Adjustable Frequency Drives—Low Voltage

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Adjustable Frequency Drives—Low Voltage Application Guide

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Specifications

See Eaton's *Product Specification Guide*, available on CD or on the Web.

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Adjustable Frequency Drives

Motor Application and Performance

AFD Output Harmonics

For the purpose of performance evaluation, the non-sinusoidal output waveforms produced by AFDs are represented by their mathematically equivalent component parts. All such waveforms consist of an infinite number of sinusoidal components of different amplitudes and frequencies. The fundamental component is the "good" part of the waveform, which provides power to the motor at the desired operating frequencies. The harmonics are unwanted components, which provide unusable voltages and currents to the motor at frequencies that are multiples of the fundamental.

State-of-the-art designs for pulse width modulated AFDs provide a sine weighted modulation strategy with a high switching frequency, and reduced output harmonic content as compared to other types of drives. A motor operating on a PWM drive will have an additional heat loss due to the harmonic content as compared to utility line operation.

PWM drives that are comprised of IGBT (insulated gate bipolar transistor) power devices are also capable of rapid voltage rise times, which can stress the insulation system of the AC motor. For this reason, motors designed for operation on IGBT PWM inverter power incorporating insulation systems rated for rapid voltage rise times and higher operating temperatures are recommended for use with the drives. Standard motors with a 1.15 service factor or energy efficient motors can be used provided that additional drive output filtering is incorporated to limit voltage rise times and to reduce the output harmonic content.

Multiple Motor Operation

Any number of motors can be connected in parallel and controlled on an open loop (frequency control) configuration by a single AFD as long as the total connected load does not exceed the rating of the drive. A closed loop vector controlled drive cannot be used with multiple motors. Although the basic principles of multiple motor operation are not difficult to understand, Application Engineering assistance should be requested to make certain that the application is successful.

Because the frequency of the power supplied by the AFD is the same for all motors, the motors will always operate at relatively the same speed. With NEMA design B motors, the speeds will be matched within 3% or less, depending on the load variation among the motors and their rated slip. Exact speed matching between motors is not possible. If an adjustable speed ratio is required between motors, each motor must be connected to its own individual AFD.

AC Drive Application

Matching the AFD to the Motor

Voltage source AFDs are designed for use with any standard three-phase induction motor. AFD sizing and motor matching are often simply a matter of matching the AFD output voltage, frequency and current ratings to the requirements of the motor. If the load torque exceeds 150% for Constant Torque (CT) drives or 110% for Variable Torque (VT) drives during starting or intermittently while running the drive, oversizing may be required.

Output Voltage and Frequency

For AFDs rated at 480V, motors are connected for 460V at 60 Hz. 380V/50 Hz motors can also be used because the V/Hz ratio, 380/50, is 7.6V/Hz, the same as a 460V/60 Hz motor. 415V motors can be operated if the AFD V/Hz adjustment is reset. With proper V/Hz adjustment, 575V motors can be operated at constant V/Hz up to 80% speed and at constant voltage from 80% to 100% speed. Maximum motor torque and hp for this mode of operation is limited above 80% speed because of the reduced V/Hz levels. For AFDs rated at 240V, the motor will be connected for 230V.

Output Current

The full load current ratings of typical AFDs are matched to typical full load motor current ratings as listed in National Electrical Code® Table 430.150. Generally, an AFD of a given horsepower rating will be adequate for a motor of the same rating, but the actual motor current required under operating conditions is the determining factor for AFD sizing. If the motor will be run at full load, the AFD output current rating must be equal to or greater than the motor nameplate current. If the motor is oversized to provide a wide speed range, the AFD should be sized to provide the current required by the motor at the maximum operating torque. Motor oversizing should generally be limited to one horsepower size increase.

Motor Protection

Motor overload protection must be provided as required by applicable codes. Direct motor protection is not automatically provided as part of the AC drive.

AFDs are equipped with electronic protection circuits with an inverse time or I^2t characteristic equivalent to a conventional overload relay. Conventional overload relays are also used with AFDs equipped with bypass. If these current sensing protective devices are used with motors driving constant torque loads, the minimum speed should be adjusted to prevent the motor from running at speeds at which overheating could occur, unless the I^2t circuit provides a speed and load calibrated trip. The best means of AC drive motor protection is direct winding overtemperature sensing, such as an overtemperature switch or thermistor imbedded in the motor windings. Overtemperature switches are more convenient because they can normally be connected directly to the AC drive control circuit. Thermistors generally require a special sensing relay. Direct overtemperature protection is preferred over overcurrent sensing protective devices because motor overheating can occur with normal operating current at low operating speeds.

Motor short-circuit protection is not required because the AC drive protection circuits nearly always adequately protect the motor in this respect.

When a single AFD provides power to multiple motors connected in parallel, special considerations must be given to motor protection. Individual overload protection must be provided for each motor. Short-circuit protection may be required for some applications.

Bearing and DV/DT Protection

The rapid voltage rise times present in today's IGBT PWM drives may cause current to flow in the motor bearings due to shaft voltage caused by capacitive coupling. This current flow can result in minute electrical discharges within the bearing, potentially damaging the bearing over time. Therefore a DV/DT filter should be used where the drive and motor are separated by 100 feet or more. Using an insulated motor shaft bearing and/or setting the inverter carrier frequency to the lowest acceptable level can help minimize the potential for this phenomenon as well.

AC Drive Performance

Operator Control and Interface

Operator controls are often via the drive keypad. In other situations, an operator station or remote control may be desired. If these requirements cannot be achieved by remotely mounting the keypad, terminal blocks with digital and analog interface capability are provided.

Acceleration and Deceleration

AFDs are always equipped with adjustable acceleration and deceleration control. Acceleration and deceleration rates must be adjusted to suit the characteristics of the load to prevent shutdown due to overcurrent or overvoltage. Increasing acceleration or deceleration times will proportionally decrease the torque requirement.

Speed Range

The characteristics of the motor usually determine the speed range of an AC drive. The AFD output frequency range is usually wider than the range that can be effectively used by the motor.

Speed Regulation

The open loop speed regulation of an AC drive is determined by the motor slip. Because NEMA design B motors usually have 3% slip or less, at 60 Hz and rated load the speed regulation of the drive is 3%.

AFDs equipped with slip compensation or flux or vector control can provide speed regulation, which is better than the open loop regulation of the motor. Slip compensation and flux or vector control improves speed regulation by increasing and decreasing the operating frequency by a small amount as the load increases and decreases.

Further improvement in steady-state speed regulation can be obtained by using a tachometer generator to provide speed feedback to a closed loop speed regulator option, or an external device such as the Durant® Strider.

Service Deviation

Speed regulation specifies only that portion of the drive speed change that is directly caused by a change in load. Several other factors can cause unintended changes in the drive operating speed. These factors contribute to the drive's service deviation. **Table 31.0-1** lists some of these factors and the typical effect that they have on drive speed.

Table 31.0-1. Factors Affecting Service Deviation

Influencing Factor	Typical Speed Change
Line voltage variations within rated tolerance.	0.0%
Ambient temperature variations of controller within rated tolerance after warmup.	0.25%
Motor temperature variations. Cold to maximum operating temperature.	0.5%

Current Limit

If an AC drive was not equipped with current limit, the overcurrent trip circuits would shut down the drive should the motor draw excessive current due to an overload or too rapid an acceleration rate. Current limit provides a means of maintaining control of the drive under these conditions.

If the output current reaches the current limit setting while the drive is running at set speed, the drive will decelerate to a lower speed. If possible, the speed will decrease to whatever operating speed is required to prevent exceeding the current limit setting.

If the output current reaches the current limit setting while the drive is accelerating, the drive will deviate from the programmed acceleration ramp and accelerate at a rate that will prevent the current from exceeding the set limit.

If the drive reaches the negative current limit setting (if applicable) while the drive is decelerating, the drive will deviate from the programmed deceleration ramp, and decelerate at a rate that will try to prevent the current from exceeding the limit.

Regeneration Limit and Braking

Regeneration limit prevents the motor from developing braking torque above a limit that corresponds to the normal losses that are inherent in the motor and controller.

When the drive is equipped with dynamic braking, the motor is allowed to develop a higher level of braking torque. The regenerated braking energy is dissipated in the dynamic braking resistors. A fully regenerative drive includes circuitry that returns the regenerated braking energy to the power lines.

IR Compensation

A V/Hz AC drive can provide improved starting torque and low speed overload capability if the lower speed voltage boost is changed automatically to compensate for changing load conditions. This feature is called IR compensation. Without IR compensation, it is difficult to achieve the maximum possible motor torque because the voltage boost required for maximum torque can cause the motor to saturate and draw excessive current when it is lightly loaded. The IR compensation circuit senses the motor load and reduces the voltage boost when the motor is lightly loaded.

A flux control AC drive provides a similar result by modifying its instantaneous voltage and frequency to allow the motor to develop the required torque for the load.

Installation Compatibility

The successful application of an AC drive requires the assurance that the drive will be compatible with the environment in which it will be installed. The following are some of the aspects of compatibility that should be considered.

Cooling Air

Even though AFDs are very efficient, the heat produced in the controller cabinet can be substantial. The electronic circuitry is subject to immediate failure if its operating temperature limits are exceeded. Junction temperatures of transistors, SCRs and IGBTs typically can only increase 20–25°C from full load to failure. It is important to remove heat through the usual mechanisms of radiation, conduction (heat sinks) or convection (fans). The enclosure must be located away from direct sunlight and hot surfaces. The room temperature must be kept within the specified limits and adequate cooling air must be allowed to flow around the enclosure. Excessively moist, corrosive or dirty air must be prevented from entering the enclosure.

Isolation Transformers

Drive isolation transformers are sometimes recommended or specified by others for various reasons. Eaton does not require the use of isolation transformers because Eaton drives are designed to operate directly from plant power distribution systems without using isolation transformers.

Eaton AFDs are designed to withstand line voltage transients and noise generated by other equipment in a typical installation environment when applied to systems with the required minimum impedance levels. They are also designed to prevent nuisance levels of noise from being reflected back to the power lines. Electronic protection circuits fully protect the drives from output short circuits and ground faults regardless of available fault current without requiring isolation or external impedance. Isolation transformers are generally not recommended as a preventative or curative measure for suspected difficulties of these types.

Efficiency

Figure 31.0-1 shows typical efficiency curves for an IGBT AFD. The efficiency of an AC drive can be accurately determined only for a particular set of operating conditions. The characteristics of the motor and controller are interrelated in such a way that a change in the characteristics of either component will cause a change in the efficiency of the other.

The efficiency of the total AC drive system cannot be accurately determined from just the controller efficiency curves and the manufacturer's published motor data. **Table 31.0-2** provides adjustment factors that can be used to estimate the total drive system efficiency. The adjustment factors take into account efficiency variations due to a typical range of different motor characteristics and operating conditions. The factors include data from the controller efficiency curves and adjust for motor characteristics at various speed and load points.

To calculate total AC drive system efficiency, multiply the published motor efficiency by the adjustment factors listed in **Table 31.0-2**. Use the published motor efficiency for full load 60 Hz operation only. The adjustment factors account for changes in motor efficiency due to changing the speed and load.

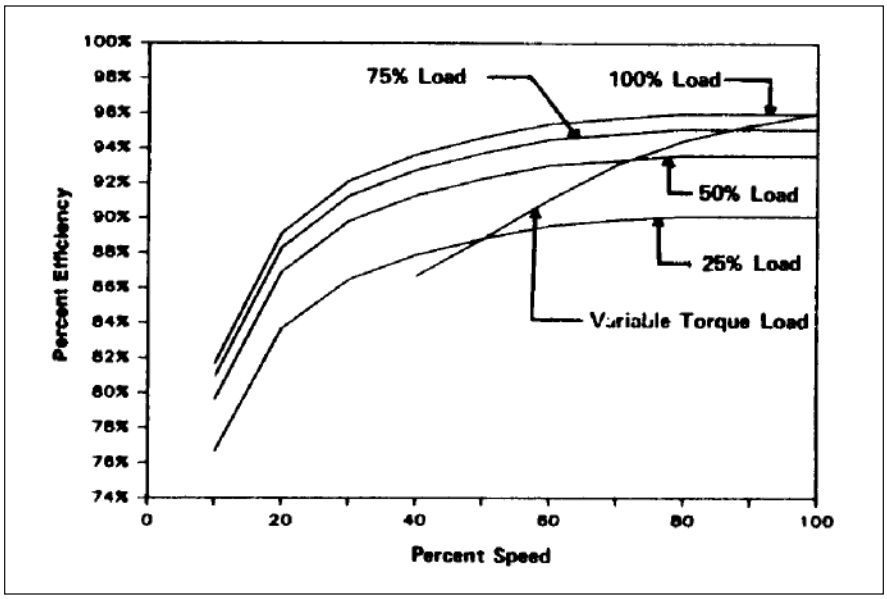

Figure 31.0-1. Typical AFD Efficiency

Table 31.0-2. Adjustment Factors for Calculating Total AC Drive System Efficiency

Percent Speed	Constant Torque Load Load: Percent of Rated Torque				Variable Torque Load	
	100	75	50	25	Adjustment Factor	Percent Torque
100	0.930–0.950	0.912–0.932	0.878–0.899	0.800–0.820	0.930–0.950	100
90	0.931–0.951	0.912–0.933	0.879–0.900	0.800–0.821	0.919–0.940	81
80	0.930–0.951	0.912–0.933	0.878–0.900	0.800–0.821	0.900–0.921	64
70	0.928–0.949	0.909–0.931	0.876–0.898	0.798–0.820	0.874–0.895	49
60	0.924–0.946	0.906–0.928	0.872–0.895	0.794–0.817	0.836–0.859	36
50	0.910–0.934	0.892–0.916	0.859–0.883	0.782–0.806	0.782–0.806	25
40	0.889–0.915	0.872–0.897	0.839–0.864	0.763–0.788	0.689–0.714	16
30	0.855–0.883	0.838–0.866	0.805–0.833	0.732–0.760	—	—
20	0.793–0.826	0.766–0.810	0.746–0.780	0.675–0.709	—	—
10	0.625–0.675	0.610–0.660	0.584–0.634	0.522–0.572	—	—

Example:

Suppose you wish to estimate AC drive efficiency for a 50 hp drive on a centrifugal pump. Efficiency is to be estimated for operation at full speed and 70% speed. The motor is nameplated 94.5% NEMA nominal efficiency.

From the variable torque columns in **Table 31.0-2**, the adjustment factors for full speed operation range from 0.93 to 0.95 and the adjustment factors for 70% speed range from 0.874 to 0.895.

For 100% speed:

- Eff. = 94.5 x 0.93 = 87.9% (low estimate)
- Eff. = 94.5 x 0.95 = 89.8% (high estimate)

For 70% speed:

- Eff. = 94.5 x 0.874 = 82.6% (low estimate)
- Eff. = 94.5 x 0.895 = 84.6% (high estimate)

Power Factor

The power factor typically specified for AFDs is displacement power factor, which is defined as the cosine of the angle between the fundamental voltage and current. Many instruments used for utility billing purposes give readings equivalent to displacement power factor. Another definition and measurement method combines the effects of power and harmonic content to define total power factor. Newer utility instrumentation is capable of recording total power factor, resulting in potential power factor penalty billing.

Displacement power factor for a PWM drive is approximately 0.95 at all operating points. The displacement power factor is not significantly affected by the motor speed, the motor load or the motor power factor. Total power factor will vary with line voltage, utility feeder size and total system and drive load.

Power factor correction capacitors should not be connected at the AC drive power input. Correction should be done on a plantwide basis. If capacitors are located too close to the drive, or if drives represent a high percentage of the total plant electrical load, there may be an undesirable interaction between the capacitors and the drives, leading to a failure of either or both.

If the capacitors must be located near the drive, a line reactor should be used on the drive input to reduce the possibility of interaction. Note that adding this reactor does not eliminate the potential for harmonic resonance.

To be assured of a solution that will improve power factor and avoid resonance, a system study must be performed to determine the optimum selection of capacitance and inductive reactance.

Power factor correction capacitors must never, under any circumstances, be connected at the AC drive controller output. They would serve no useful purpose, and they may damage the drive.

AC Drive Input Harmonics

AFDs use a rectifier to convert AC line voltage to the DC levels required by the inverter section. Rectifiers are nonlinear devices that cause a current to be drawn from the line, which includes many harmonics. These harmonic currents will cause harmonic voltages to be created in the line, which may affect sensitive devices on the same line. IEEE 519-1992 provides recommendations for the harmonic current levels reflected to the utility by any user, where the feeder ties into the utility grid. For difficult installations where the levels of IEEE 519 cannot be met, or those using on-site generated power, a “Clean Power” rectifier can be used. The “Clean Power” rectifier uses phase shifted semiconductors to significantly reduce harmonics to levels well within the IEEE guidelines. For more specific information, see CPX section on **Page 31.2-1**.

Motor Load Types and Characteristics

Introduction

This section of your *Application Guide* discusses the following topics on motor load types and characteristics:

- Motor load types
- Other functional considerations

The process of selecting an electrical adjustable speed drive is one where the load is of primary consideration. It is important to understand the speed and torque characteristics as well as horsepower requirements of the type of load to be considered.

When considering load characteristics, the following should be evaluated:

- What type of load is associated with the application?
- Does the load have a shock component?
- What is the size of the load?
- Are large inertial loads involved?
- What are the motor considerations?
- Over what speed range are heavy loads encountered?
- How fast is the load to be accelerated or decelerated?

Motor loads are classified into three main groups, depending on how their torque and horsepower vary with operating speed. The following paragraphs deal with the various motor load types usually found in process, manufacturing, machining and commercial applications.

Motor Load Types

Constant Torque Load

This type of load is frequently encountered. In this group, the torque demanded by the load is constant throughout the speed range. The load requires the same amount of torque at low speeds as at high speeds. Loads of this type are essentially friction loads. In other words, the constant torque characteristic is needed to overcome friction. **Figure 31.0-2** shows the constant torque and variable horsepower demanded by the load.

As seen in **Figure 31.0-2**, torque remains constant while horsepower is directly proportional to speed. A look at the basic horsepower equation also verifies this fact:

$$hp = \frac{\text{Torque x Speed}}{5252}$$

Where:

Torque is measured in lb-ft.
Speed is measured in rpm.
5252 is proportionality constant.

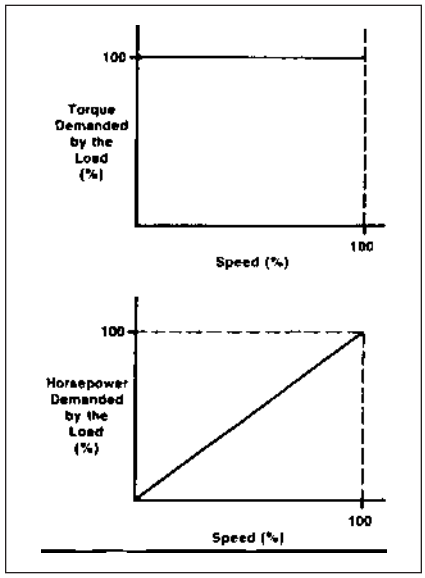

Figure 31.0-2. Constant Torque Load

Examples of this type of load are conveyors, extruders and surface winders. Constant torque capability may also be used when shock loads, overloads or high inertia loads require special drive sizing.

Constant Horsepower Load

In this type of load, the horsepower demanded by the load is constant over the speed range. The load requires high torque at low speeds. From the previous formula, you can see that with the horsepower held constant, the torque will decrease as the speed increases. Put another way, the speed and torque are inversely proportional to each other. **Figure 31.0-3** shows the constant horsepower and variable torque demanded by the load.

Examples of this type of load are center-driven winders and machine tool spindles. A specific example of this application would be a lathe that requires slow speeds for rough cuts where large amounts of material are removed, and high speeds for fine cuts where little material is removed. Usually very high starting torques are required for quick acceleration. Constant horsepower range is usually limited on an AC drive from base speed to 1.5–2 times base speed.

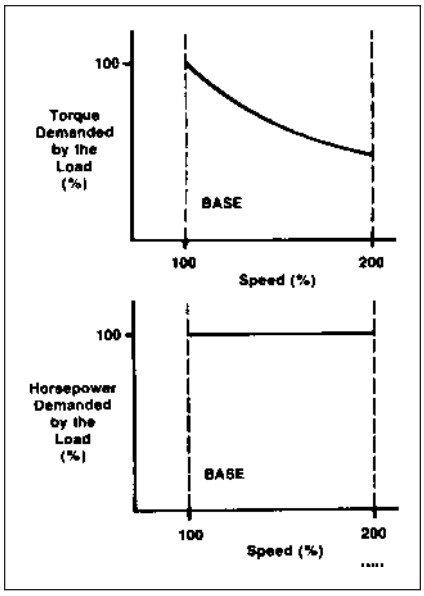

Figure 31.0-3. Constant Horsepower Load

Variable Torque Load

With this type of load, the torque is directly proportional to some mathematical power of speed, usually speed squared (Speed^2). Mathematically:

$$\text{Torque} = \text{Constant}\left(\frac{\text{Operating Speed}}{\text{Nameplate Speed}}\right)^2$$

Horsepower is typically proportional to speed cubed (speed^3). **Figure 31.0-4** shows the variable torque and variable horsepower demanded by the load.

Examples of loads that exhibit variable load torque characteristics are centrifugal fans, pumps and blowers. This type of load requires much lower torque at low speeds than at high speeds.

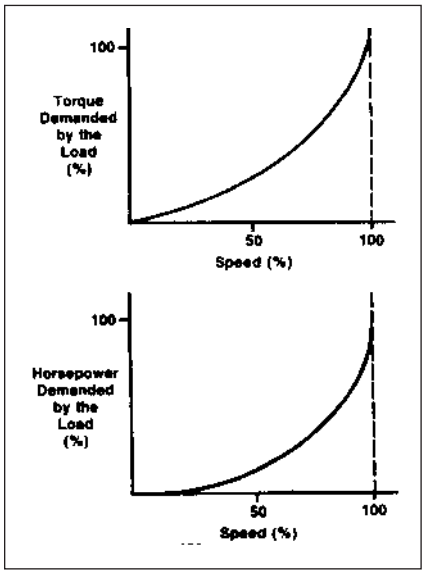

Figure 31.0-4. Variable Torque Load

Drive Selection

Introduction

This section discusses the following topics on selecting the appropriate drive:

- Selection considerations
- Selecting a drive for a machine
- Drive application questions

Selection Considerations

When selecting a drive and associated equipment for an application, the following points should be considered:

Environment

The environment in which the motor and power conversion equipment operates is of prime concern. Conditions such as ambient temperature, cooling air supply and the presence of gas, moisture and dust should all be considered when choosing a drive, its enclosures and protective features.

Speed Range

The minimum and maximum motor speeds for the application will determine the drive's base speed.

Speed Regulation

The allowable amount of speed variation should be considered. Does the application require unvarying speed at all torque values or will variations be tolerated?

Torque Requirements

The starting, peak and running torques should be considered when selecting a drive. Starting torque requirements can vary from a small percentage of the full load to a value several times full load torque. The peak torque varies because of a change in load conditions or mechanical nature of the machine. The motor torque available to the driven machine must be more than that required by the machine from start to full speed. The greater the excess torque, the more rapid the acceleration potential.

Acceleration

The necessary acceleration time should be considered. Acceleration time is directly proportional to the total inertia and inversely proportional to the torque available.

Duty Cycle

Selecting the proper drive depends on whether the load is steady, varies, follows a repetitive cycle of variation or has pulsating torques. The duty cycle, which is defined as a fixed repetitive load pattern over a given period of time, is expressed as the ratio of on-time to the cycle period. When the operating cycle is such that the drive operates at idle, or a reduced load for more than 25% of the time, the duty cycle becomes a factor in selecting the proper drive.

Heating

The temperature of a motor or controller is a function of ventilation and losses. Operating self-ventilated motors at reduced speeds may cause above normal temperature rises. Derating or forced ventilation may be necessary to achieve the rated motor torque output at reduced speeds.

Drive Type

Does the application require performance elements such as quick speed response or torque control? These may require the use of a flux vector or closed loop vector drive, instead of a volts per hertz drive.

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Table 31.0-3. Drive Specifications

Description	hp Range	Current Harmonic Distortion	Applications
M-Max H-Max SVX	1/4–10 10–600 3/4–800	35–40% 35–40% 35–40%	Micro drive HVAC specific—6 pulse General use—6 pulse
CFX CPX	3/4–400 25–800	7–10% 3%	General use with passive filters 18 pulse clean power

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M-Max Series

M-Max Series Drives for Machinery Applications

General Description

Eaton's M-Max™ Series sensorless vector adjustable frequency AC drives are the next generation of drives specifically engineered for today's machinery applications. These microprocessor-based drives have standard features that can be programmed to tailor the drive's performance to suit a wide variety of application requirements. The M-Max product line uses a 32-bit microprocessor and insulated gate bipolar transistors (IGBTs) that provide quiet motor operation, high motor efficiency and smooth low-speed performance. The size and simplicity of the M-Max make it ideal for hassle-free installation. Models rated at 575V, three-phase, 50/60 Hz are available in sizes ranging from 1 to 7-1/2 hp. Models rated at 480V, three-phase, 50/60 Hz are available in sizes ranging from 1/2 to 10 hp. Models rated at 240V, single- or three-phase, 50/60 Hz are available in sizes ranging from 1/4 to 3 hp. Models rated at 115V, single-phase, 50/60 Hz are available in the 1/4 to 1-1/2 hp size range.

The standard drive includes a digital display, and operating and programming keys on a visually appealing, efficient application programming interface. The display provides drive monitoring, as well as adjustment and diagnostic information. The keys are used for digital adjustment and programming of the drive, as well as for operator control. Separate terminal blocks for control and power wiring are provided for customer connections.

Features

- Ease of use—preset application macros, startup wizard, diagnostic capabilities
- Compact, space-saving design
- Rugged and reliable—150% for 1 minute, 50C rated, conformal coated boards
- DIN rail and screw mountable
- Side-by-side installation
- Parameter upload and download without the need for a main power supply
- Industry-leading efficiency delivers energy savings to the customer
- Integrated EMC filters make the unit suitable for commercial and industrial networks
- Available in the enclosure class IP20 as standard, options for IP21 and NEMA® 1
- Brake chopper as standard in three-phase, applications of frames 2 (FS2) and larger
- Temperature-controlled fan
- RS-485/Modbus® as standard
- PID controller as standard
- Several fieldbus options

Standards and Certifications

Product

- Complies with EN61800-3 (2004)

Safety ①

- 61800-5-1
- EN60204-1
- CE
- UL
- cUL
- IEC
- RoHS compliant

① See unit nameplate for more detailed approvals.

EMC (At Default Settings)

- EMC Category C2, C3 and C4 (Level H): With an internal RFI filter option

I/O Specifications

- Digital inputs DI1–DI6 are freely programmable. The user can assign multiple functions to a single input
- Digital, relay and analog outputs are freely programmable includes:
  - ❑ Six digital inputs
  - ❑ Two analog inputs
    - – 4–20 mA
    - – 0–10V
  - ❑ One analog output
  - ❑ One digital output
  - ❑ Two relay outputs
  - ❑ RS-485 interface

Reliability

- Pretested components: standard
- Computerized testing: standard
- Final test with full load: standard
- Conformal-coated boards
- 50°C rated
- 150% for 1 minute
- 200% for 2 seconds
- Eaton's Electrical Services & Systems: national network of AF drive specialists

Catalog Number Selection

Table 31.1-1. Catalog Numbering System

MMX 1 1 AA 1D1 F 0 – 0

Description	Phase	Voltage	Software Designation Series	Output Current	EMC Filter	Enclosure Class	Option
MMX = Base catalog number	**1** = Single-phase **3** = Three-phase	**1** = 120V **2** = 230V **4** = 480V **5** = 575V	**AA**	**1D6** = 1.6A **010** = 10A	**F** = Filter **N** = No filter	**0** = NEMA 0 or IP2	**0** = Full version

Product Selection

M-Max

Table 31.1-2. M-Max Basic Controller

hp ①	Volts ②	100% Continuous Current I_N (A)	Nominal Input Current (A)	Frame Size	Catalog Number
1/4 1/2 3/4	200–240V single-phase in 230V three-phase out	1.7 2.4 2.8	4.2 5.7 6.6	FS1 FS1 FS1	**MMX12AA1D7F0-0** **MMX12AA2D4F0-0** **MMX12AA2D8F0-0**
1/4 1/2 3/4	200–240V three-phase in 230V three-phase out	1.7 2.4 2.8	2.7 3.5 3.8	FS1 FS1 FS1	**MMX32AA1D7N0-0** ③ **MMX32AA2D4N0-0** ③ **MMX32AA2D8N0-0** ③
1/2 3/4 1	380–480V three-phase in 460V three-phase out	1.3 1.9 2.4	2.2 2.8 3.2	FS1 FS1 FS1	**MMX34AA1D3F0-0** **MMX34AA1D9F0-0** **MMX34AA2D4F0-0**
1/4 1/2 3/4 1	100–120V single-phase in 230V three-phase out	1.7 2.4 2.8 3.7	9.2 11.6 12.4 15.0	FS2 FS2 FS2 FS2	**MMX11AA1D7N0-0** ③ **MMX11AA2D4N0-0** ③ **MMX11AA2D8N0-0** ③ **MMX11AA3D7N0-0** ③
1 1-1/2 2	200–240V single-phase in 230V three-phase out	3.7 4.8 7.0	8.3 11.2 14.1	FS2 FS2 FS2	**MMX12AA3D7F0-0** **MMX12AA4D8F0-0** **MMX12AA7D0F0-0**
1 1-1/2 2	200–240V three-phase in 230V three-phase out	3.7 4.8 7.0	4.3 6.8 8.4	FS2 FS2 FS2	**MMX32AA3D7N0-0** ③ **MMX32AA4D8N0-0** ③ **MMX32AA7D0N0-0** ③
1-1/2 2 3	380–480V three-phase in 460V three-phase out	3.3 4.3 5.6	4.0 5.6 7.3	FS2 FS2 FS2	**MMX34AA3D3F0-0** **MMX34AA4D3F0-0** **MMX34AA5D6F0-0**
1-1/2	100–120V single-phase in 230V three-phase out	4.8	16.5	FS3	**MMX11AA4D8N0-0** ③
3	200–240V single-phase in 230V three-phase out	9.6	15.8	FS3	**MMX12AA9D6F0-0**
3	200–240V three-phase in 230V three-phase out	11.0	13.4	FS3	**MMX32AA011N0-0** ③
4 5 7-1/2 10	380–480V three-phase in 460V three-phase out	7.6 9.0 12.0 14.0	9.6 11.5 14.9 18.7	FS3 FS3 FS3 FS3	**MMX34AA7D6F0-0** **MMX34AA9D0F0-0** **MMX34AA012F0-0** **MMX34AA014F0-0**
1 2 3	575V three-phase in 575V three-phase out	1.7 2.7 3.9	2.0 3.6 5.0	FS3 FS3 FS3	**MMX35AA1D7N0-0** ③ **MMX35AA2D7N0-0** ③ **MMX35AA3D9N0-0** ③
5 7-1/2	575V three-phase in 575V three-phase out	6.1 9.0	7.6 10.4	FS3 FS3	**MMX35AA6D1N0-0** ③ **MMX35AA9D0N0-0** ③

① Horsepower ratings are based on the use of a 240V, 460V and 575V NEMA B, four- or six-pole squirrel cage induction motor and are for reference only. Units are to be selected such that the motor current is less than or equal to the MMX rated continuous output current.

② For 208V, 380V or 415V applications, select the unit such that the motor current is less than or equal to the MMX rated continuous output current.

③ For MMX11_, MMX32_ and MMX35_, there are no options for units with filters.

Accessories

Table 31.1-3. M-Max Copy/Paste Module

Description	Catalog Number
Module is plugged onto the front of the drive to provide: upload/download of all parameters, direct link to a PC via USB interface for parameter assignment via MaxConnect software, and copying of parameters for a series of devices or when exchanging devices. No PC required.	MMX-COM-PC

Table 31.1-4. Optional Communication Modules

Description	Catalog Number
Communication adapter kit CANopen network card PROFIBUS DP network card with serial connection	MMX-NET-XA XMX-NET-CO-A XMX-NET-PS-A
PROFIBUS DP network card with Sub-D connection DeviceNet network card	XMX-NET-PD-A XMX-NET-DN-A

Technical Data and Specifications

Ratings

Table 31.1-5. M-Max Basic Controller IP20 Standard Ratings

Description	Specification
Protections	
Overcurrent protection	Trip limit 4.0 x I_H instantaneously
Overvoltage protection	115/230V series: 437 Vdc; 400V series: 874 Vdc; 575V series: 1048 Vdc trip level
Undervoltage protection	115/230V series: 183 Vdc; 400V series: 333 Vdc; 575V series: 460 Vdc trip level
Ground fault protection	Ground fault is tested before every start. In case of ground fault in motor or motor cable, only the frequency converter is protected
Overtemperature protection	Yes
Motor overload protection	Yes
Motor stall protection	Yes
Motor underload protection	Yes

Table 31.1-6. Programmable Parameters

Description
Application macros: basic, pump, fan and high load (hoist) Programmable start/stop and reverse signal logic (sinking or sourcing) Reference scaling
Programmable start and stop functions DC-brake at start and stop Programmable V/Hz curve
Adjustable switching frequency Autorestart function after fault Protections and supervisions (all fully programmable; off, warning, fault)
Current signal input fault External fault Fieldbus communication
Eight preset speeds Analog input range selection, signal scaling and filtering PID controller Skip frequencies

Table 31.1-7. Options

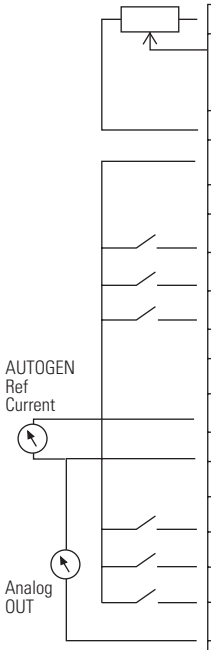
Description	Specification
3% line reactors 3% line reactors	Single-phase Three-phase

Specifications

Table 31.1-8. M-Max Series Drives

Description	Specification
Input Ratings	
Input voltage (V_{in})	+10%/–15% (575V units: +15%/–15%)
Input frequency (f_{in})	50/60 Hz (variation up to 45–66 Hz)
Connection to power	Once per minute or less (typical operation)
Output Ratings	
Output voltage	0 to V_{in} ①
Continuous output current	Continuous rated current I_N at ambient temperature max. 122°F (50°C), overload 1.5 x I_N max. 1 min/10 min
Output frequency	0 to 320 Hz
Frequency resolution	0.01 Hz
Initial output current (I_H)	Current 2 x I_N for 2 seconds in every 20-second period. Torque depends on motor
Control Characteristics	
Control method	Frequency control (V/Hz) open loop or sensorless vector control
Switching frequency	1.5 to 16 kHz; default 6 kHz
Frequency reference	Analog input: resolution 0.1% (10-bit), accuracy ±1% V/Hz. Panel reference: resolution 0.01 Hz
Field weakening point	30 to 320 Hz
Acceleration time	0 to 3000 sec
Deceleration time	0 to 3000 sec
Braking torque	DC brake: 30% x T_n (without brake option)
Brake Resistor (Minimum Values) ②	
230V Series	FS2 35 ohms and FS3 26 ohms
400V Series	FS2 75 ohms and FS3 54 ohms
575V Series	FS# 103 ohms
Ambient Conditions	
Ambient operating temperature	14°F (–10°C), no frost to 122°F (+50°C): Rated loadability I_N
Storage temperature	–40°F (–40°C) to 158°F (70°C)
Relative humidity	0 to 95% RH, noncondensing, non-corrosive, no dripping water
Air quality	Chemical vapors: IEC 721-3-3, unit in operation, Class 3C2; Mechanical particles: IEC 721-3-3, unit in operation, Class 3S2
Altitude	100% load capacity (no derating) up to 3280 ft (1000m); 1% derating for each 328 ft (100m) above 3280 ft (1000m); max. 6560 ft (2000m)
Vibration	EN 60068-2-6; 3 to 150 Hz, displacement amplitude 1 mm (peak) at 3 to 15.8 Hz, max. acceleration amplitude 1G at 15.8 to 150 Hz
Shock	EN 50178, IEC 68-2-27 UPS Drop test (for applicable UPS weights); storage and shipping: max. 15G, 11 ms (in package)
Enclosure class	IP20

① Exception: 115V single-phase in, 230V three-phase out.
② Only three-phase FS2 and FS3 drives are equipped with brake chopper circuit.



Terminal		Signal	Factory Preset	Description
1	+10V	Ref. output voltage	—	Maximum load 10 mA
2	AI1	Analog signal in 1	Freq. reference P)	0–+10 V Ri = 200k ohms [min.]
3	GND	I/O signal ground	—	—
6	24V	24V output for DIs	—	±20%, max. load 50 mA
7	GND	I/O signal ground	—	—
8	DI1	Digital input 1	Start forward P)	0–+30 V Ri = 12k ohms min.
9	DI2	Digital input 2	Start reverse P)	—
10	DI3	Digital input 3	Preset speed P)	—
A	A	RS-485 signal A	FB communication	—
B	B	RS-485 signal B	FB communication	—
4	AI2	Analog signal in 2	PI actual value P)	0[4]–20 mA, Ri = 200k ohms
5	GND	I/O signal ground	—	—
13	GND	I/O signal ground	—	—
14	DI4	Digital input 4	Preset speed B1 P)	0–+30 V Ri = 12k ohms min.
15	DI5	Digital input 5	Fault reset P)	0–+30 V Ri = 12k ohms min.
16	DI6	Digital input 6	Disable PI contr. P)	0–+30 V Ri = 12k ohms min.
18	AO	Analog output	Output frequency P)	0[2]–10V, RL = 500 ohms
20	DO	Digital signal out	Active = READY P)	Open collector, max. load 48V/50 mA
22	RO11	Relay out 1	Active = RUN P)	Max. switching load: 250 Vac/2A or 250 Vdc/0.4A
23	RO12			
24	RO21	Relay out 2	Active = FAULT P)	Max. switching load: 250 Vac/2A or 250 Vdc/0.4A
25	RO22			
26	RO23			

Note: P) Parameter-selectable function.

Figure 31.1-1. M-Max I/O Interface

Dimensions—Approximate Dimensions in Inches (mm)

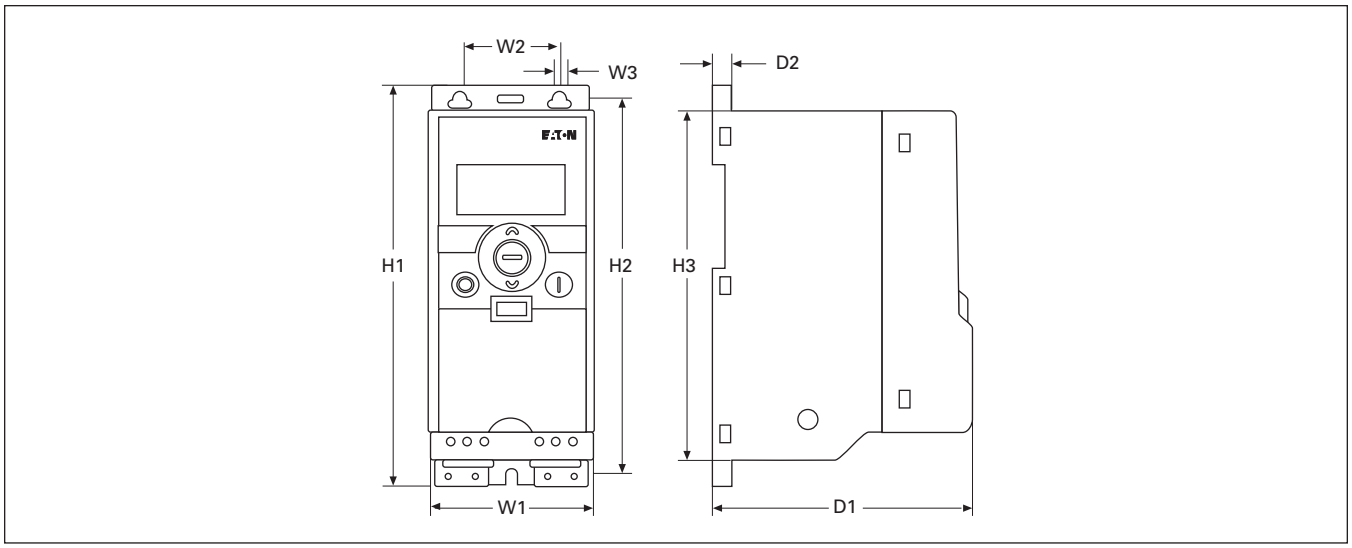


Figure 31.1-2. M-Max Drives

Table 31.1-9. M-Max Drives

Frame Type	H1	H2	H3	W1	W2	W3	D1	D2	Weight in Lbs (kg)
FS1	6.16 (156.5)	5.79 (147.0)	5.40 (137.3)	2.58 (65.5)	1.49 (37.8)	0.17 (4.5)	3.88 (98.5)	0.27 (7.0)	1.213 (0.550)
FS2	7.68 (195.0)	7.20 (183.0)	6.69 (170.0)	3.54 (90.0)	2.46 (62.5)	0.22 (5.5)	4.00 (101.5)	0.27 (7.0)	1.543 (0.699)
FS3	10.33 (262.5)	9.93 (252.3)	9.50 (241.3)	3.94 (100.0)	2.95 (75.0)	0.22 (5.5)	4.27 (108.5)	0.27 (7.0)	2.183 (0.990)

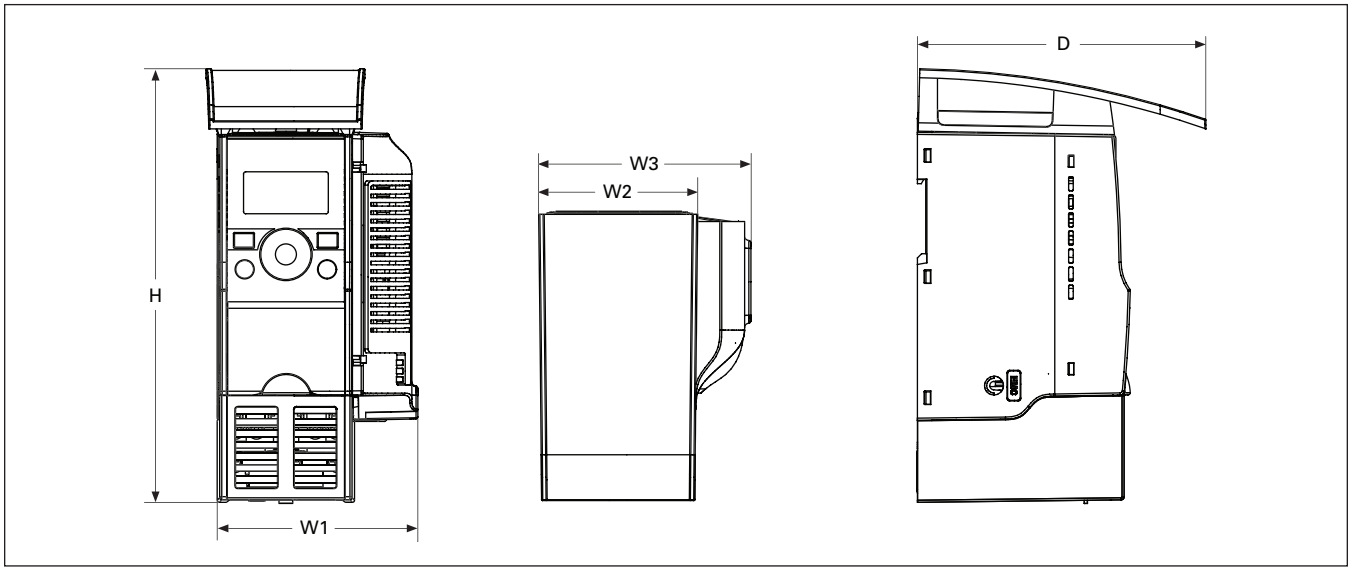


Figure 31.1-3. NEMA 1/IP21 M-Max Drives and Communication Adapter Kit

Table 31.1-10. NEMA 1/IP21 M-Max Drives and Communication Adapter Kit

Frame Type	H	W1	W2	W3	D
FS1	8.14 (206.7)	3.77 (95.7)	2.99 (75.9)	3.98 (101.2)	5.41 (137.5)
FS2	9.90 (251.5)	4.72 (120.0)	3.97 (100.8)	4.94 (125.5)	5.68 (144.2)
FS3	12.26 (311.5)	5.12 (130.1)	4.36 (110.8)	5.33 (135.3)	6.32 (160.5)

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CPX9000 Enclosed Drives

CPX9000—150 hp I_L

General Description

Eaton's CPX9000 Clean Power Drives use advanced 18-pulse, clean power technology that significantly reduces line harmonics at the drive input terminals, resulting in one of the purest sinusoidal waveforms available.

Enhancements to the CPX9000 Clean Power Drives include smaller enclosures and higher temperature ratings than CP9000 for selected drives.

The CPX9000 drive also delivers true power factor—in addition to reducing harmonic distortion, the CPX9000 drive prevents transformer overheating and overloading of breakers and feeders, which enables the application of adjustable frequency drives on generators and other high impedance power systems.

CPX9000 Enclosed Products

- **Standard enclosed**—covers a wide range of the most commonly ordered options. Pre-engineering eliminates the lead time normally associated with customer specific options. Available configurations are listed on **Pages 31.2-5–31.2-18**
- **Modified standard enclosed**—applies to specific customer requirements that vary from the Standard Enclosed offering, such as the need for an additional indicating light or minor modifications to drawings. *Contact your local sales office for assistance in pricing and lead time*
- **Custom engineered**—for those applications with more unique or complex requirements, these are individually engineered to the customer's needs. *Contact your local sales office for pricing and lead time*

Features and Benefits

CPX9000 Clean Power Drive features include:

- 25–150 hp I_L drives available in 30-inch enclosure
- 200 and 250 hp I_L drives available in 48-inch enclosure
- 300–400 hp I_L drives available in 60-inch enclosure
- 500–600 hp I_L drives available in 80-inch enclosure
- NEMA Type 1, NEMA 12 with gaskets and filters
- Input voltage: 480V, 208/230V
- Complete range of control, network and power options
- Horsepower range:
  - 480V, 25–700 hp I_H; 25–800 hp I_L
  - 208/230V, 25–100 hp I_L; consult factory for details
- Over 10 years of 18-pulse clean power experience

Application Description

Designed to exceed the IEEE 519-1992 requirements for harmonic distortion, the CPX9000 is the clear choice for applications in the water, wastewater, HVAC, industrial and process industries where harmonics are a concern.

What are Harmonics?

Take a perfect wave with a fundamental frequency of 60 Hz, which is close to what is supplied by the power company.

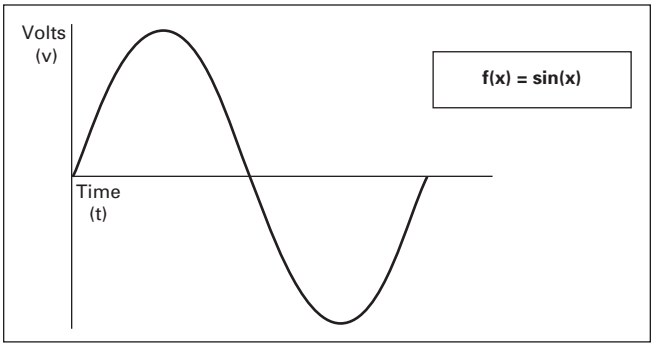


Figure 31.2-1. Perfect Wave

Add a second wave that is five times the fundamental frequency—300 Hz (typical of frequency added to the line by a fluorescent light).

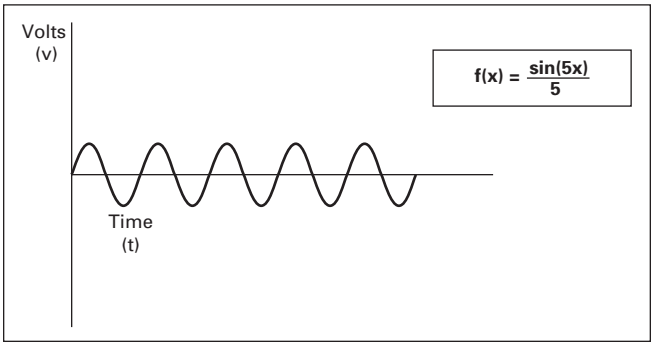


Figure 31.2-2. Second Wave

Combine the two waves. The result is a 60 Hz supply rich in fifth harmonics.

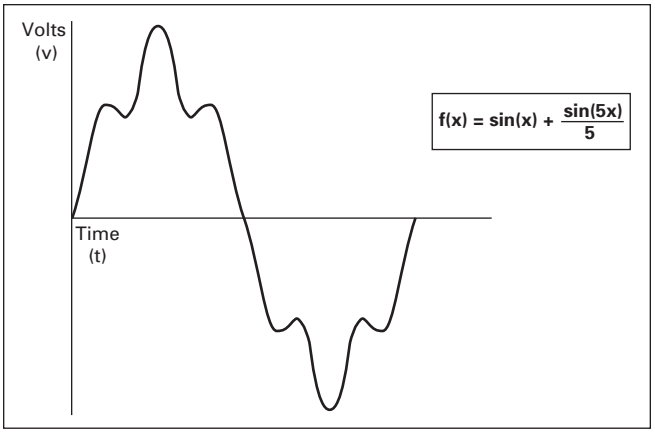


Figure 31.2-3. Resulting Supply

What Causes Harmonics?

Harmonics are the result of nonlinear loads that convert AC line voltage to DC. Examples of equipment that are nonlinear loads are listed below:

- AC variable frequency drives
- DC drives
- Fluorescence lighting, computers, UPS systems
- Industrial washing machines, punch presses, welders, etc.

How Can Harmonics Due to VFDs Be Diminished?

By purchasing Eaton's 18-pulse Eaton drive that is guaranteed to meet IEEE Std. 519-1992 Harmonic Distortion Limits.

What are Linear Loads?

Linear loads are primarily devices that run across the line and do not add harmonics. Motors are prime examples. The downside to having large motor linear loads is that they draw more energy than a VFD, because of their inability to control motor speed. In most applications, there is a turn down valve used with the motor that will reduce the flow of the material, without significantly reducing the load to the motor. While this provides some measure of speed control, it is extremely inefficient.

Why be Concerned About Harmonics?

1. ***Installation and utility costs increase.*** Harmonics cause damage to transformers and lower efficiencies due to the IR loss. These losses can become significant (from 16.6–21.6%), which can have a dramatic effect on the HVAC systems that are controlling the temperatures of the building where the transformer and drive equipment reside.
2. ***Downtime and loss of productivity.*** Telephones and data transmissions links may not be guaranteed to work on the same power grids polluted with harmonics.
3. ***Downtime and nuisance trips of drives and other equipment.*** Emergency generators have up to three times the impedance that is found in a conventional utility source. Thus the harmonic voltage can be up to three times as large, causing risk of operation problems.
4. ***Larger motors must be used.*** Motors running across the line that are connected on polluted power distribution grids can overheat or operate at lower efficiency due to harmonics.
5. ***Higher installation costs.*** Transformers and power equipment must be oversized to accommodate the loss of efficiencies. This is due to the harmonic currents circulating through the distribution without performing useful work.

How Does a VFD Convert Three-Phase AC to a Variable Output Voltage and Frequency?

The 6-pulse VFD: The majority of all conventional drives that are built consist of a 6-pulse configuration. **Figure 31.2-4** represents a 6-diode rectifier design that converts three-phase utility power to DC. The inverter section uses IGBTs to convert DC power to a simulated AC sine wave that can vary in frequency from 0–400 Hz.

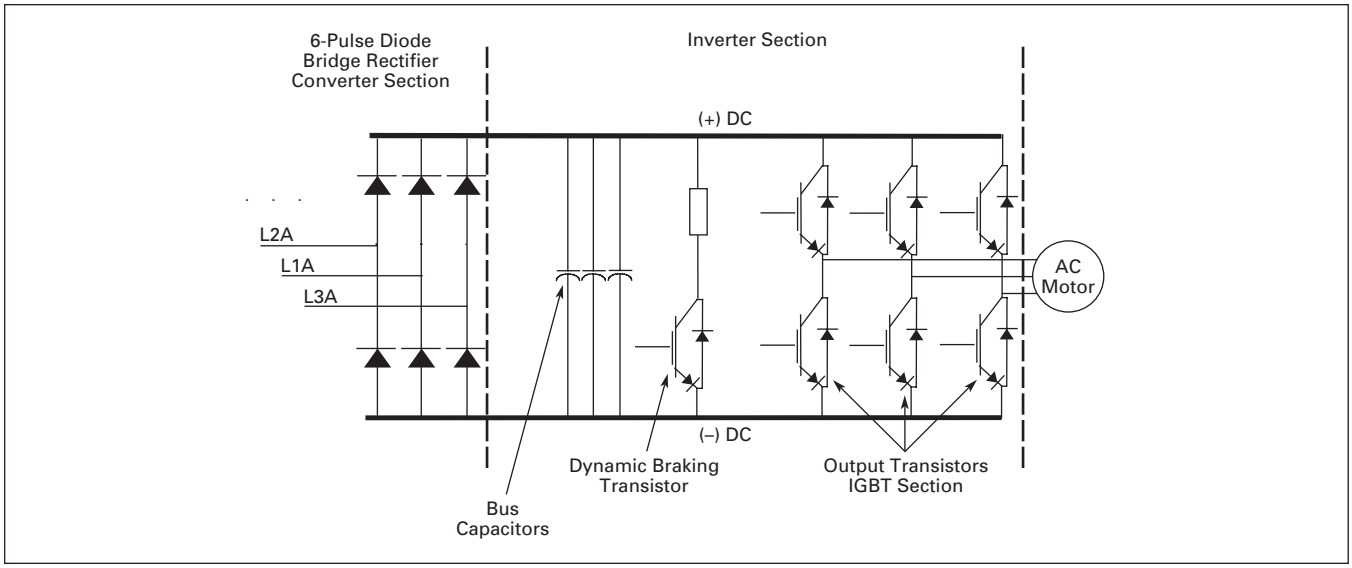


Figure 31.2-4. 6-Diode Rectifier Design

The 6-pulse VFD drive creates harmonic current distortion. The harmonic current that is created is energy that can not be used by customers and causes external heat and losses to all components including other drives that are on the same power distribution. **Figure 31.2-5** is a 500 hp drive with 167A of damaging harmonic current.

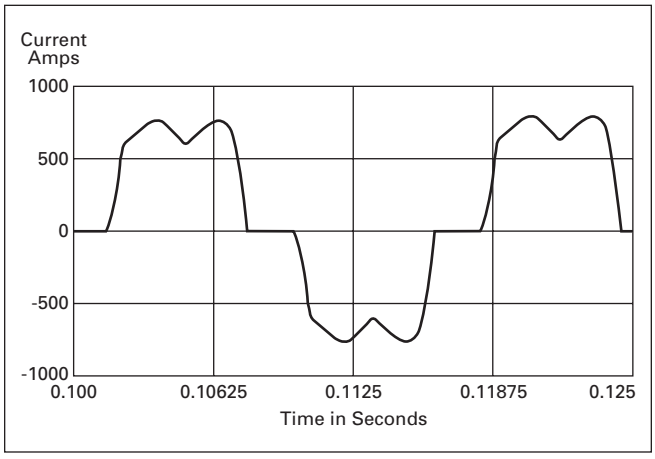


Figure 31.2-5. 6-Pulse Nonproductive Harmonic Current

Table 31.2-1. 6-Pulse Nonproductive Harmonic Current

6-Pulse Circuit		
Current harmonics		
I_1 = 100%	I_{11} = 6.10%	I_{19} = 1.77%
I_5 = 22.5%	I_{13} = 4.06%	I_{23} = 1.12%
I_7 = 9.38%	I_{17} = 2.26%	I_{25} = 0.86%
Power = 500 hp		
Harmonic current = 167A		

Standards and Certifications

Guidelines of Meeting IEEE Std. 519-1992 Harmonic Distortion Limits

The IEEE 519-1992 Specification is a standard that provides guidelines for commercial and industrial users that are implementing medium and low voltage equipment.

Table 31.2-2. Maximum Harmonic Current Distortion in % of the Fundamental (120V through 69,000V)

I_{sc}/I_L	Harmonic Order (Odd Harmonics)					TDD
	h<11	11≤h<17	17≤h<23	23≤h<35	35≤h	
<20	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

The ratio ISC/IL is the ratio of the short-circuit current available at the point of common coupling (PCC), to the maximum fundamental load current. Consequently, as the size of the user load decreases with respect to the size of the system, the percentage of harmonic current that the user is allowed to inject into the utility system increases.

Notes: TDD = Total demand distortion is the harmonic current distortion in percent of the maximum demand load current (15 or 30 minute demand).
I_{SC} = Maximum short-circuit current at the PCC not counting motor contribution.
I_L = Maximum demand load current for all of the connected loads (fundamental frequency component) at the PCC.
All of the limits are measured at a point of common coupling.

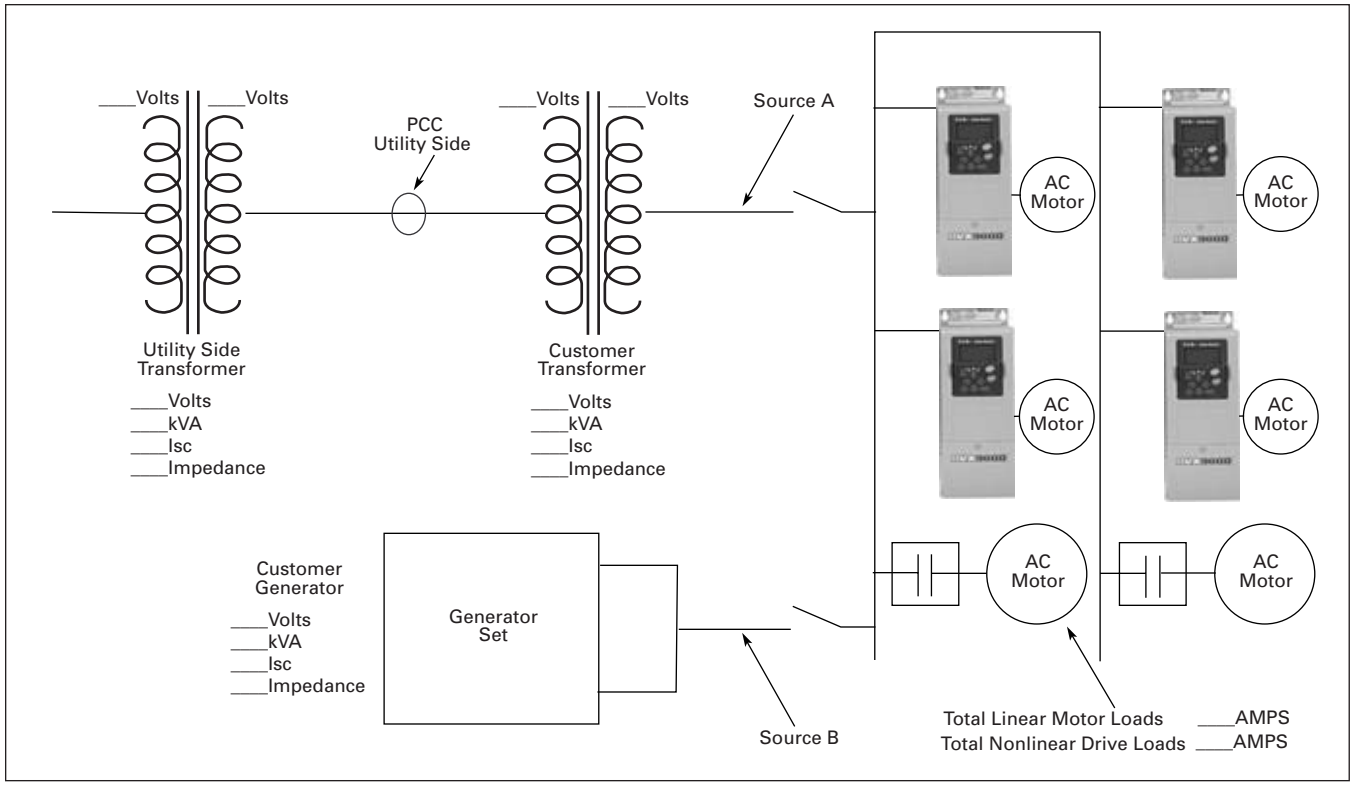


Figure 31.2-6. One-Line Diagram for Harmonic Analysis

The best way to estimate AFD harmonic contribution to an electrical system is to perform a harmonic analysis based on known system characteristics. The one line in this figure would provide the data to complete the calculations.

Terms

- PCC (point of common coupling) is defined as the electrical connecting point between the utility and multiple customers per the specifications in IEEE 519
- POA (point of analysis) is defined as where the harmonic calculations are taken

An oscilloscope can make all measurements at the PCC or POA to do an on-site harmonic evaluation

Harmonic Reduction Methods to Meet IEEE 519

1. Line Reactor

A line reactor is a three-phase series inductance filter on the line side of an AFD. If a line reactor is applied on all AFDs, it is possible to meet IEEE guidelines where 10–25% of system loads are AFDs, depending on the stiffness of the line and the value of line reactance. Line reactors are available in various values of percent impedance, most typically 1–1.5%, 3% and 5%. (Note: the SVX9000 comes standard with a nominal 3% input impedance.)

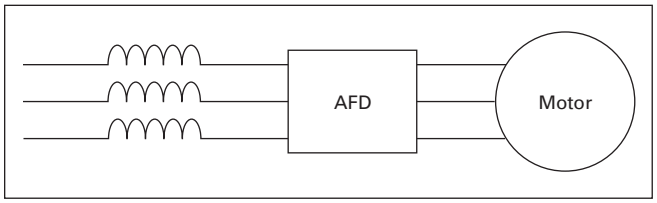


Figure 31.2-7. Line Reactor

Advantages

- Low cost
- Can provide moderate reduction in voltage and current harmonics
- Available in various values of percent impedance
- Provides increased input protection for AFD and its semiconductors from line transients

Disadvantages

- May not reduce harmonic levels to below IEEE 519-1992 guidelines
- Voltage drop due to IR loss

2. Clean Power Drives

When the total load is comprised of nonlinear load such as drives and the ratio is Isc/I_L, the greatest harmonic mitigation is required. Under these conditions, the currents drawn from the supply need to be sinusoidal and "clean" such that system interference and additional losses are negligible. The Eaton CPX9000 Clean Power Drive uses a phase-shifting auto transformer with delta-connected winding that carries only the ampere-turns caused by the difference in load currents. This results in nine separate phases. In this type of configuration, the total kVA rating of the transformer magnetic system was only 48% that of the motor load. A traditional isolated transformer system, with multipulse windings, would require the full kVA rating to be supported, which is more common in a MV step-down transformer.

The integrated 18-pulse clean power drive, with near sine wave input current and low harmonics will meet the requirements of IEEE 519-1992 under all practical operating conditions. The comparisons with 6-pulse and 12-pulse systems are shown in **Figures 31.2-5** and **31.2-9**.

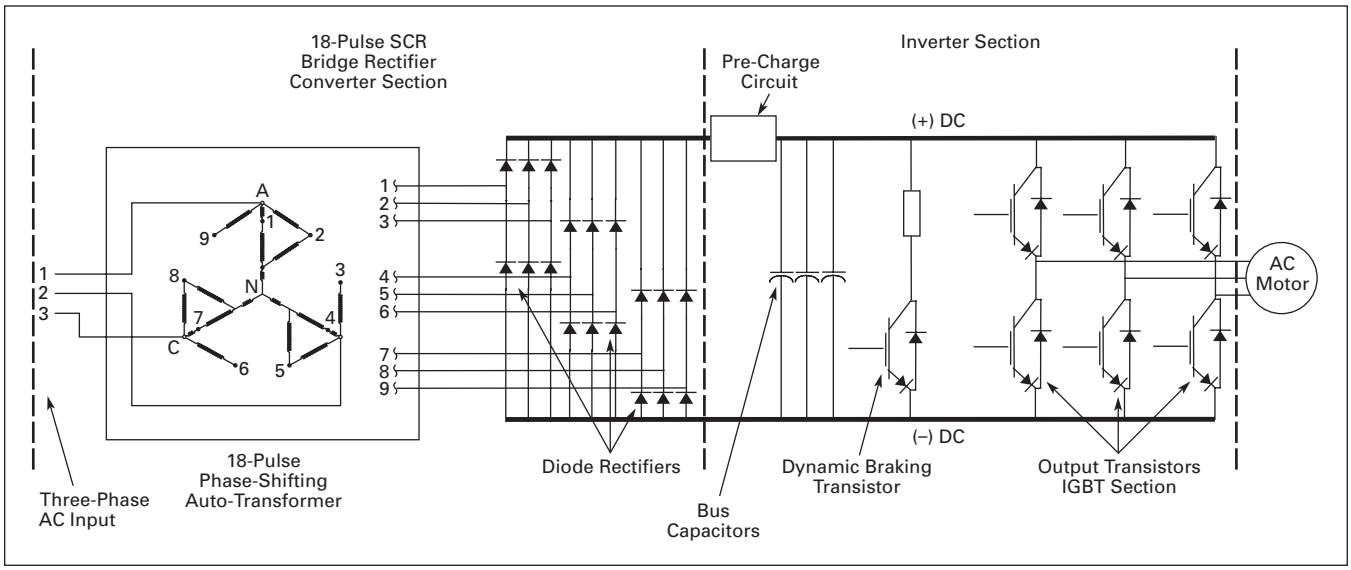


Figure 31.2-8. Basic 18-Pulse Rectifier with "Differential Delta" Transformer

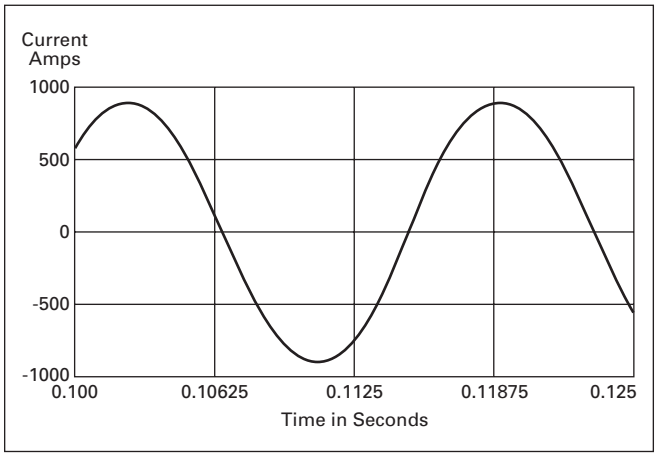


Figure 31.2-9. 500 hp 480V Drive with 18-Pulse Rectifiers

Table 31.2-3. 500 hp 480V Drive with 18-Pulse Rectifiers

18-Pulse Clean Power		
Current harmonics		
I_1 = 100%	I_{11} = 0.24%	I_{19} = 1.00%
I_5 = 0.16%	I_{13} = 0.10%	I_{23} = 0.01%
I_7 = 0.03%	I_{17} = 0.86%	I_{25} = 0.01%
Power = 428.8 kW		
H_C = 24A		

Advantages

- Virtually guarantees compliance with IEEE 519-1992
- Provides increased input protection for AFD and its semiconductors from line transients
- Up to four times the harmonic reduction of 12-pulse methods
- Smaller transformer than isolation transformer used in 12-pulse converter

Disadvantages

- Larger and heavier magnetics than applying a line reactor on SVX or tuned harmonic filter/cap on CFX

Technical Data and Specifications

Table 31.2-4. Specifications

Feature Description	CPX9000 Enclosed Products—NEMA Type 1
Primary Design Features	
45–66 Hz input frequency	Standard
Output: AC volts maximum	Input voltage base
Output frequency range: Hz	0–500
Initial output current (I_H)	250% for 2 seconds
Overload: 1 minute (I_H/I_L)	150%/110%
Enclosure space heater	Optional
Oversize enclosure	Standard
Output contactor	Optional
Bypass motor starter	Optional
Listings	UL, cUL
Protection Features	
Incoming line fuses	Standard 200 kA rating
AC input circuit disconnect	Optional
Phase rotation insensitive	Standard
EMI filter	FR6–FR9 ①
Input phase loss protection	Standard
Input overvoltage protection	Standard
Line surge protection	Standard
Output short circuit protection	Standard
Output ground fault protection	Standard
Output phase protection	Standard
Overtemperature protection	Standard
DC overvoltage protection	Standard
Drive overload protection	Standard
Motor overload protection	Standard
Programmer software	Optional
Local/remote keypad	Standard
Keypad lockout	Standard
Fault alarm output	Standard
Built-in Diagnostics	Standard
MOV	Standard
Input/Output Interface Features	
Setup Adjustment Provisions	
Remote keypad/display	Standard
Personal computer	Standard
Operator Control Provisions	
Drive mounted keypad/display	Standard
Remote keypad/display	Standard
Conventional control elements	Standard
Serial communications	Optional
115 Vac control circuit	Optional
Speed Setting Inputs	
Keypad	Standard
0–10 Vdc potentiometer/voltage signal	Standard
4–20 mA isolated	Configurable
4–20 mA differential	Configurable
3–15 psig	Optional
Analog Outputs	
Speed/frequency	Standard
Torque/load/current	Programmable
Motor voltage	Programmable
Kilowatts	Programmable
0–10 Vdc signals	Configurable w/jumpers
4–20 mA DC signals	Standard
Isolated signals	Optional

① The EMI filter is optional in FR10 and larger.

Feature Description	CPX9000 Enclosed Products—NEMA Type 1
Input/Output Interface Features (Continued)	
Discrete Outputs	
Fault alarm	Standard
Drive running	Standard
Drive at set speed	Programmable
Optional parameters	14
Dry contacts	1 (2 relays Form C)
Open collector outputs	1
Additional discrete outputs	Optional
Communications	
RS-232	Standard
RS-422/485	Optional
DeviceNet™	Optional
Modbus RTU	Optional
CANopen (slave)	Optional
PROFIBUS-DP	Optional
LonWorks®	Optional
Johnson Controls Metasys™ N2	Optional
Performance Features	
Sensorless vector control	Standard
Volts/hertz control	Standard
IR and slip compensation	Standard
Electronic reversing	Standard
Dynamic braking	Optional
DC braking	Standard
PID set point controller	Programmable
Critical speed lockout	Standard
Current (torque) limit	Standard
Adjustable acceleration/deceleration	Standard
Linear or S curve accel/decel	Standard
Jog at preset speed	Standard
Thread/preset speeds	7
Automatic restart	Selectable
Coasting motor start	Standard
Coast or ramp stop selection	Standard
Elapsed time meter	Optional
Carrier frequency adjustment	1–16 kHz
Standard Conditions for Application and Service	
Maximum operating ambient temperature	0° to 50°C up to FR9 0° to 40°C FR10 and larger, consult factory for 50°C rating above FR9
Storage temperature	–40° to 60°C
Humidity (maximum), noncondensing	95%
Altitude (maximum without derate)	3300 ft (1000m)
Line voltage variation	+10/–15%
Line frequency variation	45–66 Hz
Efficiency	>96%
Power factor (displacement)	0.99

Table 31.2-5. Standard I/O Specifications

Description	Specification
6–Digital input programmable	24 V: "0" ≤ 10V, "1" ≥ 18V, R_i > 5 kΩ
2–Analog input configurable w/jumpers	Voltage: 0–±10V, R_i > 200 kΩ Current: 0 (4)–20 mA, R_i = 250 kΩ
2–Digital output programmable	Form C relays 250 Vac 2A or 30 Vdc 2A resistive
1–Digital output programmable	Open collector 48 Vdc 50 mA
1–Analog output programmable configurable w/jumper	0–20 mA, impedance 500 ohms, resolution 106 ±3%

Catalog Number Selection

Table 31.2-6. CPX9000 Enclosed NEMA Type 1 Drive Catalog Numbering System

CPX 100 1 4 A A

Build options alphabetically and numerically.

_ _ _ _ _ _ _ _ _ _

Product Family

CPX = Clean power 18-pulse enclosed drives

Horsepower Rating

025 = 25 hp	**200** = 200 hp
030 = 30 hp	**250** = 250 hp
040 = 40 hp	**300** = 300 hp
050 = 50 hp	**350** = 350 hp
060 = 60 hp	**400** = 400 hp
075 = 75 hp	**500** = 500 hp
100 = 100 hp	**600** = 600 hp
125 = 125 hp	**700** = 700 hp
150 = 150 hp	**800** = 800 hp

Enclosure Rating

1 = NEMA Type 1
6 = NEMA 12 filtered

Voltage Rating

4 = 480V

Application—Torque/Braking ①

A = I_L/no brake chopper
B = I_L/internal brake chopper
D = I_H/no brake chopper
E = I_H/internal brake chopper

Enclosed Style

A = Enclosed drive

Enclosed Options ②③④		Type
K1	Door-mounted speed potentiometer ⑤	Control
K2	Door-mounted speed potentiometer with HOA selector switch ⑤	Control
K3	3–15 psig follower	Control
K4	HAND/OFF/AUTO switch (22 mm)	Control
K5	MANUAL/AUTO reference switch (22 mm)	Control
K6	START/STOP pushbuttons (22 mm)	Control
KF	Bypass test switch for RA and RB	Addl. bypass
KO	Standard elapsed time meter	Control
L1	Power on and fault pilot lights	Light
L2	Bypass pilot lights for RA, RB, bypass options	Addl. bypass
LE	Red RUN light	Light
P1	Input disconnect	Input
PE	Output contactor	Output
PF	Output filter	Output
PG	MotoRx (up to 600 ft) 1000 V/µS DV/DT filter	Output
PH	Single overload relay	Output
PI	Dual overload relays	Output
PN	Dual overloads for bypass	Addl. bypass
RA	Manual HOA bypass controller	Bypass
RB	Manual IOB bypass controller	Bypass
RC	Auto transfer HOA bypass controller	Bypass
RD	Auto transfer IOB bypass controller	Bypass
RG	Reduced voltage starter for bypass	Bypass
S7	10-inch expansion	Enclosure
S8	20-inch expansion	Enclosure
S9	Space heater	Enclosure

Communication Options ⑥

C2 = Modbus	**C8** = Modbus (D9 Type connector)
C3 = PROFIBUS DP	**CA** = Johnson Controls N2
C4 = LonWorks	**CI** = Modbus TCP
C5 = PROFIBUS DP (D9 connector)	**CJ** = BACnet
C6 = CANopen (slave)	**D3** = RS-232 with D9 connection
C7 = DeviceNet	

Control Options

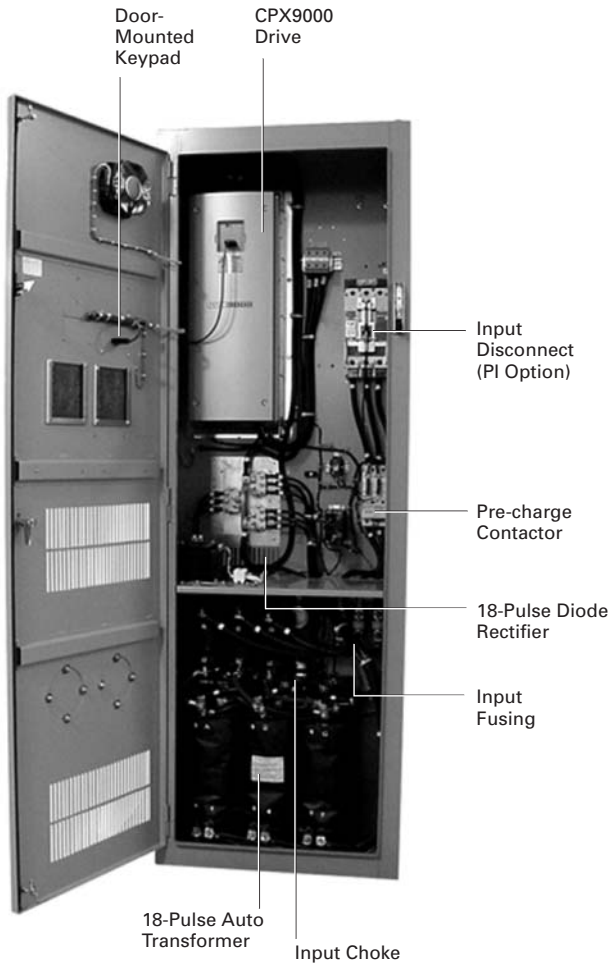
B1 = 6 DI, 1 ext +24 Vdc/EXT +24 Vdc
B2 = 1 RO (NC/NO), 1 RO (NO), 1 Therm
B4 = 1 AI (mA isolated), 2 AO (mA isolated), 1 ext +24 Vdc/EXT +24 Vdc
B5 = 3 RO (NO)
B8 = 1 ext +24 Vdc/EXT +24 Vdc, 3 Pt100
B9 = 1 RO (NO), 5 DI 42–240 Vac Input

Engineered Options

HT = High temperature rating for 50°C (FR10 and above) ⑦
VB = Varnished boards

① Brake chopper is standard in drives up to 30 hp I_H or 40 hp I_L. It is optional in larger drives.
② Local/remote keypad is included as the standard control panel and as a digital HOA switch.
③ Some options are voltage and/or horsepower specific. Consult your Eaton representative for details.
④ See **Pages 31.2-15** and **31.2-16** for descriptions.
⑤ Includes local/remote speed reference switch.
⑥ See **Pages 31.2-17** and **31.2-18** for complete descriptions.
⑦ Consult Eaton for pricing and availability.

Product Selection



NEMA Type 1, 25–150 hp (30 x 90 x 21.5)

When Ordering

- Select a base catalog number that meets the application requirements—nominal horsepower, voltage and enclosure rating. (The enclosed drive's continuous output amp rating should be equal to or greater than the motor's full load ampere rating.) The base enclosed package includes a standard drive, door-mounted alphanumeric panel and enclosure
- The CPX9000 product uses the term High Overload (I_H) in place of the term Constant Torque (CT). Likewise, Low Overload (I_L) is used in place of the term Variable Torque (VT). The new terms are a more precise description of the rating. The older terms included ambient temperature ratings in addition to overload ratings. In order to minimize enclosure size and offer the highest ambient temperature rating, overload and temperature ratings are now treated separately. Ambient temperature ratings are shown in **Table 31.2-7**. Consult the factory for 50°C ratings of FR10 and above

Table 31.2-7. Ambient Temperature Ratings

Frame Size	I_H	I_L
FR4–FR9	50°C	50°C
FR10 and above	40°C	40°C

- If dynamic brake chopper or Control/Communication option is desired, change the appropriate code in the base catalog number

  Note: All of the programming is exactly the same as the standard SVX9000 drive.

- Select enclosed options. Add the codes as suffixes to the base catalog number in alphabetical and numeric order

Table 31.2-8. 480 Vac CPX9000 Base Drive Product Selection

Enclosure Size ①	hp	Current (A)	Chassis Frame	Drawing Number
Low Overload Drive—I_L = Variable Torque				
7	25 30 40	38 46 61	FR6 FR6 FR6	1 1 1
7	50 60 75	72 87 105	FR7 FR7 FR7	1 1 1
7	100 125 150	140 170 205	FR8 FR8 FR8	1 1 1
8	200 250	261 300	FR9 FR9	2 2
9	300 350 400	385 460 520	FR10 FR10 FR10	3 3 3
10	500 550 600	590 650 730	FR11 FR11 FR11	4 4 4
11	650 700 800	820 920 1030	FR12 FR12 FR12	② ② ②
High Overload Drive—I_H = Constant Torque				
7	25 30 40	38 46 61	FR6 FR6 FR7	1 1 1
7	50 60 75	72 87 105	FR7 FR7 FR8	1 1 1
7	100 125	140 170	FR8 FR8	1 1
8	150 200	205 245	FR9 FR9	2 2
9	250 300 350	300 385 460	FR10 FR10 FR10	3 3 3
10	400 500 550	520 590 650	FR11 FR11 FR11	4 4 4
11	600 650 700	720 820 840	FR12 FR12 FR12	② ② ②

① See enclosure dimensions in **Table 31.2-9**.
② Consult factory.

Table 31.2-9. CPX9000 Enclosure Dimensions

Enclosure Size ③	Approximate Dimensions in Inches (mm)		
	Width	Height	Depth
7 8 9	30.00 (762.0) 48.00 (1219.2) 60.00 (1524.0)	90.00 (2286.0) 90.00 (2286.0) 90.00 (2286.0)	21.50 (546.1) 26.14 (664.0) 25.74 (653.8)
10 11 ④	80.00 (2032.0) —	90.00 (2286.0) —	31.75 (806.5) —

③ Enclosure sizes accommodate drive and options, including bypass and disconnect. For other power options, consult your Eaton representative.
④ Consult factory.

Dimensions

CPX Drawing 1—Enclosure Size 7

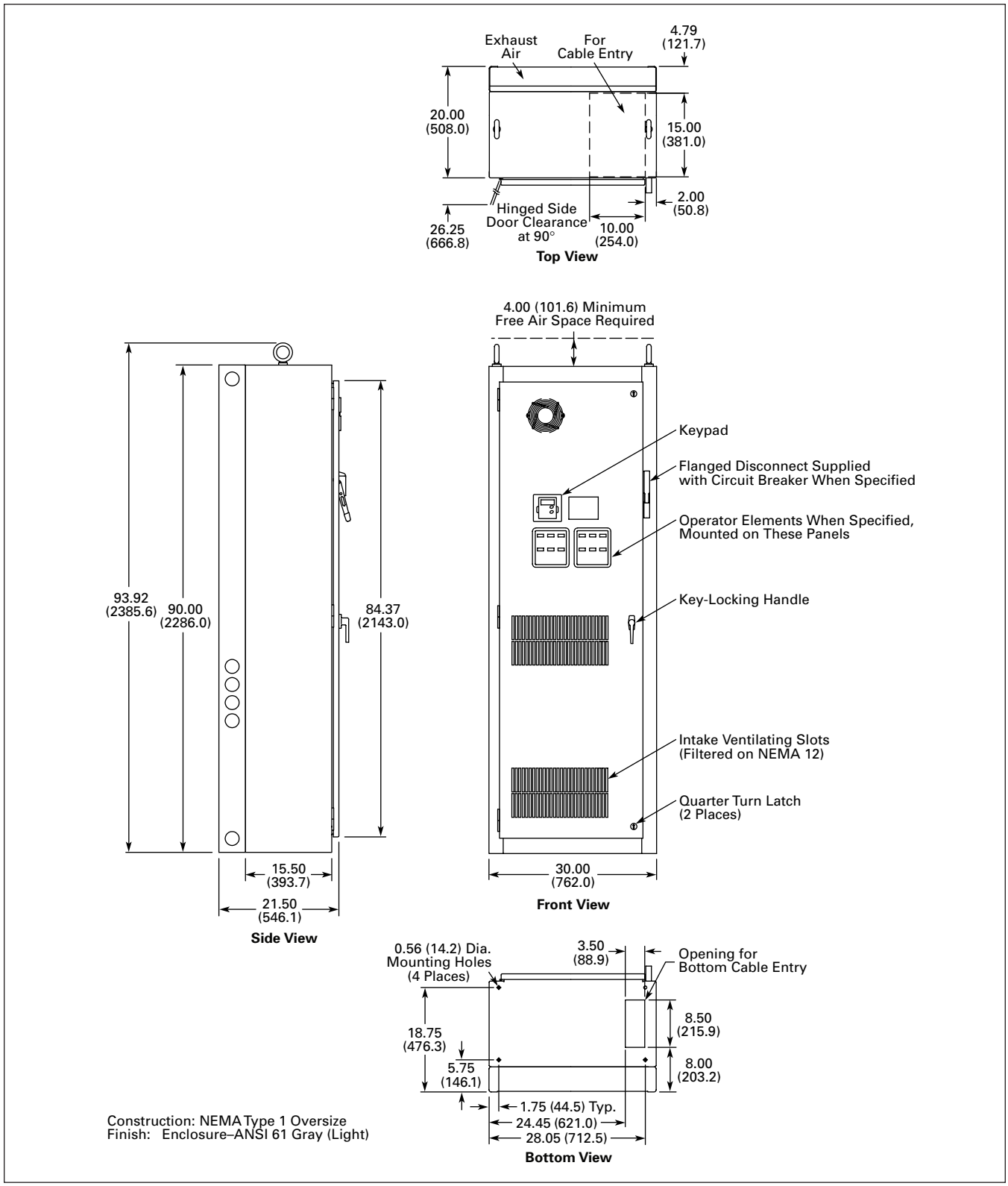


Figure 31.2-10. 25–150 hp I_L and 25–125 hp I_H—Approximate Dimensions in Inches (mm)

CPX Drawing 2—Enclosure Size 8

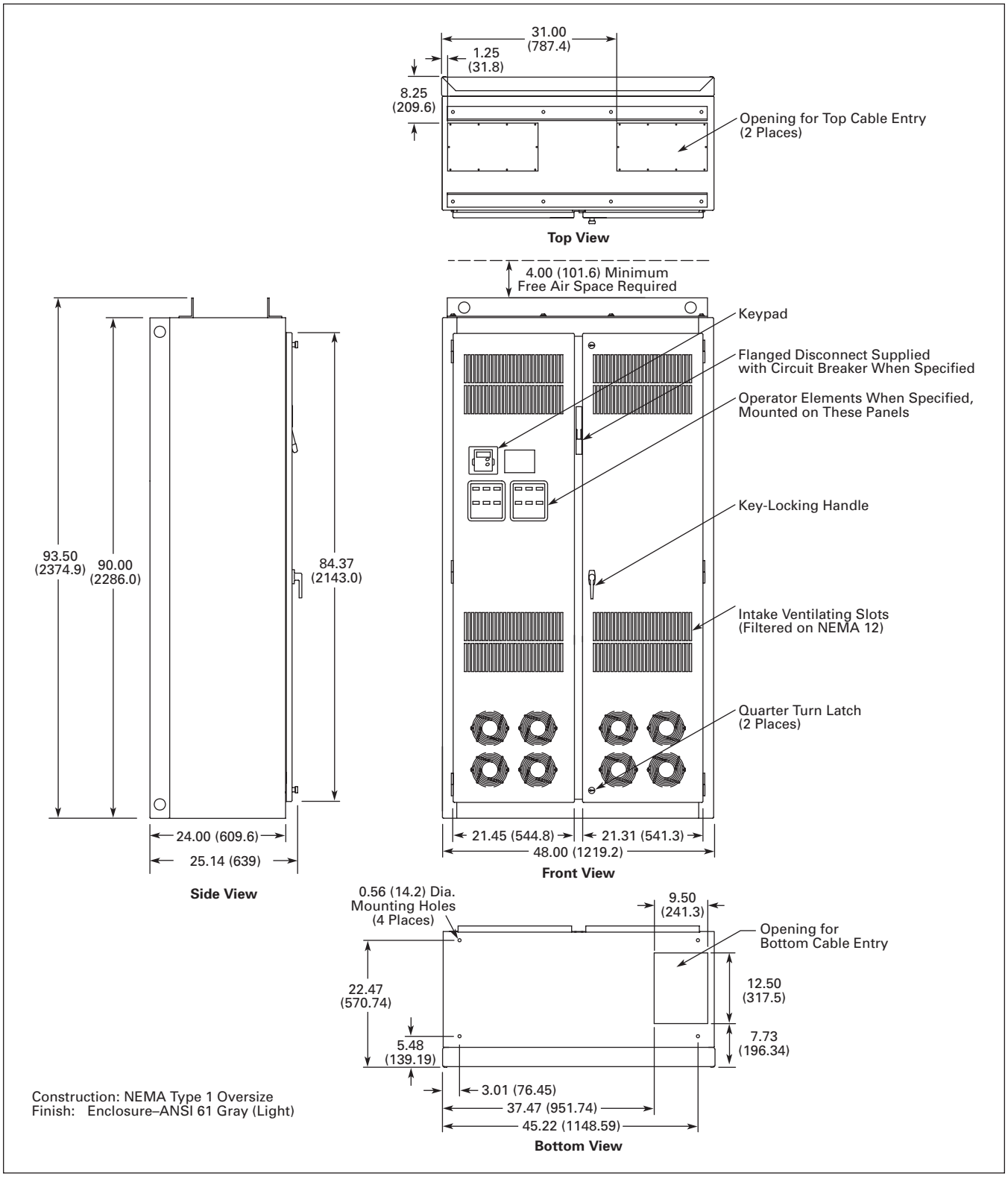


Figure 31.2-11. 200–250 hp I_L and 150–200 hp I_H—Approximate Dimensions in Inches (mm)

CPX Drawing 3—Enclosure Size 9

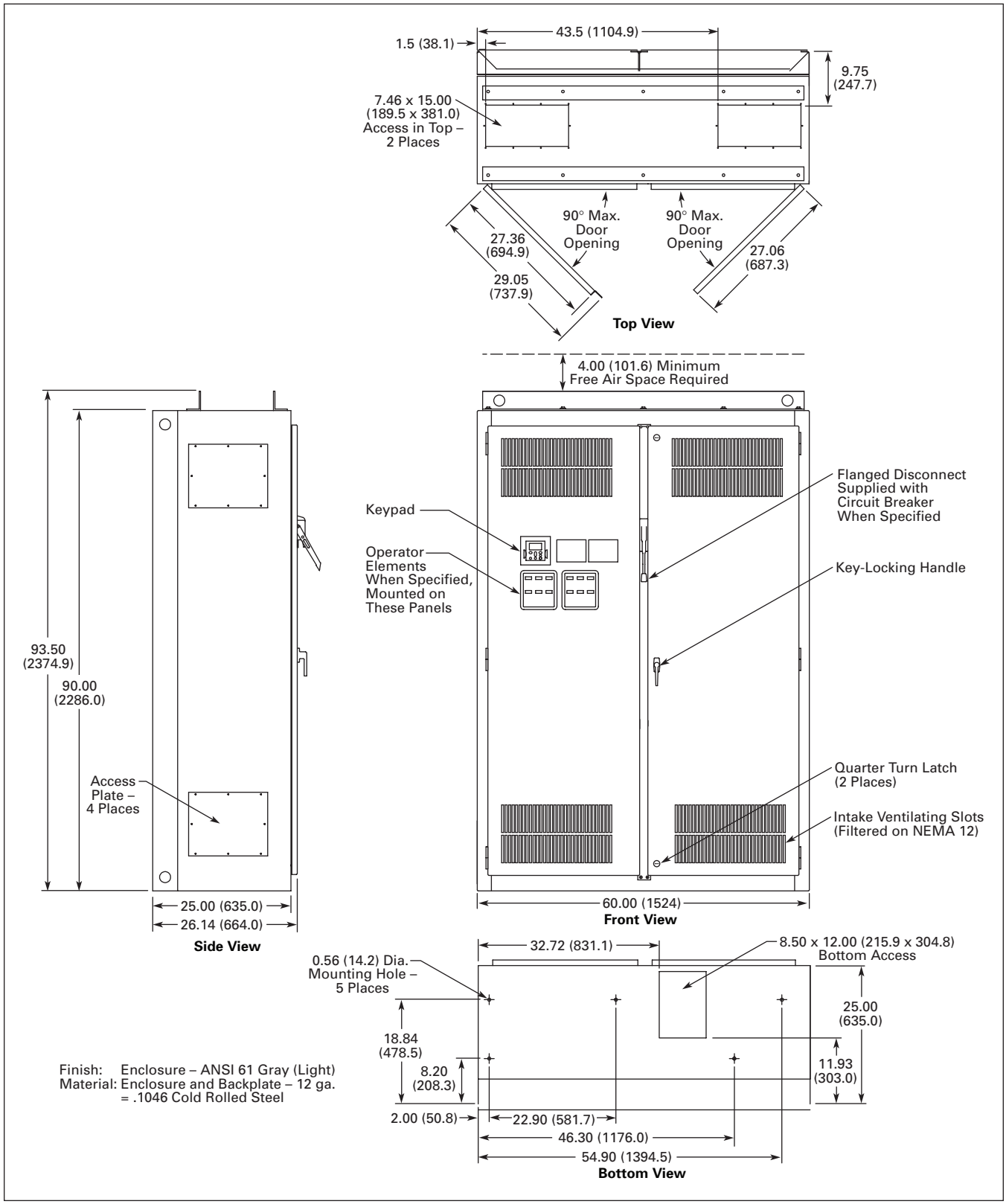


Figure 31.2-12. 300–400 hp I_L and 250–350 hp I_H—Approximate Dimensions in Inches (mm)

CPX Drawing 4—Enclosure Size 10

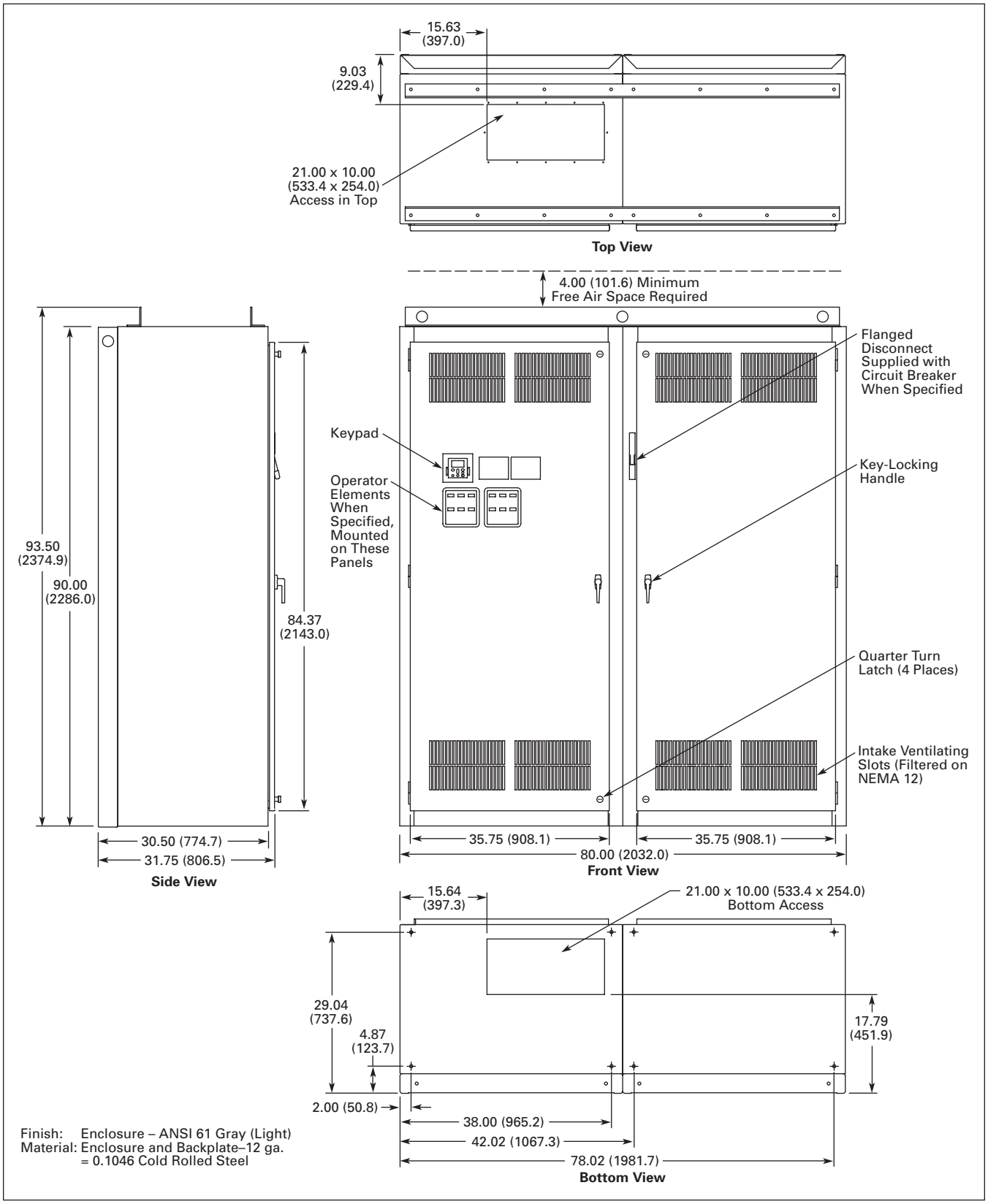


Figure 31.2-13. 500–600 hp I_L and 400–500 hp I_H—Approximate Dimensions in Inches (mm)

Wiring Diagrams

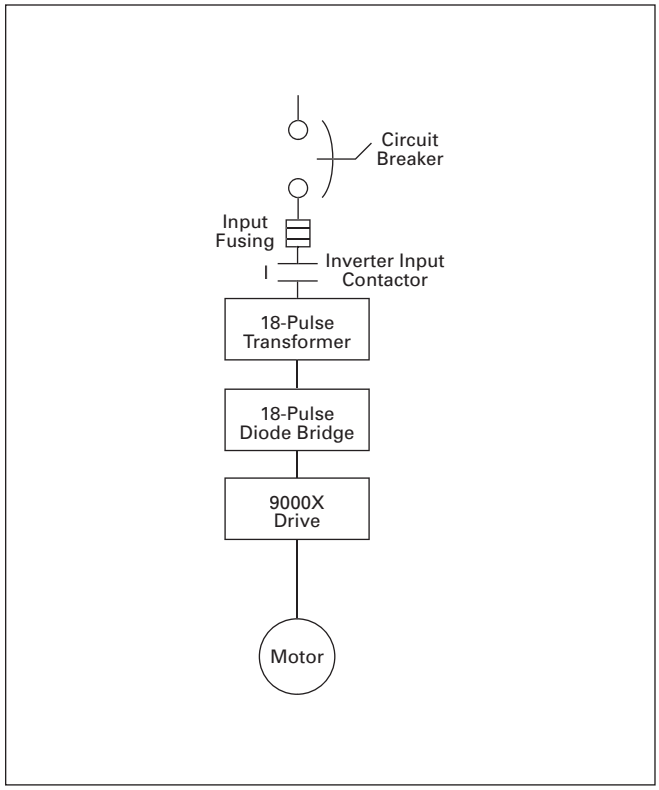


Figure 31.2-14. Power Diagram 25–250 hp I_L and 25–200 hp I_H

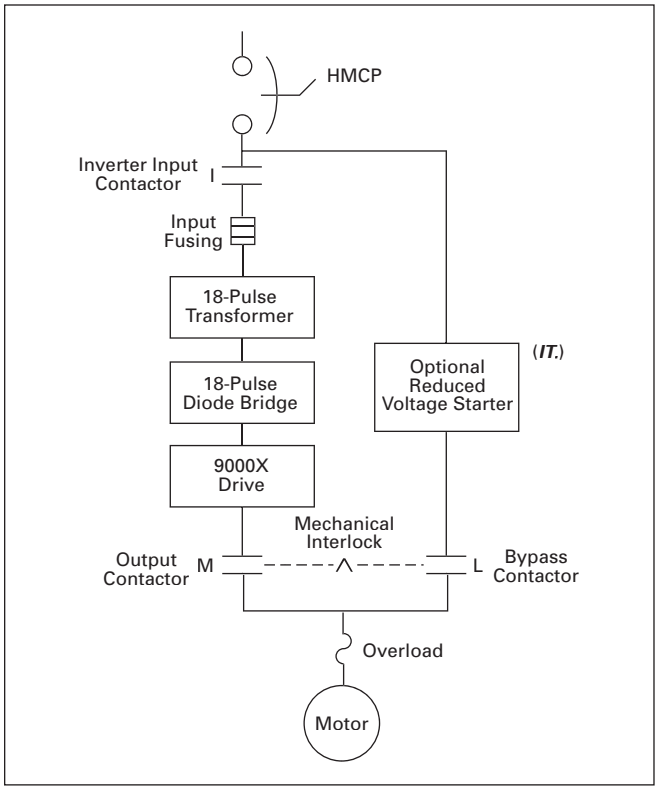


Figure 31.2-16. Power Diagram 25–250 hp I_L and 25–200 hp I_H with Bypass

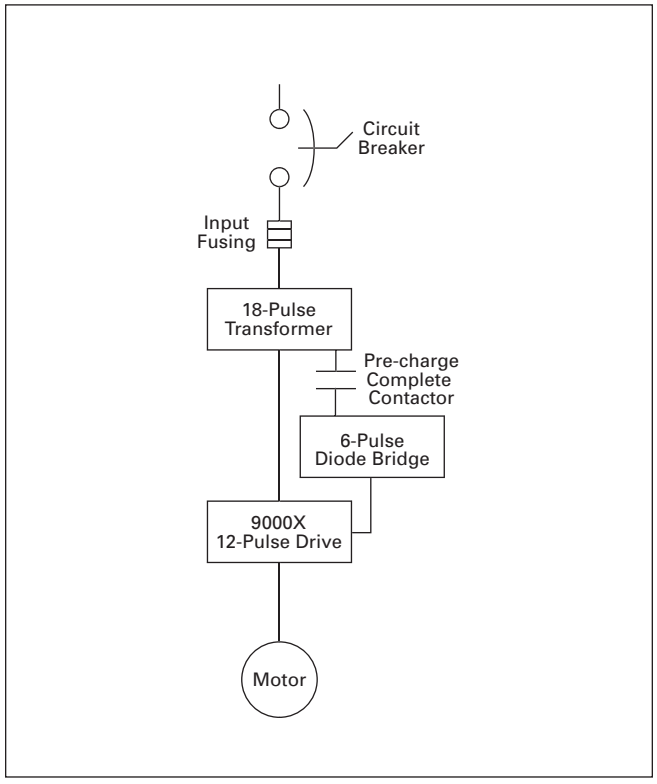


Figure 31.2-15. Power Diagram 300+ hp I_L and 250+ hp I_H

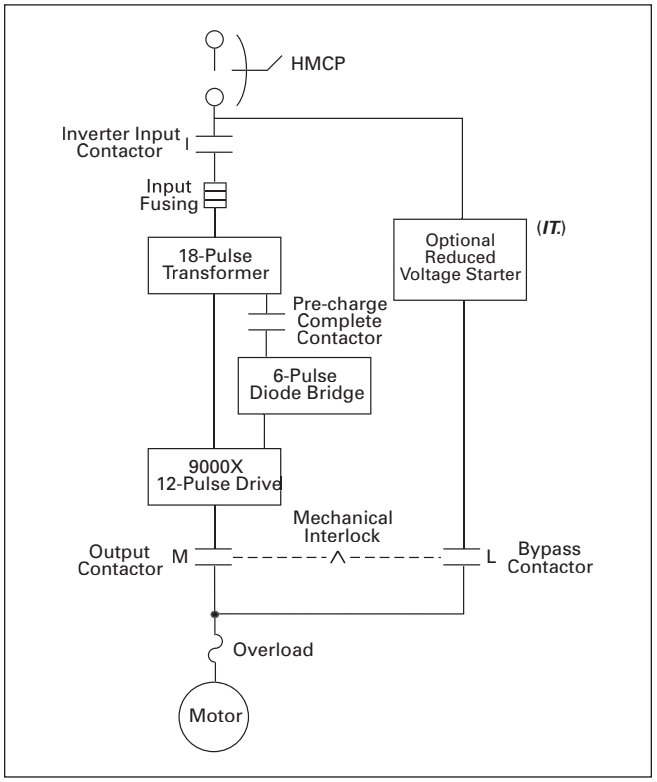


Figure 31.2-17. Power Diagram 300+ hp I_L/250+ hp I_H with Bypass

Options

Control/Communication Option Descriptions

Table 31.2-10. Available Control/Communications Options

Option	Description	Option Type
K1	**Door-Mounted Speed Potentiometer—**Provides the CPX9000 with the ability to adjust the frequency reference using a door-mounted potentiometer. This option uses the 10 Vdc reference to generate a 0–10V signal at the analog voltage input signal terminal. When the HOA bypass option is added, the speed is controlled when the HOA switch is in the hand position. Without the HOA bypass option, a two-position switch (labeled local/remote) is provided on the keypad to select speed reference from the speed potentiometer or a remote speed signal.	Control
K2	**Door-Mounted Speed Potentiometer with HOA Selector Switch—**Provides the CPX9000 with the ability to start/stop and adjust the speed reference from door-mounted control devices or remotely from customer supplied inputs. In HAND position, the drive will start and the speed is controlled by the door-mounted speed potentiometer. The drive will be disabled in the OFF position. When AUTO is selected, the run enable and speed reference are controlled from remote inputs. Speed reference can be either 0–10 Vdc or 4–20 mA. The drive default is 4–20 mA, parameter is field programmable. Run enable is controlled by a dry contact closure. *This option requires a customer supplied 115V power source.*	Control
K3	**3–15 psig Follower**—Provides a pneumatic transducer that converts a 3–15 psig pneumatic signal to either 0–8 Vdc or a 1–9 Vdc signal interface with the CPX9000. The circuit board is mounted on the inside of the front enclosure panel and connects to the user's pneumatic control system via 6 ft (1.8m) of flexible tubing and a 1/4-inch (6.4 mm) brass tube union.	Control
K4	**HAND/OFF/AUTO Switch for Non-bypass Configurations**—Provides a three-position selector switch that allows the user to select either a Hand or Auto mode of operation. Hand mode is defaulted to keypad operation, and Auto mode is defaulted to control from an external terminal source. These modes of operation can be configured via drive programming to allow for alternate combinations of start and speed sources. Start and speed sources include keypad, I/O and Fieldbus.	Control
K5	**MANUAL/AUTO Speed Reference Switch**—Provides door-mounted selector switch for Manual/Auto speed reference.	Control
K6	**START/STOP Pushbuttons**—Provides door-mounted START and STOP pushbuttons for either bypass or non-bypass configurations.	Control
KF	**Bypass Test Switch for RB and RA—**Allows the user to energize the AF drive for testing while operating the motor on the bypass controller. The Test Switch is mounted on the inside of the enclosure door.	Addl. bypass
KO	**Standard Elapsed Time Meter**—Provides a door-mounted elapsed run time meter.	Control
L1	**Power On and Fault Power Lights**—Provides a white power on light that indicates power to the enclosed cabinet and a red fault light that indicates a drive fault has occurred.	Light
L2	**Bypass Pilot Lights for RB, RA Bypass Options**—A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. The lights are mounted on the enclosure door, above the switches.	Addl. bypass
LE	**RUN Pilot Light**—Provides a green run light that indicates the drive has been commanded to start.	Light
P1	**Input Disconnect Assembly Rated to 100 kAIC**—High Interrupting Motor Circuit Protector (HMCP) or circuit breaker that provides a means of short-circuit protection for the power cables between it and the CPX9000, and protection from high-level ground faults on the power cable. Allows a convenient means of disconnecting the CPX9000 from the line and the operating mechanism can be padlocked in the OFF position. This is factory mounted in the enclosure.	Input
PE	**Output Contactor**—Provides a means for positive disconnection of the drive output from the motor terminals. The contactor coil is controlled by the drive's run or permissive logic. NC and NO auxiliary contacts rated at 10A, 600 Vac are provided for customer use. Bypass options **RB** and **RA** include an output contactor as standard. This option includes a low VA 115 Vac fused control power transformer and is factory mounted in the enclosure.	Output
PF	**Output Filter—**Used to reduce the transient voltage (DV/DT) at the motor terminals. The output filter is recommended for cable lengths exceeding 100 ft (30m) with a drive of 3 hp and above, for cable lengths of 33 ft (10m) with a drive of 2 hp and below, or for a drive rated at 525–690V. This option is mounted in the enclosure, and may be used in conjunction with a brake chopper circuit.	Output
PG	**MotoRx (300–600 ft) 1000 V/µS DV/DT Filter**—Used to reduce transient voltage (DV/DT) and peak voltages at the motor terminals. This option is comprised of a 0.5% line reactor, followed by capacitive filtering and an energy recovery/clamping circuit. Unlike the output filter (see option **PF**), the MotoRx recovers most of the energy from the voltage peaks, resulting in a lower voltage drop to the motor, and therefore conserving power. This option is used when the distance between a single motor and the drive is 300–600 ft (91–183m). *This option can not be used with the brake chopper circuit. The output filter (option **PF**) should be investigated as an alternative.*	Output
PH	**Single Overload Relay**—Uses a bimetallic overload relay to provide additional overload current protection to the motor on configurations without bypass options. It is included with the bypass configurations for overload current protection in the bypass mode. The overload relay is mounted within the enclosure, and is manually resettable. Heater pack included.	Output
PI	**Dual Overload Relays**—This option is recommended when a single drive is operating two motors and overload current protection is needed for each of the motors. The standard configuration includes two bimetallic overload relays, each sized to protect a motor with 50% of the drive hp rating. For example, a 100 hp drive would include two overload relays sized to protect two 50 hp motors. The relays are mounted within the enclosure, and are manually resettable. Heater packs not included.	Output
PN	**Dual Overloads for Bypass**—This option is recommended when a single drive is operating two motors in the bypass mode and overload current protection is needed for each of the motors. The standard configuration includes two bimetallic overload relays, each sized to protect a motor with 50% of the drive hp rating. For example, a 100 hp drive would include two overload relays sized to protect two 50 hp motors. The relays are mounted within the enclosure, and are manually resettable.	Addl. bypass

Table 31.2-10. Available Control/Communications Options (Continued)

Option	Description	Option Type
RA	**Manual HOA Bypass Controller**—The manual HAND/OFF/AUTO (HOA)—three-contactor—bypass option provides a means of bypassing the CPX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. This option consists of an input disconnect, a fused control power transformer, and a full voltage bypass starter with a door-mounted HOA selector switch and an INVERTER/BYPASS switch. The HOA switch provides the ability to start and stop the drive in the inverter mode. The Bypass includes an input contactor, an output contactor, and a bypass starter with an electronic overload relay. The contactors are mechanically and electrically interlocked.	Bypass
RB	**Manual IOB Bypass Controller**—The manual INVERTER/OFF/BYPASS (IOB)—three-contactor—bypass option provides a means of bypassing the CPX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. This option consists of an input disconnect, a fused control power transformer, and a full voltage bypass starter with a door-mounted IOB selector switch. The Bypass includes an input contactor, an output contactor, and a bypass starter with an electronic overload relay. The contactors are mechanically and electrically interlocked.	Bypass
RC	**Auto Transfer HOA Bypass Controller**–The manual HAND/OFF/AUTO (HOA)—three-contactor—bypass option provides a means of bypassing the CPX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. The circuitry provides an automatic transfer of the load to "across the line" operation after a drive trip. This option consists of an input disconnect, a fused control power transformer, and a full voltage bypass starter with a door-mounted HOA selector switch and an INVERTER/BYPASS switch. The HOA switch provides the ability to start and stop the drive in either mode. The Bypass includes an input contactor, an output contactor, and a bypass starter with an electronic overload relay. The contactors are mechanically and electrically interlocked. Door-mounted pilot lights are provided, which indicate bypass or inverter operation. A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. **WARNING**: The motor may restart when the overcurrent relay is reset when operating in bypass, unless the HOA selector switch is turned to the OFF position.	Bypass
RD	**Auto Transfer IOB Bypass Controller**—The auto INVERTER/OFF/BYPASS (IOB)—three-contactor—bypass option provides a means of bypassing the CPX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. The circuitry provides an automatic transfer of the load to "across the line" operation after a drive trip. This option consists of an input disconnect, a fused control power transformer, and a full voltage bypass starter with a door-mounted IOB selector switch. The Bypass includes an input contactor, an output contactor, and a bypass starter with an electronic overload relay. The contactors are mechanically and electrically interlocked. Door-mounted pilot lights are provided, which indicate bypass or inverter operation. A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. **Warning**: The motor may restart when the overcurrent relay is reset when operating in bypass, unless the IOB selector switch is turned to the OFF position.	Bypass
RG	**Reduced Voltage Starter for Bypass**—Used in conjunction with bypass option RA, RB, RC or RD. This option adds S801 or S811 Series reduced voltage soft starter to bypass assembly for soft starting in bypass mode.	Bypass
S7	**10-Inch Expansion**—Expansion cabinet allows for special components, customer-supplied components or oversized cables. **Note:** Enclosure expansion rated NEMA Type 1 only.	Enclosure
S8	**20-Inch Expansion**—Expansion cabinet allows for special components, customer-supplied components or oversized cables. **Note:** Enclosure expansion rated NEMA Type 1 only.	Enclosure
S9	**Space Heater—**Prevents condensation from forming in the enclosure when the drive is inactive or in storage. Includes a thermostat for variable temperature control. The 400W heater requires a customer supplied 115V remote supply source.	Enclosure

CPX9000 Series Option Board Kits

The CPX9000 Series drives can accommodate a wide selection of expander and adapter option boards to customize the drive for your application needs. The drive's control unit is designed to accept a total of five option boards (see **Figure 31.2-18**).

The CPX9000 Series factory-installed standard board configuration includes an A9 I/O board and an A2 relay output board, which are installed in slots A and B.

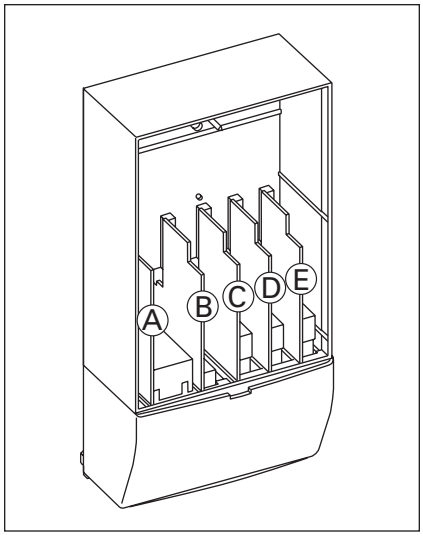


Figure 31.2-18. CPX9000 Series Option Boards

Table 31.2-11. Option Board Kits

Option Kit Description ②	Allowed Slot Locations ①	Field Installed Catalog Number	Factory Installed Option Designator	SVX Ready Programs Basic	Local/ Remote	Standard	MSS	PID	Multi-P.	PFC
Standard I/O Cards (See Figure 31.2-18)										
2 RO (NC/NO)	B	**OPTA2**	—	■	■	■	■	■	■	■
6 DI, 1 DO, 2 AI, 1AO, 1 +10 Vdc ref, 2 ext +24 Vdc/ EXT +24 Vdc	A	**OPTA9**	—	■	■	■	■	■	■	■
Extended I/O Card Options										
6 DI, 1 ext +24 Vdc/EXT +24 Vdc	B, C, **D**, E	**OPTB1**	**B1**						■	■
1 RO (NC/NO), 1 RO (NO), 1 Therm	B, C, **D**, E	**OPTB2**	**B2**						■	■
1 AI (mA isolated), 2 AO (mA isolated), 1 ext +24 Vdc/EXT +24 Vdc	B, C, **D**, E	**OPTB4**	**B4**	■	■	■	■	■	■	■
3 RO (NO)	B, C, **D**, E	**OPTB5**	**B5**						■	■
1 ext +24 Vdc/EXT +24 Vdc, 3 Pt100	B, C, **D**, E	**OPTB8**	**B8**							
1 RO (NO), 5 DI 42–240 Vac input	B,C, **D**, E	**OPTB9**	**B9**						■	■
Communication Cards ③										
Modbus	D, **E**	**OPTC2**	**C2**	■	■	■	■	■	■	■
Modbus TCP	D, **E**	**OPTCI**	**CI**	■	■	■	■	■	■	■
BACnet	D, **E**	**OPTCJ**	**CJ**	■	■	■	■	■	■	■
Johnson Controls N2	D, **E**	**OPTC2**	**CA**							
PROFIBUS DP	D, **E**	**OPTC3**	**C3**	■	■	■	■	■	■	■
LonWorks	D, **E**	**OPTC4**	**C4**	■	■	■	■	■	■	■
PROFIBUS DP (D9 connector)	D, **E**	**OPTC5**	**C5**	■	■	■	■	■	■	■
CANopen (slave)	D, **E**	**OPTC6**	**C6**	■	■	■	■	■	■	■
DeviceNet	D, **E**	**OPTC7**	**C7**	■	■	■	■	■	■	■
Modbus (D9 Type connector)	D, **E**	**OPTC8**	**C8**	■	■	■	■	■	■	■
RS-232 with D9 connection	D, **E**	**OPTD3**	**D3**	■	■	■	■	■	■	■

① Option card must be installed in one of the slots listed for that card. Slot indicated in **Bold** is the preferred location.
② AI = Analog Input; AO = Analog Output, DI = Digital Input, DO = Digital Output, RO = Relay Output
③ OPTC2 is a multi-protocol option card.

Modbus RTU Network Communications

The Modbus Network Card OPTC2 is used for connecting the CPX9000 as a slave on a Modbus network. The interface is connected by a 9-pin DSUB connector (female) and the baud rate ranges from 300 to 19200 baud. Other communication parameters include an address range from 1 to 247; a parity of None, Odd or Even; and the stop bit is 1.

Johnson Controls Metasys N2 Network Communications

The OPTC2 fieldbus board provides communication between the CPX9000 drive and a Johnson Controls Metasys N2 network. With this connection, the drive can be controlled, monitored and programmed from the Metasys system. The N2 fieldbus is available as a factory-installed option and as a field-installable kit.

PROFIBUS Network Communications

The PROFIBUS Network Card OPTC3 is used for connecting the CPX9000 as a slave on a PROFIBUS-DP network. The interface is connected by a 9-pin DSUB connector (female). The baud rates range from 9.6K baud to 12M baud, and the addresses range from 1 to 127.

LonWorks Network Communications

The LonWorks Network Card OPTC4 is used for connecting the CPX9000 on a LonWorks network. This interface uses Standard Network Variable Types (SNVT) as data types. The channel connection is achieved using a FTT-10A Free Topology transceiver via a single twisted transfer cable. The communication speed with LonWorks is 78 kBits/s.

CANopen (Slave) Communications

The CANopen (slave) Network Card OPTC6 is used for connecting the CPX9000 to a host system. According to ISO 11898, standard cables to be chosen for CANbus should have a nominal impedance of 120 ohms, and specific line delay of nominal 5 nS/m. 120 ohm line termination resistors required for installation.

DeviceNet Network Communications

The DeviceNet Network Card OPTC7 is used for connecting the CPX9000 on a DeviceNet Network. It includes a 5.08 mm pluggable connector. Transfer method is via CAN using a two-wire twisted shielded cable with two-wire bus power cable and drain. The baud rates used for communication include 125k baud, 250k baud and 500k baud.

Table 31.2-12. I/O Specifications for the Control/Communication Options

Description	Specifications
Analog voltage, input	0–±10V, $R_i \geq 200$k ohms
Analog current, input	0 (4)–20 mA, $R_i = 250$ ohms
Digital Input	24V: "0" ≤ 10V, "1" ≥ 18V, $R_i > 5$k ohms
Auxiliary voltage	24V (±20%), maximum 50 mA
Reference voltage	10V ±3%, maximum 10 mA
Analog current, output Analog voltage, output	0 (4)–20 mA, $R_L = 500$ kΩ, resolution 10 bit, accuracy ≤ ±2% 0 (2)–10V, $R_L \geq 1$k ohm, resolution 10 bit, accuracy ≤ ±2%
Relay output Max. switching voltage Max. switching load Max. continuous load	 300 Vdc, 250 Vac 8A/24 Vdc, 0.4A/300 Vdc, 2 kVA/250 Vac 2A rms
Thermistor input	$R_{trip} = 4.7$k ohms

CFX9000 Drives

CFX9000 Enclosed Drives

General Description

Eaton's CFX9000 Clean Power Drives use tuned passive filters to significantly reduce line harmonics at the drive input terminals.

The CFX9000 drive also delivers true power factor—in addition to reducing harmonic distortion, the CFX9000 drive prevents transformer overheating and overloading of breakers and feeders, which enables the application of adjustable frequency drives on generators and other high impedance power systems.

CFX9000 Enclosed Products

- **Standard enclosed**—covers a wide range of the most commonly ordered options. Pre-engineering eliminates the lead time normally associated with customer specific options. Available configurations are listed on **Pages 31.3-3–31.3-8**
- **Modified standard enclosed**—applies to specific customer requirements that vary from the Standard Enclosed offering, such as the need for an additional indicating light or minor modifications to drawings. *Contact your local sales office for assistance in pricing and lead time*
- **Custom engineered**—for those applications with more unique or complex requirements, these are individually engineered to the customer's needs. *Contact your local sales office for assistance in pricing and lead time*

Application Description

Terms

- PCC (point of common coupling) is defined as the electrical connecting point between the utility and multiple customers per the specifications in IEEE 519
- POA (point of analysis) is defined as where the harmonic calculations are taken

An oscilloscope can make all measurements at the PCC or POA to do an on-site harmonic evaluation.

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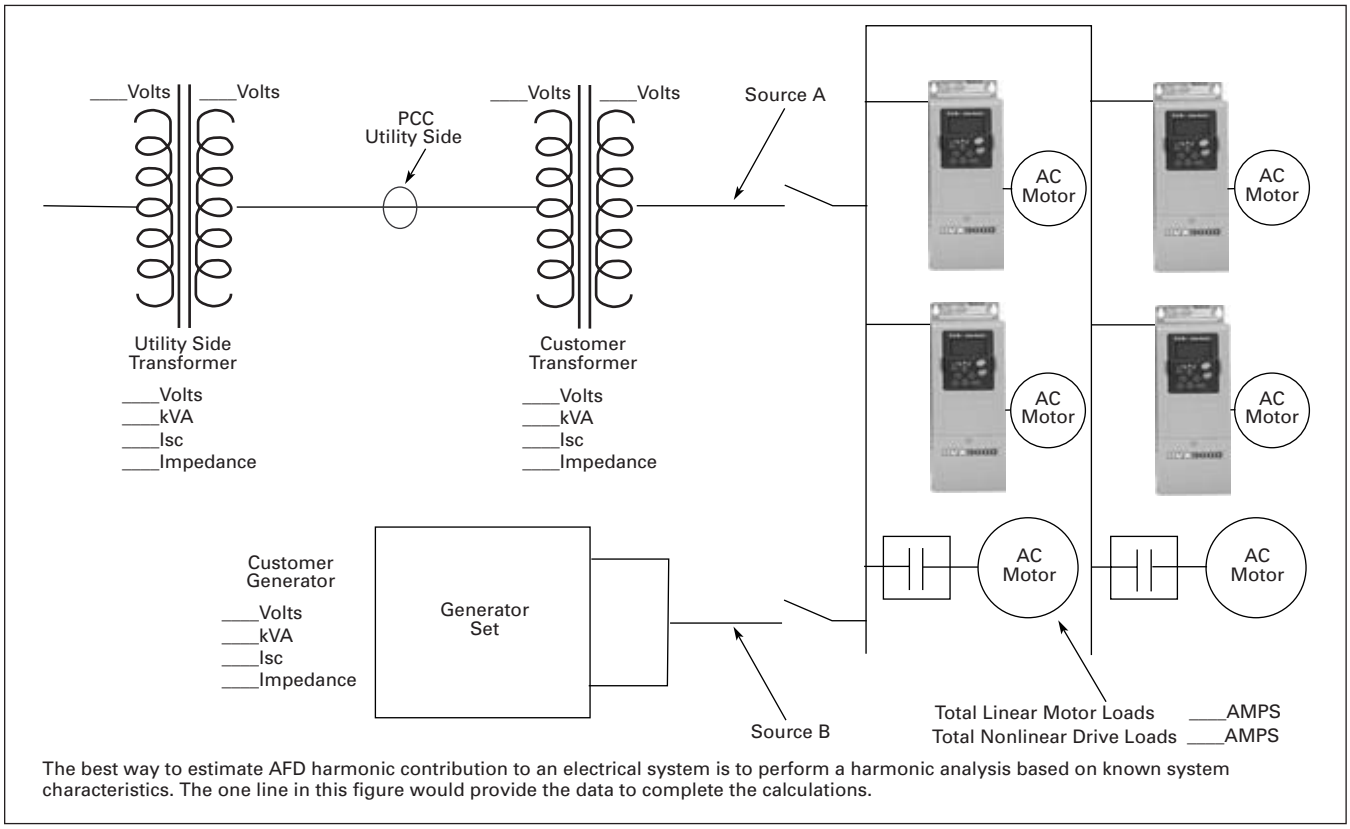


The best way to estimate AFD harmonic contribution to an electrical system is to perform a harmonic analysis based on known system characteristics. The one line in this figure would provide the data to complete the calculations.

Figure 31.3-1. One-Line Diagram for Harmonic Analysis

Harmonic Reduction Methods to Meet IEEE 519

1. Line Reactor

A line reactor is a three-phase series inductance on the line side of an AFD. If a line reactor is applied on all AFDs, it is possible to meet IEEE guidelines where 10–25% of system loads are AFDs, depending on the stiffness of the line and the value of line reactance. Line reactors are available in various values of percent impedance, most typically 1–1.5%, 3% and 5%.

Note: The 9000X drives come standard with a nominal 3% input impedance.

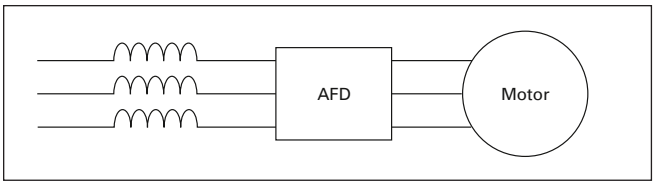


Figure 31.3-2. Line Reactor

Advantages

- Low cost
- Can provide moderate reduction in voltage and current harmonics
- Available in various values of percent impedance
- Provides increased input protection for AFD and its semiconductors from line transients

Disadvantages

- May not reduce harmonic levels to below IEEE 519-1992 guidelines
- Voltage drop due to IR loss

2. Passive Filters

Tuned harmonic filters involve the series connection of an inductor with the shunt connection of an inductor and capacitor to form a low impedance path to ground for a specific range of frequencies. This path presents an alternative to the flow of harmonic currents back into the utility source.

Table 31.3-1. 100 hp CFX9000 480V Drive with Integrated Passive Filter

Passive Filter		
Current harmonics		
I_1 = 100% I_5 = 3.76% I_7 = 1.65%	I_{11} = 0.24% I_{13} = 1.1% I_{17} = 0.80%	I_{19} = 0.50% I_{23} = 0.55% I_{25} = 0.80%
Power = 100 hp H_C = 8.6A		

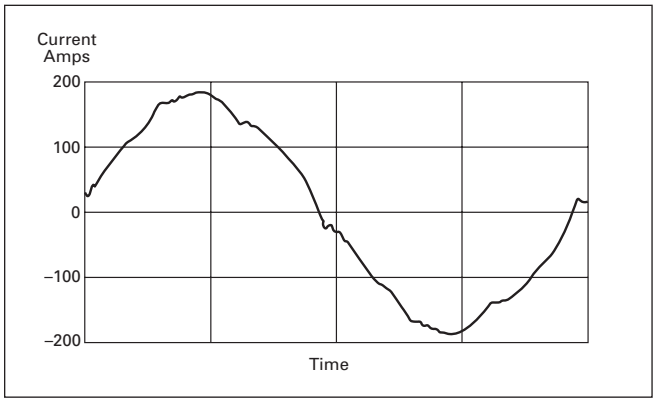


Figure 31.3-3. 100 hp CFX9000 480V Drive with Integrated Passive Filter

Advantages

- Low cost for smaller horsepower applications
- More effective harmonic attenuation than 12-pulse drives
- Provides increased input protection for AFD from line transients

Disadvantages

- Capacitors age over time, unlike magnetics
- Not as effective as 18-pulse drives
- Challenging to retrofit with bypass applications

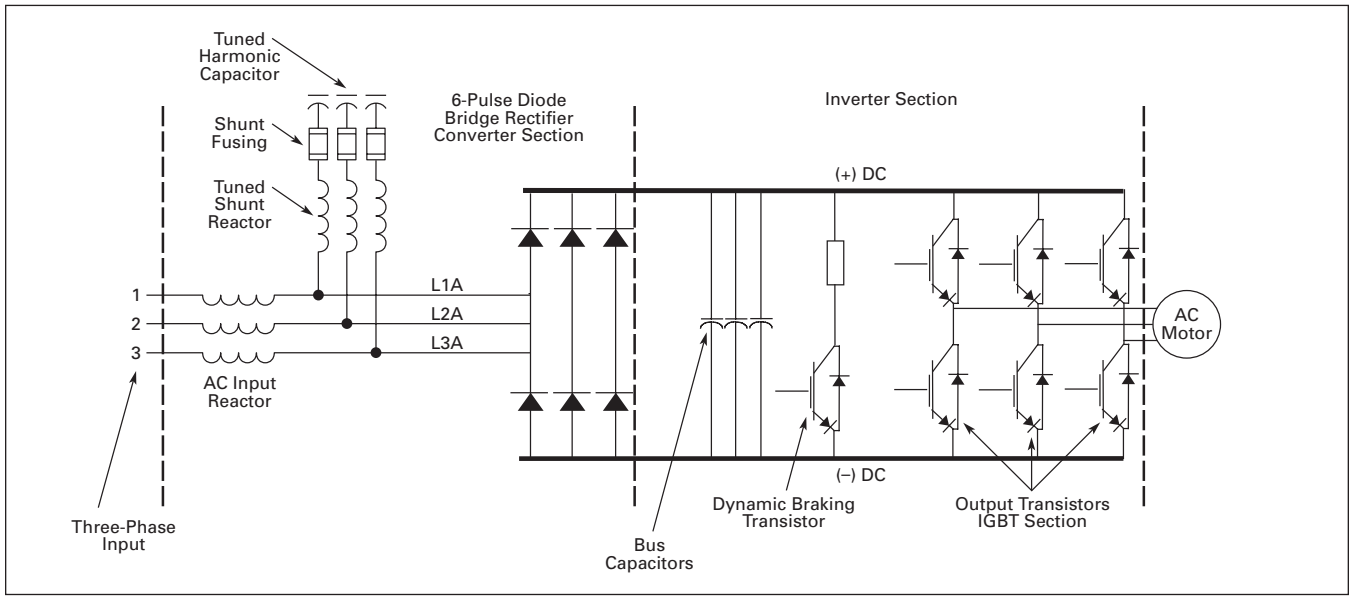


Figure 31.3-4. CFX9000 Drive with Integrated Passive Filter

Features and Benefits

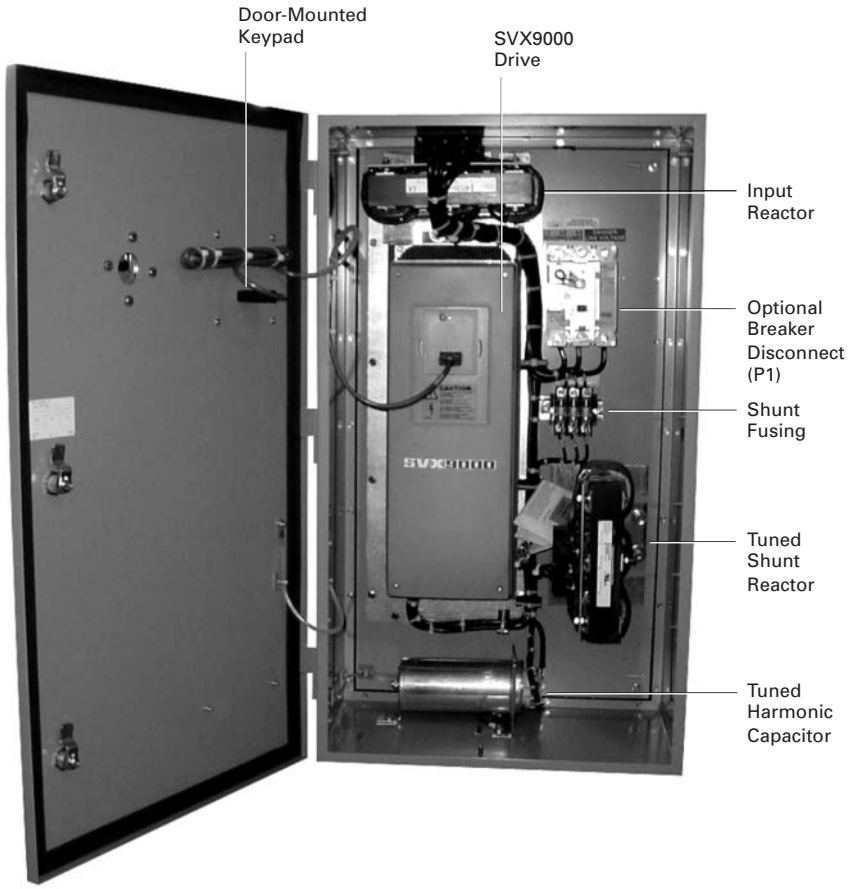
CFX9000 Integrated Filter Clean Power Drive features include (at 480V):

- UL Type 1, UL Type 12, UL Type 3R and NEMA 12 with gaskets and filters
- Input voltage: 480V, 230V, 575V
- Complete range of control, network and power options
- Horsepower range:
  - 480V, 7-1/2–400 hp I_L
  - 230V, 7-1/2–100 hp I_L; consult factory for details
  - 575V, 15–400 hp I_L; consult factory for details
- Single enclosure for both drive and filter reduces field wiring and enables convenient bypass installation
- Packaged solution ensures optimal coordination of drive and filter

Standards and Certifications

- UL
- cUL
- 508C

Product Identification



CFX9000 Drive—UL Type 12, 40 hp

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Technical Data and Specifications

Table 31.3-2. 208 Vac

hp	NEC Current	Chassis Frame	NEMA 1		NEMA 12		NEMA 3R	
			Disconnect Only	Power Options	Disconnect Only	Power Options	Disconnect Only	Power Options
Low Overload Drive (Variable Torque)								
7-1/2	24.2	FR5	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
10	30.8	FR5	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
15	46.2	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
20	59.4	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
25	74.8	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
30	88.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
40	114.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
50	143.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
60	169.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
75	211.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
100	273.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
High Overload Drive (Constant Torque)								
7-1/2	24.2	FR5	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
10	30.8	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
15	46.2	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
20	59.4	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
25	74.8	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
30	88.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
40	114.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
50	143.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
60	169.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
75	211.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
100	273.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6

Table 31.3-3. 230 Vac

hp	NEC Current	Chassis Frame	NEMA 1		NEMA 12		NEMA 3R	
			Disconnect Only	Power Options	Disconnect Only	Power Options	Disconnect Only	Power Options
Low Overload Drive (Variable Torque)								
7-1/2	22.0	FR5	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
10	28.0	FR5	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
15	42.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
20	54.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
25	68.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
30	80.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
40	104.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
50	130.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-5
60	154.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
75	192.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
100	248.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
High Overload Drive (Constant Torque)								
7-1/2	22.0	FR5	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
10	28.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
15	42.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
20	54.0	FR7	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
25	68.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
30	80.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
40	104.0	FR8	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
50	130.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
60	154.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
75	192.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
100	248.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6

Table 31.3-4. 480 Vac

hp	NEC Current	Chassis Frame	NEMA 1		NEMA 12		NEMA 3R	
			Disconnect Only	Power Options	Disconnect Only	Power Options	Disconnect Only	Power Options
Low Overload Drive (Variable Torque)								
7-1/2	11.0	FR4	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
10	14.0	FR5	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
15	21.0	FR5	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
20	27.0	FR5	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
25	34.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
30	40.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
40	52.0	FR7	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
50	65.0	FR8	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
60	77.0	FR8	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
75	96.0	FR8	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
100	124.0	FR9	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
125	156.0	FR8	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
150	180.0	FR8	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
200	240.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
250	302.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
300	361.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
350	414.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
400	477.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
High Overload Drive (Constant Torque)								
7-1/2	11.0	FR4	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
10	14.0	FR5	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
15	21.0	FR5	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
20	27.0	FR5	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
25	34.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
30	40.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
40	52.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
50	65.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
60	77.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
75	96.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
100	124.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
125	156.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
150	180.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
200	240.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
250	302.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
300	361.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
350	414.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①

① Consult factory.

Table 31.3-5. 575 Vac

hp	NEC Current	Chassis Frame	NEMA 1		NEMA 12		NEMA 3R	
			Disconnect Only	Power Options	Disconnect Only	Power Options	Disconnect Only	Power Options
Low Overload Drive (Variable Torque)								
15	17.0	FR6	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
20	22.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
25	27.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
30	32.0	FR6	DRW-1	DRW-3	DRW-1	DRW-3	DRW-2	DRW-4
40	41.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
50	52.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
60	62.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
75	77.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
100	99.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
125	125.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
150	144.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
200	192.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
250	242.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
300	289.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
400	382.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
High Overload Drive (Constant Torque)								
10	14.0	FR6	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
15	17.0	FR6	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
20	22.0	FR6	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
25	27.0	FR6	DWG-1	DRW-3	DWG-1	DRW-3	DRW-2	DRW-4
30	32.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
40	41.0	FR7	DRW-3	DRW-7	DRW-3	DRW-7	DRW-4	DRW-5
50	52.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
60	62.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
75	77.0	FR8	DRW-7	DRW-7	DRW-7	DRW-7	DRW-6	DRW-6
100	99.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
125	125.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
150	144.0	FR9	DRW-8	DRW-8	DRW-8	DRW-8	DRW-6	DRW-6
200	192.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
250	242.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①
300	289.0	FR10	DRW-9	DRW-9	DRW-9	DRW-9	①	①

① Consult factory.

CFX9000 Drives

Table 31.3-6. Primary Design Features

Description	Specification
45–66 Hz input frequency Output: AC volts maximum Output frequency range	Standard Input Voltage Base 0–320 Hz
Initial output current (I_H) Overload (1 minute [I_H/I_L]) Enclosure space heater	250% for 2 seconds 150%/110% Optional
Oversize enclosure Output contactor Bypass motor starter Listings	Standard Optional Optional UL, cUL, 508C

Table 31.3-7. Protection Features

Description	Specification
Incoming line fuses AC input circuit disconnect Phase rotation insensitive	Optional Optional Standard
EMI filter Input phase loss protection Input overvoltage protection	Standard—FR6 thru FR9 ① Standard Standard
Line surge protection Output short circuit protection Output ground fault protection	Standard Standard Standard
Output phase protection Overtemperature protection DC overvoltage protection	Standard Standard Standard
Drive overload protection Motor overload protection Programmer software	Standard Standard Optional
Local/remote keypad Keypad lockout Fault alarm output	Standard Standard Standard
Built-in diagnostics Surge protective device	Standard Optional

① The EMI filter is optional in FR10.

Table 31.3-8. Input/Output Interface Features

Description	Specification
Setup Adjustment Provisions	
Remote keypad/display Personal computer	Standard Standard
Operator Control Provisions	
Drive mounted keypad/display Remote keypad/display Conventional control elements	Standard Standard Standard
Serial communications 115 Vac control circuit	Optional Optional
Speed Setting Inputs	
Keypad 0–10 Vdc potentiometer/voltage signal 4–20 mA isolated	Standard Standard Configurable
4–20 mA differential 3–15 psig	Configurable Optional
Analog Outputs	
Speed/frequency Torque/load/current Motor voltage	Standard Programmable Programmable
Kilowatts 0–10 Vdc signals 4–20 mA DC signals Isolated signals	Programmable Configurable w/jumpers Standard Optional
Discrete Outputs	
Fault alarm Drive running Drive at set speed Optional parameters	Standard Standard Programmable 14
Dry contacts Open collector outputs Additional discrete outputs	2 relays Form C 1 Optional

Table 31.3-9. Communications

Description	Specification
RS-232 RS-422/485 DeviceNet	Standard Optional Optional
Modbus RTU CANopen (slave) PROFIBUS-DP	Optional Optional Optional
LonWorks Johnson Controls Metasys N2 EtherNet/IP/Modbus TCP	Optional Optional Optional
BACnet	Optional

Table 31.3-10. Performance Features

Description	Specification
Sensorless vector control Volts/hertz control IR and slip compensation	Standard Standard Standard
Electronic reversing Dynamic braking DC braking	Standard Optional Standard
PID setpoint controller Critical speed lockout Current (torque) limit	Programmable Standard Standard
Adjustable acceleration/deceleration Linear or S curve acceleration/deceleration Jog at preset speed	Standard Standard Standard
Thread/preset speeds Automatic restart Coasting motor start	7 Selectable Standard
Coast or ramp stop selection Elapsed time meter	Standard Optional

Table 31.3-11. Standard Conditions for Application and Service

Description	Specification
Maximum operating ambient temperature	0 to 40°C, contact factory for 50°C ①
Storage temperature	–40 to 60°C
Humidity (maximum), noncondensing	95%
Altitude	100% load capacity (no derating) up to 3280 ft (1000m); 1% derating for each 328 ft (100m) above 3280 ft (1000m); max. 9842 ft (3000m)
Line voltage variation Line frequency variation	+10/–15% 45–66 Hz
Efficiency Power factor (displacement)	>96% 0.99

① Units FR10 rated 40°C.

Table 31.3-12. Standard I/O Specifications

Description	Specification
Six–digital input programmable	24V: "0" ≤10V, "1" ≥18V,R_i >5 kohms
Two–analog input configurable w/jumpers	Voltage: 0–±10V, R_i >200 kohms Current: 0 (4)–20 mA, R_i = 250 kohms
Two–digital output programmable	Form C relays 250 Vac or 30 Vdc 2A resistive
One–digital output programmable	Open collector 48 Vdc 50 mA
One–analog output programmable configurable w/jumper	0–20 mA, R_L max. 500 ohms 10 bits ±2%

Table 31.3-13. I/O Specifications for Control/Communication Options

Description	Specification
Analog voltage, input	0–±10V, R_i ≥200 kilohms
Analog current, input	0 (4)–20 mA, R_i = 250 ohms
Digital input	24V: "0" ≤10V, "1" ≥18V, R_i >5 kilohms
Auxiliary voltage	24V (±20%), max. 50 mA
Reference voltage	10V ±3%, max. 10 mA
Analog current, output	0 (4)–20 mA, R_L = 500 kilohms, resolution 10 bit, accuracy ≤±2%
Analog voltage, output	0 (2)–10V, R_L ≥1 kohm, resolution 10 bit, accuracy ≤±2%
Relay output maximum switching voltage	300 Vdc, 250 Vac
Relay output maximum switching load	3A/24 Vdc, 300 Vdc, 250 Vac ②
Relay output maximum continuous load	2A rms
Thermistor input	R_{trip} = 4.7 kohms

② For applications above 3A, consult instruction manual.

Catalog Number Selection

Table 31.3-14. CFX9000 Enclosed Drives Catalog Numbering System

CFX 050 1 4 A A — — — — — — —

Build Alphabetically and Numerically

Product Family

CFX = Integrated filter clean power drive

Horsepower Rating

007 = 7-1/2	**075** = 75
010 = 10	**100** = 100
015 = 15	**125** = 125
020 = 20	**150** = 150
025 = 25	**200** = 200
030 = 30	**250** = 250
040 = 40	**300** = 300
050 = 50	**350** = 350
060 = 60	**400** = 400

Enclosure Rating

1 = UL Type 1
2 = UL Type 12
3 = UL Type 3R

Voltage Rating

1 = 208V
2 = 230V
4 = 480V
5 = 575V (575–600V)

Application—Torque/Braking ①

A = I_L/no brake chopper
B = I_L/internal brake chopper
D = I_H/no brake chopper
E = I_H/internal brake chopper

Enclosed Style

A = Enclosed drive

Enclosed Options ②③④		Type
K1	Door-mounted speed potentiometer ⑤	Control
K2	Door-mounted speed potentiometer with HOA selector switch ⑤	Control
K3	3–15 psig follower	Control
K4	HAND/OFF/AUTO switch (22 mm)	Control
K5	MANUAL/AUTO reference switch (22 mm)	Control
K6	START/STOP pushbuttons (22 mm)	Control
KF	Bypass test switch for RA and RB	Addl. bypass
KO	Standard elapsed time meter	Control
L1	Power, RUN and fault pilot lights	Light
L2	Bypass pilot lights for RA, RB, bypass options	Addl. bypass
LE	Red RUN light	Light
P1	Input circuit breaker	Input
P3	Input line fuses (200 kAIC)	Input
P7	Input power surge protection	Input
P8	SPD surge protective device	Input
PE	Output contactor	Output
PF	Output filter	Output
PG	MotoRx (up to 600 ft) 1000 V/µS DV/DT filter	Output
PH	Single overload relay	Output
PI	Dual overload relays	Output
PN	Dual overloads for bypass	Addl. bypass
RA	Manual HOA bypass controller	Bypass
RB	Manual IOB bypass controller	Bypass
RC	Auto transfer HOA bypass controller	Bypass
RD	Auto transfer IOB bypass controller	Bypass
RG	Reduced voltage starter for bypass	Bypass
S4	Floor stand 6.00 inches	Enclosure
S5	Floor stand 22.00 inches	Enclosure
S6	Floor stand 12.00 inches	Enclosure
S9	Space heater	Enclosure

Communication Options ⑥

C2 = Modbus	**C8** = Modbus (D9 type connector)
C3 = PROFIBUS DP	**CA** = Johnson Controls N2
C4 = LonWorks	**CI** = Modbus TCP/EtherNet/IP
C5 = PROFIBUS DP (D9 connector)	**CJ** = BACnet
C6 = CANopen (slave)	**D3** = RS-232 with D9 connection
C7 = DeviceNet	

Control Options

B1 = 6 DI, 1 ext +24 Vdc/EXT +24 Vdc
B = 1 RO (NC-NO), 1 RO (NO), 1 therm
B4 = 1 AI (mA isolated), 2 AO (mA isolated), 1 ext +24 Vdc/EXT +24 Vdc
B5 = 3 RO (NO)
B8 = 1 ext +24 Vdc/EXT +24 Vdc, 3 Pt100
B9 = 1 RO (NO), 5 DI 42–240 Vac input

Engineered Options

HT = High temperature rating for 50°C ⑦
VB = Varnished boards

① Brake chopper is standard in 208V, 230V and 480V drives up to FR6; optional in all other drives.
② Local/remote keypad is included as the standard control panel.
③ Some options are voltage and/or horsepower specific. Consult your Eaton representative for details.
④ See **Pages 31.3-12** and **31.3-13** for complete descriptions.
⑤ Includes local/remote speed reference switch.
⑥ See **Pages 31.3-10** and **31.3-11** for complete descriptions.
⑦ Consult Eaton for availability.

Table 31.3-15. Ambient Temperature Ratings

Enclosure Size	I_H	I_L
B, C, 9 ①	40°C	40°C
7, 8	50°C	50°C

① For high temperature rating, select HT option code and contact factory.

- If dynamic brake chopper or control/communication option is desired, change the appropriate code in the base catalog number
- All of the programming is exactly the same as the standard SVX9000 drive
- Select enclosed options. Add the codes as suffixes to the base catalog number in alphabetical and numeric order

Options

CFX9000 Series Option Board Kits

The CFX9000 Series drives can accommodate a wide selection of expander and adapter option boards to customize the drive for your application needs. The drive's control unit is designed to accept a total of five option boards.

The CFX9000 Series factory-installed standard board configuration includes an A9 I/O board and an A2 relay output board, which are installed in slots A and B.

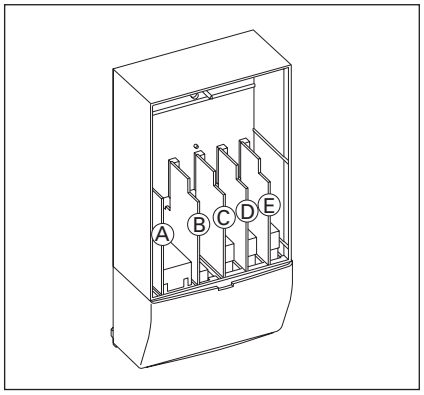


Figure 31.3-5. Option Boards

Table 31.3-16. Option Board Kits

Option Kit Description ①	Allowed Slot Locations ②	Field Installed	Factory Installed	SVX Ready Programs						
		Catalog Number	Option Designator	Basic	Local/ Remote	Standard	MSS	PID	Multi-P.	PFC
Standard I/O Cards										
2 RO (NC/NO)	B	**OPTA2**	—	■	■	■	■	■	■	■
6 DI, 1 DO, 2 AI, 1AO, 1 +10 Vdc ref, 2 ext +24 Vdc/ext +24 Vdc	A	**OPTA9**	—	■	■	■	■	■	■	■
Extended I/O Cards										
6 DI	B, C, **D**, E	**OPTB1**	B1						■	■
1 RO (NC/NO), 1 RO (NO), 1 therm	B, C, **D**, E	**OPTB2**	B2						■	■
1 AI (mA isolated), 2 AO (mA isolated)	B, C, **D**, E	**OPTB4**	B4	■	■	■	■	■	■	■
3 RO (NO)	B, C, **D**, E	**OPTB5**	B5						■	■
3 Pt100 RTD board	B, C, **D**, E	**OPTB8**	B8						■	
1 RO (NO), 5 DI 42–240 Vac input	B, C, **D**, E	**OPTB9**	B9						■	■
Communication Cards ③										
Modbus	D, **E**	**OPTC2**	C2	■	■	■	■	■	■	■
Modbus TCP	D, **E**	**OPTCI**	CI	■	■	■	■	■	■	■
BACnet	D, **E**	**OPTCJ**	CJ	■	■	■	■	■	■	■
EtherNet/IP	D, **E**	**OPTCK**	CK	■	■	■	■	■	■	■
Johnson Controls N2	D, **E**	**OPTC2**	CA	■	■	■	■	■	■	■
PROFIBUS DP	D, **E**	**OPTC3**	C3	■	■	■	■	■	■	■
LonWorks	D, **E**	**OPTC4**	C4	■	■	■	■	■	■	■
PROFIBUS DP (D9 connector)	D, **E**	**OPTC5**	C5	■	■	■	■	■	■	■
CANopen (slave)	D, **E**	**OPTC6**	C6	■	■	■	■	■	■	■
DeviceNet	D, **E**	**OPTC7**	C7	■	■	■	■	■	■	■
Modbus (D9 type connector)	D, **E**	**OPTC8**	C8	■	■	■	■	■	■	■
RS-232 with D9 connection	D, **E**	**OPTD3**	D3	■	■	■	■	■	■	■

① AI = Analog Input; AO = Analog Output, DI = Digital Input, DO = Digital Output, RO = Relay Output
② Option card must be installed in one of the slots listed for that card. Slot indicated in bold is the preferred location.
③ OPTC2 is a multi-protocol option card.

Modbus RTU Network Communications

The Modbus Network Card OPTC2 is used for connecting the 9000X Drive as a slave on a Modbus network. The interface is connected by a 9-pin DSUB connector (female) and the baud rate ranges from 300 to 19,200 baud. Other communication parameters include an address range from 1 to 247; a parity of None, Odd or Even; and the stop bit is 1.

PROFIBUS Network Communications

The PROFIBUS Network Card OPTC3 is used for connecting the 9000X Drive as a slave on a PROFIBUS-DP network. The interface is connected by a 9-pin DSUB connector (female). The baud rates range from 9.6K baud to 12M baud, and the addresses range from 1 to 127.

LonWorks Network Communications

The LonWorks Network Card OPTC4 is used for connecting the 9000X Drive on a LonWorks network. This interface uses Standard Network Variable Types (SNVT) as data types. The channel connection is achieved using a FTT-10A Free Topology transceiver via a single twisted transfer cable. The communication speed with LonWorks is 78 kBits/s.

CANopen (Slave) Communications

The CANopen (Slave) Network Card OPTC6 is used for connecting the 9000X Drive to a host system. According to ISO 11898 standard cables to be chosen for CANbus should have a nominal impedance of 120 ohms, and specific line delay of nominal 5 as/m. 120 ohm line termination resistors required for installation.

DeviceNet Network Communications

The DeviceNet Network Card OPTC7 is used for connecting the 9000X Drive on a DeviceNet Network. It includes a 5.08 mm pluggable connector. Transfer method is via CAN using a two-wire twisted shielded cable with two-wire bus power cable and drain. The baud rates used for communication include 125K baud, 250K baud and 500K baud.

Johnson Controls Metasys N2 Network Communications

The OPTC2 fieldbus board provides communication between the 9000X Drive and a Johnson Controls Metasys N2 network. With this connection, the drive can be controlled, monitored and programmed from the Metasys system. The N2 fieldbus is available as a factory-installed option and as a field-installable kit.

Modbus/TCP Network Communications

The Modbus/TCP Network Card OPTCI is used for connecting the 9000X Drive to Ethernet networks using Modbus protocol. It includes an RJ-45 pluggable connector. This interface provides a selection of standard and custom register values to communicate drive parameters. The board supports 10 Mbps and 100 Mbps communication speeds. The IP address of the board is configurable over Ethernet using a supplied software tool.

BACnet Network Communications

The BACnet Network Card OPTCJ is used for connecting the 9000X Drive to BACnet networks. It includes a 5.08 mm pluggable connector. Data transfer is Master-Slave/Token Passing (MS/TP) RS-485. This interface uses a collection of 30 Binary Value Objects (BVOs) and 35 Analog Value Objects (AVOs) to communicate drive parameters. The card supports 9.6, 19.2 and 38.4 Kbaud communication speeds and supports network addresses 1 to 127.

EtherNet/IP Network Communications

The EtherNet/IP Network Card OPTCK is used for connecting the 9000X Drive to Ethernet/Industrial Protocol networks. It includes an RJ-45 pluggable connector. The interface uses CIP objects to communicate drive parameters (CIP is “Common Industrial Protocol,” the same protocol used by DeviceNet). The board supports 10 Mbps and 100 Mbps communication speeds. The IP address of the board is configurable by Static, BOOTP and DHCP methods.

Control/Communication Option Descriptions

Table 31.3-17. Available Control/Communications Options

Option	Description	Option Type
K1	**Door-Mounted Speed Potentiometer**—Provides the drive with the ability to adjust the frequency reference using a door-mounted potentiometer. This option uses the 10 Vdc reference to generate a 0–10V signal at the analog voltage input signal terminal. When the HOA bypass option is added, the speed is controlled when the HOA switch is in the HAND position. Without the HOA bypass option, a two-position switch (labeled local/remote) is provided on the keypad to select speed reference from the speed potentiometer or a remote speed signal.	Control
K2	**Door-Mounted Speed Potentiometer with HOA Selector Switch**—Provides the drive with the ability to start/stop and adjust the speed reference from door-mounted control devices or remotely from customer supplied inputs. In HAND position, the drive will start and the speed is controlled by the door-mounted speed potentiometer. The drive will be disabled in the OFF position. When AUTO is selected, the drive run and speed control commands are via user-supplied dry contact and 4–20 mA signal.	Control
K3	**3–15 psig Follower**—Provides a pneumatic transducer that converts a 3–15 psig pneumatic signal to either 0–8 Vdc or a 1–9 Vdc signal interface with the drive. The circuit board is mounted on the inside of the front enclosure panel and connects to the user's pneumatic control system via 6 ft (1.8m) of flexible tubing and a 1/4-inch (6.4 mm) brass tube union.	Control
K4	**HAND/OFF/AUTO Switch for Non-Bypass Configurations**—Provides a three-position selector switch that allows the user to select either a HAND or AUTO mode of operation. HAND mode is defaulted to keypad operation, and AUTO mode is defaulted to control from an external terminal source. These modes of operation can be configured via drive programming to allow for alternate combinations of start and speed sources. Start and speed sources include keypad, I/O and fieldbus.	Control
K5	**MANUAL/AUTO Speed Reference Switch**—Provides door-mounted selector switch for MANUAL/AUTO speed reference.	Control
K6	**START/STOP Pushbuttons**—Provide door-mounted START and STOP pushbuttons for either bypass or non-bypass configurations.	Control
KF	**Bypass Test Switch for RB and RA**—Allows the user to energize the AF drive for testing while operating the motor on the bypass controller. The Test Switch is mounted on the inside of the enclosure door.	Addl. bypass
KO	**Standard Elapsed Time Meter**—Provides a door-mounted elapsed run time meter.	Control
L1	**Power On, Run and Fault Lights**—Provide a white power on light that indicates power to the enclosed cabinets, a green run light and a red fault light that indicates a drive fault has occurred.	Light
L2	**Bypass Pilot Lights for RB, RA Bypass Options**—A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. The lights are mounted on the enclosure door, above the switches.	Addl. bypass
LE	**Red Run Pilot Light (22 mm)**—Provides a red run pilot light that indicates the drive is running.	Light
P1	**Input Circuit Breaker**—High interrupting circuit breaker that provides a means of short-circuit protection for the power cables between it and the CPX9000, and protection from high-level ground faults on the power cable. Allows a convenient means of disconnecting the CPX9000 from the line and the operating mechanism can be padlocked in the OFF position. This is factory mounted in the enclosure. Standard rating is 65 kAIC at 208/480V. 100 kAIC is available as an option.	Input
P3	**Input Line Fuses Rated to 200 kAIC**—Provide high-level fault protection of the drive input power circuit from the load side of the fuses to the input side of the power transistors. This option consists of three 200 kA fuses, which are factory mounted in the enclosure.	Input
P7	**MOV Surge Suppressor**—Provides a metal oxide varistor (MOV) connected to the line side terminals and is designed to clip line side transients.	Input
P8	**SPD Surge Protective Device with 50 kA Rating**—Provides transient voltage protection, eliminating surges and spikes that can damage the diode bridge of the drive.	Input
PC	**Capacitor Contactor**—This option provides a contactor between the tuned reactor and capacitor to disconnect the capacitor from the circuit when desired, typically at light or no load conditions. This contactor is wired to a programmable relay output.	Input
PE	**Output Contactor**—Provides a means for positive disconnection of the drive output from the motor terminals. The contactor coil is controlled by the drive's run or permissive logic. NO auxiliary contacts rated at 10A, 600 Vac are provided for customer use. Bypass options **RB** and **RA** include an output contactor as standard. This option includes a low VA 115 Vac fused control power transformer and is factory mounted in the enclosure.	Output
PF	**Output Filter**—Used to reduce the transient voltage (DV/DT) at the motor terminals. The output filter is recommended for cable lengths exceeding 100 ft (30m) or for a drive rated at 525–690V. This option is mounted in the enclosure, and may be used in conjunction with a brake chopper circuit.	Output
PG	**MotoRx (300–600 ft) 1000 V/µS DV/DT Filter**—Used to reduce transient voltage (DV/DT) and peak voltages at the motor terminals. This option is comprised of a 0.5% line reactor, followed by capacitive filtering and an energy recovery/clamping circuit. Unlike the output filter (see option **PF**), the MotoRx recovers most of the energy from the voltage peaks, resulting in a lower voltage drop to the motor, and therefore conserving power. This option is used when the distance between a single motor and the drive is 300–600 ft (91–183m). *This option cannot be used with the brake chopper circuit. The output filter (option **PF**) should be investigated as an alternative.*	Output
PH	**Single Overload Relay**—Uses a bimetallic overload relay to provide additional overload current protection to the motor on configurations without bypass options. It is included with the bypass configurations for overload current protection in the bypass mode. The overload relay is mounted within the enclosure, and is manually resettable. Heater pack included.	Output
PI	**Dual Overload Relays**—This option is recommended when a single drive is operating two motors and overload current protection is needed for each of the motors. The standard configuration includes two bimetallic overload relays, each sized to protect a motor with 50% of the drive hp rating. For example, a 100 hp drive would include two overload relays sized to protect two 50 hp motors. The relays are mounted within the enclosure, and are manually resettable. Heater packs not included.	Output
PN	**Dual Overloads for Bypass**—This option is recommended when a single drive is operating two motors in the bypass mode and overload current protection is needed for each of the motors. The standard configuration includes two bimetallic overload relays, each sized to protect a motor with 50% of the drive hp rating. For example, a 100 hp drive would include two overload relays sized to protect two 50 hp motors. The relays are mounted within the enclosure, and are manually resettable.	Addl. bypass

Table 31.3-17. Available Control/Communications Options (Continued)

Option	Description	Option Type
RA	**Manual HOA Bypass Controller**—The manual HAND/OFF/AUTO (HOA)—three-contactor—bypass option provides a means of bypassing the CFX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. This option consists of an input HMCP, a fused control power transformer, and a full voltage bypass starter with a door-mounted HOA selector switch and an INVERTER/BYPASS switch. The HOA switch provides the ability to start and stop the drive in the inverter mode. IEC type input, bypass and input contactors are provided. The contactors are mechanically and electrically interlocked (see wiring diagram on **Page 31.3-24**).	Bypass
RB	**Manual IOB Bypass Controller**—The manual INVERTER/OFF/BYPASS (IOB)—three-contactor—bypass option provides a means of bypassing the CFX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. This option consists of an input HMCP, a fused control power transformer, and a full voltage bypass starter with a door-mounted IOB selector switch. IEC type input, bypass and input contactors are provided. The contactors are mechanically and electrically interlocked (see wiring diagram on **Page 31.3-24**).	Bypass
RC	**Auto Transfer HOA Bypass Controller** —The manual HAND/OFF/AUTO (HOA)—three-contactor—bypass option provides a means of bypassing the CFX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. The circuitry provides an automatic transfer of the load to "across the line" operation after a drive trip. This option consists of an input HMCP, a fused control power transformer, and a full voltage bypass starter with a door-mounted HOA selector switch and an INVERTER/BYPASS switch. The HOA switch provides the ability to start and stop the drive in either mode. IEC type input, bypass and input contactors are provided. The contactors are mechanically and electrically interlocked (see wiring diagram on **Page 31.3-24**). Door-mounted pilot lights are provided that indicate bypass or inverter operation. A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. **Warning**: The motor may restart when the overcurrent relay is reset when operating in bypass, unless the IOB selector switch is turned to the OFF position.	Bypass
RD	**Auto Transfer IOB Bypass Controller**—The auto INVERTER/OFF/BYPASS (IOB)—three-contactor—bypass option provides a means of bypassing the CFX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. The circuitry provides an automatic transfer of the load to "across the line" operation after a drive trip. This option consists of an input HMCP, a fused control power transformer, and a full voltage bypass starter with a door-mounted IOB selector switch. IEC type input, bypass and input contactors are provided. The contactors are mechanically and electrically interlocked (see wiring diagram on **Page 31.3-24**). Door-mounted pilot lights are provided that indicate bypass or inverter operation. A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. **Warning**: The motor may restart when the overcurrent relay is reset when operating in bypass, unless the IOB selector switch is turned to the OFF position.	Bypass
RG	**Reduced Voltage Starter for Bypass**—Used in conjunction with bypass option RA, RB, RC or RD. This option adds ***IT.*** Series reduced voltage soft starter to bypass assembly for soft starting in bypass mode.	Bypass
S4	**Floor Stand 6.00-inch**—Raises "F" box off the ground 6.00 inches (152.4 mm). Recommended when box is not installed on an appropriate concrete pad.	Enclosure
S5	**Floor Stand 22.00-inch**—Converts a Size B or C, normally wall mounted enclosure to a floor standing enclosure with a height of 22.00 inches (558.8 mm).	Enclosure
S6	**Floor Stand 12.00-inch**—Converts a Size C or D, normally wall mounted enclosure to a floor standing enclosure with a height of 12.00 inches (304.8 mm).	Enclosure
S9	**Space Heater**—Prevents condensation from forming in the enclosure when the drive is inactive or in storage. Includes a thermostat for variable temperature control. Heater requires a customer supplied 115V remote supply source.	Enclosure

Enclosed Drive Options

Table 31.3-18. Conformal (Varnished) Coating ①

Chassis Frame	Delivery Code
FR6 FR7 FR8	FP FP FP
FR9 FR10 FR11 FR12	FP FP FP FP

① See catalog number description to order.

Table 31.3-19. Light Options

Description	Catalog Number Suffix
Power on, run, fault LED lights (22 mm)	**L1**
Power on, fault LED lights (22 mm)	**L3**
Green LED run light (22 mm)	**LA**
Green LED stop light (22 mm)	**LD**
Red LED run light (22 mm)	**LE**
Red LED stop light (22 mm)	**LF**
Red LED fault light (22 mm)	**LG**
Power on white LED light (22 mm)	**LJ**
Miscellaneous LED light (22 mm)	**LU**

Table 31.3-20. Control Options

Description	Catalog Number Suffix
Door-mounted speed potentiometer	**K1**
Door-mounted speed potentiometer with HOA selector switch	**K2**
3–15 psig follower	**K3**
HOA selector switch	**K4**
MANUAL/AUTO reference switch	**K5**
START-STOP pushbuttons	**K6**
Type D2 control relay	**SD**
On-delay relay	**SE**
Off-delay relay	**SF**
Additional terminal blocks per 4 points	**SD**

Table 31.3-21. Bypass Control Options

Description	Catalog Number Suffix
Bypass test switch used with RA and RB	KF
Inverter/bypass pilot lights	L2

Table 31.3-22. Meter Options

Description	Catalog Number Suffix
Standard elapsed time meter	KO
Frequency meter	KS
MP-3000 relay with URTD	KV
MP-3000 relay with URTD and CTs	KU

Table 31.3-23. Enclosure Options

Enclosure Size	Catalog Number Suffix
Space Heater ①	
7	S9
8	S9
9	S9
B	S9
C	S9
D	S9
F	S9
Plastic Nameplate	
All	SN
Floor Stand/Enclosure Size	
6.00-inch floor stand, size F	S4
22.00-inch floor stand, size B and C	S5
12.00-inch floor stand, size C and D	S6

① Requires customer-supplied 115 Vac supply.

Table 31.3-24. 208V Power Options, 7-1/2–100 hp

Description	Catalog Number Suffix
Input breaker	P1
Input line fusing	P2
Input line fuses 200 kAIC	P3
Output contactor	PE
Single overload relay	PH
Dual overload relays	PI
MOV	P7
50 kA surge protective device	P8
100 kA surge protective device	P9

Table 31.3-25. 230V Power Options, 7-1/2–125 hp

Description	Catalog Number Suffix
Input breaker	P1
Input line fusing	P2
Input line fuses 200 kAIC	P3
Output contactor	PE
Single overload relay	PH
Dual overload relays	PI
MOV	P7
50 kA surge protective device	P8
100 kA surge protective device	P9

Table 31.3-26. 480 and 575V Power Options, 7-1/2–400 hp

Description	Catalog Number Suffix
Input breaker	P1
Input line fusing	P2
Input line fuses 200 kAIC	P3
Output contactor	PE
Output filter	PF
MotoRx (300–600 ft) DV/DT filter	PG
Single overload relay	PH
Dual overload relays	PI
Input MOV	P7
50 kA surge protective device	P8
100 kA surge protective device	P9

Table 31.3-27. 208V Bypass Options, 7-1/2–100 hp

Description	Catalog Number Suffix
Manual HOA bypass controller	RA
IOB bypass controller	RB
Auto transfer HOA bypass controller	RC
Auto transfer IOB bypass controller	RD
Reduced voltage starter for bypass	RG
Dual overloads for bypass	PN

Table 31.3-28. 230V Bypass Options, 7-1/2–125 hp

Description	Catalog Number Suffix
Manual HOA bypass controller	RA
IOB bypass controller	RB
Auto transfer HOA bypass controller	RC
Auto transfer IOB bypass controller	RD
Reduced voltage starter for bypass	RG
Dual overloads for bypass	PN

Table 31.3-29. 480 and 575V Bypass Options, 7-1/2–400 hp

Description	Catalog Number Suffix
Manual HOA bypass controller	RA
IOB bypass controller	RB
Auto transfer HOA bypass controller	RC
Auto transfer IOB bypass controller	RD
Reduced voltage starter for bypass	RG
Dual overloads for bypass	PN

Dimensions

CFX9000—Drawing 1

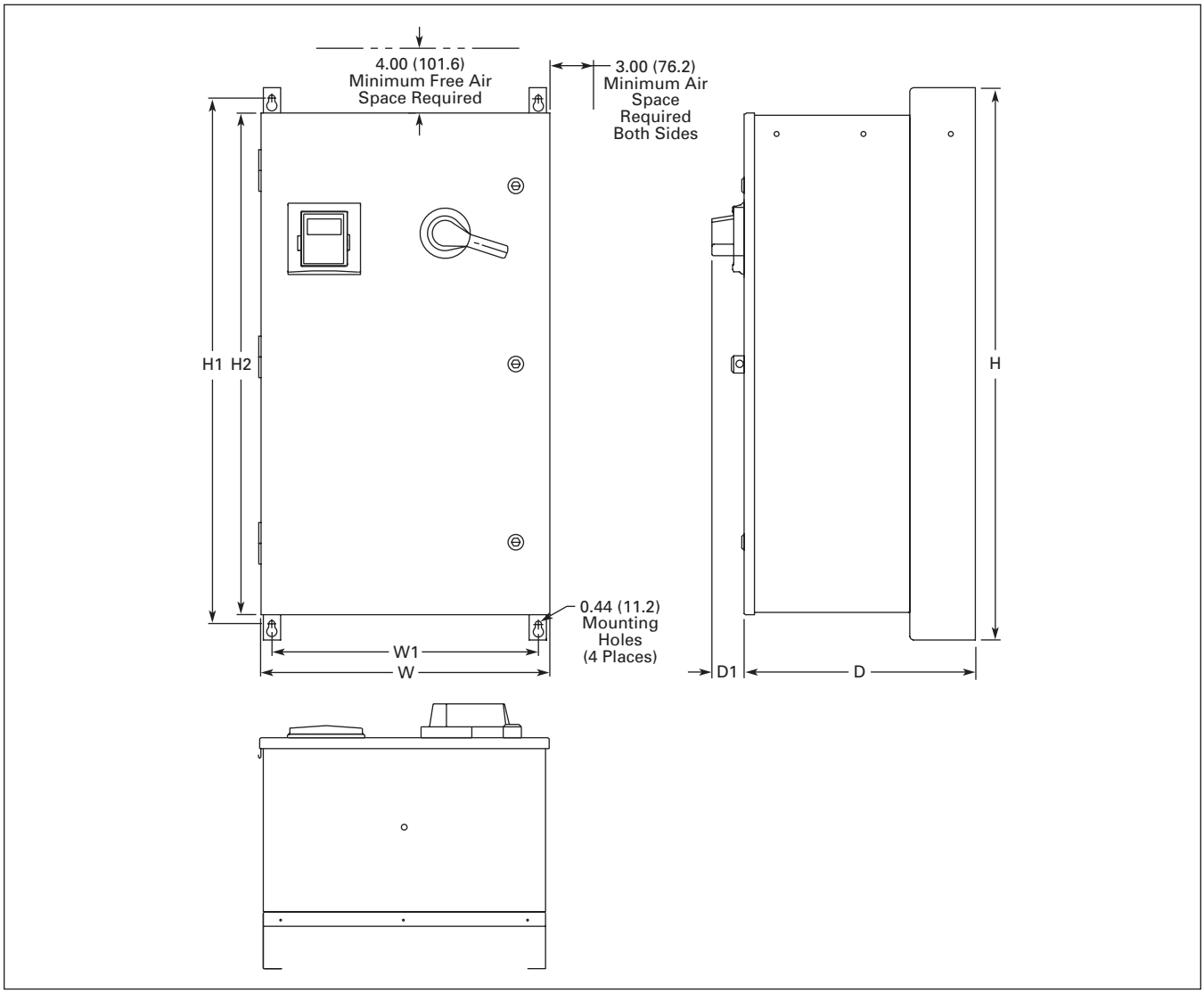


Figure 31.3-6. Enclosure Size B—UL Type 12—Approximate Dimensions in Inches (mm)

Table 31.3-30. CFX9000 Drive Dimensions

H	H1	H2	W	W1	D	D1	Approximate Weight Lbs (kg)	Approximate Shipping Weight Lbs (kg)
40.00 (1016.0)	38.00 (965.2)	36.35 (923.3)	20.92 (531.4)	19.30 (490.2)	16.76 (425.7)	2.34 (59.4)	185 (84)	229 (104)

CFX9000—Drawing 2

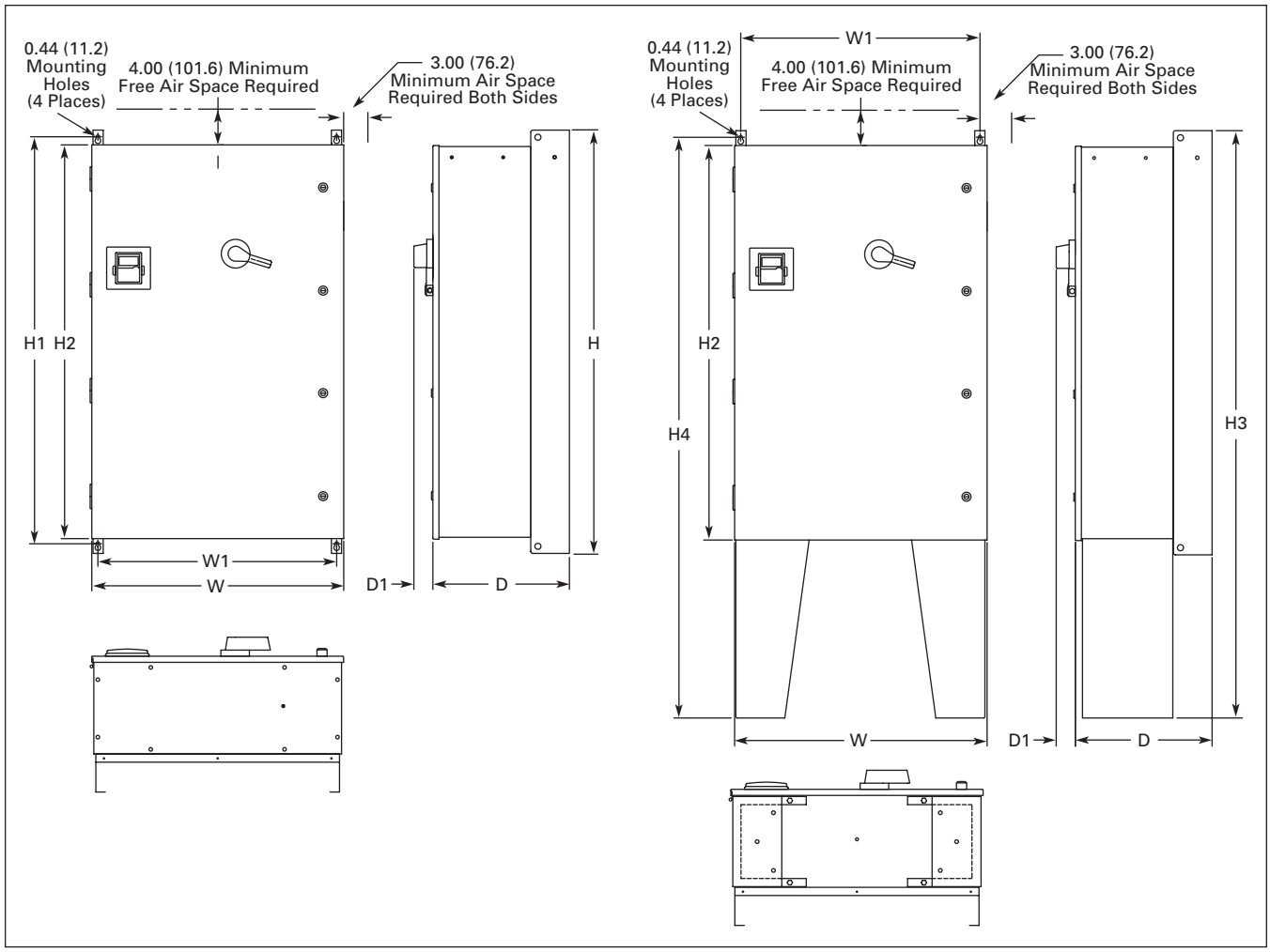


Figure 31.3-7. Enclosure Size C—UL Type 12—Approximate Dimensions in Inches (mm)

Table 31.3-31. CFX9000 Drive Dimensions

H	H1	H2	H3	H4	W	W1	D	D1	Approx. Weight Lbs (kg)	Approx. Shipping Weight Lbs (kg)
52.00 (1320.8)	50.00 (1270.0)	48.35 (1228.1)	72.00 (1828.8)	71.19 (1808.2)	30.92 (785.4)	29.30 (744.2)	16.78 (426.2)	2.34 (59.4)	320 (145)	435 (197)

CFX9000—Drawing 3

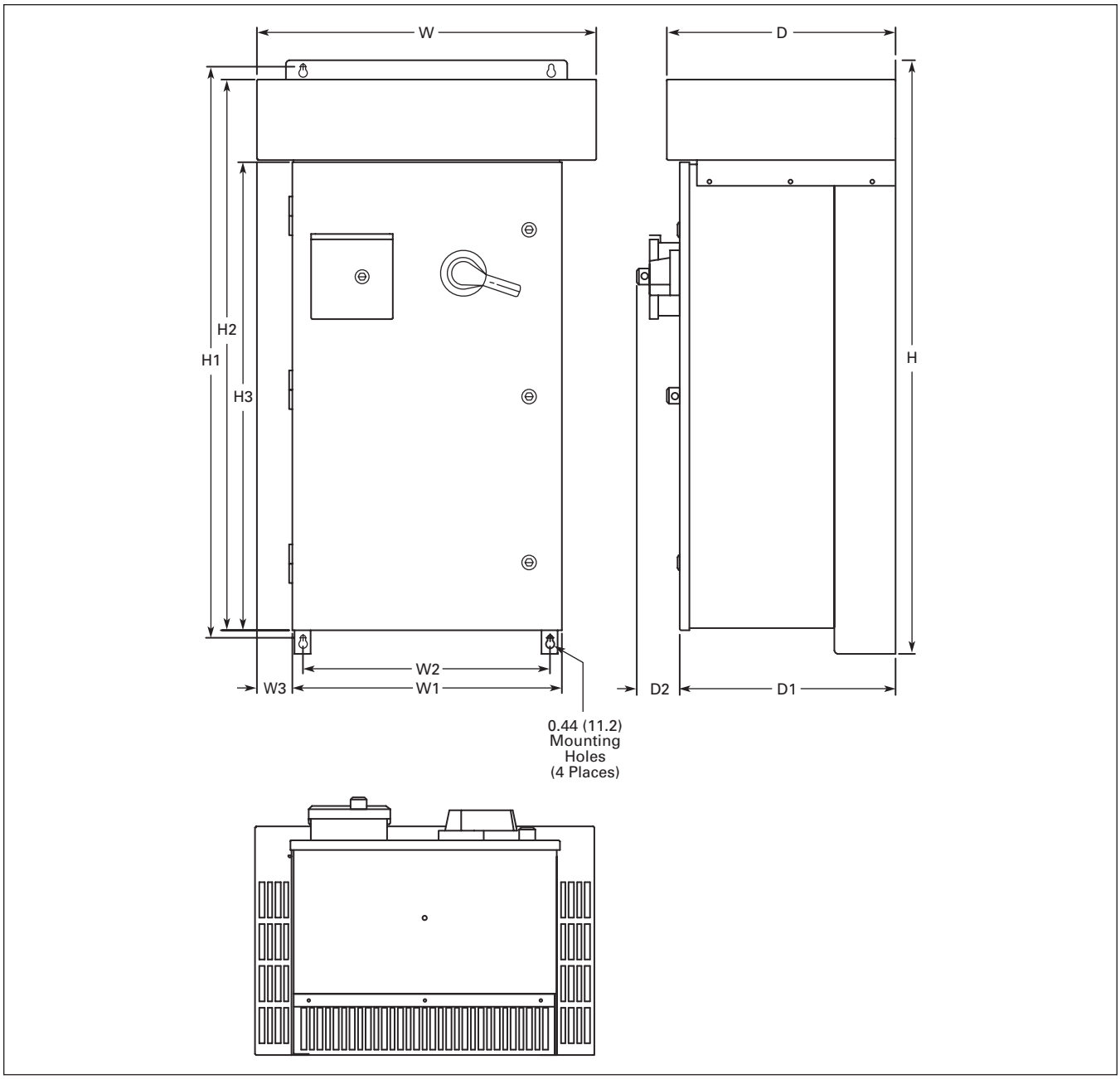


Figure 31.3-8. Enclosure Size B—UL Type 3R—Approximate Dimensions in Inches (mm)

Table 31.3-32. CFX9000 Drive Dimensions

H	H1	H2	H3	W	W1	W2	W3	D	D1	D2	Approx. Weight Lbs (kg)	Approx. Shipping Weight Lbs (kg)
46.09 (1170.7)	44.45 (1129.0)	42.77 (1086.4)	36.35 (923.3)	26.31 (668.3)	20.92 (531.4)	19.30 (490.2)	2.69 (68.3)	17.74 (450.6)	16.76 (425.7)	3.31 (840.1)	235 (107)	290 (132)

CFX9000—Drawing 4

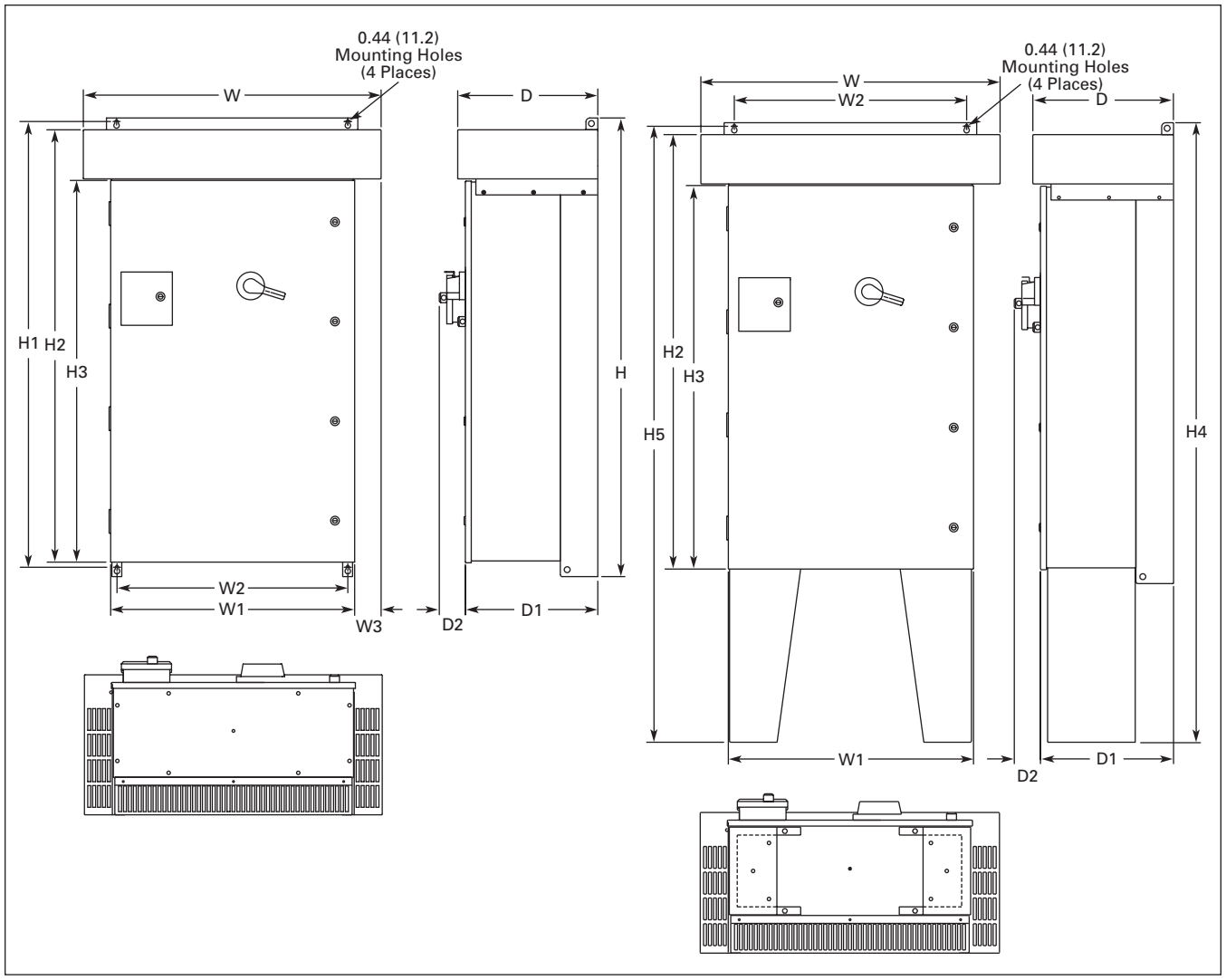


Figure 31.3-9. Enclosure Size C—UL Type 3R—Approximate Dimensions in Inches (mm)

Table 31.3-33. CFX9000 Drive Dimensions

H	H1	H2	H3	H4	H5	W	W1	W2	W3	D	D1	D2	Approximate Weight Lbs (kg)	Approximate Shipping Weight Lbs (kg)
58.09 (1475.5)	56.45 (1433.8)	54.77 (1391.2)	48.35 (1228.1)	78.09 (1983.5)	77.64 (1972.1)	37.73 (958.3)	30.92 (785.4)	29.30 (744.2)	3.34 (84.8)	17.74 (450.6)	16.77 (426.0)	3.31 (840.1)	370 (168)	485 (220)

CFX9000—Drawing 5

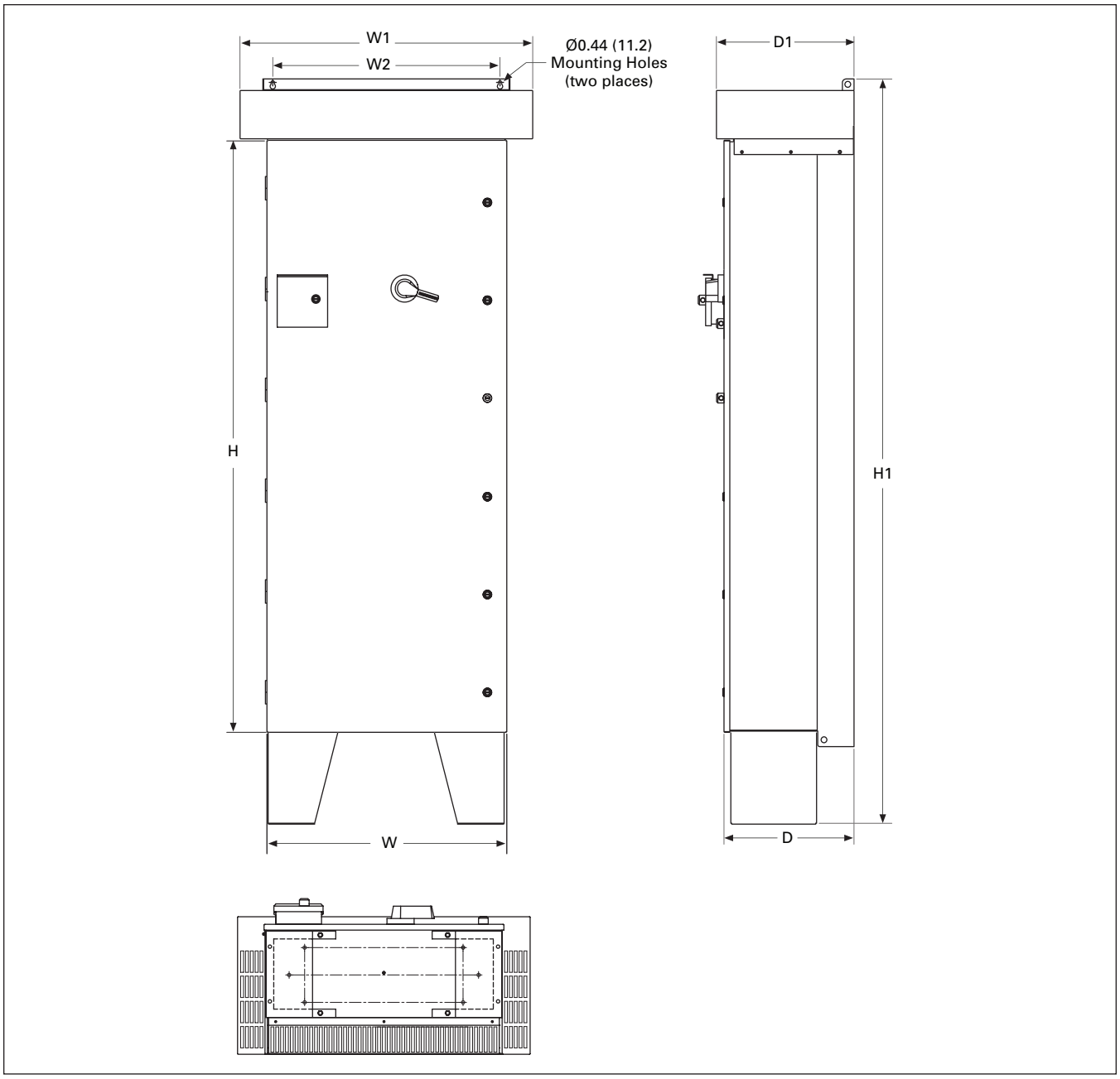


Figure 31.3-10. Enclosure Size D—UL Type 3R—Approximate Dimensions in Inches (mm)

Table 31.3-34. CFX9000 Drive Dimensions

H	H1	W	W1	W2	D	D1	Approximate Shipping Weight Lbs (kg)
76.27 (1937.3)	96.00 (2438.4)	30.92 (784.4)	37.73 (958.3)	29.30 (744.2)	16.76 (424.7)	17.74 (450.6)	1000 (454)

Note: Shown with optional floor stands.

CFX9000—Drawing 6

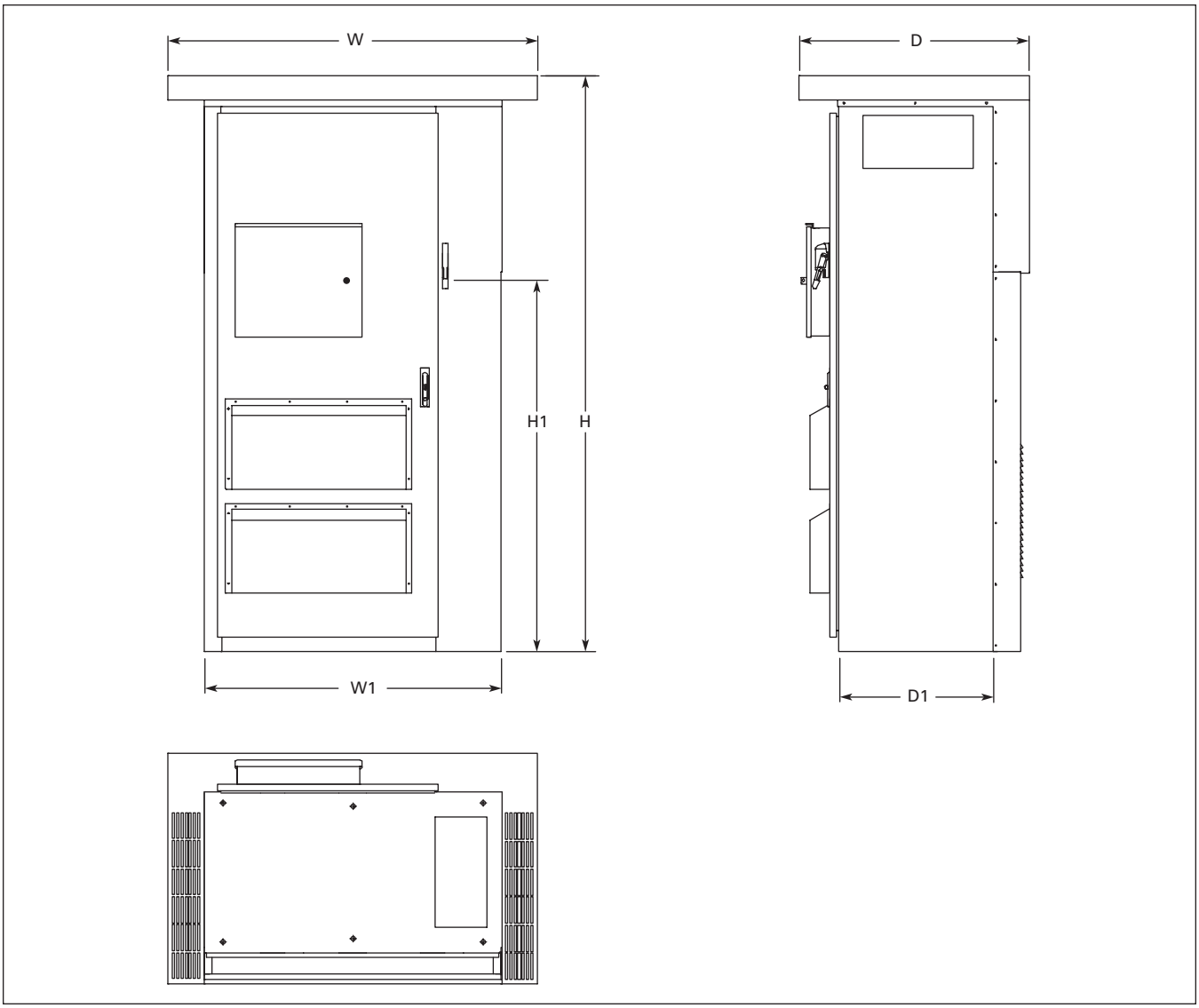


Figure 31.3-11. Enclosure Size F—Approximate Dimensions in Inches (mm)

Table 31.3-35. CFX9000 Drive Dimensions

H	H1	W	W1	D	D1	Approximate Weight Lbs (kg)	Approximate Shipping Weight Lbs (kg)
93.58 (2376.9)	69.51 (1765.60)	60.00 (1524.0)	48.00 (1219.2)	37.50 (952.5)	26.00 (660.4)	1700 (771)	1850 (839)

CFX9000—Drawing 7

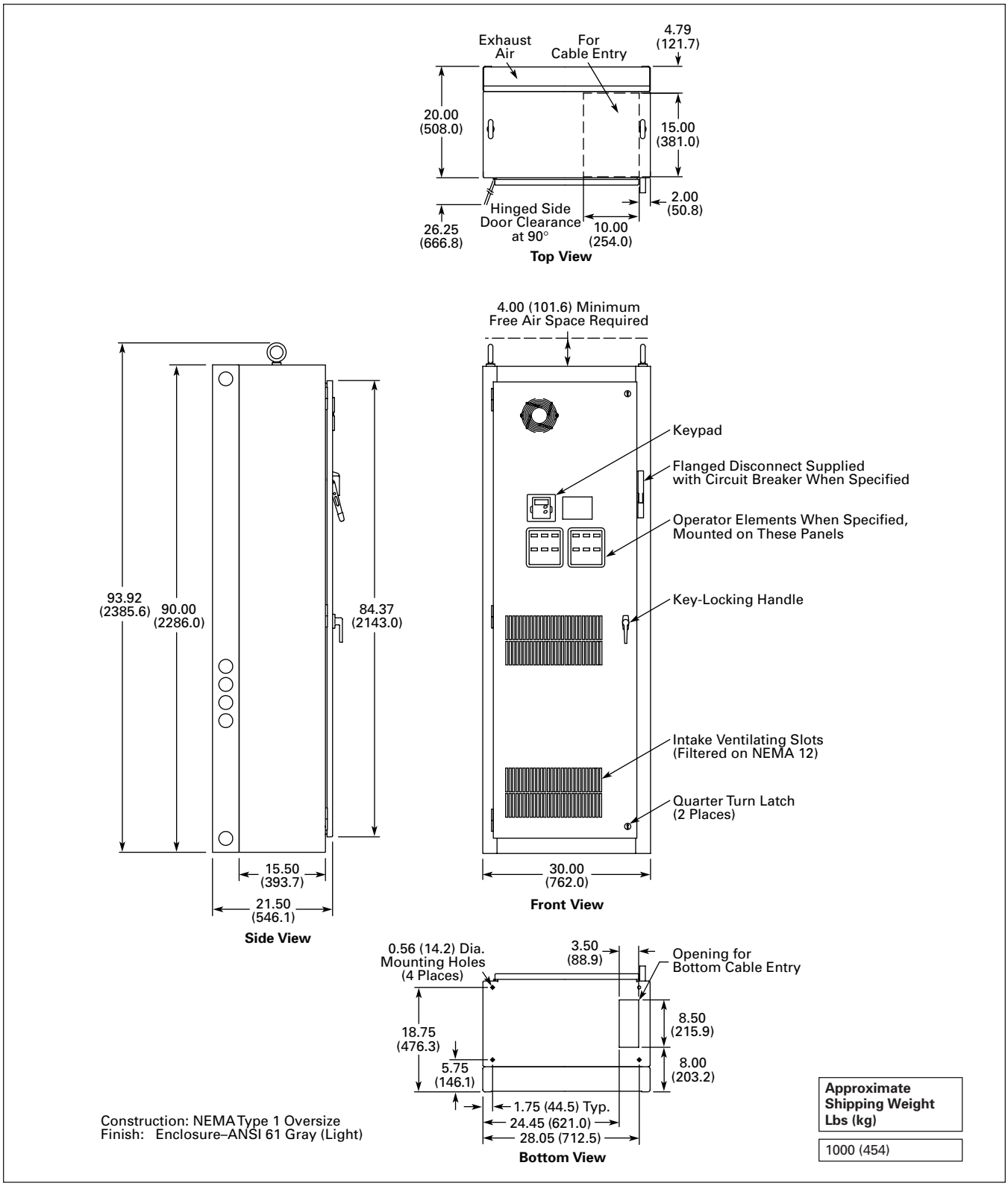


Figure 31.3-12. Enclosure Size 7—Approximate Dimensions in Inches (mm)

CFX9000—Drawing 8

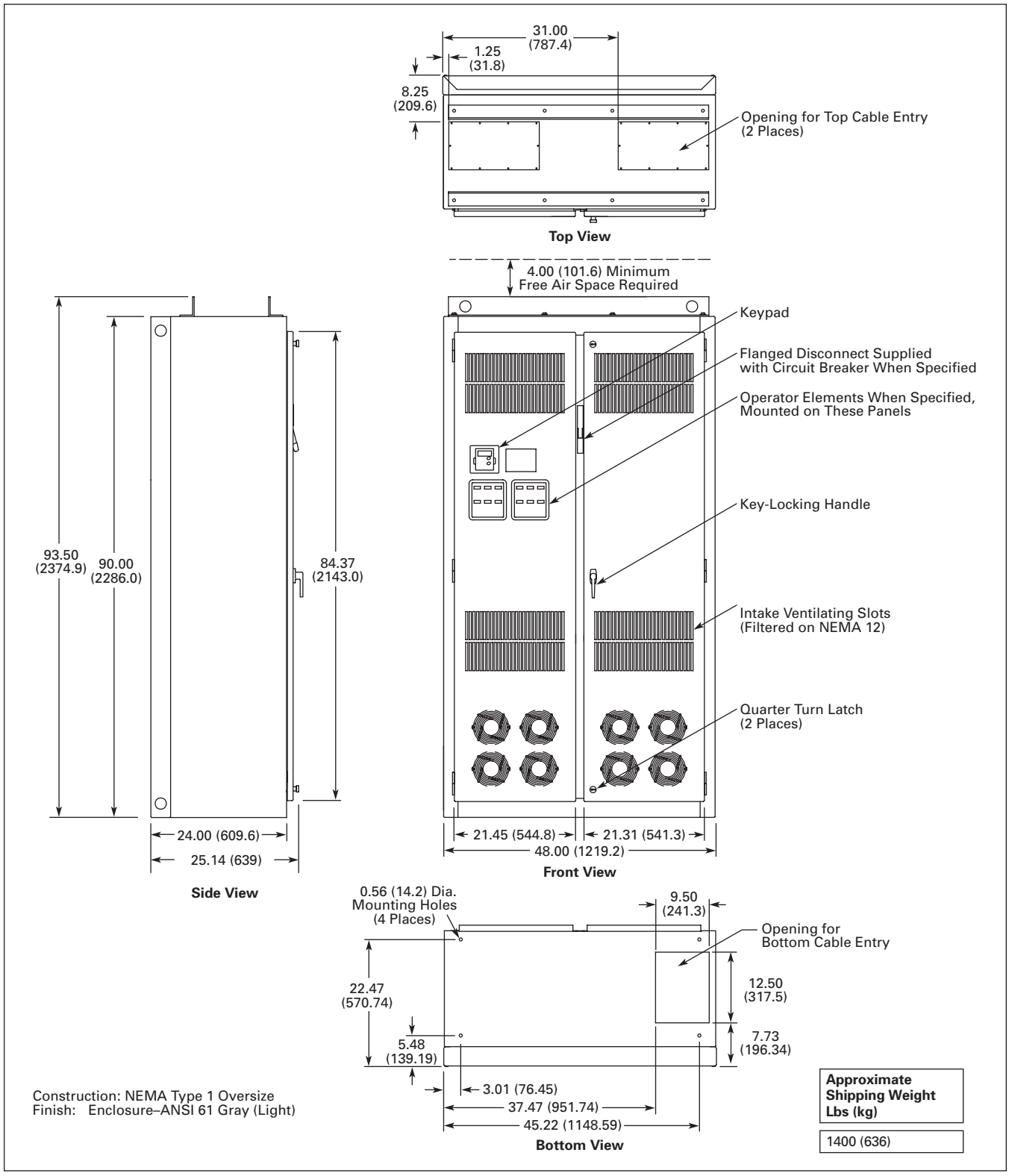


Figure 31.3-13. Enclosure Size 8—Approximate Dimensions in Inches (mm)

CFX9000—Drawing 9

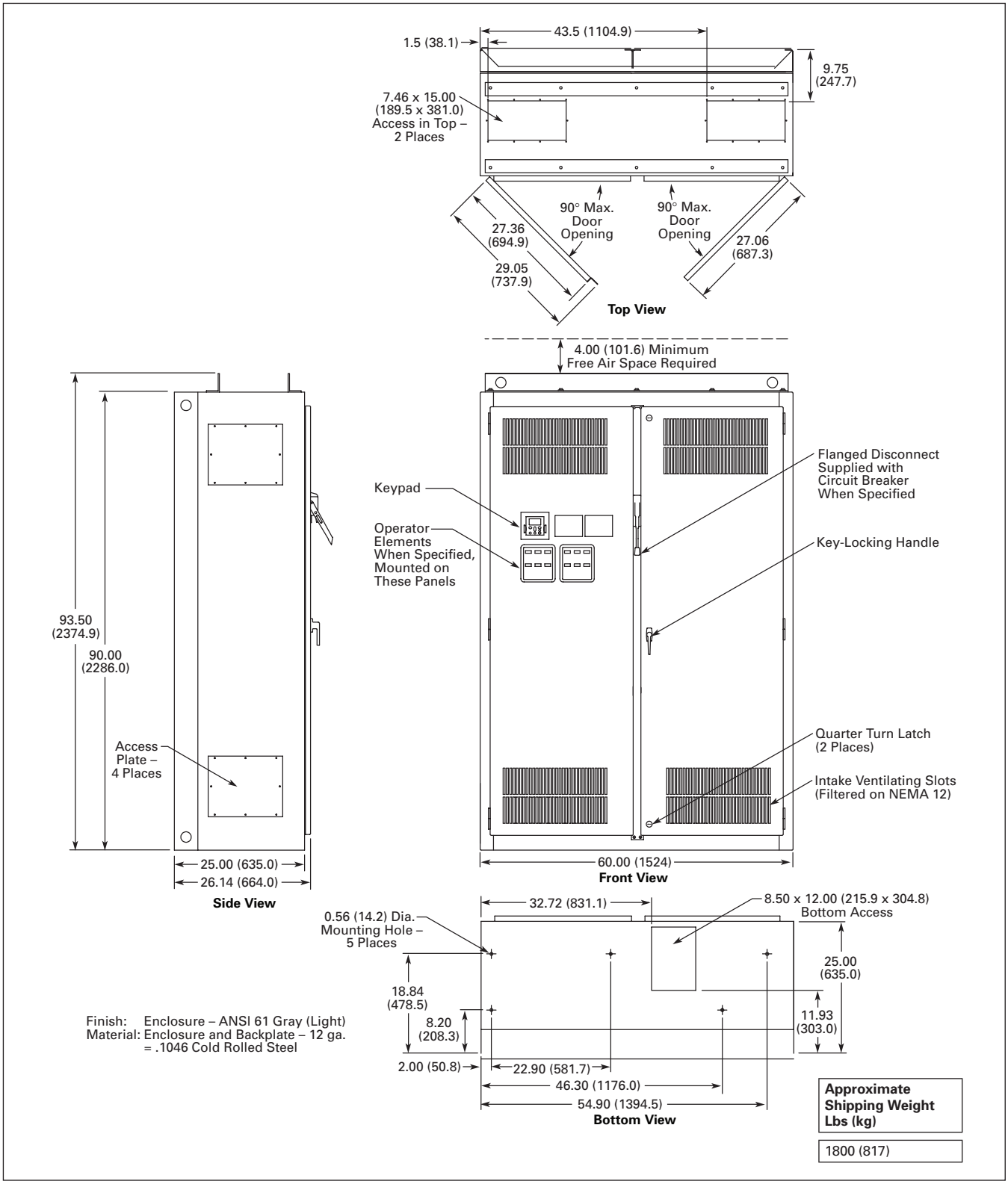
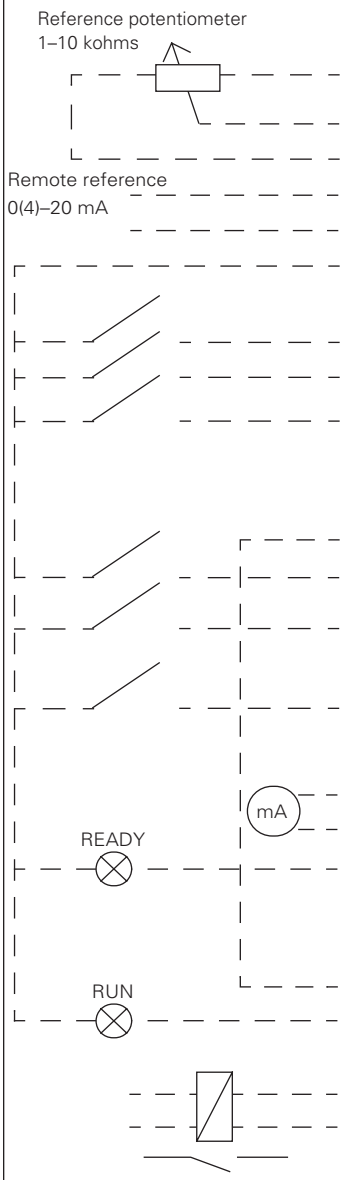


Figure 31.3-14. Enclosure Size 9—Approximate Dimensions in Inches (mm)

Wiring Diagram

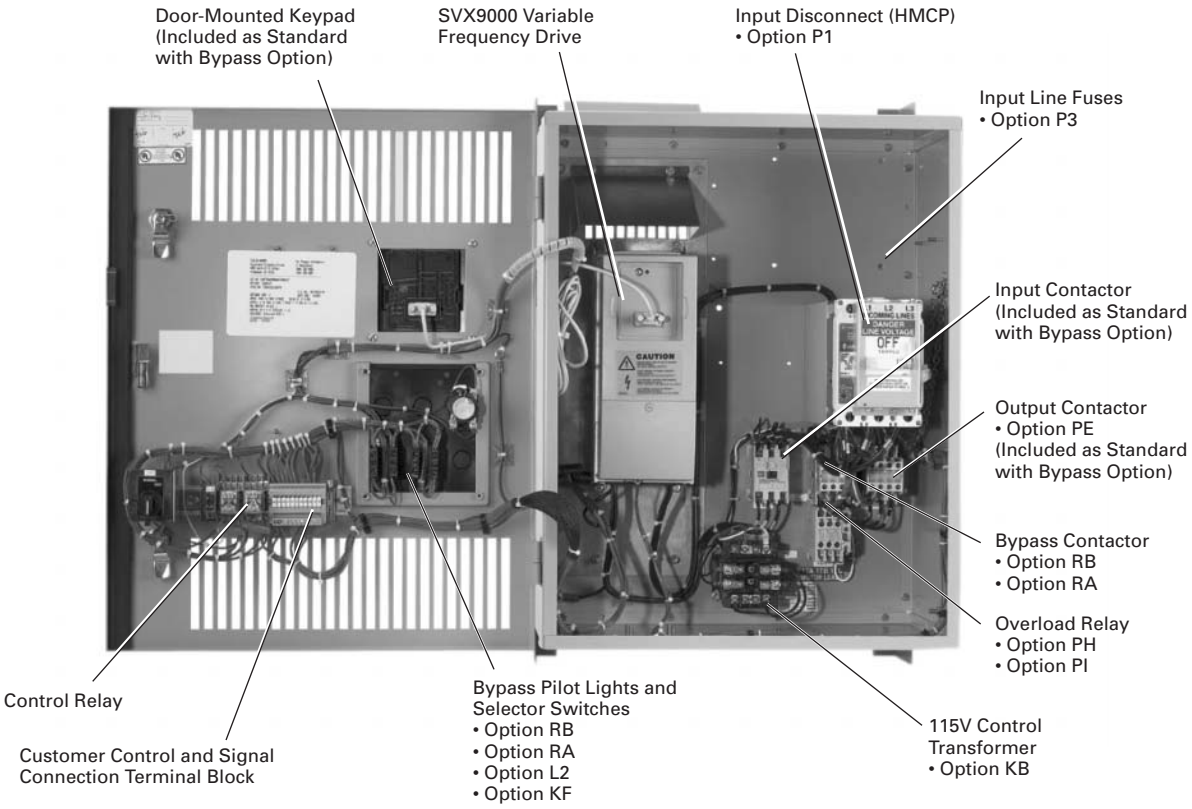


Basic Application Default I/O Configuration

Terminal		Signal	Description
OPTA9			
1	+10V_{ref}	Reference output	Voltage for potentiometer, etc.
2	AI1+	Analog input, voltage range 0–10 Vdc	Voltage input frequency reference
3	AI1–	I/O Ground	Ground for reference and controls
4	AI2+	Analog input, current range 0–20 mA	Current input frequency reference
5	AI2–		
6	+24V	Control voltage output	Voltage for switches, etc. max 0.1A
7	GND	I/O ground	Ground for reference and controls
8	DIN1	Start forward	Contact closed = start forward
9	DIN2	Start reverse	Contact closed = start reverse
10	DIN3	External fault input (programmable)	Contact open = no fault Contact closed = fault
11	CMA	Common for DIN 1–DIN 3	Connect to GND or +24V
12	+24V	Control voltage output	Voltage for switches (see terminal 6)
13	GND	I/O ground	Ground for reference and controls
14	DIN4	Multi-step speed select 1	**DIN4 DIN5 Frequency Ref.**
15	DIN5	Multi-step speed select 2	Open Open Ref.V_{in} Closed Open Multi-step ref.1 Open Closed Multi-step ref.2 Closed Closed Ref_{Max}
16	DIN6	Fault reset	Contact open = no action Contact closed = fault reset
17	CMB	Common for DIN4–DIN6	Connect to GND or +24V
18	AO1+	Output frequency Analog output	Programmable Range 0–20 mA, R_L max. 500 ohms
19	AO1–		
20	DO1	Digital output READY	Programmable Open collector, I ≤50 mA, V ≤48 Vdc
OPTA2			
21	RO1	Relay output 1 RUN	
22	RO1		
23	RO1		
24	RO2	Relay output 2 FAULT	
25	RO2		
26	RO2		

Figure 31.3-15. Control Input/Output

SVX9000 Enclosed Drives



Enclosed 9000X Series Drive

General Description

- **Standard enclosed—**covers a wide range of the most commonly ordered options. Pre-engineering eliminates the lead time normally associated with customer specific options
- **Modified standard enclosed**—applies to specific customer requirements that vary from the Standard Enclosed offering, such as the need for an additional indicating light or minor modifications to drawings. *Consult your Eaton representative for assistance in pricing and lead time*
- **Custom engineered**—for those applications with more unique or complex requirements, these are individually engineered to the customer's needs. *Consult your Eaton representative for assistance in pricing and lead time*

Features

- NEMA Type 1 or Type 12 enclosures
- Input voltage: 208V, 230V, 480V and 575V
- Complete range of control, network and power options
- Horsepower range:
  - 208V—3/4 to 100 hp I_H; 1 to 100 hp I_L
  - 230V—3/4 to 100 hp I_H; 1 to 100 hp I_L
  - 480V—1 to 700 hp I_H; 1-1/2 to 800 hp I_L
- HMCP padlockable

Standards and Certifications

- UL listed
- cUL listed

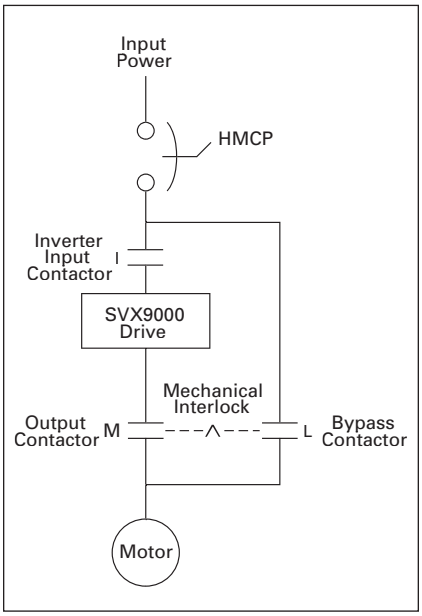


Figure 31.4-1. Power Diagram for Bypass Options RB and RA

Technical Data and Specifications

Table 31.4-1. SVX9000 Specifications

Description	Specification
Input Ratings	
Input voltage (V_{in})	+10%/–15%
Input frequency (f_{in})	50/60 Hz (variation up to 45–66 Hz)
Connection to power	Once per minute or less (typical operation)
High withstand rating	100 kAIC
Output Ratings	
Output voltage	0 to V_{in}
Continuous output current	I_H rated 100% at 122°F (50°C), FR9 and below I_L rated 100% at 104°F (40°C), FR9 and below I_H/I_L 100% at 104°F (40°C), FR10 and above
Overload current (I_H/I_L)	150% I_H, 110% I_L for 1 minute
Output frequency	0 to 320 Hz
Frequency resolution	0.01 Hz
Initial output current (I_H)	250% for 2 seconds
Control Characteristics	
Control method	Frequency control (V/f) Open loop: sensorless vector control, Closed loop: SPX9000 drives only
Switching frequency Frame 4–6 Frame 7–12	Adjustable with parameter 2.6.9 1 to 16 kHz; default 10 kHz 1 to 10 kHz; default 3.6 kHz
Frequency reference	Analog input: resolution 0.1% (10-bit), accuracy ±1% V/Hz Panel reference: resolution 0.01 Hz
Field weakening point	30 to 320 Hz
Acceleration time	0 to 3000 seconds
Deceleration time	0 to 3000 seconds
Braking torque	DC brake: 30% x T_n (without brake option)
Ambient Conditions	
Ambient operating temperature	14°F (–10°C), no frost to 122°F (+50°C) I_H (FR4–FR9) 14°F (–10°C), no frost to 104°F (+40°C) I_H (FR10 and up) 14°F (–10°C), no frost to 104°F (+40°C) I_L (all frames)
Storage temperature	–40°F (–40°C) to 158°F (70°C)
Relative humidity	0 to 95% RH, noncondensing, non-corrosive, no dripping water
Air quality	Chemical vapors: IEC 721-3-3, unit in operation, class 3C2; Mechanical particles: IEC 721-3-3, unit in operation, Class 3S2
Altitude	100% load capacity (no derating) up to 3280 ft (1000m); 1% derating for each 328 ft (100m) above 3280 ft (1000m); max. 9842 ft (3000m)
Vibration	EN 50178, EN 60068-2-6; 5 to 50 Hz, displacement amplitude 1 mm (peak) at 3 to 15.8 Hz, max. acceleration amplitude 1G at 15.8 to 150 Hz
Shock	EN 50178, EN 60068-2-27 UPS drop test (for applicable UPS weights) storage and shipping: max. 15G, 11 ms (in package)
Enclosure class	NEMA 1/IP21 or NEMA 12/IP54, open chassis/IP20

Description	Specification
Standards	
Product	IEC 61800-2
Safety	UL 508C
EMC (at default settings)	Immunity: fulfills all EMC immunity requirements; emissions: EN 61800-3, LEVEL H
Control Connections	
Analog input voltage	0 to 10V, R = 200k ohms (–10 to 10V joystick control) resolution 0.1%; accuracy ±1%
Analog input current	0(4) to 20 mA; R_i - 250 ohms differential
Digital inputs (6)	Positive or negative logic; 18 to 30 Vdc
Auxiliary voltage	+24V ±15%, maximum 250 mA
Output reference voltage	+10V +3%, maximum load 10 mA
Analog output	0(4) to 20 mA; R_L max. 500 ohms; resolution 10 bit; accuracy ±2%
Digital outputs	Open collector output, 50 mA/48V
Relay outputs	Two programmable Form C relay outputs Switching capacity: 24 Vdc/8A, 250 Vac/8A, 125 Vdc/0.4A
Protections	
Overcurrent protection	Trip limit 4.0 x I_H instantaneously
Overvoltage protection	Yes
Undervoltage protection	Yes
Earth fault protection	In case of earth fault in motor or motor cable, only the frequency converter is protected
Input phase supervision	Trips if any of the input phases are missing
Motor phase supervision	Trips if any of the output phases are missing
Overtemperature protection	Yes
Motor overload protection	Yes
Motor stall protection	Yes
Motor underload protection	Yes
Short circuit protection	Yes (+24V and +10V reference voltages)

Table 31.4-2. Standard I/O Specifications

Description	Specification
6–digital input programmable	24V: "0" ≤ 10V, "1" ≥ 18V, R_i > 5k ohms
2–analog input configurable w/jumpers	Voltage: 0–±10V, R_i > 200k ohms Current: 0 (4)–20 mA, R_i = 250k ohms
2–digital output programmable	Form C Relays 250 Vac 2A or 30 Vdc 2A resistive
1–digital output programmable	Open collector 48 Vdc 50 mA
1–analog output programmable configurable w/jumper	0–20 mA, R_L < 500 ohms, resolution 10 bits/0.1%

Table 31.4-3. Specifications

Feature Description	9000X Enclosed Products—NEMA Type 1 or NEMA Type 12
Primary Design Features	
45–66 Hz input frequency	Standard
Output: AC volts maximum	Input voltage base
Output frequency range: Hz	0–500
Initial output current (I_H)	250% for 2 seconds
Overload: 1 minute (I_H/I_L)	150%/110%
Enclosure space heater	Optional
Oversize enclosure	Standard
Output contactor	Optional
Bypass motor starter	Optional
Listings	UL, cUL
Protection Features	
Incoming line fuses	Optional
AC input circuit disconnect	Optional
Line reactors	Standard
Phase rotation insensitive	Standard
EMI filter	Standard
Input phase loss protection	Standard
Input overvoltage protection	Standard
Line surge protection	Standard
Output short circuit protection	Standard
Output ground fault protection	Standard
Output phase protection	Standard
Overtemperature protection	Standard
DC overvoltage protection	Standard
Drive overload protection	Standard
Motor overload protection	Standard
Programmer software	Optional
Local/remote keypad	Standard
Keypad lockout	Standard
Fault alarm output	Standard
Built-in diagnostics	Standard
Input/Output Interface Features	
Setup Adjustment Provisions:	
Remote keypad/display	Standard
Personal computer	Standard
Operator Control Provisions:	
Drive mounted keypad/display	Standard
Remote keypad/display	Standard
Conventional control elements	Standard
Serial communications	Optional
115 Vac control circuit	Optional
Speed Setting Inputs:	
Keypad	Standard
0–10 Vdc potentiometer/voltage signal	Standard
4–20 mA isolated	Configurable
4–20 mA differential	Configurable
3–15 psig	Optional
Analog Outputs:	
Speed/frequency	Standard
Torque/load/current	Programmable
Motor voltage	Programmable
Kilowatts	Programmable
0–10 Vdc signals	Configurable w/jumpers
4–20 mA DC signals	Standard
Isolated signals	Optional

Feature Description	9000X Enclosed Products—NEMA Type 1 or NEMA Type 12
Input/Output Interface Features (Continued)	
Discrete Outputs:	
Fault alarm	Standard
Drive running	Standard
Drive at set speed	Programmable
Optional parameters	14
Dry contacts	1 (2 relays Form C)
Open collector outputs	1
Additional discrete outputs	Optional
Communications:	
RS-232	Standard
RS-422/485	Optional
DeviceNet	Optional
Modbus RTU	Optional
CANopen (Slave)	Optional
PROFIBUS-DP	Optional
LonWorks	Optional
Johnson Controls Metasys N2	Optional
Performance Features	
Sensorless vector control	Standard
Volts/hertz control	Standard
IR and slip compensation	Standard
Electronic reversing	Standard
Dynamic braking	Optional ①
DC braking	Standard
PID set point controller	Programmable
Critical speed lockout	Standard
Current (torque) limit	Standard
Adjustable acceleration/deceleration	Standard
Linear or S curve accel/decel	Standard
Jog at preset speed	Standard
Thread/preset speeds	7
Automatic restart	Selectable
Coasting motor start	Standard
Coast or ramp stop selection	Standard
Elapsed time meter	Optional
Carrier frequency adjustment	1–16 kHz
Standard Conditions for Application and Service	
Operating ambient temperature	0° to 40°C
Storage temperature	–40° to 60°C
Humidity (maximum), noncondensing	95%
Altitude (maximum without derate)	3300 ft (1000m)
Line voltage variation	+10/–15%
Line frequency variation	45–66 Hz
Efficiency	>96%
Power factor (displacement)	>0.94

① Some horsepower units include dynamic braking chopper as standard—refer to individual drive sections.

31

Catalog Number Selection

Table 31.4-4. SVX9000 Enclosed NEMA Type 1/12 Drive Catalog Numbering System

SVX F07 1 4 A A _ _ _ _ _ _ _ _ _ _

Build Alphabetically and Numerically

Product Family
SVX = Enclosed drives

Horsepower Rating	
F07 = 3/4 hp	**100** = 100 hp
001 = 1 hp	**125** = 125 hp
F15 = 1-1/2 hp	**150** = 150 hp
002 = 2 hp	**200** = 200 hp
003 = 3 hp	**250** = 250 hp
005 = 5 hp	**300** = 300 hp
007 = 7-1/2 hp	**350** = 350 hp
010 = 10 hp	**400** = 400 hp
015 = 15 hp	**500** = 500 hp
020 = 20 hp	**550** = 550 hp
025 = 25 hp	**600** = 600 hp
030 = 30 hp	**650** = 650 hp
040 = 40 hp	**700** = 700 hp
050 = 50 hp	
060 = 60 hp	
075 = 75 hp	

Enclosure Rating
1 = NEMA Type 1
2 = NEMA Type 12
6 = NEMA 12 filtered

Voltage Rating
1 = 208V
2 = 230V
4 = 480V

Application—Torque/Braking ②
A = I_L/no brake chopper
B = I_L/internal brake chopper
D = I_H/no brake chopper
E = I_H/internal brake chopper

Enclosed Style
A = Enclosed drive

Enclosed Options ①④⑤		Type
K1	Door-mounted speed potentiometer ③	Control
K2	Door-mounted speed potentiometer with HOA selector switch ③	Control
K3	3–15 psig Follower	Control
K4	HAND/OFF/AUTO switch (22 mm)	Control
K5	MANUAL/AUTO ref switch (22 mm)	Control
K6	START/STOP pushbuttons (22 mm)	Control
KB	115V control transformer–550 VA	Control
KF	Bypass test switch for RA and RB	Addl. bypass
KO	Standard elapsed time meter	Control
L1	Power on and fault pilot lights	Light
L2	Bypass pilot lights for RA, RB bypass options	Addl. bypass
LE	Red RUN light	Light
P1	Input disconnect (HMCP) 100 kAIC	Input
P2	Disconnect switch ⑥	Input
P3	Input line fuses (200 kAIC)	Input
P7	Input power surge protection	Input
PE	Output contactor	Output
PF	Output filter	Output
PG	MotoRx (up to 600 ft) 1000 V/µS DV/DT filter	Output
PH	Single overload relay	Output
PI	Dual overload relays	Output
PN	Dual overloads for bypass	Addl. bypass
RA	Manual HOA bypass controller	Bypass
RB	Manual IOB bypass controller	Bypass
RC	Auto transfer HOA bypass controller	Bypass
RD	Auto transfer IOB bypass controller	Bypass
S5	Floor stand 22 inches	Enclosure
S6	Floor stand 12 inches	Enclosure
S7	10 inch expansion	Enclosure
S8	20 inch expansion	Enclosure
S9	Space heater	Enclosure

Communication Options	
C2 = Modbus	**C8** = Modbus (D9 Type connector)
C3 = PROFIBUS DP	**CA** = Johnson Controls N2
C4 = LonWorks	**CI** = Modbus TCP
C5 = PROFIBUS DP (D9 connector)	**CJ** = BACnet
C6 = CANopen (slave)	**D3** = RS-232 with D9 connection
C7 = DeviceNet	

Control Options
B1 = 6 DI, 1 ext +24 Vdc/EXT +24 Vdc
B2 = 1 RO (NC/NO), 1 RO (NO), 1 Therm
B4 = 1 AI (mA isolated), 2 AO (mA isolated), 1 ext +24 Vdc/EXT +24 Vdc
B5 = 3 RO (NO)
B8 = 1 ext +24 Vdc/EXT +24 Vdc, 3 Pt100
B9 = 1 RO (NO), 5 DI 42–240 Vac input

Engineered Options
HT = High Temperature rating for 50°C (FR10 and above) ⑦
VB = Varnished Boards

① Local/remote keypad is included as the standard control panel.

② Brake chopper is a factory installed option only, see drive option tables on **Pages 31.4-8–31.4-10**. **Note:** External dynamic braking resistors not included. Consult factory.

③ Includes local/remote speed reference switch.

④ Some options are voltage and/or horsepower specific. Consult your Eaton representative for details.

⑤ See **Pages 31.4-5** and **31.4-6** for descriptions.

⑥ Applicable only with FR10 and FR11 Freestanding designs.

⑦ Consult Eaton for pricing and availability.

Control/Communication Option Descriptions

Table 31.4-5. Available Control/Communications Options

Option	Description	Option Type
K1	**Door-Mounted Speed Potentiometer—**Provides the SVX9000 with the ability to adjust the frequency reference using a door-mounted potentiometer. This option uses the 10 Vdc reference to generate a 0–10V signal at the analog voltage input signal terminal. When the HOA bypass option is added, the speed is controlled when the HOA switch is in the hand position. Without the HOA bypass option, a 2-position switch (labeled local/remote) is provided on the keypad to select speed reference from the Speed Potentiometer or a remote speed signal.	Control
K2	**Door-Mounted Speed Potentiometer with HOA Selector Switch—**Provides the SVX9000 with the ability to start/stop and adjust the speed reference from door-mounted control devices or remotely from customer supplied inputs. In HAND position, the drive will start and the speed is controlled by the door-mounted speed potentiometer. The drive will be disabled in the OFF position. When AUTO is selected, the run enable and speed reference are controlled from remote inputs. Speed reference can be either 0–10 Vdc or 4–20 mA. The drive default is 4–20 mA, parameter is field programmable. Run enable is controlled by a dry contact closure. *This option requires a customer supplied 115V power source.*	Control
K3	**3–15 psig Follower**—Provides a pneumatic transducer that converts a 3–15 psig pneumatic signal to either 0–8 Vdc or a 1–9 Vdc signal interface with the SVX9000. The circuit board is mounted on the inside of the front enclosure panel and connects to the user's pneumatic control system via 6 ft (1.8m) of flexible tubing and a 1/4-inch (6.4 mm) brass tube union.	Control
K4	**HAND/OFF/AUTO Switch for Non-bypass Configurations**—Provides a three-position selector switch that allows the user to select either a Hand or Auto mode of operation. Hand mode is defaulted to keypad operation, and Auto mode is defaulted to control from an external terminal source. These modes of operation can be configured via programming to allow for alternate combinations of start and speed sources. Start and speed sources include keypad, I/O and FieldBus.	Control
K5	**MANUAL/AUTO Speed Reference Switch**—Provides a door-mounted selector switch for Manual/Auto speed reference.	Control
K6	**START/STOP Pushbuttons**—Provides door-mounted START and STOP pushbuttons for either bypass or non-bypass configurations.	Control
KB	**115 V Control Transformer–550 VA**—Provides a fused control power transformer with additional 550 VA at 115V for customer use.	Control
KF	**Bypass Test Switch for RB and RA—**Allows the user to energize the AF drive for testing while operating the motor on the bypass controller. The Test Switch is mounted on the inside of the enclosure door.	Addl. bypass
KO	**Standard Elapsed Time Meter**—Provides a door-mounted elapsed run time meter.	Control
L1	**Power On and Fault Pilot Lights**—Provides a white power on light that indicates power to the enclosed cabinet and a red fault light indicates a drive fault has occurred.	Light
L2	**Bypass Pilot Lights for RB, RA Bypass Options**—A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. The lights are mounted on the enclosure door, above the switches.	Addl. bypass
LE	**RUN Pilot Light**—Provides a green run light that indicates the drive has been commanded to start.	Light
P1	**Input Disconnect Assembly Rated to 100 kAIC**—High Interrupting Motor Circuit Protector (HMCP) that provides a means of short-circuit protection for the power cables between it and the SVX9000, and protection from high-level ground faults on the power cable. Allows a convenient means of disconnecting the SVX9000 from the line and the operating mechanism can be padlocked in the OFF position. This is factory mounted in the enclosure.	Input
P2	**Disconnect Switch**—Disconnect switch option is applicable only with NEMA Type 1 and NEMA Type 12 Freestanding drives. Allows a convenient means of disconnecting the SVX9000 from the line, and the operating mechanism can be padlocked in the OFF position. This is factory-mounted in the enclosure.	Input
P3	**Input Line Fuses Rated to 200 kAIC—**Provides high-level fault protection of the SVX9000 input power circuit from the load side of the fuses to the input side of the power transistors. This option consists of three 200 kA fuses, which are factory mounted in the enclosure.	Input
P7	**MOV Surge Suppressor**—Provides a metal oxide varistor (MOV) connected to the line side terminals and is designed to clip line side transients.	Input
PE	**Output Contactor**—Provides a means for positive disconnection of the drive output from the motor terminals. The contactor coil is controlled by the drive's run or permissive logic. NC and NO auxiliary contacts rated at 10A, 600 Vac are provided for customer use. Bypass Options **RB** and **RA** include an Output Contactor as standard. This option includes a low VA 115 Vac fused Control Power Transformer and is factory mounted in the enclosure.	Output
PF	**Output Filter—**Used to reduce the transient voltage (DV/DT) at the motor terminals. The Output Filter is recommended for cable lengths exceeding 100 ft (30m) with a drive of 3 hp and above, for cable lengths of 33 ft (10m) with a drive of 2 hp and below, or for a drive rated at 525–690V. This option is mounted in the enclosure, and may be used in conjunction with a brake chopper circuit.	Output
PG	**MotoRx (300–600 ft) 1000 V/µS DV/DT Filter**—Used to reduce transient voltage (DV/DT) and peak voltages at the motor terminals. This option is comprised of a 0.5% line reactor, followed by capacitive filtering and an energy recovery/clamping circuit. Unlike the Output Filter (See option **PF**), the MotoRx recovers most of the energy from the voltage peaks, resulting in a lower voltage drop to the motor, and therefore conserving power. This option is used when the distance between a single motor and the drive is 300–600 ft (91–183m). *This option can not be used with the Brake Chopper Circuit. The Output Filter (option **PF**) should be investigated as an alternative.*	Output
PH	**Single Overload Relay**—Uses a bimetallic overload relay to provide additional overload current protection to the motor on configurations without bypass options. It is included with the Bypass Configurations for overload current protection in the bypass mode. The Overload Relay is mounted within the enclosure, and is manually resettable. Heater pack included.	Output

Table 31.4-5. Available Control/Communications Options (Continued)

Option	Description	Option Type
PI	**Dual Overload Relays**—This option is recommended when a single drive is operating two motors and overload current protection is needed for each of the motors. The standard configuration includes two bimetallic overload relays, each sized to protect a motor with 50% of the drive hp rating. For example, a 100 hp drive would include two overload relays sized to protect two 50 hp motors. The relays are mounted within the enclosure, and are manually resettable. Heater packs not included.	Output
PN	**Dual Overloads for Bypass**—This option is recommended when a single drive is operating two motors in the bypass mode and overload current protection is needed for each of the motors. The standard configuration includes two bimetallic overload relays, each sized to protect a motor with 50% of the drive hp rating. For example, a 100 hp drive would include two overload relays sized to protect two 50 hp motors. The relays are mounted within the enclosure, and are manually resettable.	Addl. bypass
RA	**Manual HOA Bypass Controller**—The Manual HAND/OFF/AUTO (HOA)—three-contactor—bypass option provides a means of bypassing the SVX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. This option consists of an input disconnect, a fused control power transformer, and a full voltage bypass starter with a door-mounted HOA selector switch and an INVERTER/BYPASS switch. The HOA switch provides the ability to start and stop the drive in the inverter mode. The Bypass includes an input contactor, an output contactor, and a bypass starter with an electronic overload relay. The contactors are mechanically and electrically interlocked.	Bypass
RB	**Manual IOB Bypass Controller**—The Manual INVERTER/OFF/BYPASS (IOB)—three-contactor—bypass option provides a means of bypassing the SVX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. This option consists of an input disconnect, a fused control power transformer, and a full voltage bypass starter with a door-mounted IOB selector switch. The Bypass includes an input contactor, an output contactor, and a bypass starter with an electronic overload relay. The contactors are mechanically and electrically interlocked.	Bypass
RC	**Auto Transfer HOA Bypass Controller**–The Manual HAND/OFF/AUTO (HOA)—three-contactor—bypass option provides a means of bypassing the SVX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. The circuitry provides an automatic transfer of the load to "across the line" operation after a drive trip. This option consists of an input disconnect, a fused control power transformer, and a full voltage bypass starter with a door-mounted HOA selector switch and an INVERTER/BYPASS switch. The HOA switch provides the ability to start and stop the drive in either mode. The Bypass includes an input contactor, an output contactor, and a bypass starter with an electronic overload relay. The contactors are mechanically and electrically interlocked. Door-mounted pilot lights are provided that indicate bypass or inverter operation. A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. **Warning**: The motor may restart when the overcurrent relay is reset when operating in bypass, unless the IOB selector switch is turned to the OFF position.	Bypass
RD	**Auto Transfer IOB Bypass Controller**—The Auto INVERTER/OFF/BYPASS (IOB)—three-contactor—bypass option provides a means of bypassing the SVX9000, allowing the AC motor to be operated at full speed directly from the AC supply line. The circuitry provides an automatic transfer of the load to "across the line" operation after a drive trip. This option consists of an input disconnect, a fused control power transformer, and a full voltage bypass starter with a door mounted IOB selector switch. The Bypass includes an input contactor, an output contactor, and a bypass starter with an electronic overload relay. The contactors are mechanically and electrically interlocked. Door-mounted pilot lights are provided which indicate bypass or inverter operation. A green light indicates when the motor is running in inverter mode and an amber light indicates when the motor is running in bypass mode. **Warning**: The motor may restart when the overcurrent relay is reset when operating in bypass, unless the IOB selector switch is turned to the OFF position.	Bypass
S5	**Floor Stand 22 Inches**—Converts a Size 1 or 2, normally wall mounted enclosure to a floor standing enclosure with a height of 22 inches (558.8 mm).	Enclosure
S6	**Floor Stand 12 Inches**—Converts a Size 2, normally wall mounted enclosure to a floor standing enclosure with a height of 12 inches (304.8 mm).	Enclosure
S7	**10-Inch Expansion**—In a Size 5 enclosure, the extension allows for bottom cable entry and additional space for customer mounted components. **Note:** Enclosure expansion rated NEMA Type 1 only.	Enclosure
S8	**20-Inch Expansion**—In a Size 5 enclosure, the extension allows for bottom cable entry and additional space for customer mounted components. When the Output Filter (option **PF**) is selected for a drive using a Size 5 enclosure, this expansion box is required and included in the option pricing. **Note:** Enclosure expansion rated NEMA Type 1 only.	Enclosure
S9	**Space Heater—**Prevents condensation from forming in the enclosure when the drive is inactive or in storage. Includes a thermostat for variable temperature control. A 200W heater is installed in enclosures 0 and 1, and a 400W heater is installed in enclosures 2–5. Requires a customer supplied 115V remote supply source.	Enclosure

Note: For availability, see base drive voltage required.

Table 31.4-6. Input Molded-Case Breaker Sizes—230V Ratings

hp	Frame Size	FLA	Breaker Current
1	FR4	4.8	15
1-1/2	FR4	6.6	15
2	FR4	7.8	15
3	FR4	11	15
5	FR5	17.5	20
7-1/2	FR5	25	30
10	FR6	31	40
15	FR6	48	60
20	FR7	61	80
25	FR7	72	100
30	FR7	87	100

Note: Based on a maximum of 104°F (40°C). A UL listed breaker must be used.

Table 31.4-7. Input Molded-Case Breaker Sizes—480V Ratings

hp	Frame Size	FLA	Breaker Current
1-1/2	FR4	3.3	15
2	FR4	4.3	15
3	FR4	5.6	15
5	FR4	7.6	15
7-1/2	FR5	12	20
10	FR5	16	30
15	FR5	23	30
20	FR6	31	40
25	FR6	38	50
30	FR6	46	60
40	FR7	61	80
50	FR7	72	100
60	FR7	87	100
75	FR8	105	1 25
100	FR8	140	150
125	FR8	170	200
150	FR9	205	250
200	FR9	261	300
250	FR10	300	400
300	FR10	385	500
350	FR10	460	600
400	FR11	520	700
500	FR11	590	800
550	FR11	650	900
600	FR12	750	1000
650	FR12	820	1000
700	FR12	920	1200

Note: Based on a maximum of 104°F (40°C). A UL listed breaker must be used.

Table 31.4-8. Input Fuse Sizes—230V Ratings

VT hp	Frame Size	NEC I (A)	I (A)	Fuse Quantity	Fuse (A)
1	FR4	4.2	4.8	3	10
1-1/2	FR4	6	6.6	3	10
2	FR4	6.8	7.8	3	10
3	FR4	9.6	11	3	15
5	FR5	15.2	17.5	3	20
7-1/2	FR5	22	25	3	30
10	FR5	28	31	3	40
15	FR6	42	48	3	60
20	FR6	54	61	3	80
25	FR7	68	72	3	100
30	FR7	80	87	3	110
40	FR7	104	114	3	125
50	FR8	130	140	3	175
60	FR8	154	170	3	200
75	FR8	192	205	3	250
100	FR9	248	261	3	300

Note: UL recognized type JJS preferred but RK acceptable.

Table 31.4-9. Input Fuse Sizes—480V Ratings

VT hp	Frame Size	NEC I (A)	I (A)	Fuse Quantity	Fuse (A)
1-1/2	FR4	3	3.3	3	10
2	FR4	3.4	4.3	3	10
3	FR4	4.8	5.6	3	10
5	FR4	7.6	7.6	3	10
7-1/2	FR4	11	12	3	15
10	FR5	14	16	3	20
15	FR5	21	23	3	30
20	FR5	27	31	3	35
25	FR6	34	38	3	50
30	FR6	40	46	3	60
40	FR6	52	61	3	80
50	FR7	65	72	3	100
60	FR7	77	87	3	110
75	FR7	96	105	3	125
100	FR8	124	140	3	175
125	FR8	156	170	3	200
150	FR8	180	205	3	250
200	FR9	240	261	3	350
250	FR9	302	300	3	400
300	FR10	361	385	3	450
350	FR10	414	460	3	500
400	FR10	477	520	3	600
500	FR11	590	590	6	350
550	FR11	NS	650	6	400
600	FR11	NS	730	6	450
650	FR12	NS	820	6	500
700	FR12	NS	920	6	500
800	FR12	NS	1030	6	600

Note: UL recognized type JJS preferred but RK acceptable.

Product Selection

When Ordering

- Select a base catalog number that meets the application requirements—nominal horsepower, voltage and enclosure rating (the enclosed drive's continuous output amp rating should be equal to or greater than the motor's full load amp rating). The base enclosed package includes a standard drive, door mounted Local/Remote Keypad and enclosure
- If dynamic brake chopper or Control/Communication option is desired, change the appropriate code in the base catalog number
- Select enclosed options. Add the codes as suffixes to the base catalog number in alphabetical and numeric order
- **Read all footnotes**

208V Drives

Table 31.4-10. 208 Vac Input Base Drive

Enclosure Size ①	hp	Current (A)	NEMA Type 1 Frame Size	NEMA Type 12 Frame Size	Drawing Number
208V High Overload Drive and Enclosure—I_H = Constant Torque					
0	3/4	3.7	4	4	9
0	1	4.8	4 FR4	4	9
0	1-1/2	6.6	4	4	9
0	2	7.8	4	4	9
0	3	11	4	4	9
0	5	17.5	5	5	9
0	7-1/2	25	5	5	9
1	10	31	6	6	10
1	15	48	6	6	10
2	20	61	7	7	11
2	25	75	7	7	11
2	30	88	7	7	11
3	40	114	8	8	12
4	50	143	8	8	13
5	60	170	8	8	14
5	75	211	9	9	14
5	100	273	9	9	14
208V Low Overload Drive and Enclosure—I_L = Variable Torque					
0	1	4.8	4	4	9
0	1-1/2	6.6	4	4	9
0	2	7.8	4	4	9
0	3	11	4	4	9
0	5	17.5	5	5	9
0	7-1/2	25	5	5	9
0	10	31	5	5	9
1	15	48	6	6	10
1	20	61	6	6	10
2	25	75	7	7	11
2	30	88	7	7	11
2	40	114	7	7	11
3	50	—	8	8	12
4	60	170	8	8	13
5	75	—	8	8	14
5	100	—	9	9	14

① Enclosure dimensions listed on **Pages 31.4-11–31.4-19**.
② Includes drive, Local/Remote keypad and enclosure.

Note: Drive heat dissipation calculations listed on **Page 31.4-10**.

230V Drives

Table 31.4-11. 230 Vac Input Base Drive

Enclosure Size ①	hp	Current (A)	NEMA Type 1 Frame Size	NEMA Type 12 Frame Size	Drawing Number
230V High Overload Drive and Enclosure—I_H = Constant Torque					
0	3/4	3.7	4	4	9
0	1	4.8	4	4	9
0	1-1/2	6.6	4 FR	4 FR	9
0	2	7.8	4	4	9
0	3	11	4	4	9
0	5	17.5	5	5	9
0	7-1/2	25	5	5	9
1	10	31	6	6	10
1	15	48	6	6	10
2	20	61	7	7	11
2	25	75	7	7	11
2	30	88	7	7	11
3	40	114	8	8	12
4	50	140	8	8	13
5	60	170	8	8	14
5	75	205	9	9	14
5	100	261	9	9	14
230V Low Overload Drive and Enclosure—I_L = Variable Torque					
0	1	4.8	4	4	9
0	1-1/2	6.6	4	4	9
0	2	7.8	4	4	9
0	3	11	4	4	9
0	5	17.5	5	5	9
0	7-1/2	25	5	5	9
0	10	31	5	5	9
1	15	48	6	6	10
1	20	61	6	6	10
2	25	75	7	7	11
2	30	88	7	7	11
2	40	114	7	7	11
3	50	140	8	8	12
4	60	170	8	8	13
5	75	205	8	8	14
5	100	261	9	9	14

① Enclosure dimensions listed on **Pages 31.4-11–31.4-19.**
② Includes drive, Local/Remote keypad and enclosure.

480V Drives

Table 31.4-12. 480 Vac Input Base Drive

Enclosure Size ①	hp	Current (A)	NEMA Type 1 Frame Size	NEMA Type 12 Frame Size	Drawing Number
High Overload Drive and Enclosure—I_H = Constant Torque					
0	1	2.2	4	4	9
0	1-1/2	3.3	4	4	9
0	2	4.3	4 FR	4 FR	9
0	3	5.6	4	4	9
0	5	7.6	4	4	9
0	7-1/2	12	5	5	9
0	10	16	5	5	9
0	15	23	5	5	9
1	20	31	6	6	10
1	25	38	6	6	10
1	30	46	6	6	10
2	40	61	7	7	11
2	50	72	7	7	11
2	60	87	7	7	11
3	75	105	8	8	12
3	100	140	8	8	12
4	125	170	8	8	13
5	150	205	9	9	14
5	200	245	9	9	14
6, 8 ④⑥	250	300	10	10	15 ④, 16 ⑥
6, 8 ④⑥	300	385	10	10	15 ④, 16 ⑥
6, 8 ④⑥	350	460	10	10	15 ④, 16 ⑥
8, 9 ⑤⑥	400	520	11	11	16 ⑤, 17 ⑥
8, 9 ⑤⑥	500	590	11	11	16 ⑤, 17 ⑥
8, 9 ⑤⑥	550	650	11	11	16 ⑤, 17 ⑥
③	600	730	12	12	③
③	650	820	12	12	③
③	700	920	12	12	③
Low Overload Drive and Enclosure—I_L = Variable Torque					
0	1-1/2	3.3	4	4	9
0	2	4.3	4	4	9
0	3	5.6	4	4	9
0	5	7.6	4	4	9
0	7-1/2	12	4	4	9
0	10	16	5	5	9
0	15	23	5	5	9
0	20	31	5	5	9
1	25	38	6	6	10
1	30	46	6	6	10
1	40	61	6	6	10
2	50	72	7	7	11
2	60	87	7	7	11
2	75	105	7	7	11
3	100	140	8	8	12
4	125	170	8	8	13
4	150	205	8	8	13
5	200	261	9	9	14
5	250	300	9	9	14
6, 8 ④⑥	300	385	10	10	15 ④, 16 ⑥
6, 8 ④⑥	350	460	10	10	15 ④, 16 ⑥
6, 8 ④⑥	400	520	10	10	15 ④, 16 ⑥
8, 9 ⑤⑥	500	590	11	11	16 ⑤, 17 ⑥
8, 9 ⑤⑥	550	650	11	11	16 ⑤, 17 ⑥
8, 9 ⑤⑥	600	730	11	11	16 ⑤, 17 ⑥
③	650	820	12	12	③
③	700	920	12	12	③
③	800	1030	12	12	③

① Enclosure dimensions listed on **Pages 31.4-11–31.4-19.**
② Includes drive, Local/Remote keypad and enclosure.
③ Consult Eaton.
④ The smaller enclosure Size 6 accommodates only power options, input disconnect (P1) and input line fuses (P3). Bypass and other options require Size 8. Adding any standard control option will not require the larger enclosure.
⑤ The smaller enclosure Size 8 accommodates only power options, input disconnect (P1) and input line fuses (P3). Bypass and other options require Size 9. Adding any standard control option will not require the larger enclosure.
⑥ For other options, consult factory.

Drive Heat Dissipation Calculations

The Eaton 9000X drive is a highly efficient electric power converter releasing minimal amounts of waste heat energy into the ambient air. The amount of heat loss from the drive in operation is directly proportional to the load of the connected motor, the drive switching frequency and operating frequency. Based on the drive operating load, the heat dissipation can be calculated at a given operating point. For most cases, the following general formula can be used to estimate the heat dissipation of the power module:

P_{motor} [kW] x 0.025 = P_{loss} [kW]

Where P_{motor} is the operating power of the motor and P_{loss} is the heat dissipated from the 9000X drive.

For example, a 20 hp [15 kW] motor is applied with a 9000X inverter on a pump application. The application has been designed so that maximum motor load will be 95% or 14.3 kW.

Using the formula above, the calculated heat dissipation of the drive will be approximately 356 watts/hour or 1215 BTU/hour at the designed maximum load.

15 kW x 0.95 = 14.3 kW

14.3 kW x 0.025 = 0.356 kW/hour or 356 watts/hour

356 watts/hour x 3.412 = 1215 BTU/hour

Note: This example assumes the default switching frequency has been used.

Additional conversion formulas:

hp x 0.7457 = kW

hp x 745.7 = watts

kW x 1000 = watts

Watts/hour x 3.412 = BTU/hour

Dimensions

SVX Drawing 9—Enclosure Size 0

Table 31.4-13. Approximate Dimensions and Shipping Weight—Enclosed Products

Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	E	E1	F	G	G1		J	K
0	19.90 (504)	29.00 (737)	16.40 (416)	18.30 (465)	—	—	—	27.40 (695)	—	—	25.40 (644)	4.00 (102)	3.00 (76)

Table 31.4-13. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)										Maximum Approximate Shipping Weight Lbs (kg)
	Cable Entry					Door Clearance S	T	U	V	W	
	L	M	N	P	R						
0	5.00 (127)	—	—	6.00 (152)	9.60 (245)	26.40 (669)	1.50 (38)	6.30 (160)	4.30 (108)	5.30 (134)	200 (91)

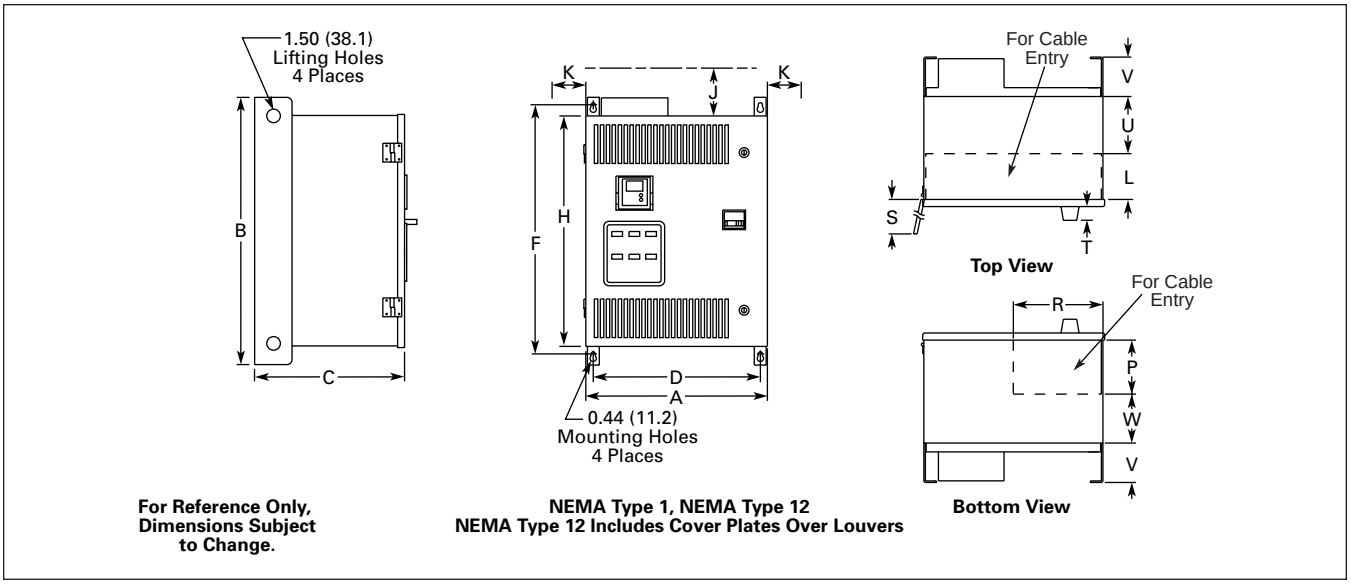


Figure 31.4-2. Approximate Dimensions

SVX Drawing 10—Enclosure Size 1

Table 31.4-14. Approximate Dimensions and Shipping Weight—Enclosed Products

Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	E	E1	F	G	G1		J	K
1	26.40 (669)	36.00 (914)	16.30 (414)	24.80 (630)	—	—	—	34.00 (864)	—	—	32.40 (822)	4.00 (102)	3.00 (76)

Table 31.4-14. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)															
	Cable Entry					Door Clearance S	T	U	V	W	Floor Stand					
	L	M	N	P	R						X	Y	Z	AA	BB	CC
1	11.00 (279)	6.00 (152)	9.00 (229)	10.00 (254)	6.50 (165)	26.40 (669)	1.50 (38)	4.30 (108)	—	—	56.00 (1422)	4.30 (108)	11.10 (281)	1.80 (46)	0.80 (19)	55.20 (1402)

Table 31.4-14. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)															Max. Approx. Ship. Wt. Lbs (kg)
	Floor Stand											RR	SS	TT	UU	VV	
	DD	EE	FF	GG	HH	JJ	KK	LL	MM	NN	PP						
1	26.00 (660)	3.50 (90)	5.50 (141)	3.00 (76)	6.00 (152)	2.00 (51)	5.40 (136)	1.10 (28)	8.80 (224)	5.40 (137)	—	—	—	—	—	—	230 (104)

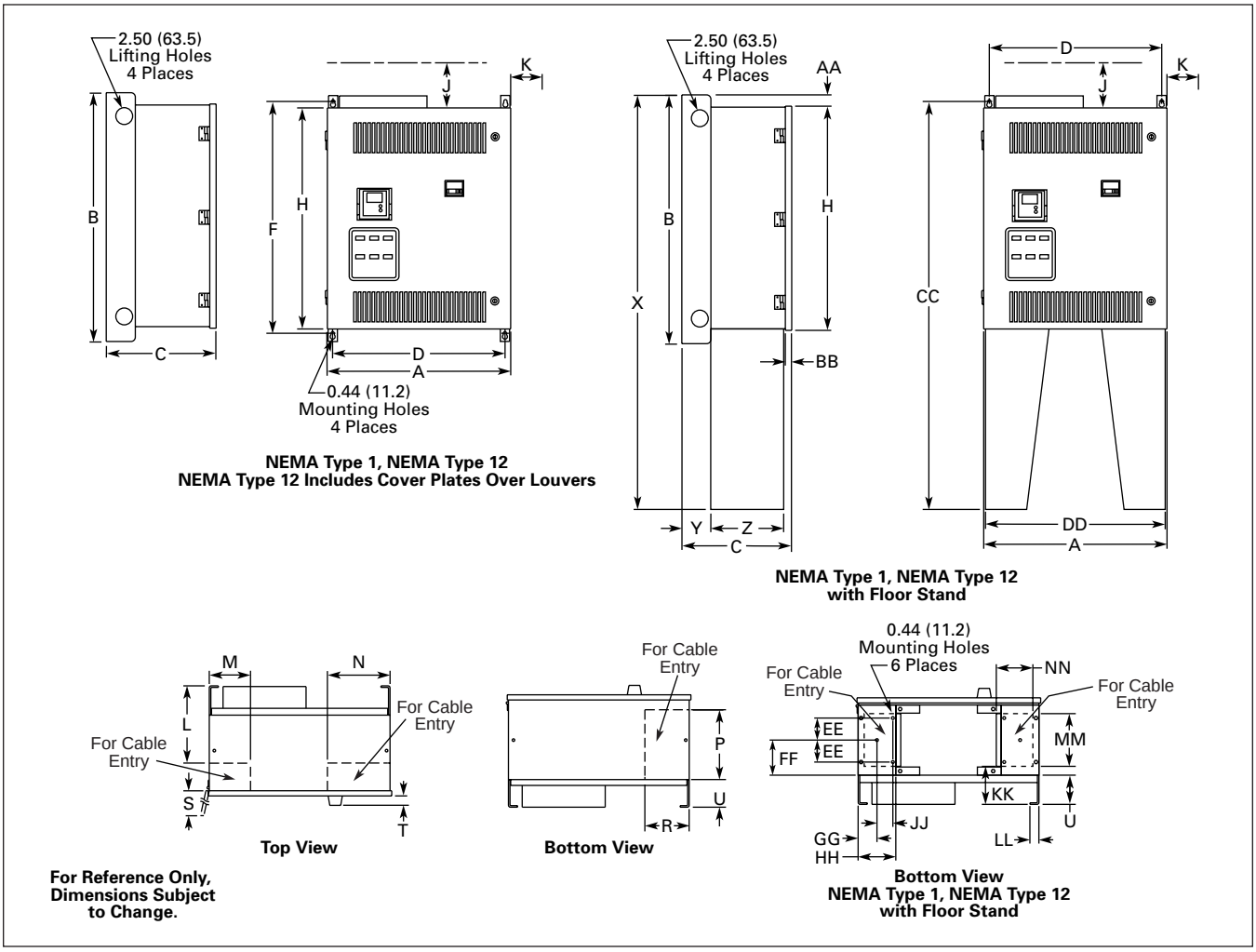


Figure 31.4-3. Approximate Dimensions

SVX Drawing 11—Enclosure Size 2

Table 31.4-15. Approximate Dimensions and Shipping Weight—Enclosed Products

Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	E	E1	F	G	G1		J	K
2	26.40 (669)	59.00 (1499)	19.40 (492)	24.80 (630)	—	—	—	57.00 (1448)	—	—	55.40 (1406)	4.00 (102)	3.00 (76)

Table 31.4-15. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)															
	Cable Entry					Door Clearance S	T	U	V	W	Floor Stand					
	L	M	N	P	R						X	Y	Z	AA	BB	CC
2	5.90 (149)	—	—	12.40 (315)	9.50 (241)	26.40 (669)	1.50 (38)	4.80 (121)	5.90 (151)	—	69.00 (1753)	4.80 (121)	13.60 (344)	1.80 (46)	0.80 (19)	68.20 (1732)

Table 31.4-15. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)															Max. Approx. Ship. Wt. Lbs (kg)
	Floor Stand											RR	SS	TT	UU	VV	
	DD	EE	FF	GG	HH	JJ	KK	LL	MM	NN	PP						
2	26.00 (660)	4.80 (121)	6.80 (172)	3.00 (76)	6.00 (152)	2.00 (51)	5.00 (127)	1.10 (28)	11.30 (288)	79.00 (2007)	78.20 (1986)	—	—	—	—	—	380 (173)

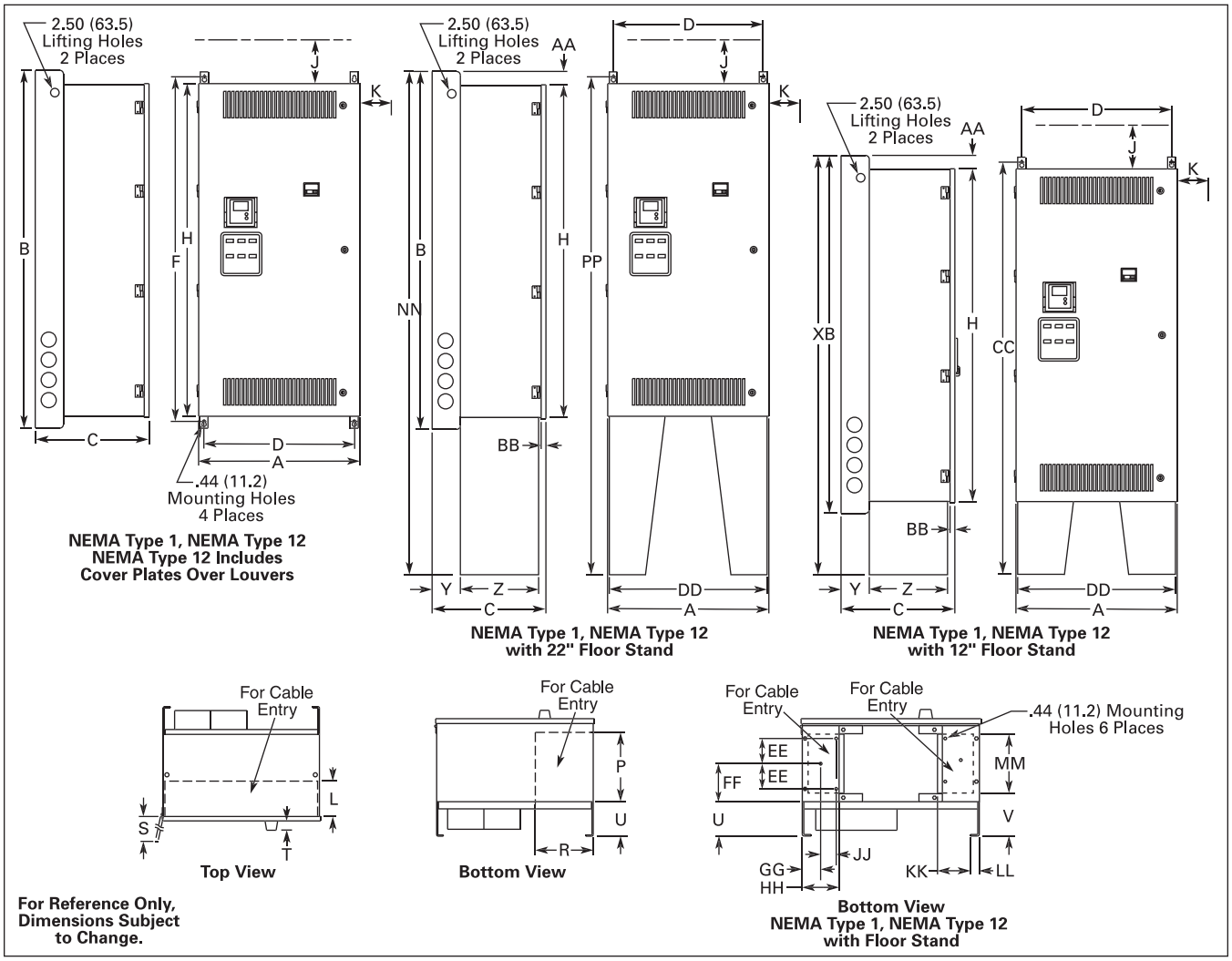


Figure 31.4-4. Approximate Dimensions

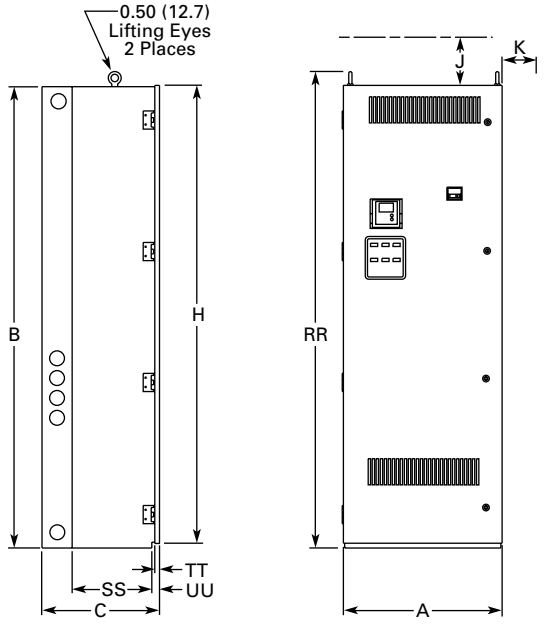
SVX Drawing 12—Enclosure Size 3

Table 31.4-16. Approximate Dimensions and Shipping Weight—Enclosed Products

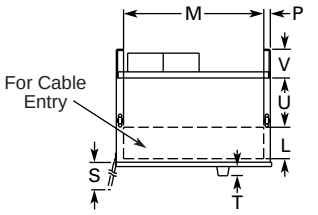
Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	E	E1	F	G	G1		J	K
3	26.40 (671)	77.00 (1956)	19.40 (493)	19.50 (495)	3.30 (83)	23.00 (584)	1.50 (38)	11.70 (298)	5.50 (140.)	0.90 (24)	76.40 (1939)	4.00 (102)	3.00 (76)

Table 31.4-16. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

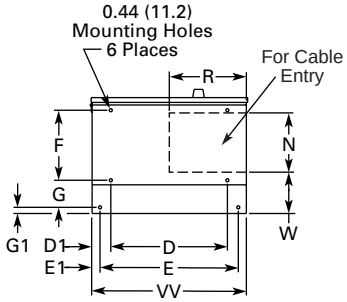
Enclosure Size	Dimensions in Inches (mm)														Max. Approx. Ship. Wt. Lbs (kg)
	Cable Entry					Door Clearance S	T	U	V	W	RR	SS	TT	UU	VV	
	L	M	N	P	R											
3	5.30 (133)	23.40 (594)	10.00 (254)	1.30 (32)	12.90 (328)	26.40 (669)	1.50 (38)	8.00 (203)	4.80 (121)	6.80 (173)	79.50 (2018)	13.40 (340)	0.80 (19)	1.30 (32)	26.00 (660)	690 (313)



NEMA Type 1, NEMA Type 12
NEMA Type 12 Includes Cover Plates Over Louvers



Top View



Bottom View

For Reference Only, Dimensions Subject to Change.

Figure 31.4-5. Approximate Dimensions

SVX Drawing 13—Enclosure Size 4

Table 31.4-17. Approximate Dimensions and Shipping Weight—Enclosed Products

Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	E	E1	F	G	G1		J	K
4	26.40 (671)	90.00 (2286)	19.40 (493)	19.50 (495)	3.30 (83)	23.00 (584)	1.50 (38)	11.70 (298)	5.50 (140)	0.90 (24)	89.40 (2270)	4.00 (102)	3.00 (76)

Table 31.4-17. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)														Max. Approx. Ship. Wt. Lbs (kg)
	Cable Entry					Door Clearance S	T	U	V	W	RR	SS	TT	UU	VV	
	L	M	N	P	R											
4	5.30 (133)	23.40 (594)	13.80 (351)	1.00 (25)	11.20 (286)	26.40 (669)	1.50 (38)	8.00 (204)	4.80 (121)	—	92.50 (2349)	0.80 (19)	1.30 (32)	—	—	825 (375)

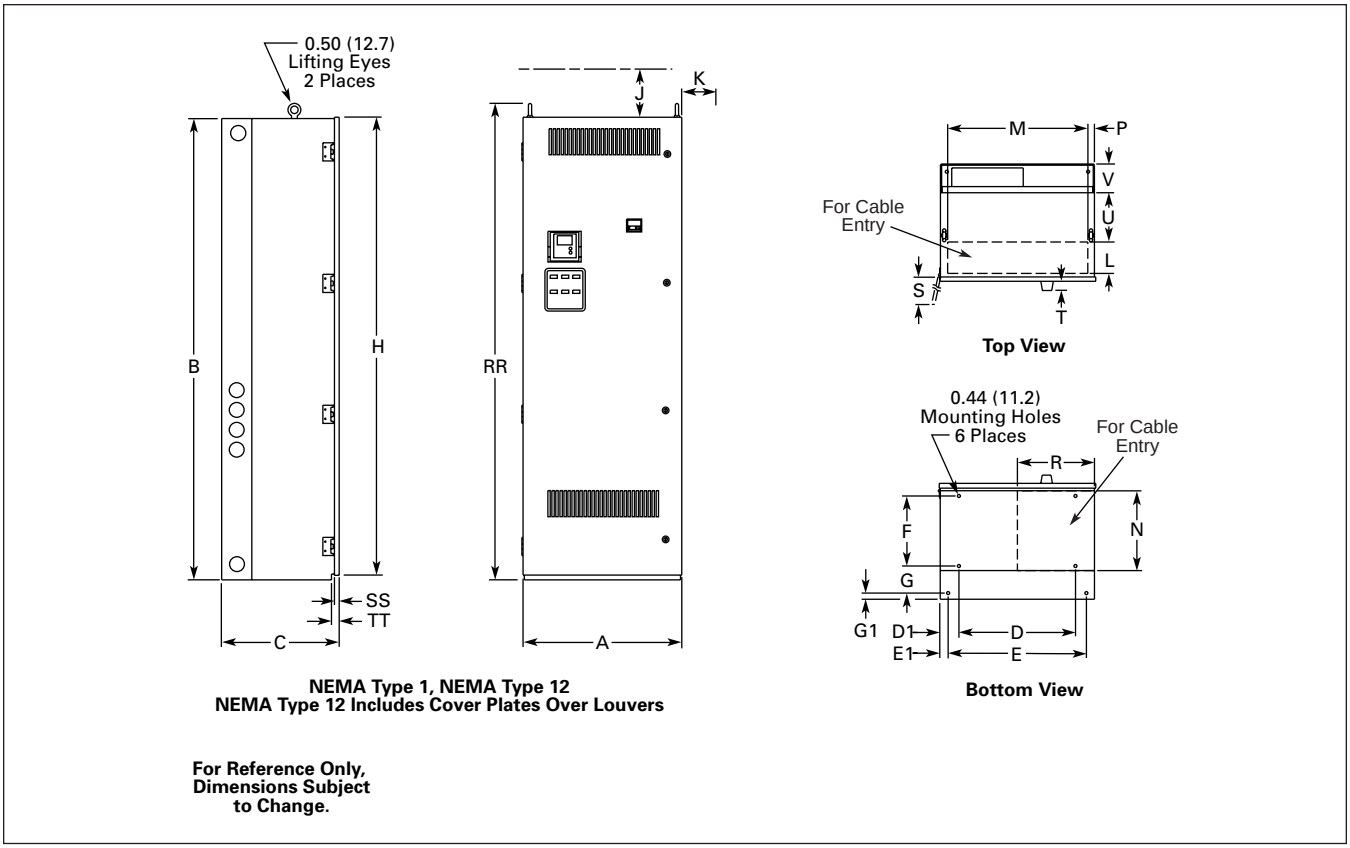


Figure 31.4-6. Approximate Dimensions

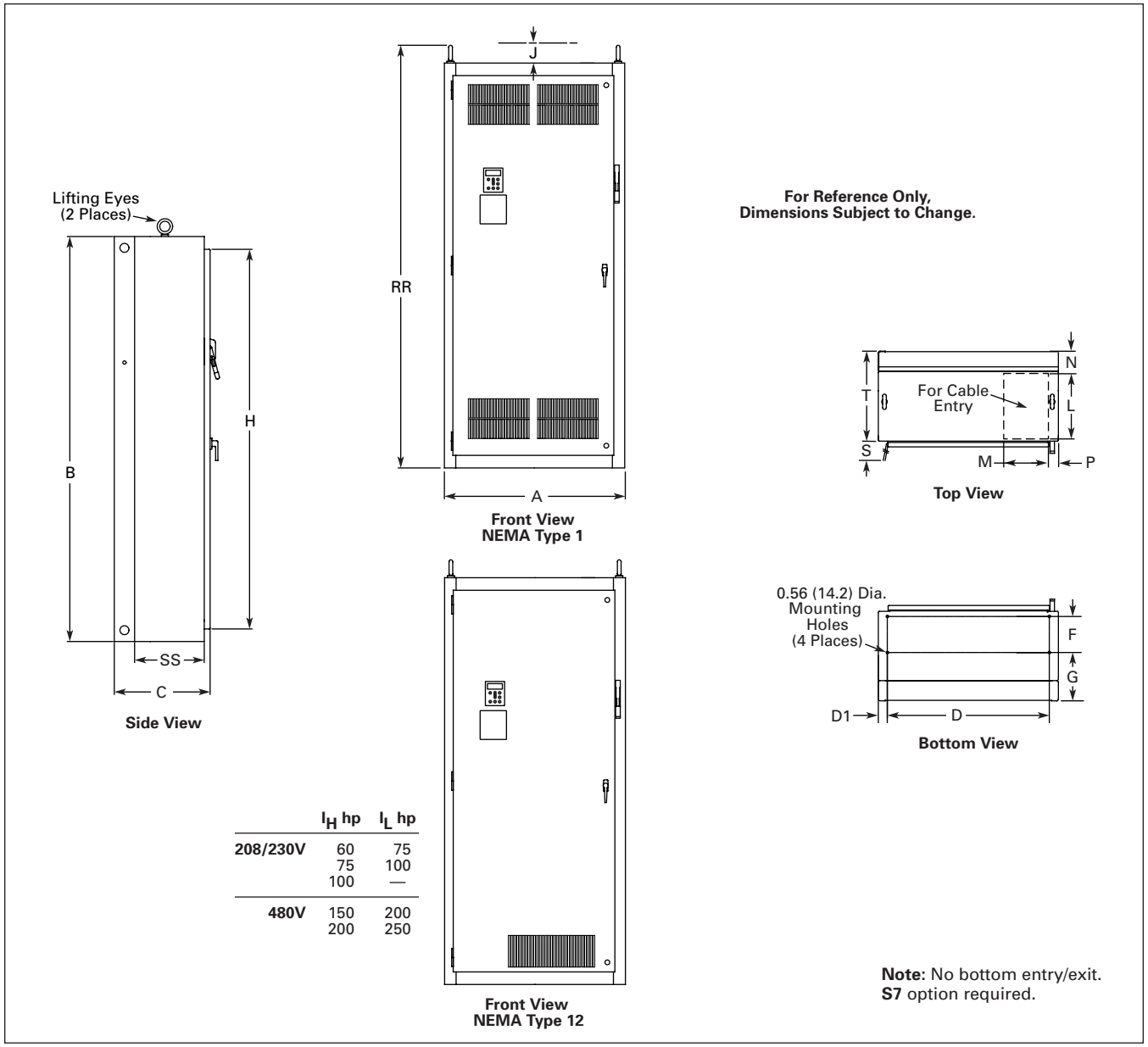
SVX Drawing 14—Enclosure Size 5

Table 31.4-18. Approximate Dimensions and Shipping Weight—Enclosed Products

Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	E	E1	F	G	G1		J	K
5	40.00 (1016)	90.00 (2286)	21.30 (541)	36.00 (914)	2.00 (51)	—	—	8.00 (203)	10.80 (273)	—	84.40 (2143)	4.00 (102)	—

Table 31.4-18. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)														Max. Approx. Ship. Wt. Lbs (kg)
	Cable Entry					Door Clearance S	T	U	V	W	RR	SS	TT	UU	VV	
	L	M	N	P	R											
5	15.00 (381)	10.00 (254)	4.80 (122)	2.00 (51)	—	36.30 (921)	20.00 (508)	—	—	—	94.00 (2387)	15.50 (394)	—	—	—	1275 (579)



	I_H hp	I_L hp
208/230V	60	75
	75	100
	100	—
480V	150	200
	200	250

Figure 31.4-7. Approximate Dimensions

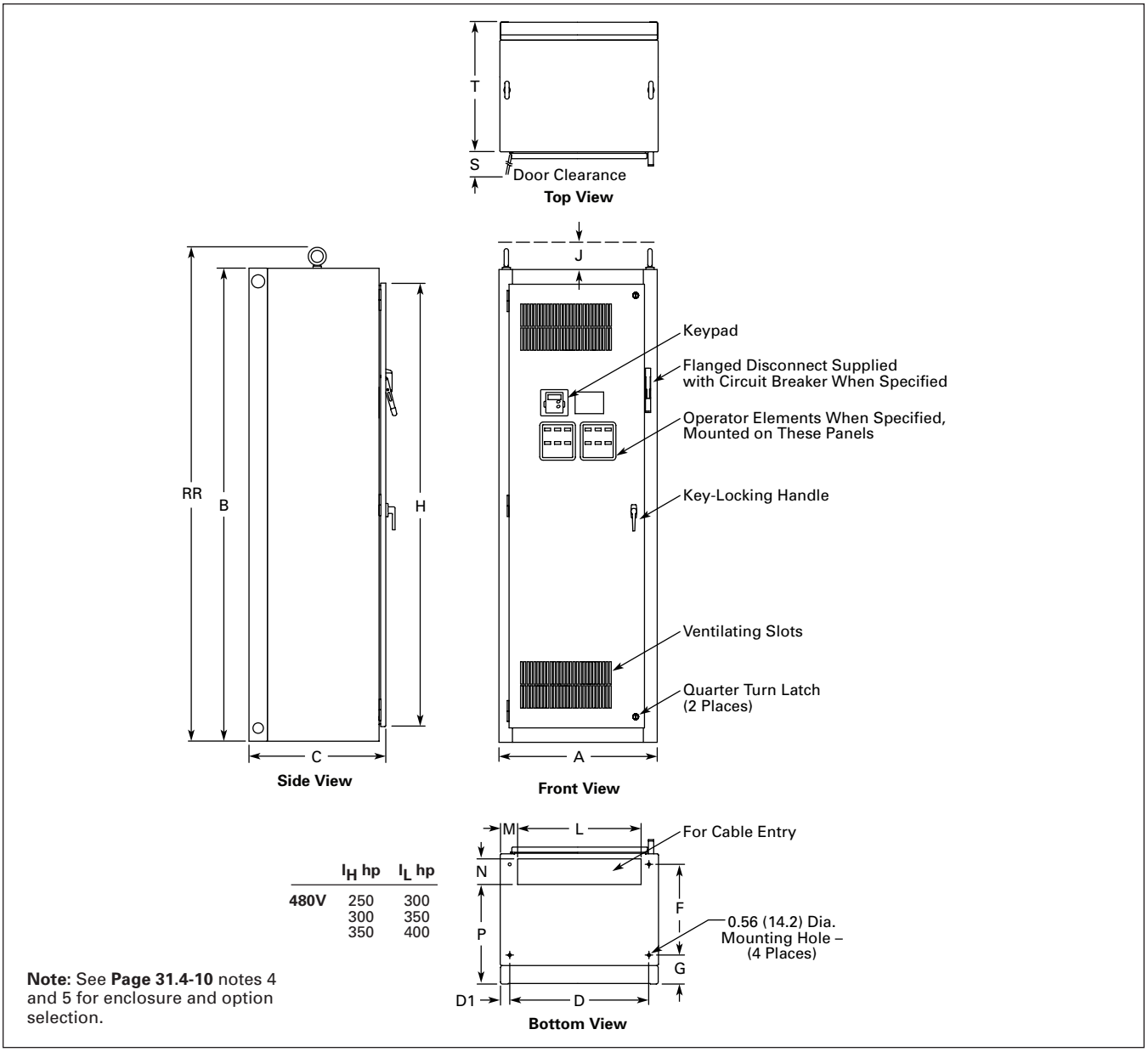
SVX Drawing 15—Enclosure Size 6

Table 31.4-19. Approximate Dimensions and Shipping Weight—Enclosed Products

Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	D2	E	F	G	G1		J	K
6	30.00 (762)	90.00 (2286)	26.00 (660)	26.50 (673)	1.80 (46)	—	—	17.30 (438)	5.50 (140)	—	84.40 (2143)	4.00 (102)	—

Table 31.4-19. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)														Max. Approx. Ship. Wt. Lbs.(kg)
	Cable Entry					Door Clearance S	T	U	V	W	RR	SS	TT	UU	VV	
	L	M	N	P	R											
6	23.5 (597)	03.30 (84)	4.50 (114)	19.30 (490)	—	26.20 (667)	24.80 (629)	—	—	—	93.90 (2386)	—	—	—	—	1500 (681)



Note: See **Page 31.4-10** notes 4 and 5 for enclosure and option selection.

Figure 31.4-8. Approximate Dimensions

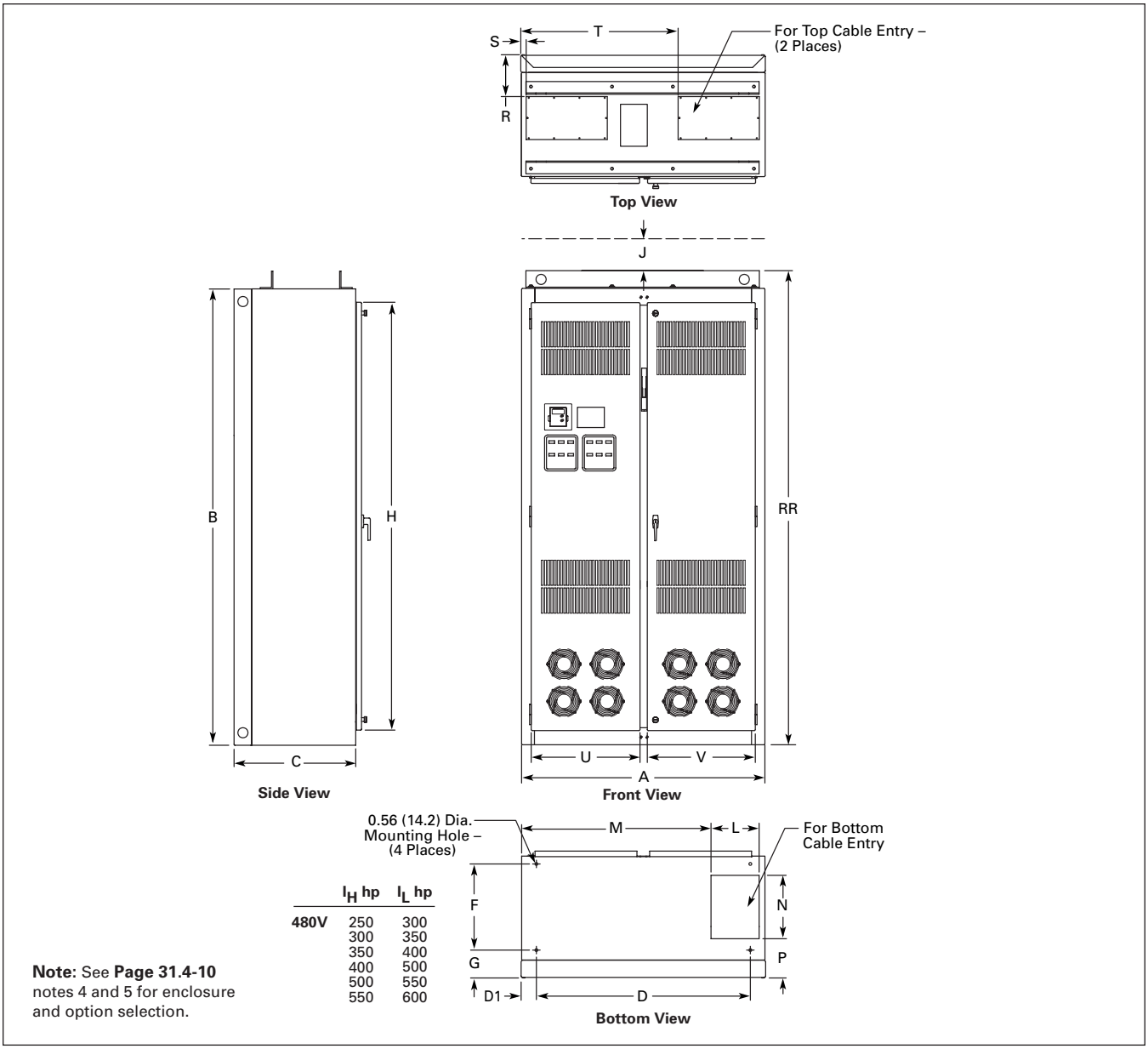
SVX Drawing 16—Enclosure Size 8

Table 31.4-20. Approximate Dimensions and Shipping Weight—Enclosed Products

Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	D2	E	F	G	G1		J	K
8	48.00 (1219)	90.00 (2286)	24.00 (610)	42.20 (1072)	3.00 (77)	—	—	—	5.50 (139)	—	84.40 (2143)	4.00 (102)	—

Table 31.4-20. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

Enclosure Size	Dimensions in Inches (mm)														Max. Approx. Ship. Wt. Lbs (kg)
	Cable Entry							U	V	W	RR	SS	TT	UU	VV	
	L	M	N	P	R	S	T									
8	9.50 (241)	37.50 (952)	12.50 (318)	7.70 (196)	8.30 (210)	1.30 (32)	31.00 (787)	21.50 (545)	21.30 (541)	—	93.50 (2375)	—	—	—	—	2000 (908)



Note: See **Page 31.4-10** notes 4 and 5 for enclosure and option selection.

Figure 31.4-9. Approximate Dimensions

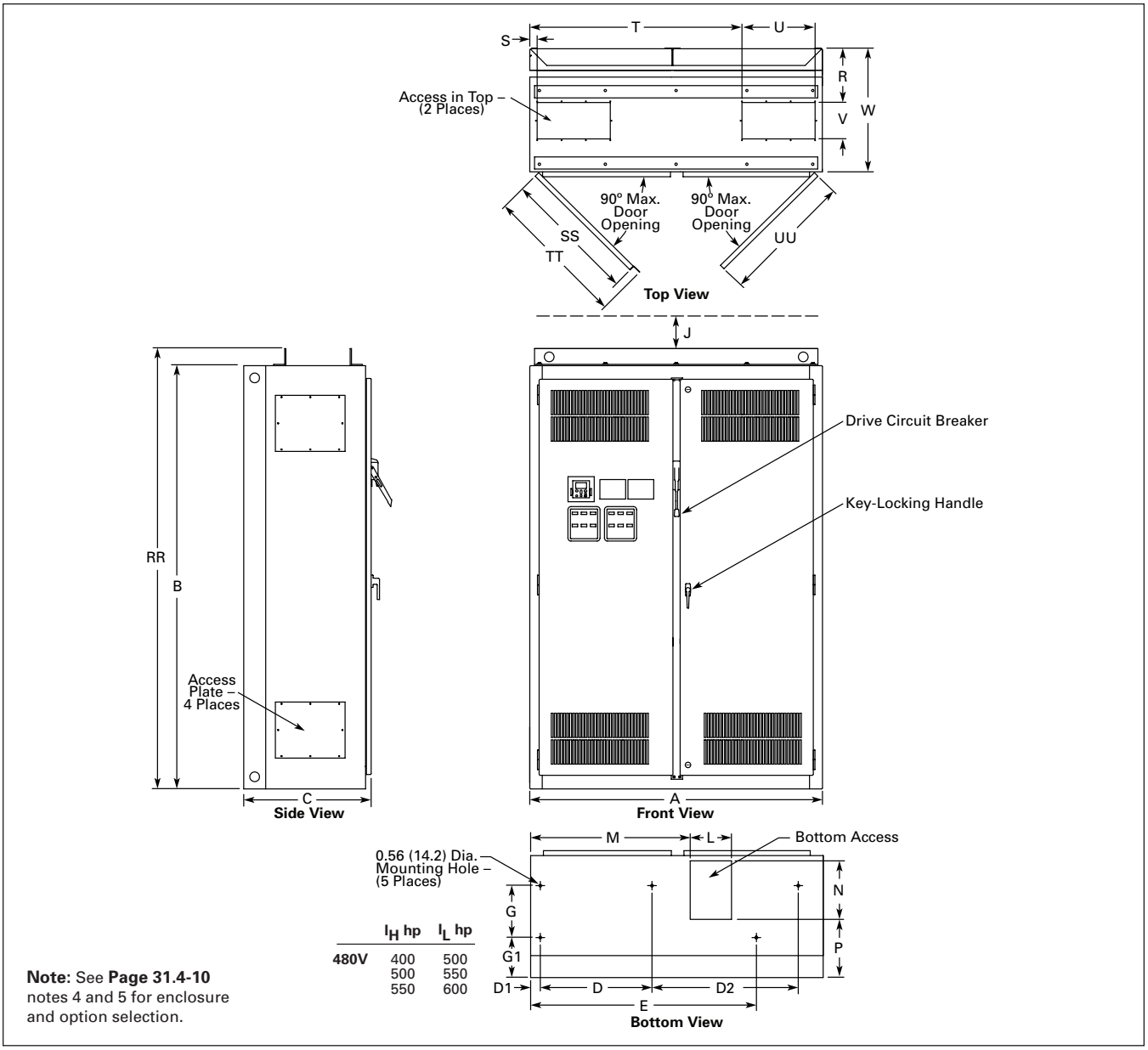
SVX Drawing 17—Enclosure Size 9

Table 31.4-21. Approximate Dimensions and Shipping Weight—Enclosed Products

Enclosure Size	Dimensions in Inches (mm)												
	Wide A	High B	Deep C	Mounting							H	Minimum Air Space	
				D	D1	D2	E	F	G	G1		J	K
9	60.00 (1524)	90.00 (2286)	26.10 (664)	22.90 (582)	2.00 (51)	30.00 (762)	44.30 (1125)	10.60 (270)	10.60 (270)	8.20 (208)	—	4.00 (102)	—

Table 31.4-21. Approximate Dimensions and Shipping Weight—Enclosed Products (Continued)

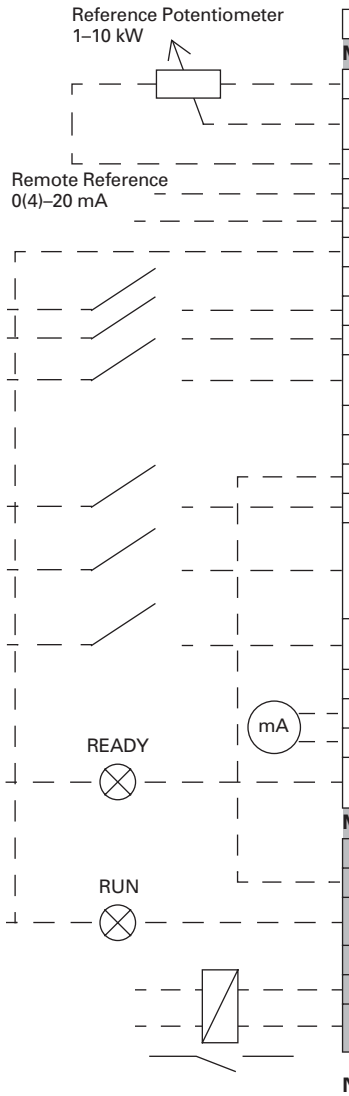
Enclosure Size	Dimensions in Inches (mm)															Max. Approx. Ship. Wt. Lbs (kg)
	Cable Entry									W	RR	SS	TT	UU	VV	
	L	M	N	P	R	S	T	U	V							
9	8.50 (216)	32.70 (831)	12.00 (305)	11.90 (303)	9.80 (249)	1.50 (38)	43.50 (1105)	15.00 (381)	7.50 (191)	25.00 (635)	93.50 (2375)	27.40 (696)	29.10 (738)	27.10 (687)	—	2500 (1135)



Note: See **Page 31.4-10** notes 4 and 5 for enclosure and option selection.

Figure 31.4-10. Approximate Dimensions

Control Input/Output



Terminal		Signal	Description		
NXOPTA9					
1	+10 V_{ref}	Reference output	Voltage for potentiometer, etc.		
2	AI1+	Analog input, voltage range 0–10 Vdc	Voltage input frequency reference		
3	AI1-	I/O ground	Ground for reference and controls		
4	AI2+	Analog input, current range 0–20 mA	Current input frequency reference		
5	AI2-				
6	+24V	Control voltage output	Voltage for switches, etc. maximum 0.1A		
7	GND	I/O ground	Ground for reference and controls		
8	DIN1	Start forward	Contact closed = start forward		
9	DIN2	Start reverse	Contact closed = start reverse		
10	DIN3	External fault input (programmable)	Contact open = no fault Contact closed = fault		
11	CMA	Common for DIN1–DIN3	Connect to GND or +24V		
12	+24V	Control voltage output	Voltage for switches (see terminal 6)		
13	GND	I/O ground	Ground for reference and controls		
14	DIN4	Multi-step speed select 1	DIN4	DIN5	Frequency ref.
15	DIN5	Multi-step speed select 2	Open Closed Open Closed	Open Open Closed Closed	Ref.V_{in} Multi-step Ref.1 Multi-step Ref.2 Ref_{Max}
16	DIN6	Fault reset	Contact open = no action Contact closed = fault reset		
17	CMB	Common for DIN4–DIN6	Connect to GND or +24V		
18	AO1+	Output frequency Analog output	Programmable Range 0–20 mA, R_L maximum 500Ω		
19	AO1-				
20	DO1	Digital output READY	Programmable Open collector, I ≤ 50 mA, V ≤ 48 Vdc		
NXOPTA2					
21	RO1	Relay Output 1 RUN	—		
22	RO1				
23	RO1				
24	RO2	Relay Output 2 FAULT	—		
25	RO2				
26	RO2				

Note: For more information on jumper selections, see the SVX9000 user manual, chapter 4.

Figure 31.4-11. Basic Application Default I/O Configuration

H-Max Series Drives

H-Max Series Drives

General Description

Drives

Eaton's H-Max™ Series VFD is the next generation of drives specifically engineered for HVAC, pump and fluid control applications. Installation, startup and maintenance are world-class with a combination of an ultra-efficient power section and a programmable main control board.

H-Max Series has an expanded startup wizard for HVAC system configuration, which provides the flexibility to meet consultants, OEM and end-user requirements.

IntelliPass and IntelliDisconnect Drives

Eaton's ultra-reliable IntelliPass/IntelliDisconnect drives are designed with the latest HVAC software and hardware features. The IntelliPass integrates electronic (***XT***) bypass with optional manual override switch, which allows the unit to run in bypass without the H-Max Series drive.

The IntelliDisconnect uses Eaton's world-class (***XT***) MMP (manual motor protector) with optional output contactor.

Features

Drives

- Integrated DC link choke standard on drives from FS4–FS9
- DC bus regulation anti-trip
- Input surge protection against voltage spikes varistor input
- HAND/OFF/AUTO and DRIVE/BYPASS selector on keypad simplifies control
- Additional I/O and communication cards provide plug-and-play functionality
- Keypad—copy/paste function allows transfer of parameter settings from one drive to the next. Also allows for redundant storage of drive settings in keypad as well as drive for backup
- Battery backup—real-time clock with PLC functionality
- Two independent PID functions
- Multimonitor up to nine values
- 110% overload for 1 minute once every 10 minutes
- EMC Category 2
- Standard EMI/RFI filter
- Conformal coated boards
- Troubleshooting diagnostics
- Onboard RS-485 (Modbus, N2, FLN, BACnet)
- Onboard Ethernet-based communications (BACnet/IP, Modbus/TCP
- Separate conduit plate allows access to control and power connections
- DB chopper standard frames FS4–FS6 for
  - 1.5–40 hp, 1.1–30 kW, 3.4–61A, 480 Vac
  - 0.75–20 hp, 0.55–15 kW, 3.7–62A, 200–240 Vac
- UL 508C

IntelliPass/IntelliDisconnect

- Circuit breaker provides flexible drive isolation configurations to meet customers' needs
- Robust steel enclosure for simple installation

IntelliPass

- Mechanical, electronic and damper interlocks
- Fire mode
- Monitored and controlled by onboard communication
- Two contactor, mechanically interlocked and fully rated bypass
- Single keypad with HAND/OFF/AUTO and DRIVE/BYPASS simplifies startups and control
- Two power sources for control ensure redundancy and provide additional ride-through capability
- NEMA Type 1
- Programmable auto restart and auto bypass while allowing critical damper interlock functionality

H-Max Drives

H-Max Drives

General Description

Eaton's H-Max Series VFD has software and hardware designed specifically for the HVAC, pump industry. The ultra-efficient DC capacitor and power structure allows the drive to consume less energy, lowering greenhouse gases.

The I/O configuration is designed with wiring ergonomics in mind by including removable terminal blocks. The main, easily removable, control board used for all drive frames with six digital IN, two analog IN, one analog OUT, three relay OUT accepts two additional I/O or communication board. In addition, the control board has built-in RS-485 and Ethernet communication.

These drives continue the tradition of robust performance, and raise the bar on features and functionality, ensuring the best solution at the right price.

Features and Benefits

- Integrated DC link choke standard on drives from FS4 through FS9
- DC bus regulation anti-trip
- Input surge protection against voltage spikes varistor input
- EMI/RFI filters standard on all drives from FS4 through FS9 to meet EMC Category 2
- HAND/OFF/AUTO and DRIVE/BYPASS selector on keypad simplifies control
- Additional I/O and communication cards provide plug-and-play functionality
- Copy/paste function allows transfer of parameter settings from one drive to the next
- Keypad can display up to nine monitored parameters simultaneously
- Remote mount keypad kit available
- NEMA Type 1 and NEMA Type 12 available
- Real-time clock with PLC functionality
- Two independent PID functions
- On-screen troubleshooting diagnostics with embedded manual assistance
- Onboard RS-485 (Modbus, N2, FLN, BACnet)
- Onboard Ethernet-based communications (BACnet/IP, Modbus/TCP
- Standard NEMA Type 12 keypad on all drives
- Quickstart wizard built into programming of drive ensures a smooth startup
- I/O connections with simple quick connection terminals
- Control logic can be powered from an external 24V power supply to simulate internal drive functions and fieldbus, if necessary, used for testing and software downloads
- Standard I/O,6DI, 2AI, 1AO 2 Form C RO (NO/NC), 1 Form A RO (NO)
- Hard wired external/damper interlock

Standards and Certifications

Product

- IEC 61800-5-1
- CE
- cUL

Safety

- UL 508C
- EN 61800-5-1
- CE
- cUL

Seismic Qualification

Refer to **Tab 1** for information on seismic qualification for this and other Eaton products.

Catalog Number Selection

Table 31.5-1. H-Max Series Drives Catalog Numbering System

Build options alphabetically and numerically.

HMX 3 4 A G 3D4 2 1 - B

Product
HMX = HVAC drive

Phase
3 =Three-phase

Voltage
2 = 200–240V
4 = 380–480V

Software Series
A–Z

Keypad
G = Graphical panel

Input Options Frame and Voltage Specific
2 = EMC C2

Enclosure
1 = Open NEMA Type 1 IP21
2 = Open NEMA Type 12 IP54

Braking/Application
N = No brake chopper (low overload)
B = Internal brake chopper (low overload FS4–FS6 included)

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

Extended I/O Options in Slot D and E
B1 = 6 x DI /DO, Each digital input can be individually programmed as digital output
B2 = 1RO (NC/NO), 1RO (NO), 1 Thermistor
B4 = 1 x AI, 2 x AO (isolated)
B5 = 3 x RO
B8 = 1 ext +24 Vdc/ext +24 Vdc, 3 Pt100
B9 = 1RO (NO), 5 DI 42–240 Vac input

Optional Communications in Slot D and E
C4 = LonWorks®

Standard Onboard Communications
RS-485 Communications
BACnet MS/TP = Master slave/token protocol (Universal BACnet) RS-485
Modbus RTU RS-485, ASCII or RTU, remote terminal unit 32 nodes
FLN Siemens APOGEE FLN (P1) ASCII or RTU, remote terminal unit 32 nodes
N2 = Johnson Controls Metasys N2 network
Onboard Ethernet-Based Communications (port left side of keypad)
BACnet/IP Ethernet industrial protocol
Modbus/TCP Transmission control protocol (Ethernet-based)

① DB chopper standard frames FS4–FS6. 1.5–40 hp, 3.4–61A, 480 Vac; 0.75–20 hp, 3.7–62A, 200–240 Vac.

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.

Product Selection

Table 31.5-2. H-Max Series Drives—230 Vac

FS Frame Size	Drive Output Current		Assigned Motor Ratings	230 Vac NEC Amperes ①	Low Overload Full Load Amperes at 50°C
	Low Overload Full Load Amperes at 40°C	Horsepower	Drive kW 230 Vac/50 Hz		
NEMA Type 1/IP21					
4	3.7 4.8 6.6	0.75 1.0 1.5	0.55 0.75 1.1	3.2 4.2 6.6	2.6 3.7 4.8
	8.0 11.0 12.5	2.0 3.0 4.0	1.5 2.2 3.0	6.8 9.6 N/A	6.6 8.0 11.0
5	18.0 24.0 31.0	5.0 7.5 10.0	4.0 5.5 7.5	15.2 22.0 28.0	12.5 18.0 24.0
6	48.0 62.0	15.0 20.0	11.0 15.0	42.0 54.0	31.0 48.0
7	75.0 88.0 105.0	25.0 30.0 40.0	18.5 22.0 30.0	68.0 80.0 104.0	62.0 75.0 88.0
8	140.0 170.0 205.0	50.0 60.0 75.0	37.0 45.0 55.0	130.0 154.0 192.0	105.0 140.0 170.0
9	261.0 310.0	100.0 125.0	75.0 90.0	248.0 N/A	205.0 261.0
NEMA Type 12/IP54					
4	3.7 4.8 6.6	0.75 1.0 1.5	0.55 0.75 1.1	3.2 4.2 6.6	2.6 3.7 4.8
	8.0 11.0 12.5	2.0 3.0 4.0	1.5 2.2 3.0	6.8 9.6 N/A	6.6 8.0 11.0
5	18.0 24.0 31.0	5.0 7.5 10.0	4.0 5.5 7.5	15.2 22.0 28.0	12.0 18.0 24.0
6	48.0 62.0	15.0 20.0	11.0 15.0	42.0 54.0	31.0 48.0
7	75.0 88.0 105.0	25.0 30.0 40.0	18.5 22.0 30.0	68.0 80.0 104.0	62.0 75.0 88.0
8	140.0 170.0 205.0	50.0 60.0 75.0	37.0 45.0 55.0	130.0 154.0 192.0	105.0 140.0 170.0
9	261.0 310.0	100.0 125.0	75.0 90.0	248.0 N/A	205.0 261.0

① For sizing reference.

Table 31.5-3. H-Max Series Drives—480 Vac

FS Frame Size	Drive Output Current		Assigned Motor Ratings	480 Vac NEC Amperes ①	Low Overload Full Load Amperes at 50°C
	Low Overload Full Load Amperes at 40°C	Horsepower	Drive kW 400 Vac/50 Hz		
NEMA Type 1/IP21					
4	3.4 4.8 5.6	1.5 2.0 3.0	1.1 1.5 2.2	2.1 3.4 5.6	2.6 3.4 4.8
	8.0 9.6 12.0	4.0 5.0 7.5	3.0 4.0 5.5	N/A 7.6 11.0	5.6 8.0 9.6
5	16.0 23.0 31.0	10.0 15.0 20.0	7.5 11.0 15.0	14.0 21.0 27.0	12.0 16.0 23.0
6	38.0 46.0 61.0	25.0 30.0 40.0	18.5 22.0 30.0	34.0 40.0 52.0	31.0 38.0 46.0
7	72.0 87.0 105.0	50.0 60.0 75.0	37.0 45.0 55.0	65.0 77.0 96.0	61.0 72.0 87.0
8	140.0 170.0 205.0	100.0 125.0 150.0	75.0 90.0 110.0	124.0 156.0 180.0	105.0 140.0 170.0
9	261.0 310.0	200.0 250.0	132.0 160.0	240.0 302.0	205.0 261.0
NEMA Type 12/IP54					
4	3.4 4.8 5.6	1.5 2.0 3.0	1.1 1.5 2.2	2.1 3.4 5.6	2.6 3.4 4.8
	8.0 9.6 12.0	4.0 5.0 7.5	3.0 4.0 5.5	N/A 7.6 11.0	5.6 8.0 9.6
5	16.0 23.0 31.0	10.0 15.0 20.0	7.5 11.0 15.0	14.0 21.0 27.0	12.0 16.0 23.0
6	38.0 46.0 61.0	25.0 30.0 40.0	18.5 22.0 30.0	34.0 40.0 52.0	31.0 38.0 46.0
7	72.0 87.0 105.0	50.0 60.0 75.0	37.0 45.0 55.0	65.0 77.0 96.0	61.0 72.0 87.0
8	140.0 170.0 205.0	100.0 125.0 150.0	75.0 90.0 110.0	124.0 156.0 180.0	105.0 140.0 170.0
9	261.0 310.0	200.0 250.0	132.0 160.0	240.0 302.0	205.0 261.0

① For sizing reference.

Onboard Network Communications

Johnson Controls Metasys N2

H-Max Series provides communication between the drive and a Johnson Controls Metasys N2 network. With this connection, the drive can be controlled, monitored and programmed from the Metasys system. N2 can be selected and programmed by the drive keypad.

BACnet

H-Max Series provides communication to BACnet networks. Data transfer is master-slave/token passing (MS/TP) RS-485.

BACnet IP

100Base-T interface.

Modbus TCP

Ethernet based protocol.

Modbus RTU

H-Max Series provides communication to Modbus RTU RS-485 as a slave on a Modbus network. Other communication parameters include an address range from 1 to 247; a parity of None, Odd or Even; and the stop bit is 1.

FLN

H-Max Series provides communication to Siemens APOGEE™ FLN (P1) RTU RS-485 as a slave on an FLN network. Other communication parameters include an address range from 1 to 247, a parity of None, Odd or Even and option boards.

H-Max Series Option Board Kits Available for Slots D and E

The H-Max Series drives can accommodate a wide selection of expander and adapter option boards to customize the drive for your application needs. The drive's control unit is designed to accept a total of two option boards.

The H-Max Series factory-installed standard board configuration includes an I/O board and a relay output board.

Table 31.5-4. Option Boards Mounted in Slots D and E

Option Kit Description	Option Kit Catalog Number
6 x DI /DO, each digital input can be individually programmed as digital output	**XMX-IO-B1-A**
1RO Form C (NO/NC), 1RO Form A (NO), 1 thermistor	**XMX-IO-B2-A**
1 x AI, 2 x AO (isolated)	**XMX-IO-B4-A**
3 x RO Form A (NO)	**XMX-IO-B5-A**
1 ext +24 Vdc/ext +24 Vdc, 3 Pt100	**XMX-IO-B8-A**
1RO Form A (NO), 5DI 42–240 Vac input	**XMX-IO-B9-A**
LonWorks	**XMX-COM-C4-A**

NEMA Type 1 to NEMA Type 12/ IP54 Conversion Kit

The NEMA Type 12/IP54 option kit is used to convert a NEMA Type 1 to a NEMA Type 12 drive.

Kit consists of a drive cover, a fan kit and plugs.

Table 31.5-5. NEMA Type 12/IP54 Cover

Option Kit Description	Option Kit Catalog Number
FS4-branded N12/IP54 cover with gasket, plastic plug, fans, Eaton logos	**FS4-N12KIT**
FS5-branded N12/IP54 cover with gasket, plastic plug, fans, Eaton logos	**FS5-N12KIT**
FS6-branded N12/IP54 cover with gasket, plastic plug, fans, Eaton logos	**FS6-N12KIT**

Flange Kits

The flange kit is used when the power section heat sink is mounted through the back panel of an enclosure.

Technical Data and Specifications

Table 31.5-6. H-Max Series Drives

Description	Specification
Input Ratings	
Input voltage (V_{in})	200–240 Vac, 380–480 Vac, –10%/+10%
Input frequency (f_{in})	50/60 Hz (variation up to 47–66 Hz)
Connection to power	Once per minute or less (typical operation)
Short-circuit withstand rating	100 kAIC
Output Ratings	
Output voltage	0 to V_{in}/U_{in} line voltage in
Continuous output current	Ambient temperature max. 104°F (40°C)
I_L overload	1.1 x I_L (1 min./10 min.)
Overload current	110% (1 min./10 min.)
Initial output current	150% for 2 seconds
Output frequency	0 to 320 Hz
Frequency resolution	0.01 Hz
Control Characteristics	
Control method	Frequency control (V/f) open loop sensorless vector control
Switching frequency	1–310A FS4–9: default 6 kHz
Frequency reference	Analog input: Resolution 0.1% (10-bit), accuracy ±1% Panel reference: Resolution 0.01 Hz
Field weakening point	8 to 320 Hz
Acceleration time	0.1 to 3000 seconds
Deceleration time	0.1 to 3000 seconds
Braking torque	DC brake: 30% x T_n (without brake option)
Ambient Conditions	
Ambient operating temperature	FS4–FS9: 14°F (–10°C), no frost to 104°F (40°C) (Drive can operate at 122°F (50°C), see **Pages 31.5-4** and **31.5-5**)
Storage temperature	–40° to 158°F (–40° to 70°C)
Relative humidity	0 to 95% RH, noncondensing, non-corrosive, no dripping water
Air quality	Chemical vapors: IEC 60721-3-3, unit in operation, Class 3C2; Mechanical particles: IEC 60721-3-3, unit in operation, Class 3S2
Altitude	100% load capacity (no derating) up to 3280 ft (1000m); 1% derating for each 328 ft (100m) above 3280 ft (1000m); max. 9842 ft (3000m); 380–480V
Vibration	FS4–FS9: EN 61800-5-1, EN 60068-2-6; 5 to 150 Hz, displacement amplitude 1 mm (peak) at 5 to 15.8 Hz, max. acceleration amplitude 1G at 15.8 to 150 Hz
Shock	EN 61800-5-1, EN 60068-2-27 UPS Drop test (for applicable UPS weights) Storage and shipping: max. 15G, 11 ms (in package)
Enclosure class	NEMA Type 1/IP21 or NEMA Type 12/IP54 (keypad required for IP54/Type 12)
Standards	
EMC	Immunity: Fulfills all EMC immunity requirements; Emissions: EN 61800-3, LEVEL H (EMC C2)
Emissions	EMC level dependent—+EMC 2: EN61800-3 (2004) Category C2 Delivered with Class C2 EMC filtering as default.

Table 31.5-6. H-Max Series Drives (Continued)

Description	Specification
Control Connections	
Analog input voltage	0 to 10V, R = 200 kohms differential Resolution 0.1%; Accuracy ±1% DIP switch selection (voltage/current)
Analog input current	0(4) to 20 mA; R_i –250 ohms differential
Digital inputs (6)	Positive or negative logic; 18 to 30 Vdc
Auxiliary voltage	+24V ±10%, max. 250 mA
Output reference voltage	+10V +3%, max. load 10 mA
Analog output	0–10V, 0(4) to 20 mA; R_L max. 500 ohms; Resolution 10 bit; Accuracy ±2% DIP switch selection (voltage/current)
Relay outputs	3 programmable, 2 Form C, 1 Form A relay outputs Switching capacity: 24 Vdc/8A, 250 Vac/8A, 125 Vdc/0.4A
Hard wire jumper	Between terminal 6 and 10 factory default
DIP switch setting default	RS-485 = off A01 = current A12 = current A11 = voltage
Protections	
Overcurrent protection	Yes
Overvoltage protection	Yes
DC bus regulation anti-trip	Yes (accelerates or decelerates the load)
Undervoltage protection	Yes
Earth fault protection	Yes (in case of earth fault in motor or motor cable, only the frequency converter is protected)
Input phase supervision	Yes (trips if any of the input phases are missing)
Motor phase supervision	Yes (trips if any of the output phases are missing)
Overtemperature protection	Yes
Motor overload protection	Yes
Motor stall protection	Yes
Motor underload protection	Yes
Short-circuit protection	Yes
Surge protection	Yes (varistor input)
Conformed coated (varnished) boards	Yes (prevents corrosion)
Seismic	
OHSPD Special Seismic Certification Pre-Approved	

Wiring Diagram

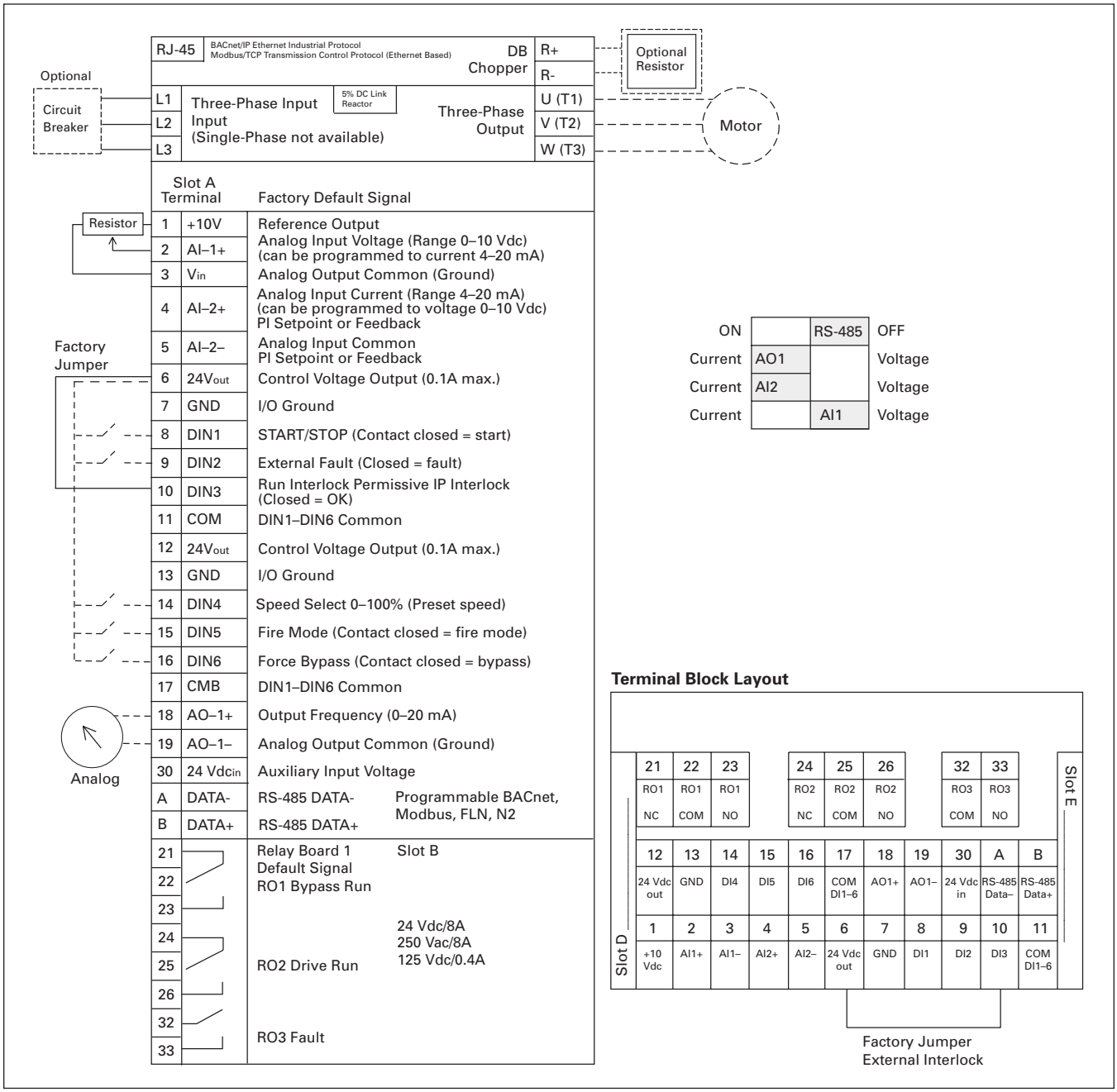


Figure 31.5-1. Control Input/Output, PID Application

Standards

- Digital inputs D1–D6, relay out, analog in/out are freely programmed
- The user can assign a single input to multiple functions

Includes

- Six digital input
- Two analog input
- One analog output
- Three relay output
- RS-485
- Ethernet (BACnet and Modbus)

Reliability

- Pretested components
- Conformal coated (varnished) boards
- 40°C rated
- 110% overload for one minute
- Eaton's Electrical Services & Systems national network of AF drive specialists

Dimensions—Approximate Dimensions in Inches (mm)

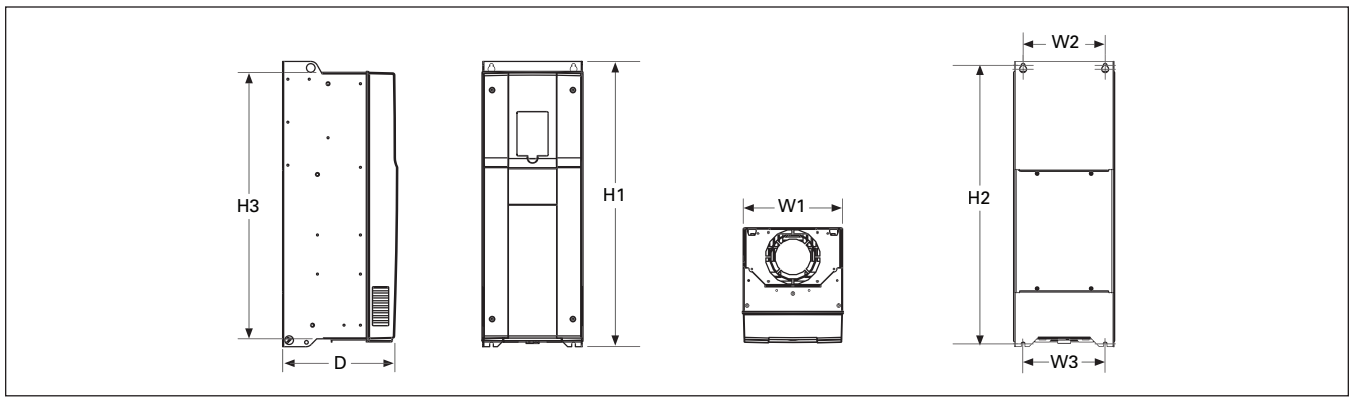


Figure 31.5-2. H-Max Series Frames FS4–FS7

Table 31.5-7. FS4–FS7 Dimensions and Weights

Voltage	hp	kW	Amperes	D	H1	Hole Center-to-Center H2	H3	W1	W2	W3	Weight in Lbs (kg)
FS4											
230 Vac	0.75–4	0.55–3.0	3.7–12.5	7.77 (197.3)	12.89 (327.5)	12.32 (313.0)	11.22 (285.0)	5.04 (128.0)	3.94 (100.0)	3.94 (100.0)	13.2 (6)
480 Vac	1.5–7.5	1.1–5.5	3.4–12	7.77 (197.3)	12.89 (327.5)	12.32 (313.0)	11.22 (285.0)	5.04 (128.0)	3.94 (100.0)	3.94 (100.0)	13.2 (6)
FS5											
230 Vac	5–10	4–7.5	18–31	8.73 (221.6)	16.50 (419.0)	15.98 (406.0)	15.04 (382.0)	5.67 (144.0)	4.53 (115.0)	3.94 (100.0)	22.0 (10)
480 Vac	10–20	7.5–15	16–31	8.73 (221.6)	16.50 (419.0)	15.98 (406.0)	15.04 (382.0)	5.67 (144.0)	4.53 (115.0)	3.94 (100.0)	22.0 (10)
FS6											
230 Vac	15–20	11–15	48–62	9.29 (236.0)	21.93 (557.0)	21.28 (540.5)	20.24 (514.0)	7.68 (195.0)	5.83 (148.0)	5.83 (148.0)	44.1 (20)
480 Vac	25–40	18.5–30	38–61	9.29 (236.0)	21.93 (557.0)	21.28 (540.5)	20.24 (514.0)	7.68 (195.0)	5.83 (148.0)	5.83 (148.0)	44.1 (20)
FS7											
230 Vac	25–30	18.5–30	75–105	10.49 (266.5)	25.98 (660.0)	25.39 (645.0)	24.29 (617.0)	9.06 (230.0)	7.48 (190.0)	7.48 (190.0)	82.6 (37.5)
480 Vac	50–75	37–55	72–105	10.49 (266.5)	25.98 (660.0)	25.39 (645.0)	24.29 (617.0)	9.06 (230.0)	7.48 (190.0)	7.48 (190.0)	82.6 (37.5)

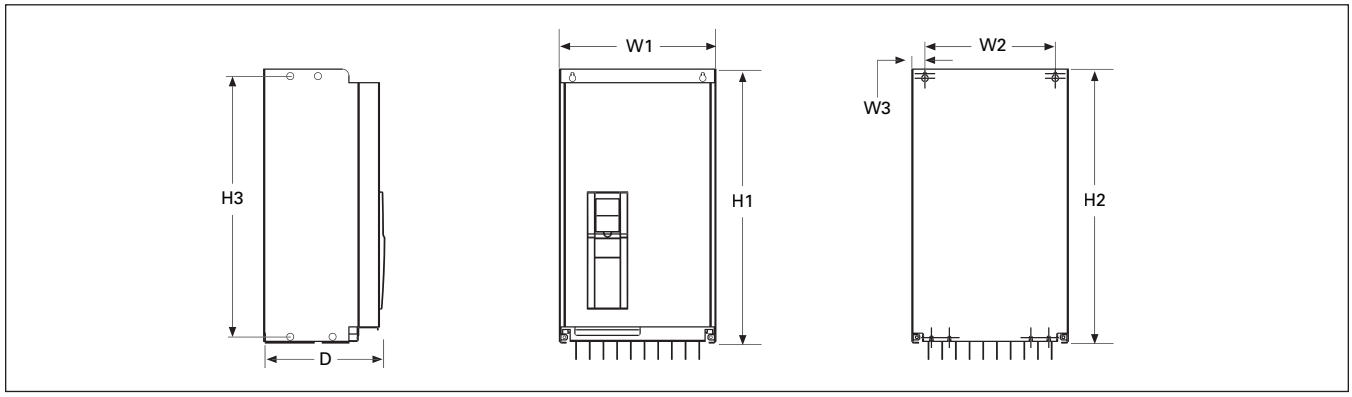


Figure 31.5-3. H-Max Series Frames FS8 and FS9

Table 31.5-8. FS8 and FS9 Dimensions and Weights

Voltage	hp	kW	Amperes	D	H1	Hole Center-to-Center H2	H3	W1	W2	W3	Weight in Lbs (kg)
FS8											
230 Vac	50–75	37–55	140–205	13.76 (349.6)	38.02 (965.7)	37.26 (946.4)	37.26 (946.4)	11.42 (290.1)	9.29 (236.0)	1.42 (36.0)	154.3 (70)
480 Vac	100–150	75–110	140–205	13.76 (349.6)	38.02 (965.7)	37.26 (946.4)	37.26 (946.4)	11.42 (290.1)	9.29 (236.0)	1.42 (36.0)	154.3 (70)
FS9											
230 Vac	100–120	75–90	261–310	14.63 (371.6)	33.09 (890.4)	31.89 (810.0)	31.89 (810.0)	18.90 (480.0)	15.75 (400.0)	1.57 (40.0)	238.1 (108)
480 Vac	200–250	132–160	261–310	14.63 (371.6)	33.09 (890.4)	31.89 (810.0)	31.89 (810.0)	18.90 (480.0)	15.75 (400.0)	1.57 (40.0)	238.1 (108)

Note: For flange dimension, please reference User Manual.

H-Max IntelliPass and IntelliDisconnect Drives

H-Max IntelliPass and IntelliDisconnect Drives

General Description

The IntelliPass electronic bypass is a two or optional three contactor design using a 24 Vdc ***XT*** Series contactor with an optional manual override switch that allows the unit to run in bypass without the H-Max Series drive.

The IntelliPass software parameters use engineering units common to the HVAC industry. Onboard startup wizard guarantees flawless commissioning with plug-and-play screen entry. Available in NEMA Type 1 and 12 with optional pre-engineered operator devices to meet all customized specification requirements.

The IntelliPass construction features allow for easy installation, reliable operation and serviceability with additional onboard wire space and removable conduit plates with knockouts.

Features and Benefits

IntelliPass/IntelliDisconnect

- Circuit breaker provides flexible drive isolation configurations to meet customers' needs
- Communication interface enables control of the motor operated by the drive or bypass
- Plenum rated
- Designed and tested to UL 508C specifications
- Standard DC link choke for enhanced transient and harmonic distortion protection
- DC bus regulation anti-trip
- Input surge protection against voltage spikes varistor input
- EMI/RFI filters standard on all drives to meet EMC Category 2
- Top and bottom conduit entry for installation ease
- Pass-through I/O capability
- Additional I/O and communication cards provide plug and play functionality
- Copy/paste keypad function allows transfer of parameter settings from one drive to the next. Also allows for redundant storage of drive settings in keypad as well as drive for backup
- Optional fusing—fuse rating 200 kAIC
- Keypad can display up to nine monitored parameters simultaneously
- OHSPD Special Seismic Certification Pre-Approved
- Standard NEMA Type 12 keypad on all drives
- Simplified operating menu allows for typical programming changes
- Accommodates a wide selection of expander boards and adapter boards
- Control logic can be powered from an external auxiliary control panel
- Standard I/O, 6 DI, 2 AI, 1 AO, 2 Form C RO, 1 Form A RO
- Onboard RS-485 (Modbus, N2, FLN, BACnet)
- Built-in Ethernet communication (BACnet/IP, Modbus/TCP)
- DB chopper standard frames FS4–FS6 for USA application
  - 1.5–40 hp, 2.1–52A, 480 Vac
  - 1–20 hp, 4.2–54A, 230 Vac
  - 1–20 hp, 4.6–60A, 208 Vac
- Hard wired external/damper interlock

IntelliPass

- Fully rated, mechanically interlocked contacts
- HAND/OFF/AUTO and DRIVE/BYPASS selector on keypad simplifies control
- Two power sources for control ensure redundancy and provide additional ride-through capability
- Self-healing power supplies
- Bypass circuit current interrupting rating up to 65 kAIC without fusing
- Fully featured mechanically interlocked bypass featuring Eaton's ***XT*** contactors
- Pre-engineered options to allow custom configurations (see option P150)
- Robust steel enclosure for simple installation
- Programmable auto restart and auto bypass while allowing critical damper interlock functionality

Standards and Certifications

Product

- IEC 61800-5-1
- CE
- cUL

Safety

- UL 508C
- EN 61800-5-1
- CE
- cUL
- OHSPD Special Seismic Certification Pre-Approved

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Catalog Number Selection

Table 31.5-9. H-Max Series IntelliPass and IntelliDisconnect Drives Catalog Numbering System

Build options alphabetically and numerically.

HMX 011 3 4 B A – – – – – – – – – –

Product
HMX = HVAC drive (VT) (low overload)

Enclosure Style
3 = IntelliPass NEMA Type 1
A = IntelliDisconnect NEMA Type 1

Software Series
A–Z

Braking/Application
N = No brake chopper (low overload)
B = Internal brake; chopper (low overload FS4–FS6 included)

Voltage
1 = 208V
2 = 230V
4 = 480V

NEC Ampere Ratings

208V
4D6 = 4.6A—1 hp ①
7D5 = 7.5A—2 hp ①
011 = 11A—3 hp ①
017 = 17A—5 hp ①
025 = 25A—7.5 hp ①
031 = 31A—10 hp ①
047 = 47A—15 hp ①
060 = 60A—20 hp ①
075 = 75A—25 hp
088 = 88A—30 hp

230V
4D2 = 4.2A—1 hp ①
6D8 = 6.8A—2 hp ①
9D6 = 9.6A—3 hp ①
016 = 16A—5 hp ①
022 = 22A—7.5 hp ①
028 = 28A—10 hp ①
042 = 42A—15 hp ①
054 = 54A—20 hp ①
068 = 68A—25 hp
080 = 80A—30 hp

480V
2D1 = 2.1A—1 hp ①
3D4 = 3.4A—2 hp ①
5D6 = 5.6A—3 hp ①
7D6 = 7.6A—5 hp ①
011 = 11A—7.5 hp ①
014 = 14A—10 hp ①
021 = 21A—15 hp ①
027 = 27A—20 hp ①
034 = 34A—25 hp ①
040 = 40A—30 hp ①
052 = 52A—40 hp ①
065 = 65A—50 hp
077 = 77A—60 hp
096 = 96A—75 hp

Extended I/O Options in Slot D and E
B1 = 6 x DI /DO, Each digital input can be individually programmed as digital output
B2 = 1RO (NC/NO), 1RO (NO), 1 Thermistor
B4 = 1 x AI, 2 x AO (isolated)
B5 = 3 x RO
B8 = 1 ext +24 Vdc/ext +24 Vdc, 3 Pt100
B9 = 1RO (NO), 5 DI 42–240 Vac input

Optional Communications in Slot D and E
C4 = LonWorks

EMC Upgrade Option
EMC C2 Standard

Keypad Options
None available

IntelliDisconnect Options
P3 = Fused drive isolation
PE = Output contactor
SA = Space heater w/transformer (Type 3R only)

IntelliPass Bypass Options
P3 = Fused drive isolation (can not be used with P6)
P6 = Third contactor drive isolation
PE = Output contactor (used for IntelliDisconnect)
M1 = Manual bypass switch located on front door
SA = Space heater w/transformer (Type 3R only)
KF = Drive test switch (used only with P6 option)
L1 = Power on and fault light (two separate lights)
L2 = Bypass pilot light (red)
L3 = Manual bypass light (amber)
LE = Drive run light
K9 = Auxiliary contacts
IS = Isolation switch

Standard Onboard Communications

RS-485 Communications
BACnet MS/TP = Master slave/token protocol (Universal BACnet) RS-485
Modbus RTU RS-485, ASCII or RTU, remote terminal unit 32 nodes
FLN Siemens APOGEE FLN (P1) ASCII or RTU, remote terminal unit 32 nodes
N2 = Johnson Controls Metasys N2 network

Onboard Ethernet-Based Communications (port left side of keypad)
BACnet/IP Ethernet industrial protocol
Modbus/TCP Transmission control protocol (Ethernet-based)

① DB chopper standard frames FS4–FS6 for USA application. 1.5–40 hp, 2.1–52A, 480 Vac; 1–20 hp, 4.2–54A, 230 Vac; 1–20 hp, 4.6–60A, 208 Vac.

Notes:
- IntelliPass—two contactor electronic bypass standard.
- All boards are varnished. Corrosion resistant.
- Battery included in all drives for real-time clock. Three year lifetime.
- Keypad kit includes HOA bypass.
- EMI/RFI filters included.
- DC link choke included.

Product Selection

Table 31.5-10. H-Max Series IntelliPass NEMA Type 1—Two Contactor Bypass Standard

FS Frame Size	Horsepower	Drive Rated NEC Amperes
208 Vac		
4	1.0 2.0 3.0	4.6 7.5 10.6
5	5.0 7.5 10.0	16.7 24.2 30.8
6	15.0 20.0	46.2 59.4
7	25.0 30.0	74.9 88.0
230 Vac		
4	1.0 2.0 3.0	4.2 6.8 9.6
5	5.0 7.5 10.0	15.2 22.0 28.0
6	15.0 20.0	42.0 54.0
7	25.0 30.0	68.0 80.0
480 Vac		
4	1.0 2.0 3.0	2.1 3.4 5.6
	5.0 7.5	9.6 11.0
5	10.0 15.0 20.0	14.0 21.0 27.0
6	25.0 30.0 40.0	34.0 40.0 52.0
7	50.0 60.0 75.0	65.0 77.0 96.0

Table 31.5-11. H-Max Series IntelliDisconnect NEMA Type 1—Main Disconnect Standard

FS Frame Size	Horsepower	Drive Rated NEC Amperes
208 Vac		
4	1.0 2.0 3.0	4.6 7.5 11.0
5	5.0 7.5 10.0	17.0 25.0 31.0
6	15.0 20.0	47.0 60.0
7	25.0 30.0	75.0 88.0
230 Vac		
4	1.0 2.0 3.0	4.2 6.8 9.6
5	5.0 7.5 10.0	15.2 22.0 28.0
6	15.0 20.0	42.0 54.0
7	25.0 30.0	68.0 80.0
480 Vac		
4	1.0 2.0 3.0	2.1 3.4 5.6
	5.0 7.5	9.6 11.0
5	10.0 15.0 20.0	14.0 21.0 27.0
6	25.0 30.0 40.0	34.0 40.0 52.0
7	50.0 60.0 75.0	65.0 77.0 96.0

Note: For Wiring Diagrams, see **Page 31.5-17**.

Onboard Network Communications

Johnson Controls Metasys N2

H-Max Series provides communication between the drive and a Johnson Controls Metasys N2 network. With this connection, the drive can be controlled, monitored and programmed from the Metasys system. N2 can be selected and programmed by the drive keypad.

BACnet

H-Max Series provides communication to BACnet networks. Data transfer is master-slave/token passing (MS/TP) RS-485.

BACnet/IP

100Base-T interface.

Modbus TCP

Ethernet based protocol.

Modbus RTU

H-Max Series provides communication to Modbus RTU RS-485 as a slave on a Modbus network. Other communication parameters include an address range from 1 to 247; a parity of None, Odd or Even; and the stop bit is 1.

FLN

H-Max Series provides communication to Siemens APOGEE FLN (P1) RTU RS-485 as a slave on an FLN network. Other communication parameters include an address range from 1 to 247, a parity of None, Odd or Even and option boards.

NEMA Type 12/IP54 Conversion Kit

The NEMA Type 12/IP54 option kit is used to convert a NEMA Type 1 to a NEMA Type 12 drive. Kit consists of a drive cover, a fan kit and plugs.

H-Max IntelliPass/IntelliDisconnect

Table 31.5-12. Primary Design Features

Description	IntelliPass	IntelliDisconnect
CB MMP Two-contactor bypass Mechanical interlock	Standard Standard Standard	Standard N/A N/A
Electrical interlock Third contactor (isolation) Isolation switch	Standard Optional Optional	N/A N/A N/A
Top entry (power) Bottom entry (power) Output contactor	Standard Standard Standard	Standard Standard Optional

Technical Data and Specifications

Table 31.5-13. H-Max Series Drives

Description	Specification
Input Ratings	
Input voltage (V_{in})	208, 230, 480 Vac, –10%/+10%
Input frequency (f_{in})	50/60 Hz (variation up to 47–66 Hz)
Connection to power	Once per minute or less (typical operation)
Short-circuit withstand rating	65 kAIC combination
Output Ratings	
Output voltage	0 to V_{in}/U_{in} line voltage in
Continuous output current	Ambient temperature max. 104°F (40°C)
I_L overload	1.1 x I_L (1 min./10 min.)
Overload current	110% (1 min./10 min.)
Initial output current	150% for 2 seconds
Output frequency	0 to 320 Hz
Frequency resolution	0.01 Hz
Control Characteristics	
Control method	Frequency control (V/f) open loop sensorless vector control
Switching frequency	1–310A; adjustable with parameter 2.6.9 FS4–FS7: default 6 kHz
Frequency reference	Analog input: Resolution 0.1% (10-bit), accuracy ±1% Panel reference: Resolution 0.01 Hz
Field weakening point	8 to 320 Hz
Acceleration time	0.1 to 3000 seconds
Deceleration time	0.1 to 3000 seconds
Braking torque	DC brake: 30% x T_n (without brake option)
Ambient Conditions	
Ambient operating temperature	FS4–FS7: 14°F (–10°C), no frost to 104°F (40°C) (Drive can operate at 122°F (50°C)
Storage temperature	–40° to 158°F (–40° to 70°C)
Relative humidity	0 to 95% RH, noncondensing, non-corrosive, no dripping water
Air quality	Chemical vapors: IEC 60721-3-3, unit in operation, Class 3C2; Mechanical particles: IEC 60721-3-3, unit in operation, Class 3S2
Altitude	100% load capacity (no derating) up to 3280 ft (1000m); 1% derating for each 328 ft (100m) above 3280 ft (1000m); max. 9842 ft (3000m); 380–480V
Vibration	FS4–FS7: EN 61800-5-1, EN 60068-2-6; 5 to 150 Hz, displacement amplitude 1 mm (peak) at 5 to 15.8 Hz, max. acceleration amplitude 1G at 15.8 to 150 Hz
Shock	EN 61800-5-1, EN 60068-2-27 UPS Drop test (for applicable UPS weights) Storage and shipping: max. 15G, 11 ms (in package)
Enclosure class	NEMA Type 1/IP21 or NEMA Type 12/IP54 (keypad required for IP54/Type 12)

Table 31.5-13. H-Max Series Drives (Continued)

Description	Specification
Standards	
EMC	Immunity: Fulfills all EMC immunity requirements; Emissions: EN 61800-3, LEVEL H (EMC C2)
Emissions	EMC level dependent— +EMC 2: EN61800-3 (2004) Category C2 Delivered with Class C2 EMC filtering as default.
Control Connections	
Analog input voltage	0 to 10V, R = 200 kohms differential Resolution 0.1%; Accuracy ±1% DIP switch selection (voltage/current)
Analog input current	0(4) to 20 mA; R_i –250 ohms differential
Digital inputs (six)	Positive or negative logic; 18 to 30 Vdc
Auxiliary voltage	+24V ±10%, max. 250 mA
Output reference voltage	+10V +3%, max. load 10 mA
Analog output	0–10V, 0(4) to 20 mA; R_L max. 500 ohms; Resolution 10 bit; Accuracy ±2%; DIP switch selection (voltage/current)
Relay outputs	3 programmable, 2 Form C, 1 Form A relay outputs Switching capacity: 24 Vdc/8A, 250 Vac/8A, 125 Vdc/0.4A
Hard wire jumper	Between terminal 6 and 10 factory default
DIP switch setting default	RS-485 = off A01 = current A12 = current A11 = voltage
Protections	
Overcurrent protection	Yes
Overvoltage protection	Yes
DC bus regulation anti-trip	Yes (accelerates or decelerates the load)
Undervoltage protection	Yes
Earth fault protection	Yes (in case of earth fault in motor or motor cable, only the frequency converter is protected)
Input phase supervision	Yes (trips if any of the input phases are missing)
Motor phase supervision	Yes (trips if any of the output phases are missing)
Overtemperature protection	Yes
Motor overload protection	Yes
Motor stall protection	Yes
Motor underload protection	Yes
Short-circuit protection	Yes
Surge protection	Yes (varistor input)
Conformed coated (varnished) board	Yes (prevents corrosion)
Seismic	
OHSPD Special Seismic Certification Pre-Approved	

Wiring Diagrams

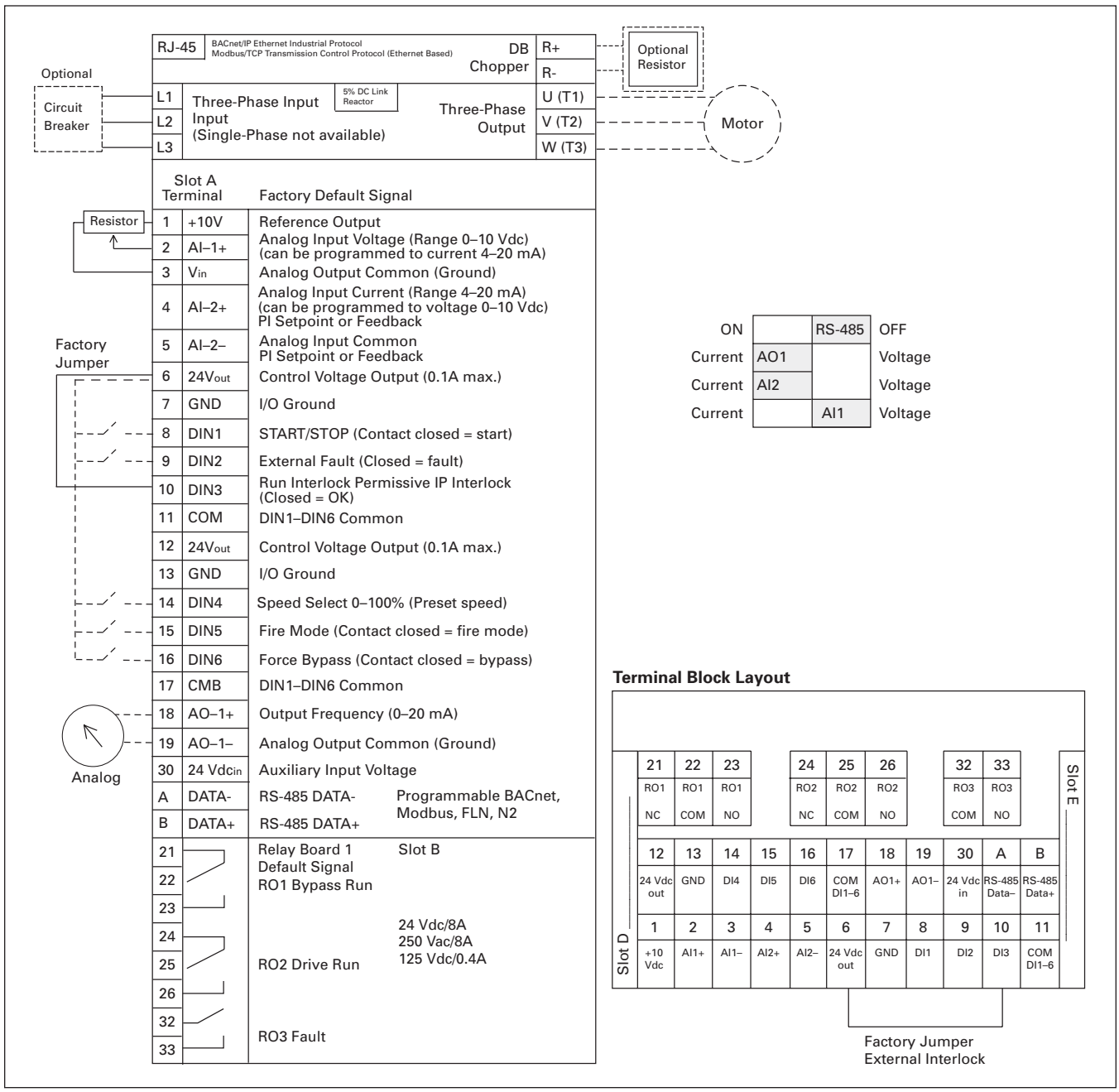

Figure 31.5-4. Control Input/Output, PID Application

Standards

- Digital inputs D1–D6, relay out, analog in/out are freely programmed
- The user can assign a single input to multiple functions

Includes

- Six digital input
- Two analog input
- One analog output
- Three relay output
- RS-485
- Ethernet

Reliability

- Pretested components
- Conformal coated (varnished) boards
- 40°C rated
- 110% overload for one minute
- Eaton's Electrical Services & Systems national network of AF drive specialists

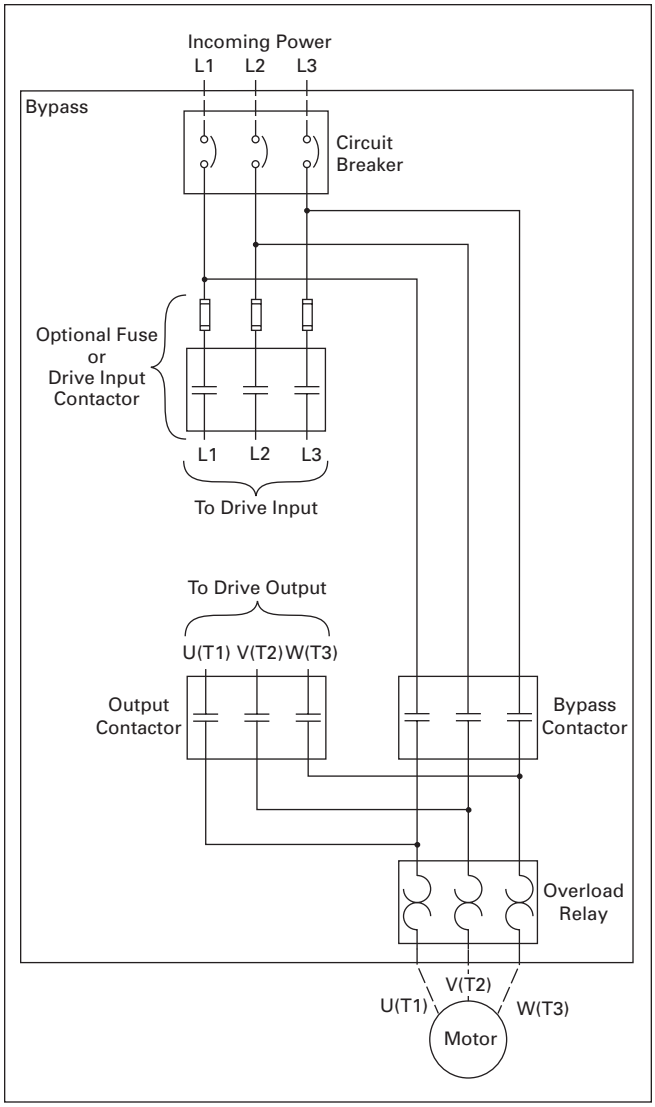

Figure 31.5-5. H-Max Series IntelliPass

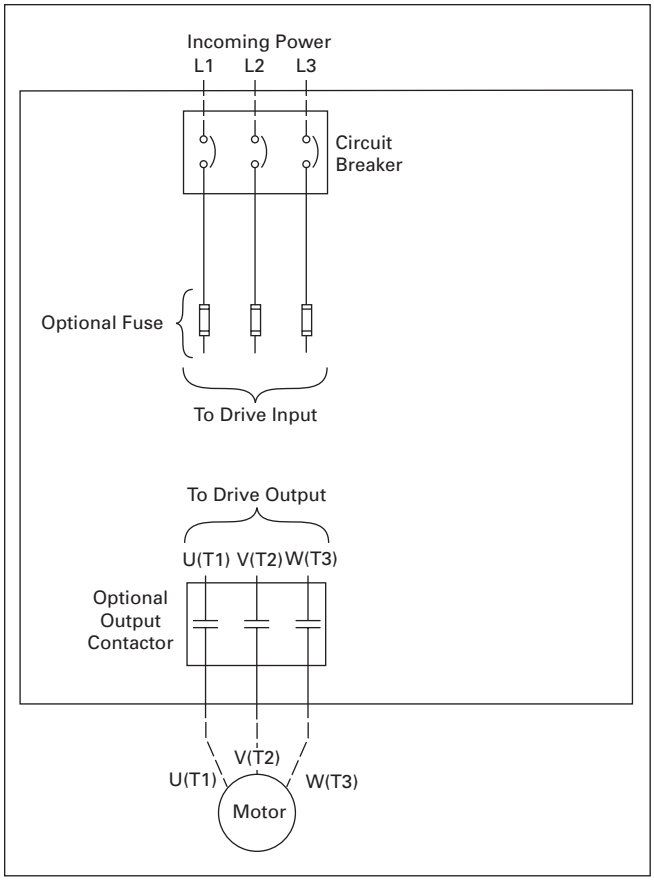

Figure 31.5-6. H-Max Series IntelliDisconnect Power Wiring

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Dimensions—Approximate Dimensions in Inches (mm)

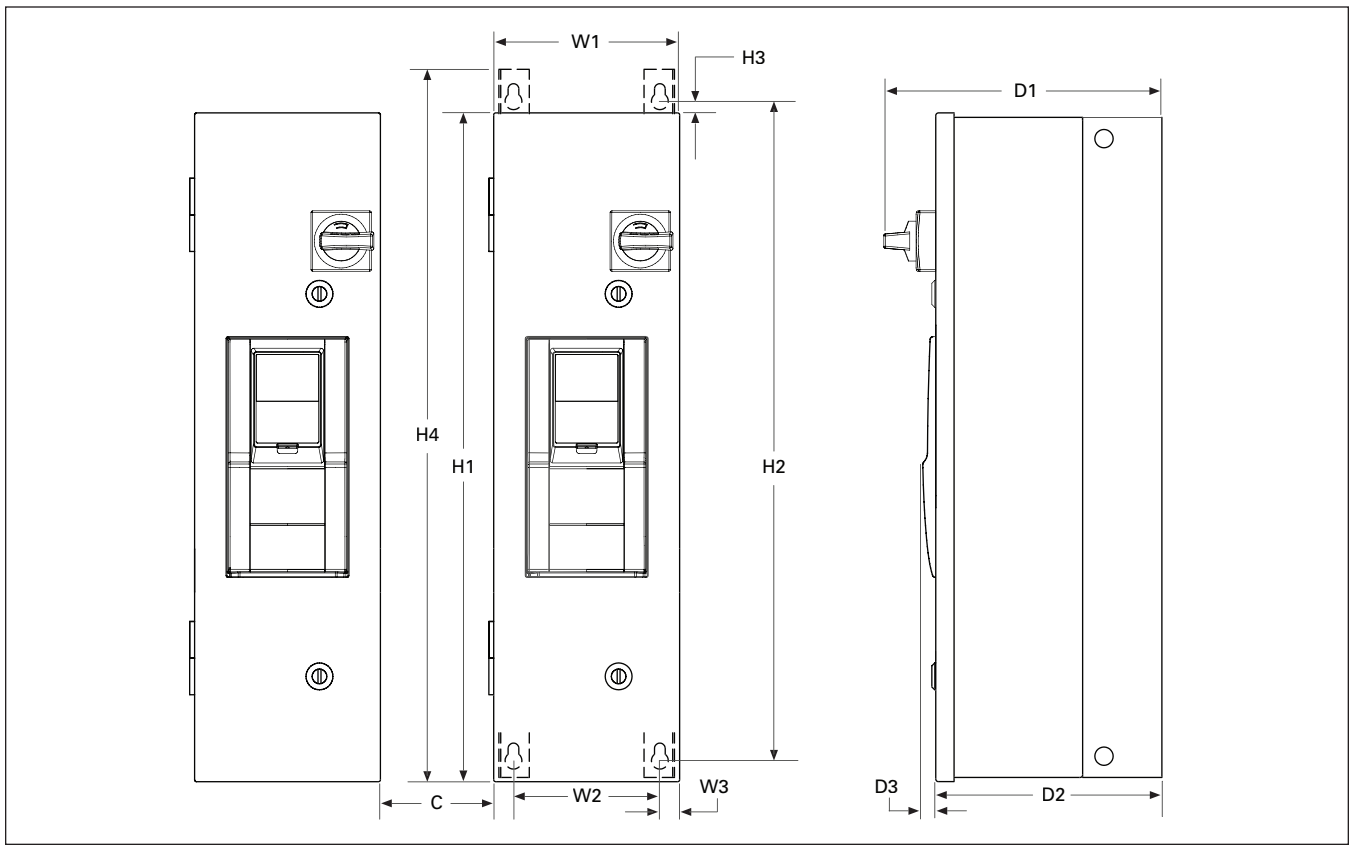

Figure 31.5-7. H-Max Series IntelliPass and IntelliDisconnect Drives
Note: Consult factory or use manual for final dimensions.

Table 31.5-14. IntelliPass and IntelliDisconnect Drive Dimensions and Weights

Frame Size	Voltage	Horsepower (I_L)	H1	H2	H3	H4	C	W1	W2	W3	D1	D2	Weight in Lbs (kg)
FS4	208 230 480	1–3 1–3 1–7.5	29.69 (754.1)	37.12 (942.9)	0.25 (6.35)	31.00 (914.4)	3.00 (76.2)	7.88 (200.2)	6.33 (160.8)	0.75 (19.1)	11.40 (289.6)	9.27 (235.5)	45.0 (20.41)
FS5	208 230 480	5–10 5–10 10–20	37.00 (939.8)	34.47 (875.5)	0.25 (6.35)	38.31 (973.0)	3.00 (76.2)	9.40 (238.8)	7.75 (196.9)	0.75 (19.1)	15.30 (388.6)	13.17 (334.6)	57.5 (26.10)
FS6	208 230 480	15–20 15–20 25–40	45.08 (1145.0)	40.28 (1023.1)	0.25 (6.35)	46.4 (1178.6)	4.00 (101.6)	10.90 (276.9)	9.35 (327.5)	0.75 (19.1)	15.75 (400.0)	13.62 (346.0)	98.0 (44.45)
FS7	208 230 480	25–30 25–30 50–75	58.32 (1481.3)	56.30 (1430.0)	0.25 (6.35)	59.46 (1510.3)	5.00 (127.0)	13.98 (355.1)	12.35 (313.7)	0.75 (19.1)	15.50 (393.7)	13.55 (244.2)	165.0 (74.84)

Note: C distance is spacing required to mount multiple drives.