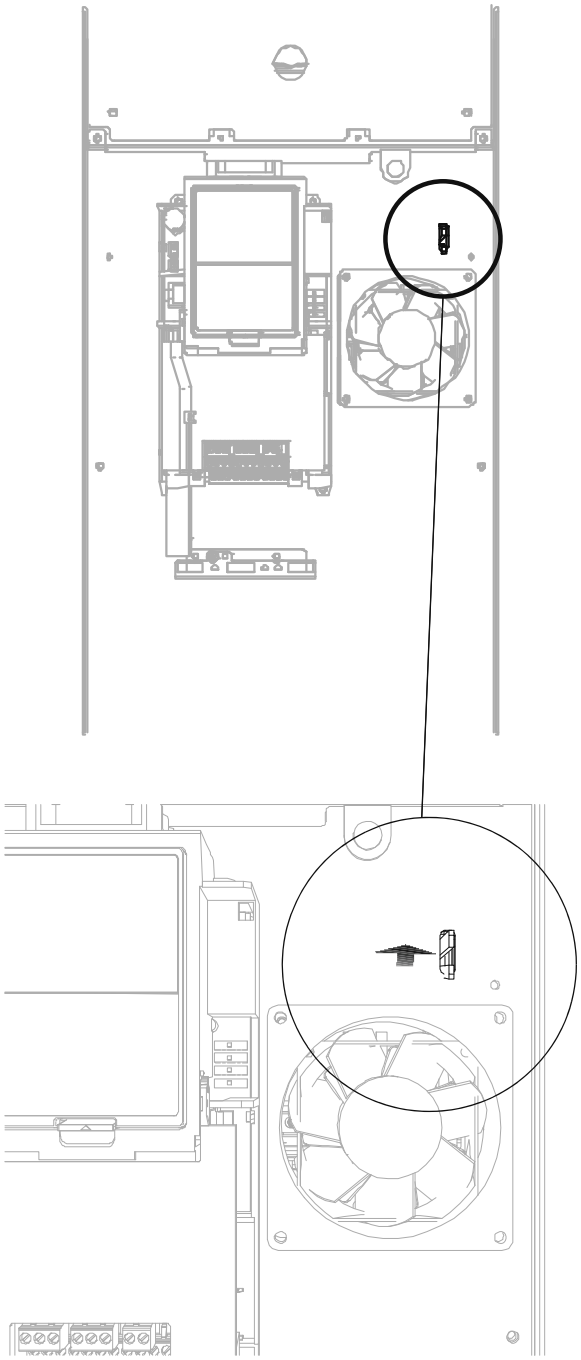


Frames FS7 and FS8

Follow the procedure described below to modify the EMC protection of the AC drive of frames FS7 and FS8 to EMC-level C4.

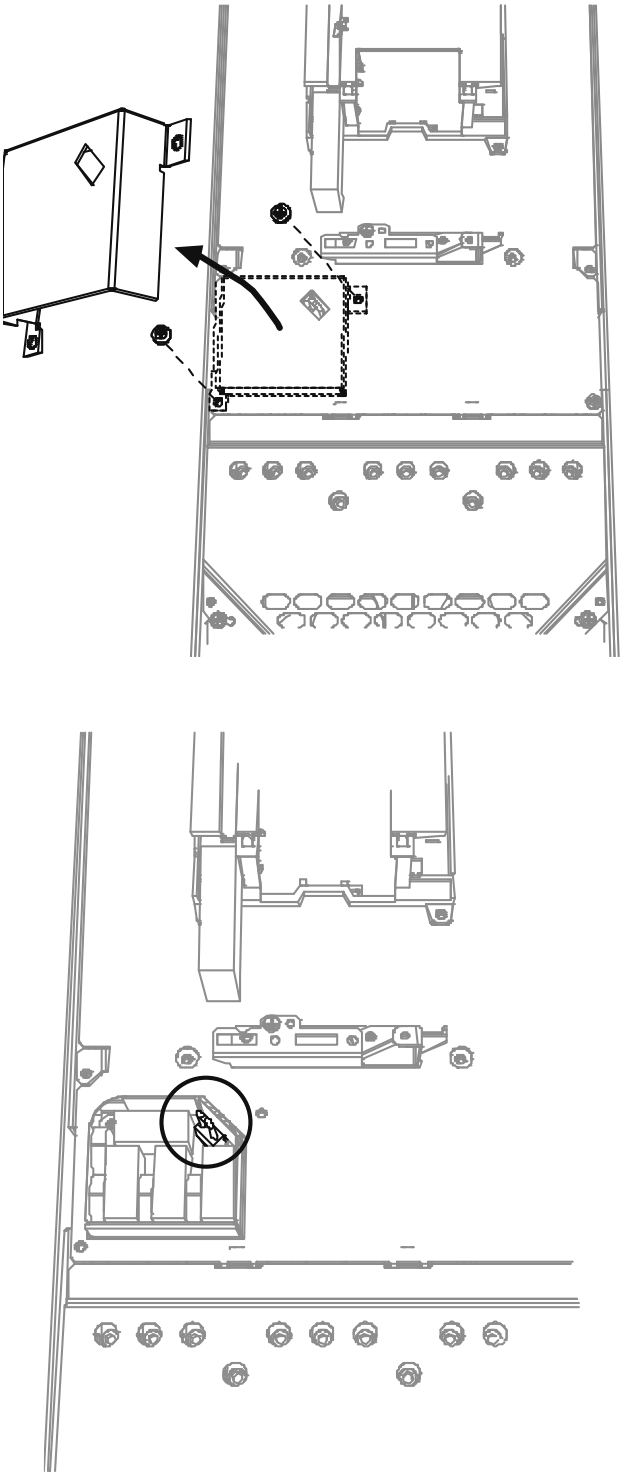
Remove the main cover of the AC drive and locate the jumper. **FS8 only: Push down** the grounding arm. See figure below.

Figure 32. Grounding Bar Location, FS8



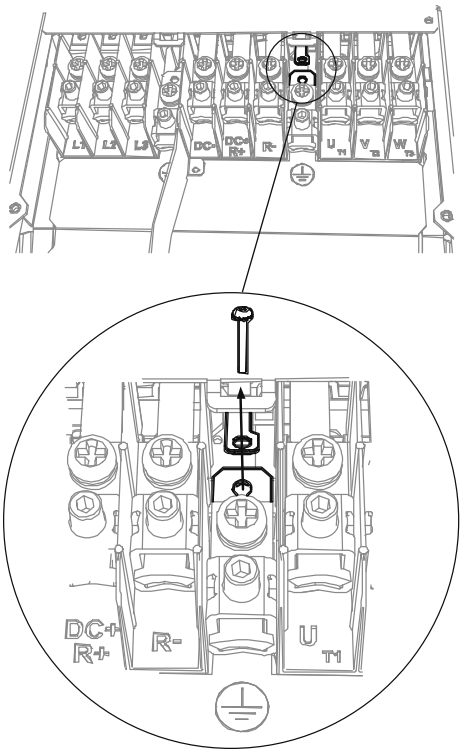
FS7 and FS8: Locate the EMC box under the cover. Remove the screws of the box cover to expose the EMC-jumper. Detach the jumper and re-fix the box cover. See figure below.

Figure 33. Removing the EMC Jumper, FS7 and FS8



FS7 only: Locate the DC grounding busbar between connectors R- and U and detach the busbar from the frame by undoing the M4 screw. See figure below.

Figure 34. Detaching the DC Grounding Bus Bar from Frame, FS7

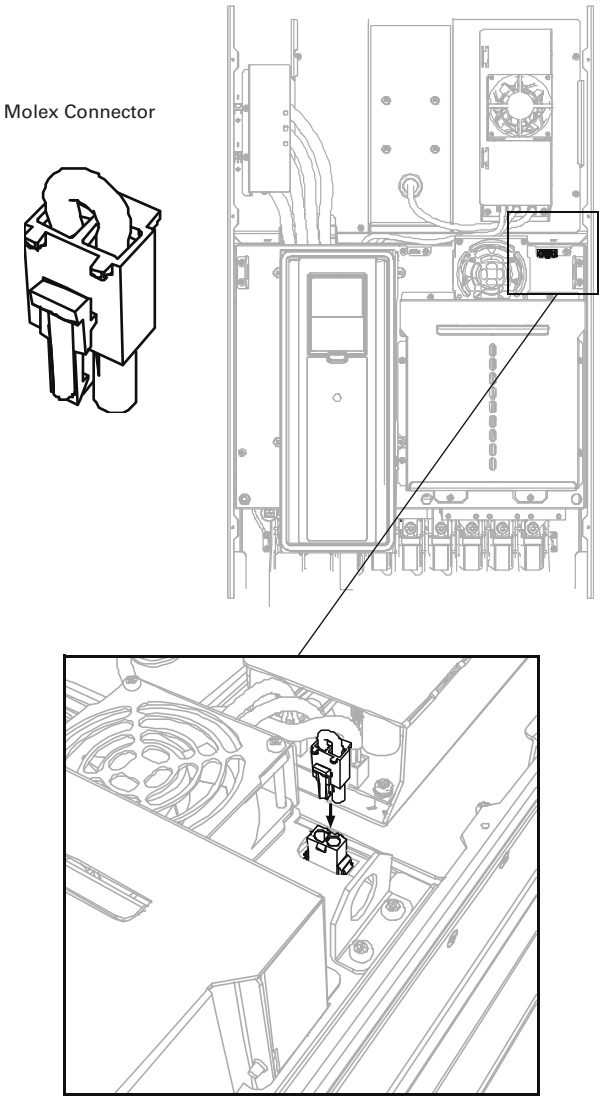


Frame FS9

Follow the procedure described below to modify the EMC protection of the AC drive of frame FS9 to EMC-level C4.

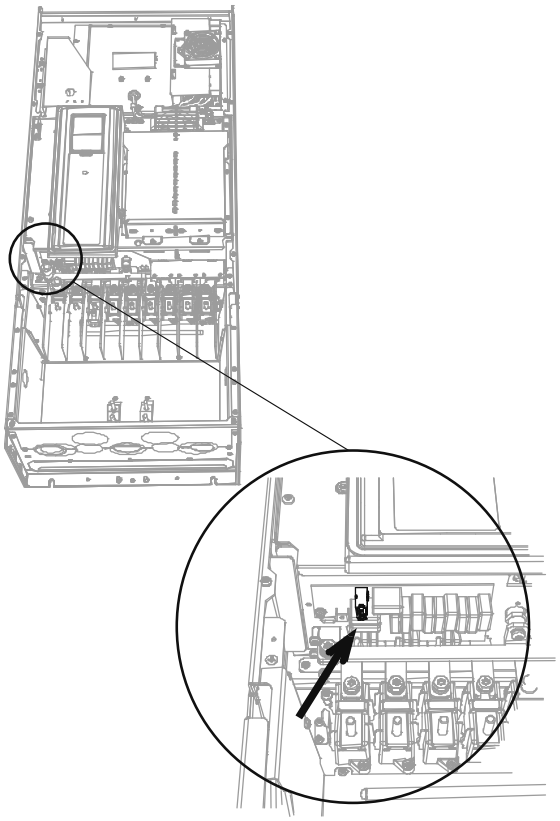
Find the *Molex* connector in the accessories bag. Remove the main cover of the AC drive and locate the place for the connector next to the fan. Push the Molex connector in its place. See figure below.

Figure 35. Molex Connector Placement, FS9



Further remove the extension box cover, the touch shield and the I/O plate with I/O grommet plate. Locate the EMC jumper on the EMC board (see magnification in figure below) and remove it.

Figure 36. Removing the EMC Jumper, FS9

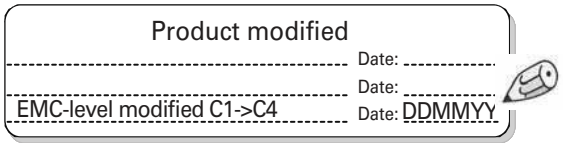


⚠ CAUTION

Before connecting the AC drive to mains make sure that the EMC protection class settings of the drive are appropriately made.

Note: After having performed the change write *"EMC level modified"* on the sticker included in the H-Max delivery (see figure below) and note the date. Unless already done, attach the sticker close to the name plate of the AC drive.

Figure 37. Product Modified Sticker



Checking the Cable and Motor Insulation

1. Check the motor cable insulation as follows:
   - Disconnect the motor cable from terminals U, V and W of the H-Max Series drive and from the motor
   - Measure the insulation resistance of the motor cable between each phase conductor as well as between each phase conductor and the protective ground conductor
   - The insulation resistance must be >1 mohm
2. Check the input power cable insulation as follows:
   - Disconnect the input power cable from terminals L1, L2 and L3 of the H-Max Series drive and from the utility line feeder
   - Measure the insulation resistance of the input power cable between each phase conductor as well as between each phase conductor and the protective ground conductor
   - The insulation resistance must be >1 mohm
3. Check the motor insulation as follows:
   - Disconnect the motor cable from the motor and open any bridging connections in the motor connection box
   - Measure the insulation resistance of each motor winding. The measurement voltage must equal at least the motor nominal voltage but not exceed 1000V
   - The insulation resistance must be >1 mohm

Appendix A

Technical Data

Table 18. H-Max Technical Data

Attribute	Description	Specification
Mains connection	Input voltage U_{in}	208–240V, 380–480V, 525–600V, –10 to 10%
	Input frequency	50–60 Hz, –5 to 10%
	Connection to mains	Once per minute or less
	Starting delay	230/480V: 4S (FS4 to FS6), 6s (FS7 to FS9) 600V: 6s (FS4 to FS6), 8s (FS7 to FS9)
Motor connection	Output voltage	0-U_{in}
	Continuous output current	I_L: Ambient temperature maximum 40°C, up to 50°C with derating, overload 1.1 x I_L (1 min./10 min.)
	Output frequency	0–320 Hz (standard)
	Frequency resolution	0.01 Hz
Control characteristics	Switching frequency (see parameter P3.1.2.1)	1.5–10 kHz Defaults: **FS4–6:** 6 kHz (except 0012 2, 0031 2, 0062 2, 0012 4, 0031 4 and 0061 4: 4 kHz) **FS7:** 4 kHz **FS8–9:** 3 kHz Automatic switching frequency derating in case of overload.
	Frequency reference	
	Analog input	Resolution 0.1% (10-bit), accuracy +1%
	Panel reference	Resolution 0.01 Hz
	Field weakening point	8–320 Hz
	Acceleration time	0.1–3000 sec.
	Deceleration time	0.1–3000 sec.
Ambient conditions	Ambient operating temperature	I_L: –10°C (no frost) to 40°C, up to 50°C with derating
	Storage temperature	–40° to 70°C
	Relative humidity	0–95% R_H, non-condensing, non-corrosive
	Air quality: • Chemical vapors • Mechanical particles	**Tested** according to IEC 60068-2-60 Test Ke: Flowing mixed gas corrosion test, Method 1 (H_2S [hydrogen sulfide] and SO_2 [sulfur dioxide]) **Designed** according to: IEC 60721-3-3, unit in operation, class 3C2 IEC 60721-3-3, unit in operation, class 3S2
	Altitude	100% load capacity (no derating) up to 1000m 1% derating for each 100m above 1000m **Max. altitudes:** 208–240V: 4500m (TN and IT systems) 380–480V: 4500m (TN and IT systems) 525–600V: 2000m (TN and IT systems, no corner grounding) **Voltage for I/O signals**: Up to 2000m: Allowed up to 240V 2000–4500m: Allowed up to 120V **Corner-grounding:** Up to 2000m only

Table 18. H-Max Technical Data, continued

Attribute	Description	Specification
Ambient conditions, continued	Vibration: • EN61800-5-1 • EN60668-2-6	5–150 Hz **Displacement amplitude:** 1 mm (peak) at 5–15.8 Hz (FS4–FS9) **Maximum acceleration amplitude:** 1g at 15.8–150 Hz (FS4–FS9)
	Shock: • EN61800-5-1 • EN60068-2-27	UPS drop test (for applicable UPS weights) Storage and shipping: Maximum 15g, 11 ms (in package)
	Enclosure class	IP21/Type 1 standard in entire kW/hp range IP54/Type 12 option **Note:** Keypad required for IP54/Type12
EMC (at default settings)	Immunity	Fulfils EN61800-3 (2004), first and second environment
	Emissions	EN61800-3 (2004), Category C3 The drive can be modified for IT-networks
Noise level	Average noise level (cooling fan) sound power level in dB(A)	FS4: 65 FS7: 77 FS5: 70 FS8: 86 FS5: 77 FS9: 87
Safety	—	EN61800-5-1 (2007), CE, cUL (see nameplate for more detailed approvals)
Protections	Overvoltage trip limit	240V drives: 456V 480V drives: 911V 600V drives: 1094V
	Undervoltage trip limit	Depends on supply voltage (0,8775*supply voltage): Supply voltage 240V: Trip limit 211V Supply voltage 400V: Trip limit 351V Supply voltage 480V: Trip limit 421V Supply voltage 600V: Trip limit 527V
	Earth fault protection	Yes
	Mains supervision	Yes
	Motor phase supervision	Yes
	Overcurrent protection	Yes
	Unit overtemperature protection	Yes
	Motor overload protection	Yes
	Motor stall protection	Yes
	Motor underload protection	Yes
	Short-circuit protection of 24V and 10V reference voltages	Yes

Technical Information on Control Connections

Table 19. Standard I/O Board

Terminal	Signal	Description
1	Reference output	10V, 3%: Maximum current 10 mA
2	Analog input, voltage or current	Analog input channel 1 0–10V (Ri = 200 kohms) 4–20 mA (Ri = 250 ohms) Resolution 0.1%, accuracy ±1% Selection V/mA with DIP switches Short-circuit protected
3	Analog input common (current)	Differential input if not connected to ground: Allows ±20V differential mode voltage to GND
4	Analog input, voltage or current	Analog input channel 2 Default: 4–20 mA (Ri = 250 ohms) 0–10V (Ri = 200 kohms) Resolution 0.1%, accuracy ±1% Selection V/mA with DIP switches Short-circuit protected
5	Analog input common (current)	Differential input if not connected to ground: Allows 20 differential mode voltage to GND
6	24V auxiliary voltage	24V, ±10%, maximum voltage ripple <100m Vrms, maximum 250 mA Dimensioning: Maximum 1000 mA/control unit Short-circuit protected
7	I/O ground	Ground for reference and controls (connected internally to frame earth through 1 mohms)
8	Digital input 1	Positive or negative logic Ri = minimum 5 kohms 0–5V = "0" 15–30V = "1"
9	Digital input 2	
10	Digital input 3	
11	Common A for DIN1–DIN6	Digital inputs can be disconnected from ground
12	24V auxiliary voltage	24V, ±10% maximum voltage ripple <100m Vrms, maximum 250 mA Dimensioning: Maximum 1000 mA/control unit Short-circuit protected
13	I/O ground	Ground for reference and controls (connected internally to frame earth through 1 mohms)
14	Digital input 4	Positive or negative logic Ri = minimum 5 kohms 0–5V = "0" 15–30V = "1"
15	Digital input 5	
16	Digital input 6	
17	Common A for DIN1–DIN6	Digital inputs can be isolated from ground
18	Analog signal (+output)	Analog output channel 1, selection 0–20 mA, load <500 ohms Default: 0–20 mA 0–10V Resolution 0.1%, accuracy ±2% Selection V/mA with DIP switches Short-circuit protected
19	Analog output common	
30	24V auxiliary input voltage	Can be used as external power backup for the control unit
A	RS-485	Differential receiver/transmitter Set bus terminal with DIP switches
B	RS-485	

Table 20. Relay Board 1 [1]

Terminal	Signal	Description	
21	Relay output 1 [2]	Switching capacity	24 Vdc/8A 250 Vac/8A 125 Vdc/0.4A
22			
23		Minimum switching load	5V/10 mA
24	Relay output 2 [2]	Switching capacity	24 Vdc/8A 250 Vac/8A 125 Vdc/0.4A
25			
26		Minimum switching load	5V/10 mA
32	Relay output 3 [2]	Switching capacity	24 Vdc/8A 250 Vac/8A 125 Vdc/0.4A
33			
		Minimum switching load	5V/10 mA

Table 21. Relay Board 2 [3]

Terminal	Signal	Description	
21	Relay output 1 [2]	Switching capacity	24 Vdc/8A 250 Vac/8A 125 Vdc/0.4A
22			
23		Minimum switching load	5V/10 mA
24	Relay output 2 [2]	Switching capacity	24 Vdc/8A 250 Vac/8A 125 Vdc/0.4A
25			
26		Minimum switching load	5V/10 mA
28	Thermistor input	Rtrip = 4.7 kohms (PTC), measuring voltage 3.5V	
29			

Notes

1 Relay board with two change-over contact (SPDT) relays and one relay with normally-open (NO or SPST) contact. 5.5 mm isolation between channels.

2 If 230 Vac is used as control voltage from the output relays, the control circuitry must be powered with a separate isolation transformer to limit short circuit current and overvoltage spikes. This is to prevent welding on the relay contacts. Refer to standard EN60204-1, section 7.2.9.

3 Relay board with two change-over contact (SPDT) relays and a PTC thermistor input. 5.5 mm isolation between channels.

Appendix B

Cable Power and Motor Wiring Guidelines

See **Page 26** for cable stripping guidelines.

Table 22. North America Cable and Fuse Sizes—208–240 Vac Ratings

Frame	Amp Suffix	hp	NEC Motor Amp Rating at 208 Vac	NEC Motor Amp Rating at 230 Vac	VFD I(L) Amps at 40°C	VFD I(L) Amps at 50°C	[kW] 230V at 50 Hz	Fuse Rating (Class T)	NEC Wire Size (AWG)		Terminal Connection Size (AWG)	
									Line and Motor	Ground	Line and Motor	Ground
FS4	3D7	0.75	3.5	2.2	3.7	2.6	0.55	10	14	14	24–10	18–10
	4D8	1.0	4.6	4.2	4.8	3.7	0.75	10	14	14	24–10	18–10
	6D6	1.5	6.6	6.0	6.6	4.6	1.1	10	14	14	24–10	18–10
	8D0	2	7.5	6.8	8.0	6.6	1.5	10	14	14	24–10	18–10
	011	3	10.6	9.6	11	8.0	2.2	15	14	14	24–10	18–10
	012	4	N/A	N/A	12	9.0	3	15	14	14	24–10	18–10
FS5	018	5	16.7	15.2	18	12.5	4	20	12	12	20–6	18–8
	024	7.5	24.2	22	24	18.0	5.5	30	10	10	20–6	18–8
	031	10	30.8	28	31	25.0	7.5	40	8	10	20–6	18–8
FS6	048	15	46.2	42	48	31.0	11	60	4	8	14–0	14–2
	062	20	59.4	54	62	48	15	80	3	8	14–0	14–2
FS7	075	25	74.9	68	75	62	18.5	100	2	8	10–2/0	10–2/0
	088	30	88	80	88	75	22	110	1	6	10–2/0	10–2/0
	105	40	114	104	105	88	30	125	2/0	6	10–2/0	10–2/0
FS8	140	50	143	130	140	114	37	175	2/0	6	1–350 kcmil	1–350 kcmil
	170	60	169	154	170	140	45	200	250 kcmil	6	1–350 kcmil	1–350 kcmil
	205	75	211	192	205	170	55	250	350 kcmil	4	1–350 kcmil	1–350 kcmil
FS9	261	100	273	248	261	211	75	350	500 kcmil	4	1–350 kcmil	1–350 kcmil
	310	125	343	312	310	251	90	400	2X 250 kcmil	3	1–350 kcmil	1–350 kcmil

Note:

1. If power cubes are used, a UL recognized Type T fuse is recommended.
2. Based on maximum environment of 104°F (40°C).
3. If bypass is used, a UL recognized Type T fuse is recommended.

Table 23. North America Cable and Fuse Sizes—380–480 Vac Ratings

Frame	Amp Suffix	hp	NEC Motor Amp Rating at 480 Vac	VFD I(L) Amps at 40°C	VFD I(L) Amps at 50°C	[kW] 230V at 50 Hz	Fuse Rating (Class T)	NEC Wire Size (AWG)		Terminal Connection Size (AWG)	
								Line and Motor	Ground	Line and Motor	Ground
FS4	3D4	1.5	3	3.4	2.6	1.1	10	14	14	24–10	18–10
	4D8	2	3.4	4.8	3.4	1.5	10	14	14	24–10	18–10
	5D6	3	4.8	5.6	4.3	2.2	10	14	14	24–10	18–10
	8D0	4	N/A	8.0	5.6	3.0	10	14	14	24–10	18–10
	9D6	5	7.6	9.6	8	4	15	14	14	24–10	18–10
	012	7.5	11	12	9.6	5.5	15	12	14	24–10	18–10
FS5	016	10	14	16	12	7.5	20	10	12	20–6	18–8
	023	15	21	23	16	11	30	10	10	20–6	18–8
	031	20	27	31	23	15	35	8	8	20–6	18–8
FS6	038	25	34	38	31	18.5	50	6	8	14–0	14–2
	046	30	40	46	38	22	60	4	8	14–0	14–2
	061	40	52	61	46	30	80	2	6	14–0	14–2
FS7	072	50	65	72	61	37	100	2	6	10–2/0	10–2/0
	087	60	77	87	72	45	110	1	6	10–2/0	10–2/0
	105	75	96	105	87	55	125	1/0	4	10–2/0	10–2/0
FS8	140	100	124	140	105	75	175	3/0	2	1–350 kcmil	1–350 kcmil
	170	125	156	170	140	90	200	4/0	0	1–350 kcmil	1–350 kcmil
	205	150	180	205	170	110	250	300	2/0	1–350 kcmil	1–350 kcmil
FS9	261	200	240	261	205	132	350	350	3/0	1–350 kcmil	1–350 kcmil
	310	250	302	310	251	160	400	2 x 250	300	1–350 kcmil	1–350 kcmil

Note:

1. If power cubes are used, a UL recognized Type T fuse is recommended.
2. Based on maximum environment of 104°F (40°C).
3. If bypass is used, a UL recognized Type T fuse is recommended.

Table 24. North America Cable and Fuse Sizes—525–600 Vac Ratings

Frame	Amp Suffix	hp	VFD I(L) Amps at 40°C	VFD I(L) Amps at 50°C	Fuse Rating (Class T)	NEC Wire Size (AWG)		Terminal Connection Size (AWG)	
						Line and Motor	Ground	Line and Motor	Ground
FR5	3D9	3	3.9	3.3	6	14	12	20–6	18–8
	6D1	5	6.1	5.2	10	14	12	20–6	18–8
	9	7.5	9	7.7	10	14	10	20–6	18–8
	11	10	11	9.4	15	14	8	20–6	18–8
FR6	18	15	18	15	20	10	8	14–0	14–2
	22	20	22	18	25	10	8	14–0	14–2
	27	25	27	23	30	8	8	14–0	14–2
	34	30	34	28	40	8	6	14–0	14–2
FR7	41	40	41	34	50	6	6	9–2/0	9–2/0
	52	50	52	44	60	6	6	9–2/0	9–2/0
	62	60	62	52	70	4	4	9–2/0	9–2/0
FR8	80	75	80	68	90	1/0	2	1 AWG–350 kcmil	1 AWG–350 kcmil
	100	100	100	85	110	1/0	0	1 AWG–350 kcmil	1 AWG–350 kcmil
	125	125	125	106	150	2/0	2/0	1 AWG–350 kcmil	1 AWG–350 kcmil
FR9	144	150	144	122	175	3/0	3/0	1 AWG–350 kcmil	1 AWG–350 kcmil
	208	200	208	176	250	300 kcmil	300 kcmil	1 AWG–350 kcmil	1 AWG–350 kcmil

Table 25. International Cable and Fuse Sizes 380–480 Vac Ratings

Frame	Amp Suffix	VFD I(L) Amps at 40° C	VFD I(L) Amps at 50° C	[kW] 400V at 50 Hz	Fuse Rating (gG/gL)	Mains and Motor Cable Cu (mm^2)	Terminal Cable Size Main Terminal Cu (mm^2)	Terminal Cable Size Earth Terminal Cu (mm^2)
FS4	3D4	3.4	2.6	1.1	6	3*1.5+1.5	1–6 solid or 1–4 stranded	1–6
	4D8	4.8	3.4	1.5	6	3*1.5+1.5	1–6 solid or 1–4 stranded	1–6
	5D6	5.6	4.3	2.2	10	3*1.5+1.53	1–6 solid or 1–4 stranded	1–6
	8D0	8.0	5.6	3.0	16	3*2.5+2.5	1–6 solid or 1–4 stranded	1–6
	9D6	9.6	8	4	16	3*2.5+2.5	1–6 solid or 1–4 stranded	1–6
	012	16	12	7.5	16	3*2.5+2.5	1–6 solid or 1–4 stranded	1–6
FS5	016	23	16	11	20	3*6+6	1–10	1–10
	023	31	23	15	25	3*6+6	1–10	1–10
	031	38	31	18.5	32	3*10+10	1–10	1–10
FS6	038	46	38	22	40	3*10+10	2.5–50	2.5–35
	046	61	46	30	50	3*16+16	2.5–50	2.5–35
	061	72	61	37	63	3*25+16	2.5–50	2.5–35
FS7	072	87	72	45	80	3*35+16	6–70	6–70
	087	105	87	55	100	3*35+16	6–70	6–70
	105	140	105	75	125	3*50+25	6–70	6–70
FS8	140	170	140	90	160	3*70+35	35–185	6–70
	170	205	170	110	200	3*95+50	35–185	6–70
	205	261	205	132	250	3*120+70	35–185	6–70
FS9	261	310	251	160	315	3*185+95	35–185	6–95
	310	3.4	2.6	1.1	350	2*3*95+50	35–185	6–95

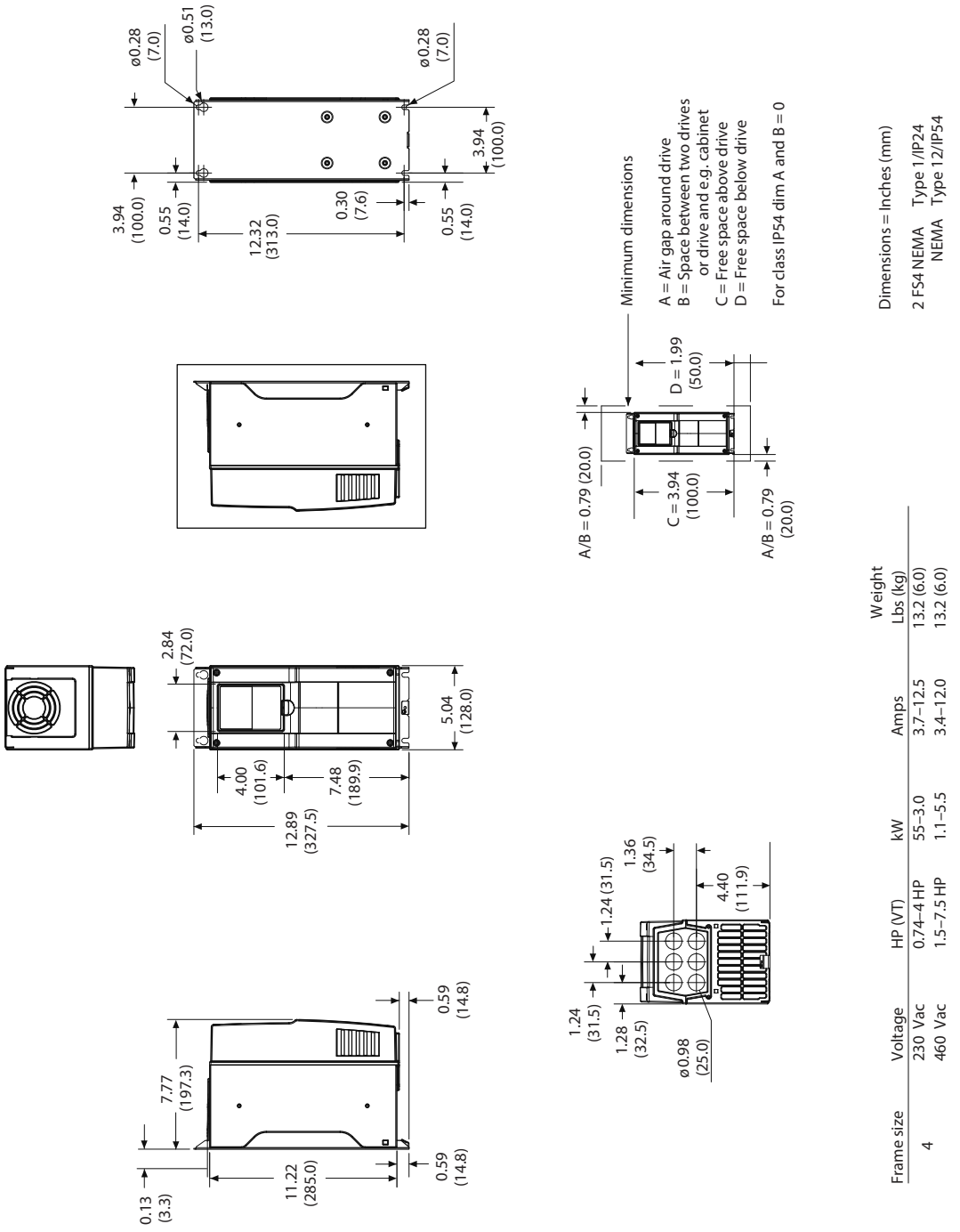
Note:

1. If power cubes are used, a UL recognized Type T fuse is recommended.
2. Based on maximum environment of 104°F (40°C).
3. If bypass is used, a UL recognized Type T fuse is recommended

Appendix C

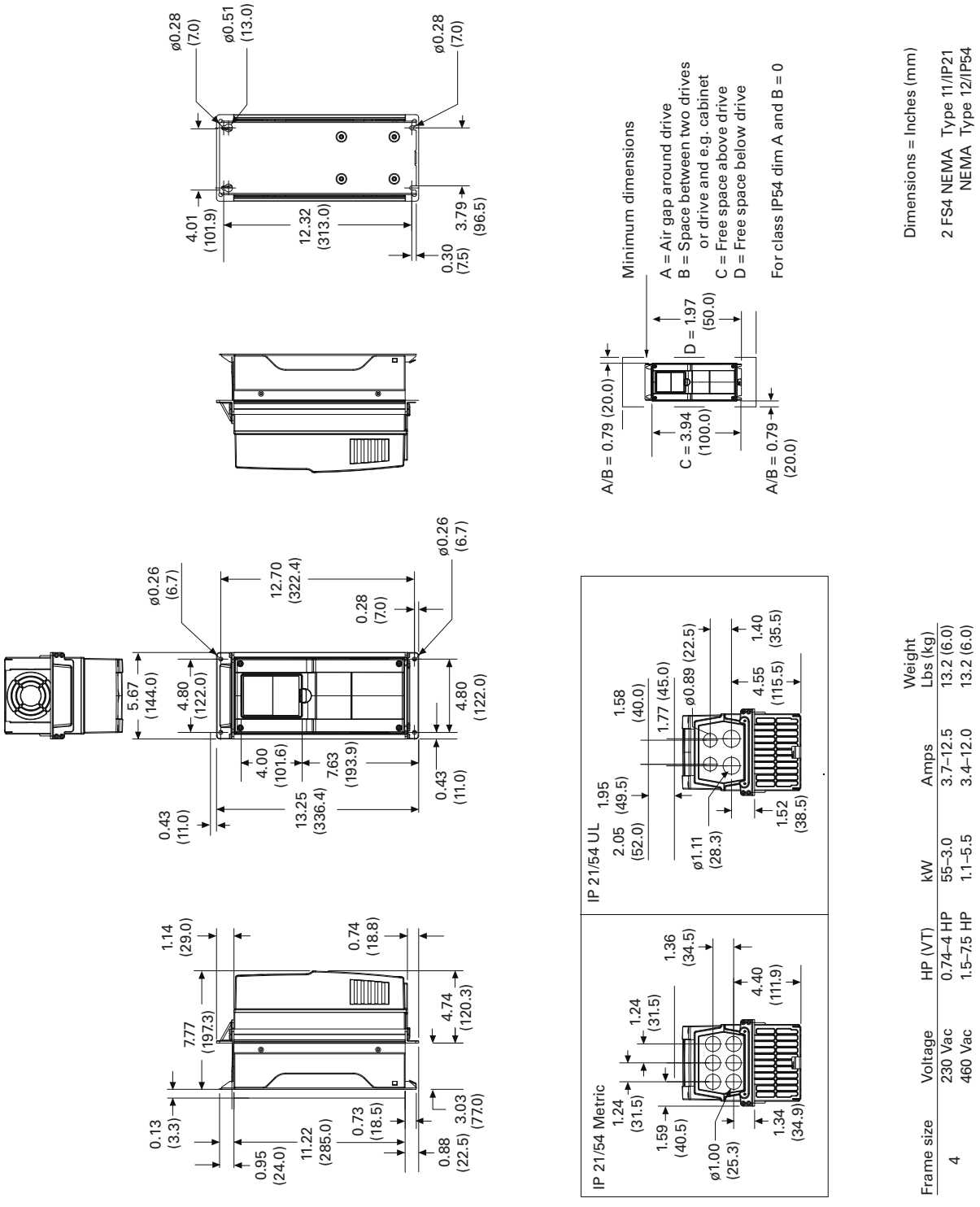
Dimension Drawings

Figure 38. FS4 Dimension Drawing



Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
4	230 Vac	0.74–4 HP	55–3.0	3.7–12.5	13.2 (6.0)
	460 Vac	1.5–7.5 HP	1.1–5.5	3.4–12.0	13.2 (6.0)

Figure 39. FS4 Dimension Drawing Flange Mount

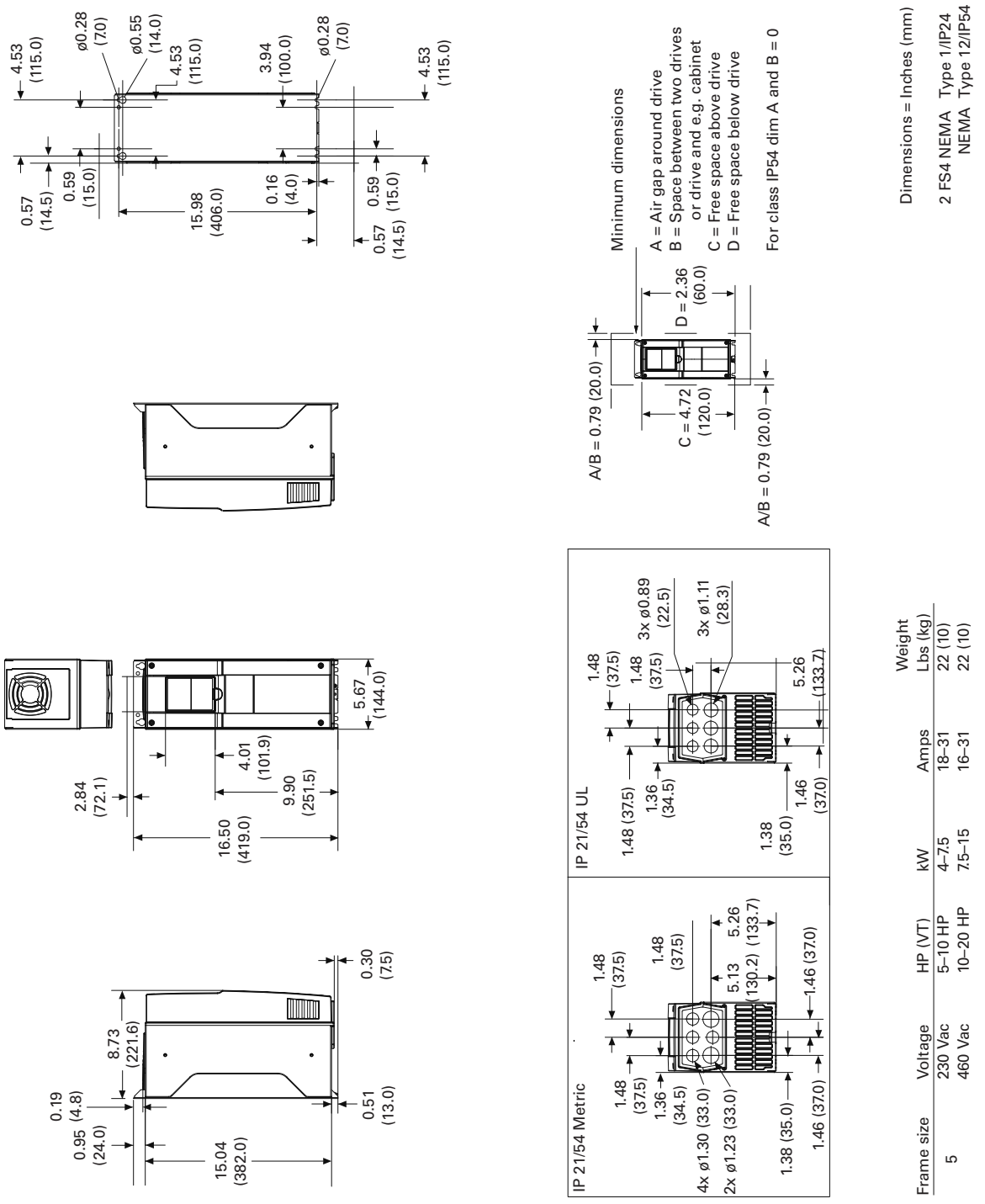


Dimensions = Inches (mm)

2 FS4 NEMA Type 11/IP21
NEMA Type 12/IP54

Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
4	230 Vac	0.74–4 HP	55–3.0	3.7–12.5	13.2 (6.0)
	460 Vac	1.5–75 HP	1.1–5.5	3.4–12.0	13.2 (6.0)

Figure 40. FS5 Dimension Drawing

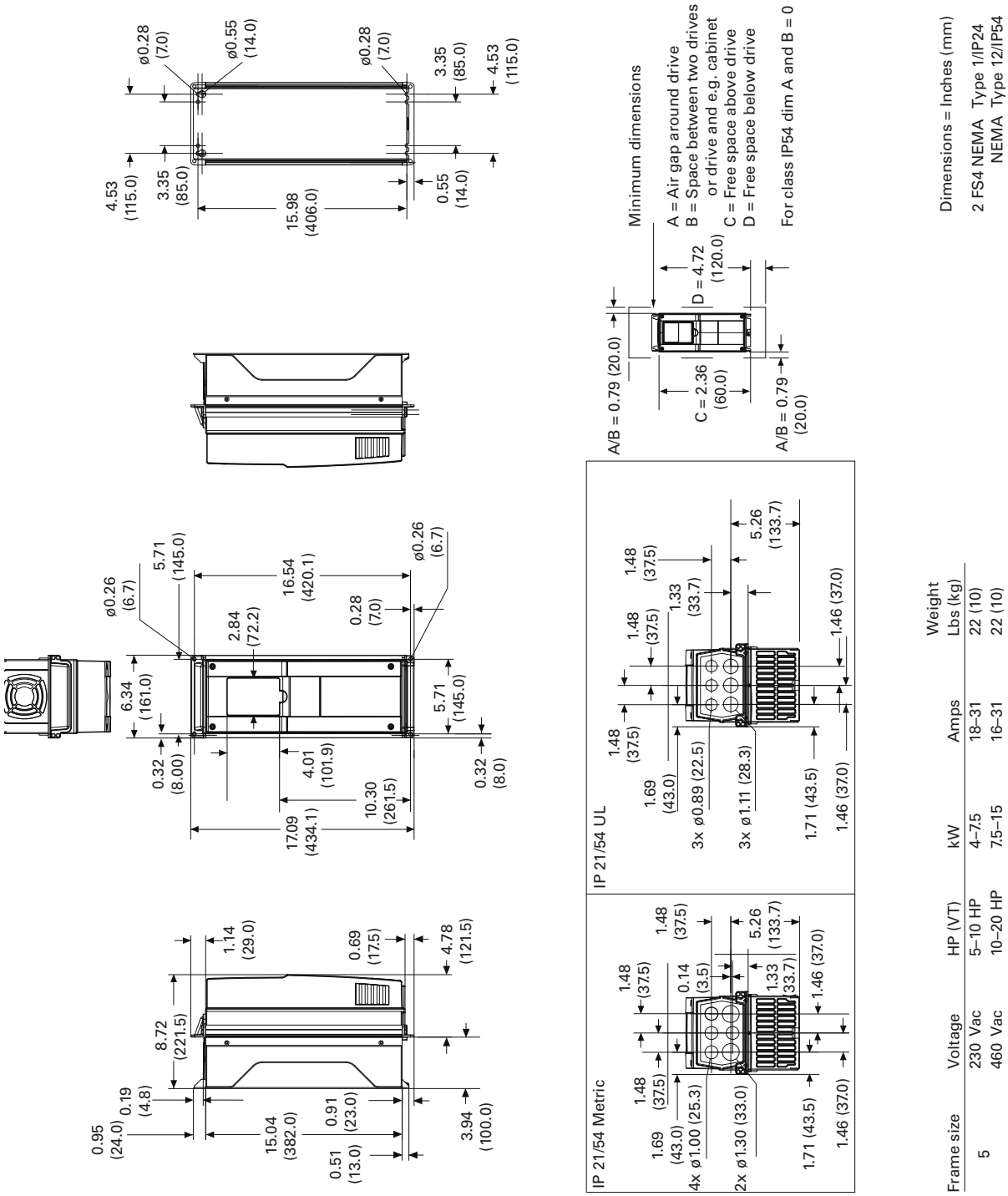


Dimensions = Inches (mm)

2 FS4 NEMA Type 1/IP24
NEMA Type 12/IP54

Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
5	230 Vac	5–10 HP	4–7.5	18–31	22 (10)
	460 Vac	10–20 HP	7.5–15	16–31	22 (10)

Figure 41. FS5 Dimension Drawing Flange Mount

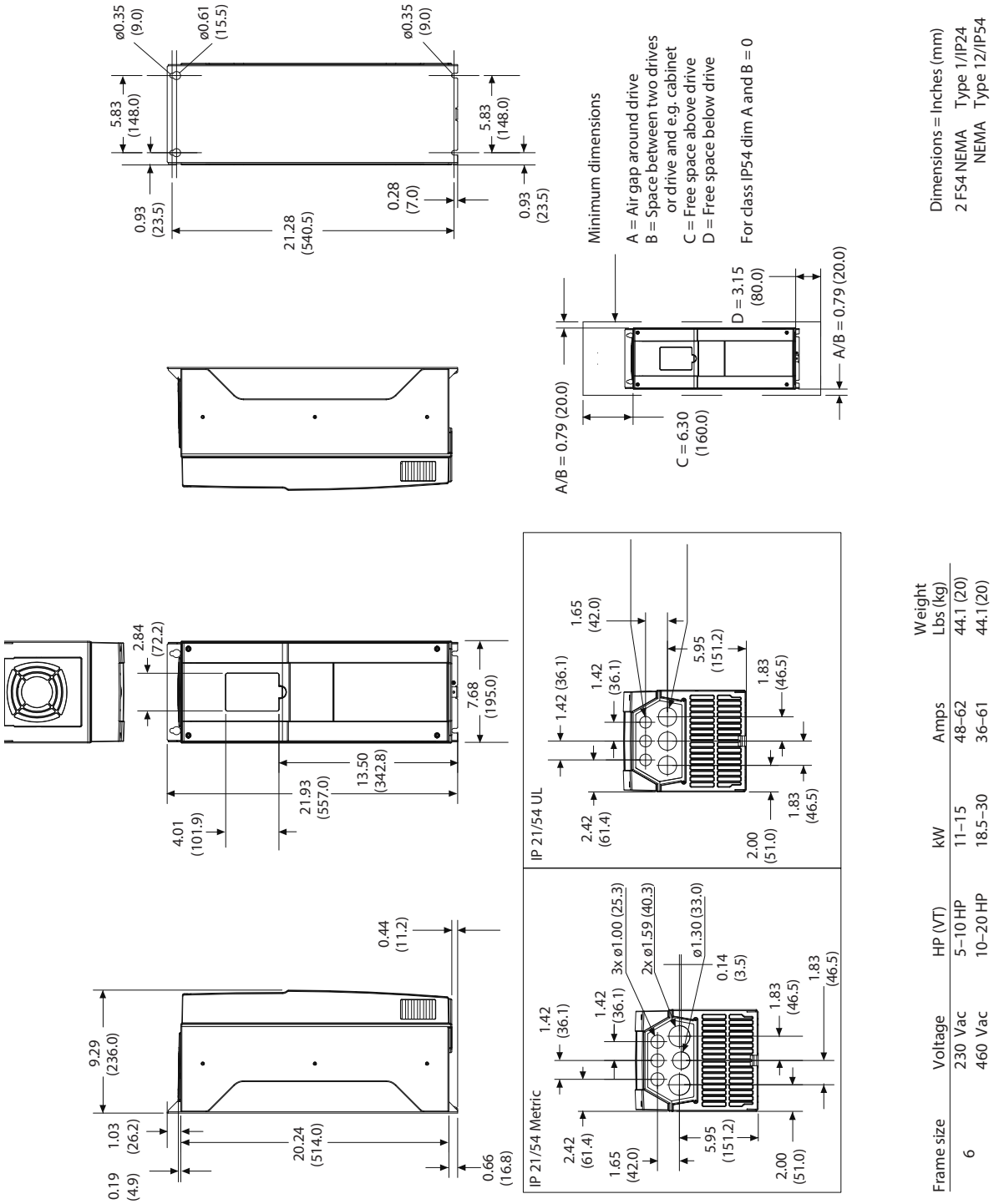


Dimensions = Inches (mm)

2 FS4 NEMA Type 1/IP24
NEMA Type 12/IP54

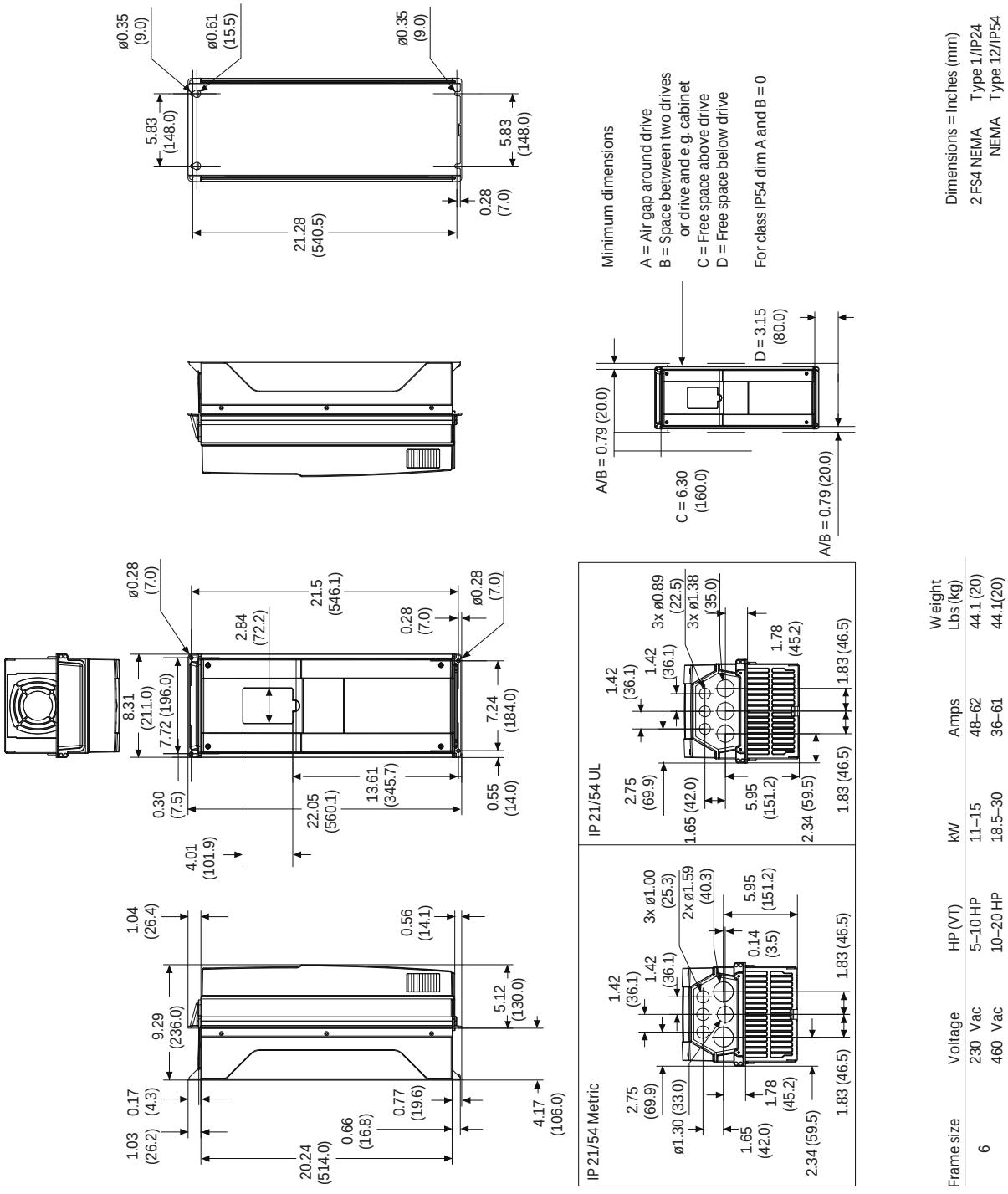
Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
5	230 Vac	5–10 HP	4–7.5	18–31	22 (10)
	460 Vac	10–20 HP	7.5–15	16–31	22 (10)

Figure 42. FS6 Dimension Drawing



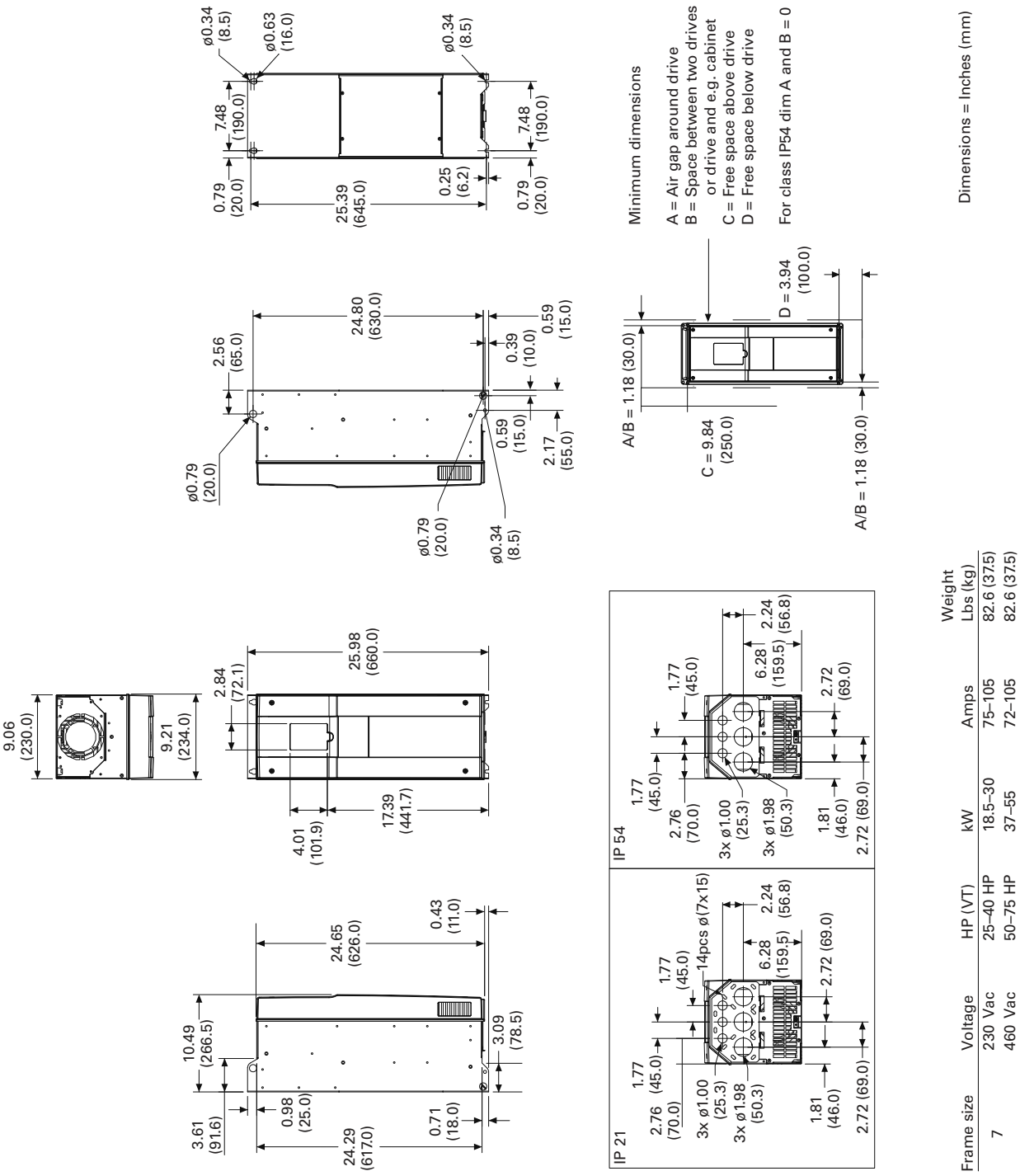
Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
6	230 Vac	5–10 HP	11–15	48–62	44.1 (20)
	460 Vac	10–20 HP	18.5–30	36–61	44.1(20)

Figure 43. FS6 Dimension Drawing Flange Mount



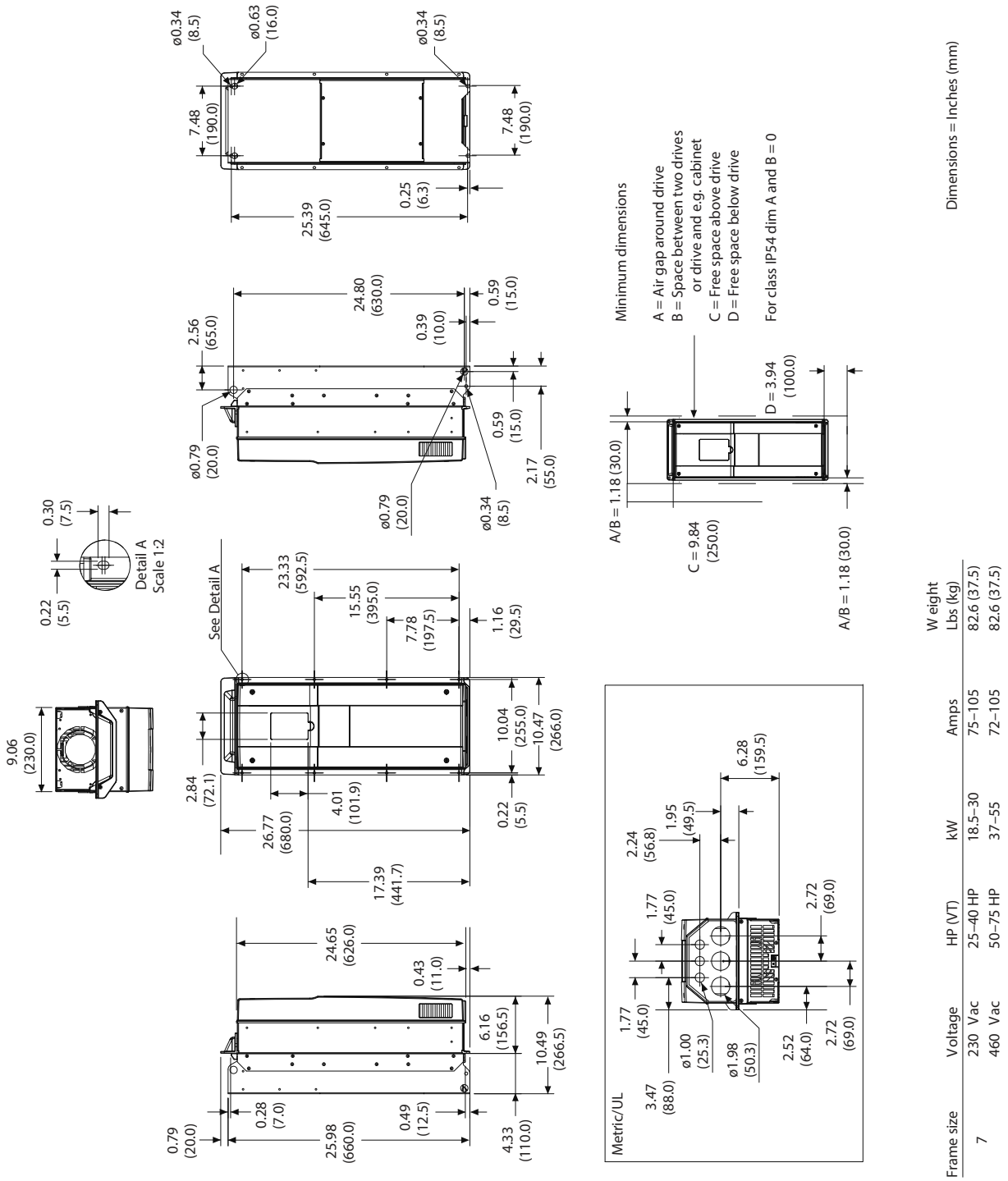
Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
6	230 Vac	5–10 HP	11–15	48–62	44.1 (20)
	460 Vac	10–20 HP	18.5–30	36–61	44.1(20)

Figure 44. FS7 Dimension Drawing



Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
7	230 Vac	25–40 HP	18.5–30	75–105	82.6 (37.5)
	460 Vac	50–75 HP	37–55	72–105	82.6 (37.5)

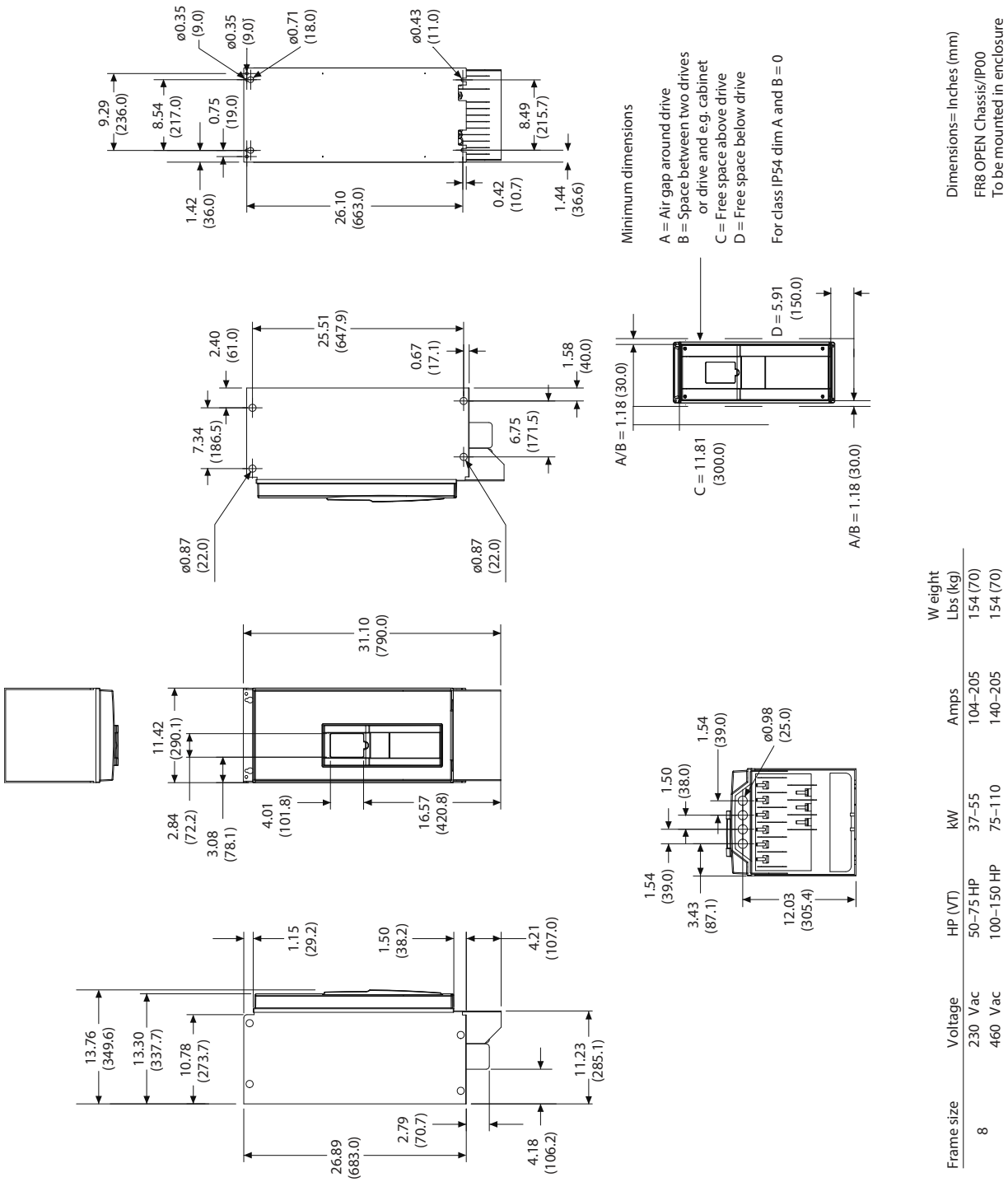
Figure 45. FS7 Dimension Drawing Flange Mount



Dimensions = Inches (mm)

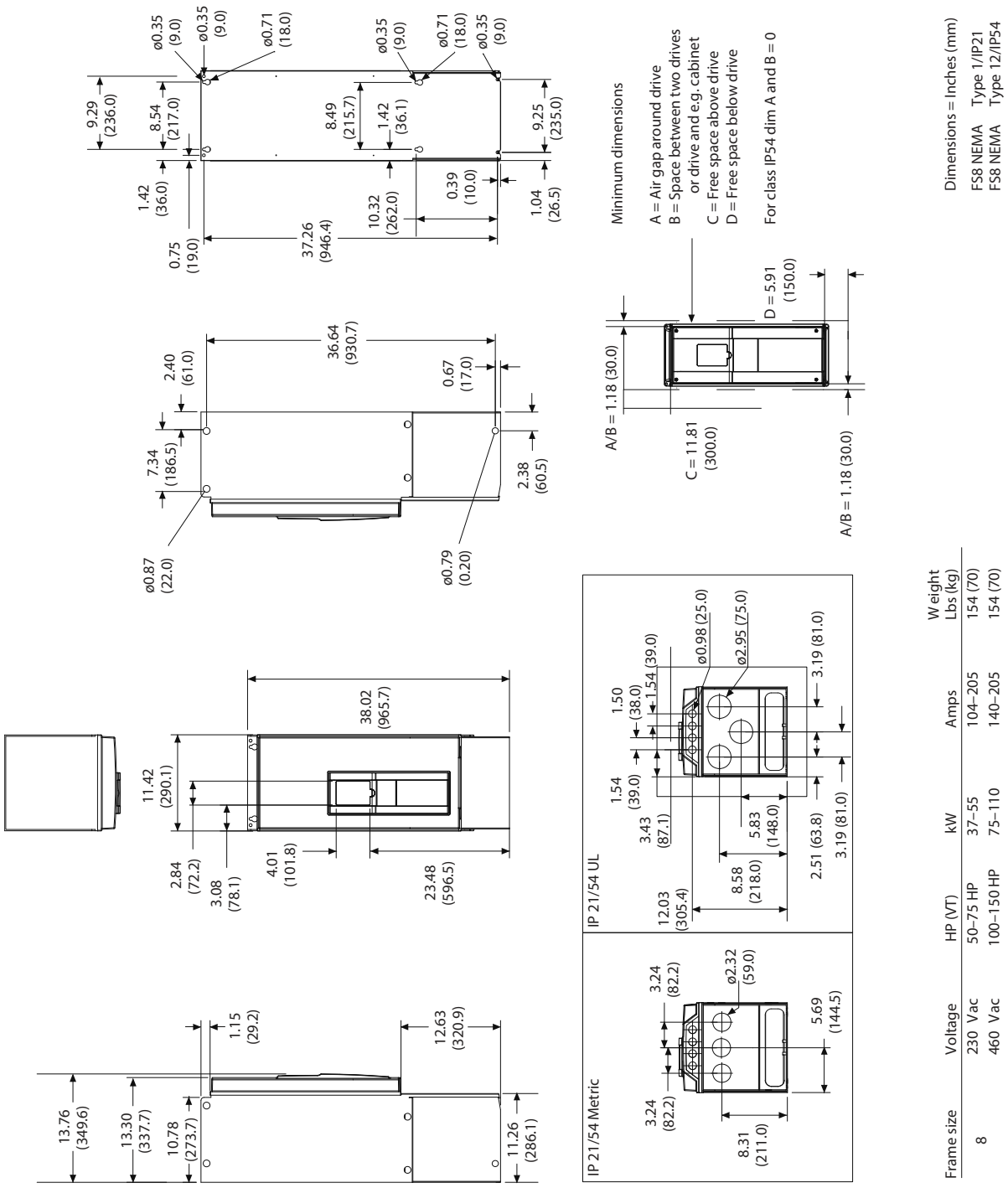
Frame size	Voltage	HP (VT)	kW	Amps	W eight Lbs (kg)
7	230 Vac	25–40 HP	18.5–30	75–105	82.6 (37.5)
	460 Vac	50–75 HP	37–55	72–105	82.6 (37.5)

Figure 46. FS8 Dimension Drawing IP00



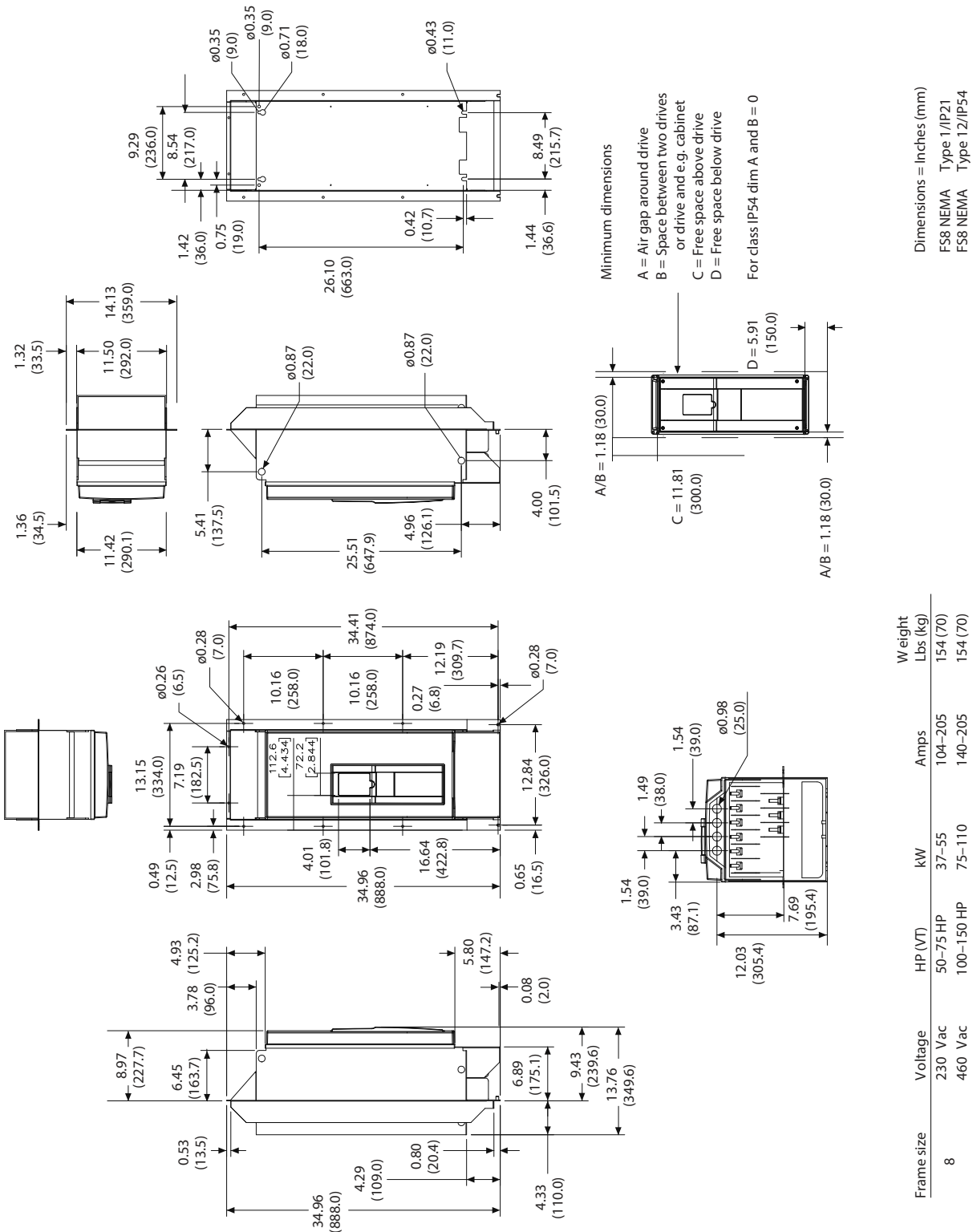
Frame size	Voltage	HP (VT)	kW	Amps	W eight Lbs (kg)
8	230 Vac	50–75 HP	37–55	104–205	154 (70)
	460 Vac	100–150 HP	75–110	140–205	154 (70)

Figure 47. FS8 Dimension Drawing IP2154 Flange Mount



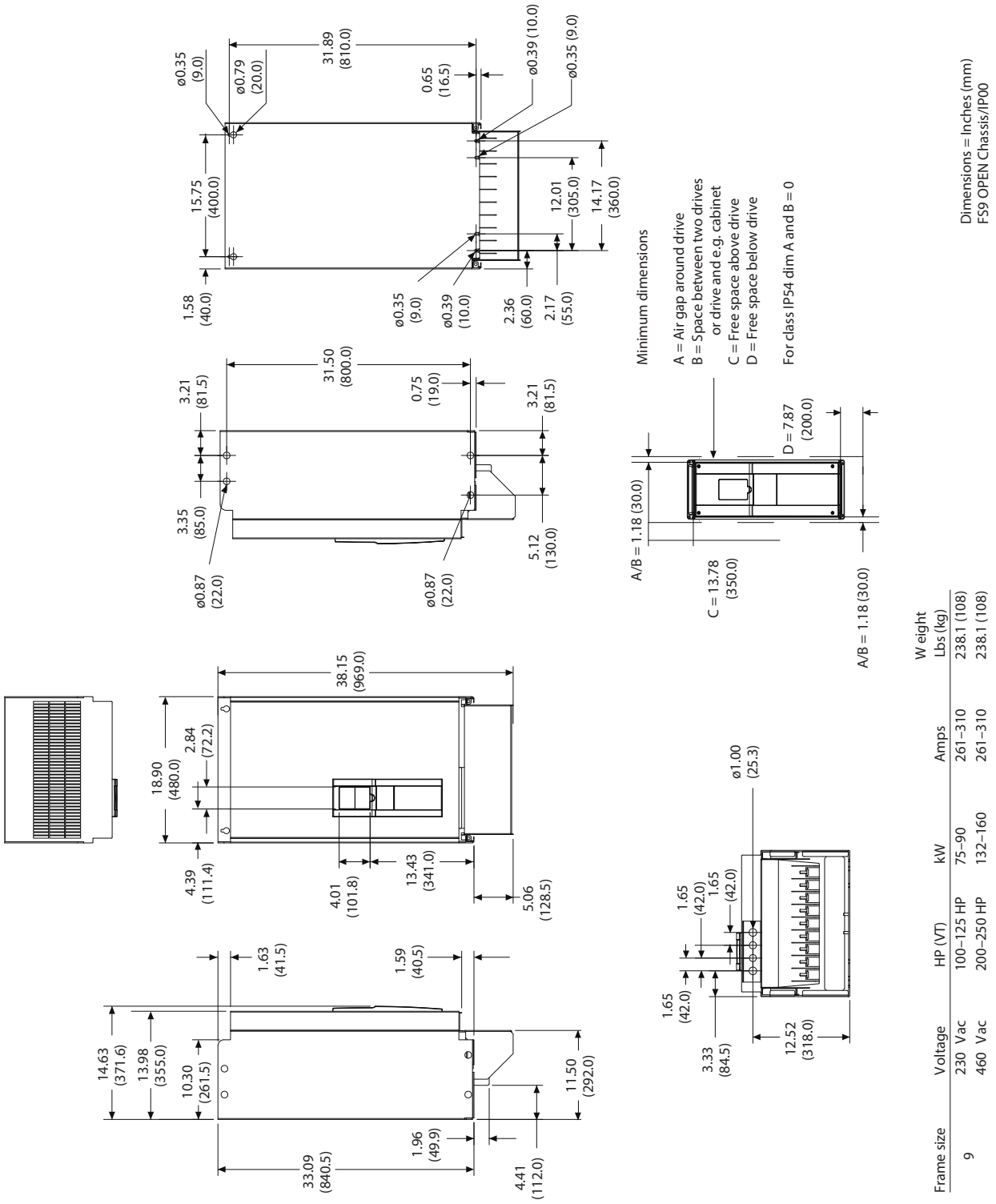
Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
8	230 Vac	50–75 HP	37–55	104–205	154 (70)
	460 Vac	100–150 HP	75–110	140–205	154 (70)

Figure 48. FS8 Dimension Drawing Flange Mount



Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
8	230 Vac	50–75 HP	37–55	104–205	154 (70)
	460 Vac	100–150 HP	75–110	140–205	154 (70)

Figure 49. FS9 Dimension Drawing



Dimensions = Inches (mm)
FS9 OPEN Chassis/IP00

Frame size	Voltage	HP (VT)	kW	Amps	W eight Lbs (kg)
9	230 Vac	100–125 HP	75–90	261–310	238.1 (108)
	460 Vac	200–250 HP	132–160	261–310	238.1 (108)

Figure 50. FS9 Dimension Drawing IP2154

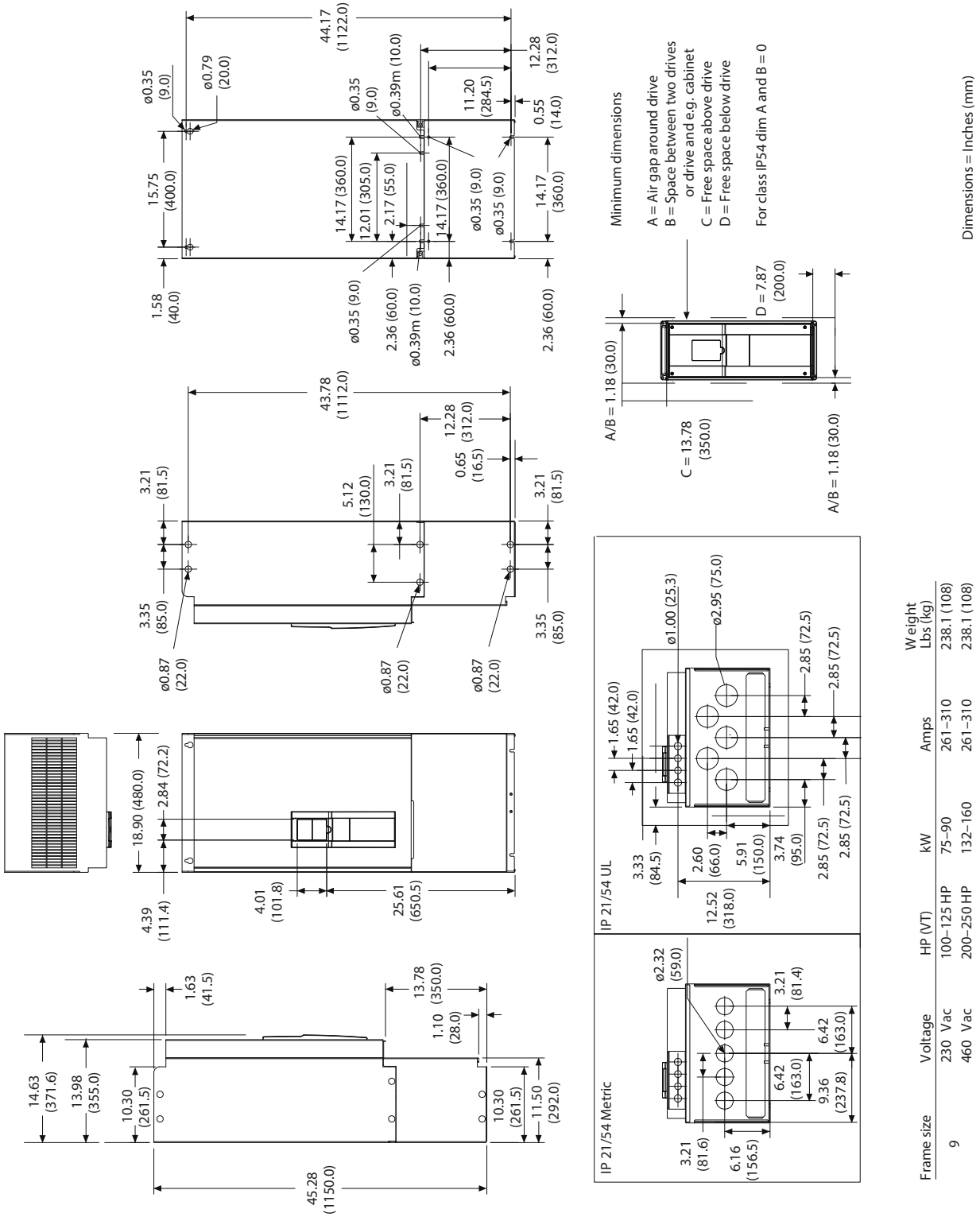
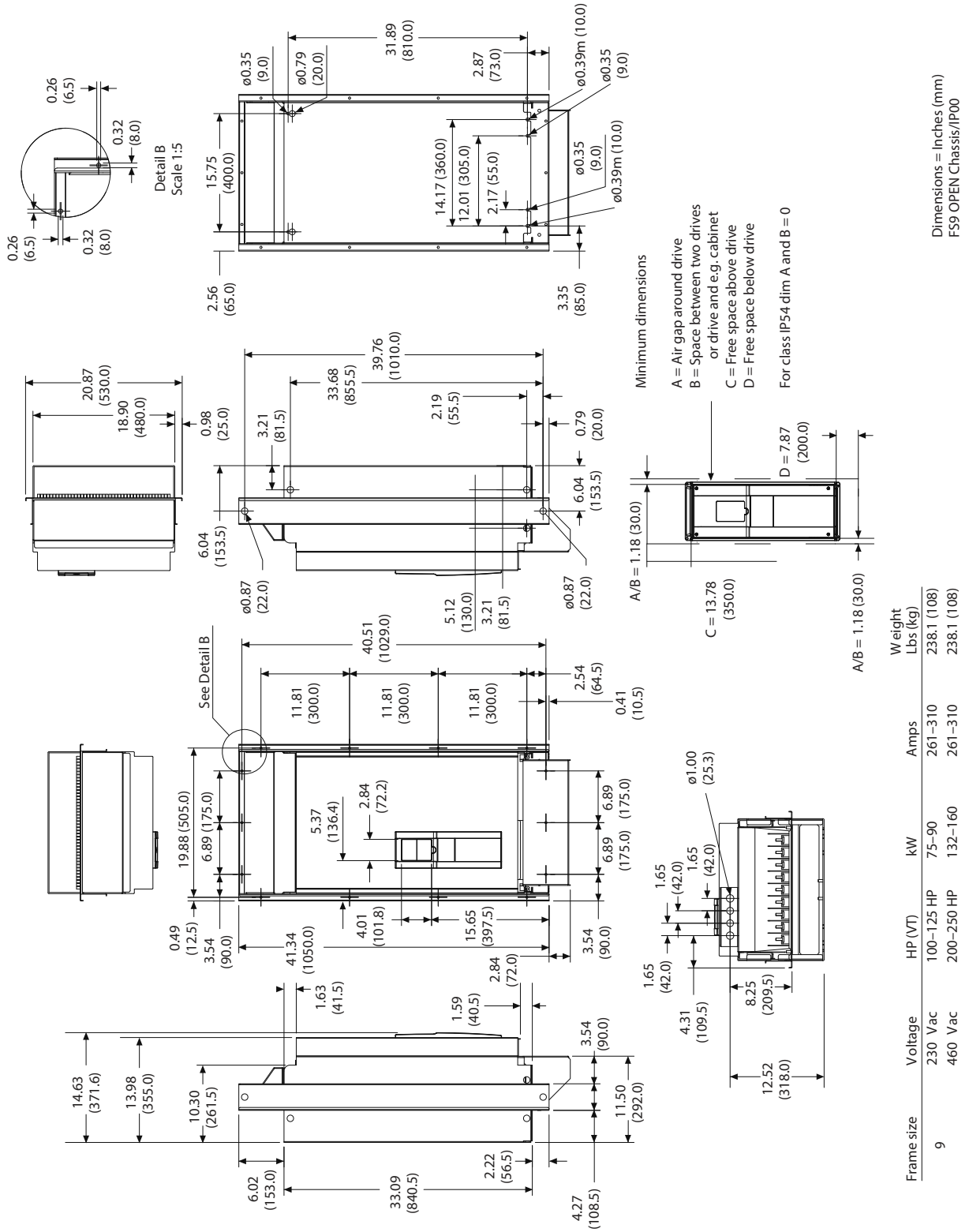


Figure 51. FS9 Dimension Drawing Flange Mount



Frame size	Voltage	HP (VT)	kW	Amps	Weight Lbs (kg)
9	230 Vac	100–125 HP	75–90	261–310	238.1 (108)
	460 Vac	200–250 HP	132–160	261–310	238.1 (108)

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* At Eaton, we believe that power is a fundamental part of just about everything people do. Technology, transportation, energy and infrastructure-these are things the world relies on every day. That's why Eaton is dedicated to helping our customers find new ways to manage electrical, hydraulic and mechanical power more efficiently, safely and sustainably. To improve people's lives, the communities where we live and work, and the planet our future generations depend upon. Because that's what really matters. And we're here to make sure it works.

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