Eaton | Cutler-Hammer

CPX9000 Adjustable Frequency Drives

Technical Data

November 2005
New Information

CPX9000 — 150 hp VT

Product Description

The Cutler-Hammer® CPX9000 Clean Power Drives from Eaton's electrical business uses 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 Program

- **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 9 – 14**.
- **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.*

Contents

Features and Benefits

New CPX9000 Clean Power Drive features include:

- 25 – 150 hp VT drives available in 30" enclosure
- 200 and 250 hp VT drives available in 48" enclosure
- 300 – 400 hp VT drives available in 60" enclosure
- NEMA Type 1, NEMA Type 1 with Gaskets and Filters
- Input Voltage: 480V
- Complete range of control, network and power options
- Horsepower range:
  - 480V, 25 – 700 hp CT;
    25 – 800 hp VT
- Over ten 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.

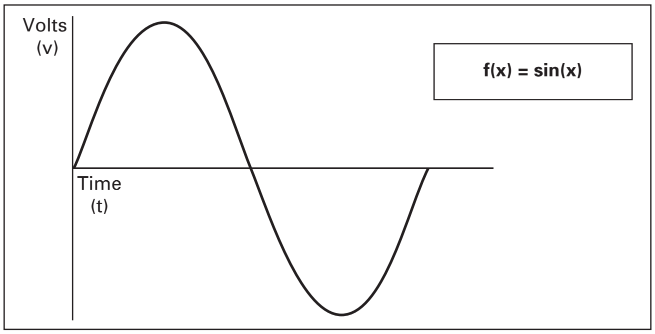

Figure 1. Perfect Wave

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

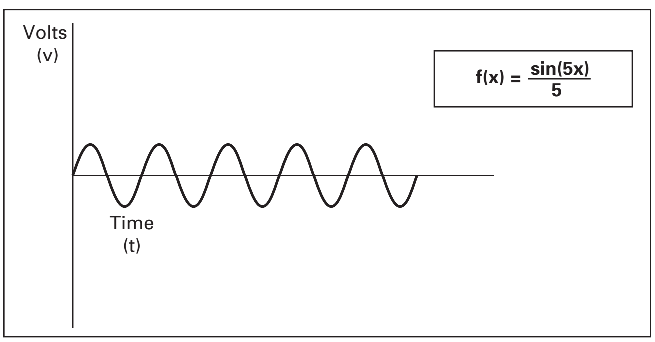

Figure 2. Second Wave

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

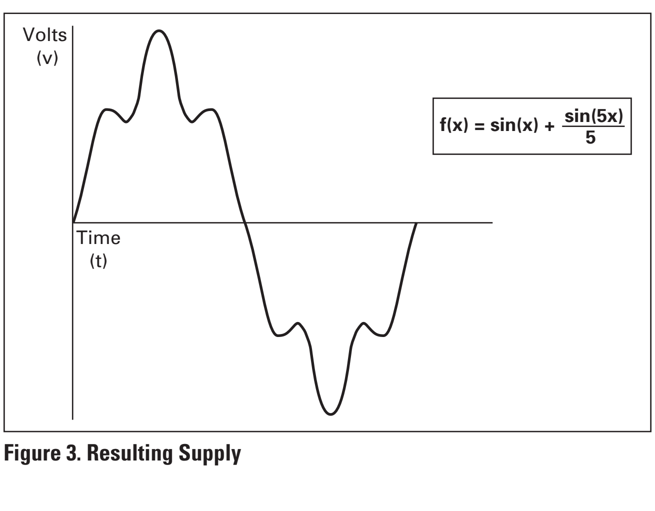

Figure 3. Resulting Supply

What Causes Harmonics?

Harmonics are the result of nonlinear loads that convert AC line voltage to DC. Examples of equipment that are non-linear 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 patented 18-Pulse Cutler-Hammer 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 which 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 (3) 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 3-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 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.

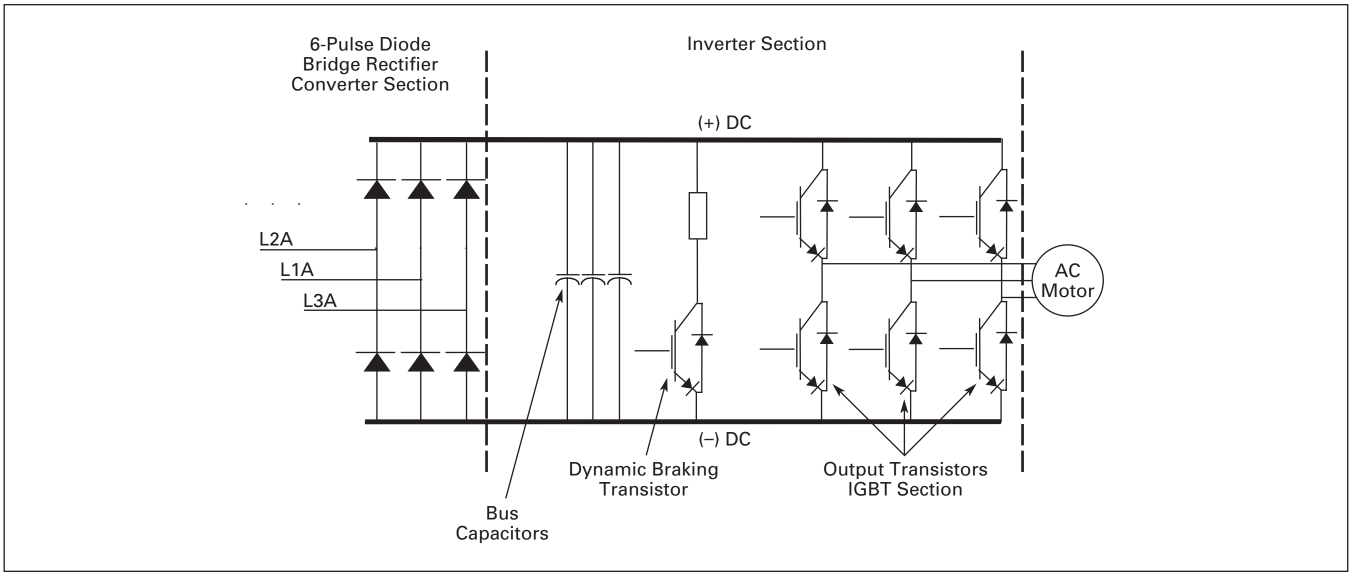

Figure 4. 6-Diode Rectifier Design

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 5** is a 500 hp drive with 167A of damaging harmonic current.

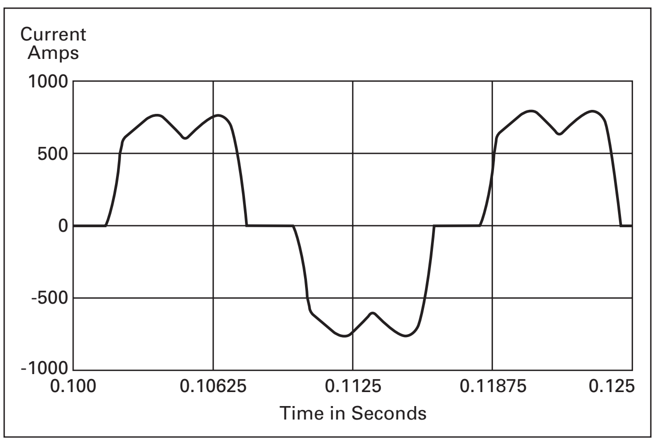

Figure 5. 6-Pulse Nonproductive Harmonic Current

Table 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 = 167 Amps		

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 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.

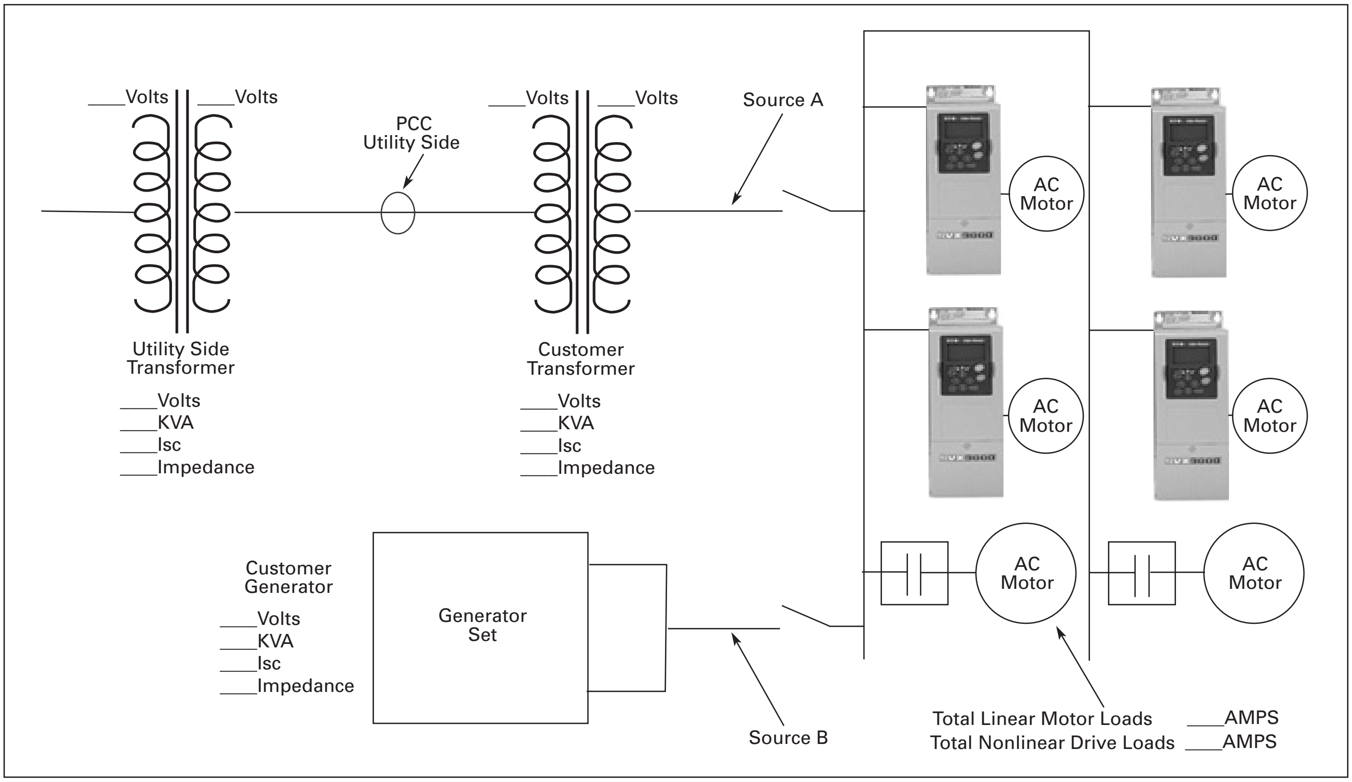

Figure 6. Oneline Diagram for Harmonic Analysis

The best way to estimate AFD harmonic contribution to an electrical system is to perform a harmonic analysis based on known system characteristics. The oneline 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 3-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 SVX9000 comes standard with a nominal 3% input impedance.)

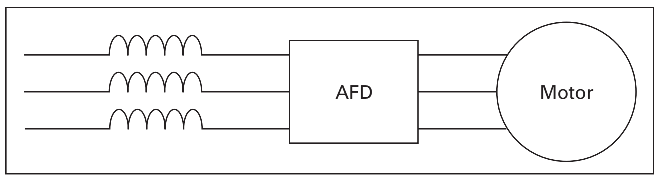

Figure 7. Line Reactor

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. 12-Pulse Converters

A 12-pulse converter incorporates two separate AFD input semiconductor bridges, which are fed from 30° phase shifted power sources with identical impedance. The sources may be two isolation transformers, where one is a delta/wye design (which provides the phase shift) and the second a delta/delta design (which does not phase shift). The 12-pulse arrangement allows the harmonics from the first converter to cancel the harmonics of the second. Up to approximately 85% reduction of harmonic current and voltage distortion may be achieved (over standard 6-pulse converter). This permits a facility to use a larger percentage of AFD loads under IEEE 519-1992 guidelines than allowable using line reactors or DC chokes. A harmonic analysis is required to guarantee compliance with guidelines.

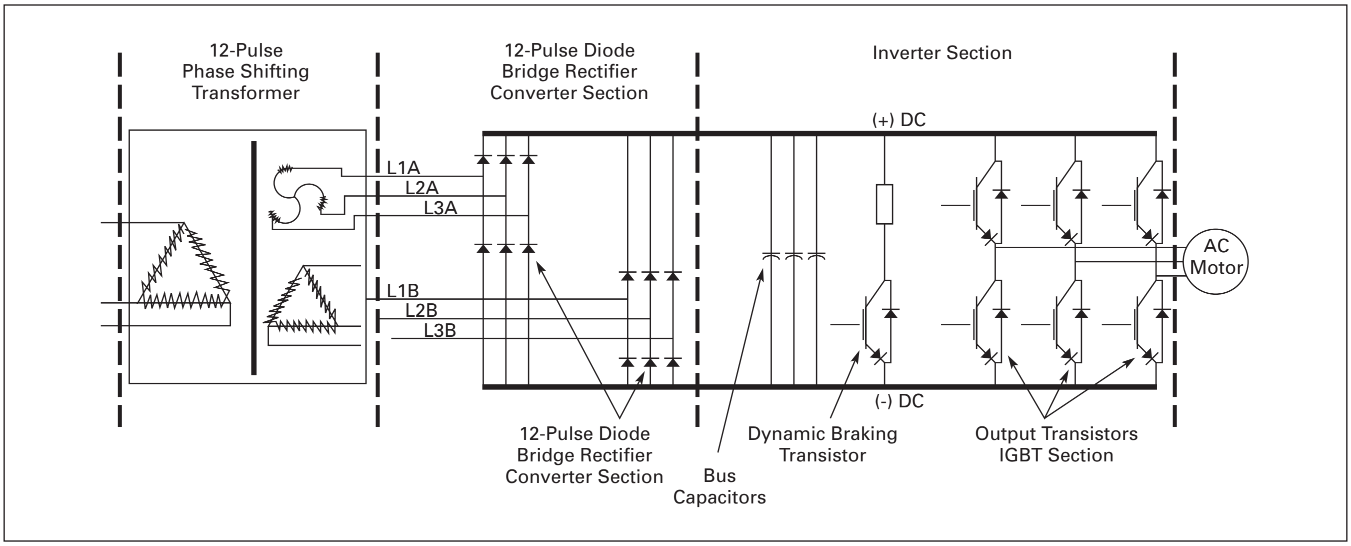

Figure 8. Basic 12-Pulse Rectifier with "Phase Shifting" Transformer

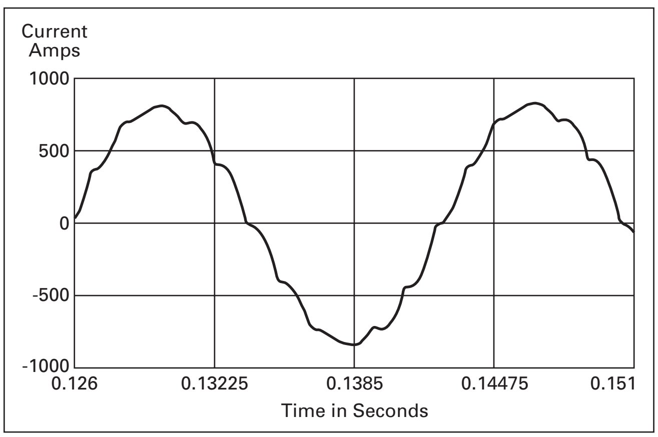

Figure 9. 500 hp 480V Drive with 12-Pulse Rectifier

Table 3. 500 hp 480V Drive with 12-Pulse Rectifier

12-Pulse Circuit		
Current Harmonics		
I_1 = 100%	I_{11} = 4.19%	I_{19} = 0.06%
I_5 = 1.25%	I_{13} = 2.95%	I_{23} = 0.87%
I_7 = 0.48%	I_{17} = 0.21%	I_{25} = 0.73%
Power = 419.6 kW		
H_c = 66.2 Amps		

Advantages

- Reasonable cost, although significantly more than reactors or chokes
- Substantial reduction (up to approx. 85%) in voltage and current harmonics
- Provides increased input protection for AFD and its semiconductors from line transients

Disadvantages

- Impedance matching of phase shifted sources is critical to performance
- Transformers often require separate mounting or larger AFD enclosures
- May not reduce distribution harmonic levels to below IEEE 519-1992 guidelines
- Cannot retrofit for most AFDs

3. Clean Power Drives

When the total load is comprised of non-linear 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 Cutler-Hammer 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 5**, **9** and **11**.

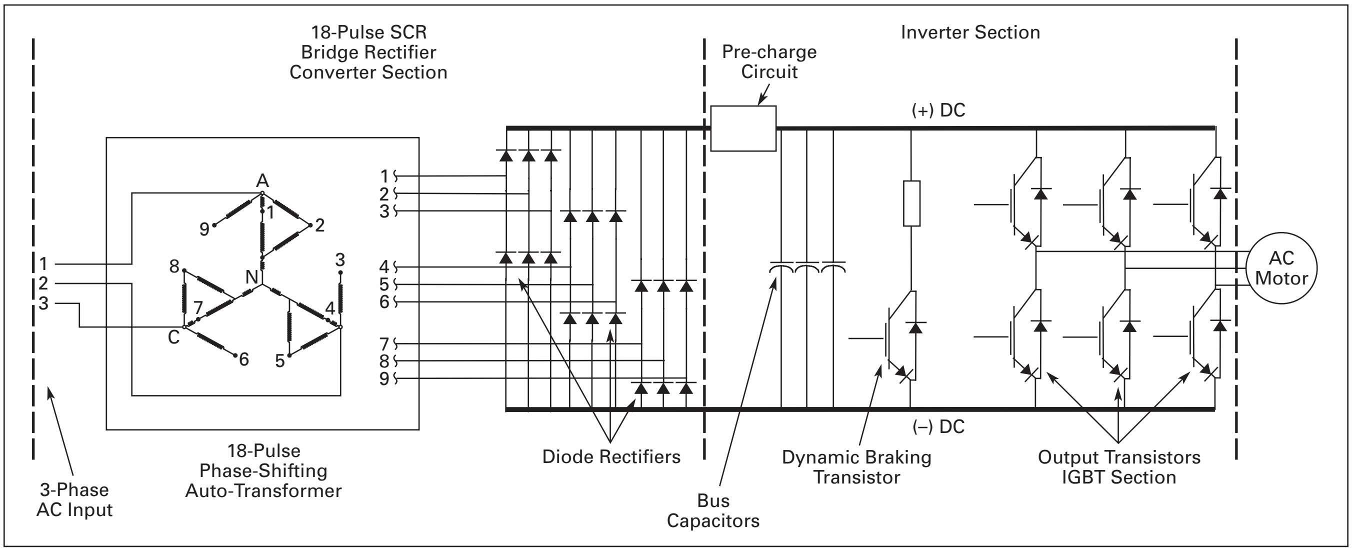

Figure 10. Basic 18-Pulse Rectifier with "Differential Delta" Transformer

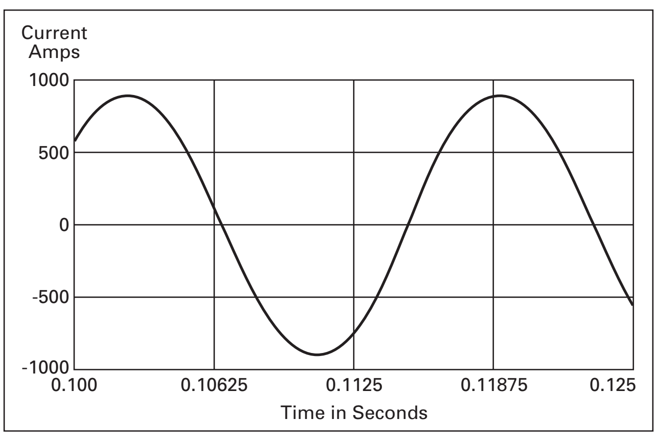

Figure 11. 500 hp 480V Drive with 18-Pulse Rectifiers

Table 4. 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 = 24 Amps		

Advantages

- Virtually guarantees compliance with IEEE 519-1992
- Provides increased input protection for AFD and its semiconductors from line transients
- Up to 4 times the harmonic reduction of 12-pulse methods
- Smaller transformer than isolation transformer used in 12-pulse converter

Disadvantages

- Larger and heavier magnetics than some other methods

Technical Data and Specifications

Table 5. 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 (CT)	250% for 2 seconds
Overload: 1 Minute (CT/VT)	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
115V AC Control Circuit	Optional
Speed Setting Inputs:	
Keypad	Standard
0 – 10V DC 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 – 10V DC 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 Setpoint 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 – 40°C
Storage Temperature	-40 – 60°C
Humidity (Maximum), Non-condensing	95%
Altitude (Maximum without Derate)	3300 ft. (1000m)
Line Voltage Variation	+10/-15%
Line Frequency Variation	45 – 66 Hz
Efficiency	>96%
Power Factor (Displacement)	.99

Table 6. Standard I/O Specifications

Description	Specification
6 – Digital Input Programmable	24V: "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 250V AC 2 Amp or 30V DC2 Amp resistive
1 – Digital Output Programmable	Open collector 48V DC 50 mA
1 – Analog Output Programmable Configurable w/Jumper	0 – 20 mA, impedance 500 ohms, resolution 106 ±3%

Catalog Number Selection

Table 7. CPX9000 Enclosed NEMA Type 1 Drive Catalog Numbering System

C P X 1 0 0 1 4 A A _ _ _ _ _ _ _ _ _ _

Build options alphabetically and numerically.

Product Family
CPX = Clean Power 18-Pulse Enclosed Drives

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

Enclosure Rating
1 = NEMA Type 1
6 = NEMA Type 1 Filtered

Voltage Rating
4 = **480V**

Application — Torque/Braking ①
A = VT/No Brake Chopper
B = VT/Internal Brake Chopper
D = CT/No Brake Chopper
E = CT/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" Expansion	Enclosure
S8	20" Expansion	Enclosure
S9	Space Heater	Enclosure

Communication Options ⑥
C2 = Modbus
C3 = Profibus DP
C4 = LonWorks
C5 = Profibus DP (D9 Connector)
C6 = CanOpen (Slave)
C7 = DeviceNet
C8 = Modbus (D9 Type Connector)
CA = Johnson Controls N2
CI = Modbus TCP
CJ = BACnet
D3 = RS-232 with D9 Connection

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

① Brake Chopper is standard in drives up to 30 hp CT or 40 hp VT. It is optional in larger 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 11** and **12** for descriptions.
⑤ Includes local/remote speed reference switch.
⑥ See **Pages 13** and **14** for complete descriptions.

Product Selection

Figure 12. NEMA 1 with Gasket and Filter, 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 amp rating.) The base enclosed package includes a standard drive, door-mounted alphanumeric panel and enclosure.
- 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 8. 480V AC CPX9000 Base Drive Product Selection

Enclosure Size ①	hp	Current (A)	Frame	NEMA Type 1 Base Catalog Number ②	NEMA Type 1 Filtered Base Catalog Number ②
Variable Torque Drive					
7	25	34	FR6	**CPX02514BA**	**CPX02564BA**
7	30	40	FR6	**CPX03014BA**	**CPX03064BA**
7	40	52	FR6	**CPX04014BA**	**CPX04064BA**
7	50	65	FR7	**CPX05014AA**	**CPX05064AA**
7	60	77	FR7	**CPX06014AA**	**CPX06064AA**
7	75	96	FR7	**CPX07514AA**	**CPX07564AA**
7	100	124	FR8	**CPX10014AA**	**CPX10064AA**
7	125	156	FR8	**CPX12514AA**	**CPX12564AA**
7	150	180	FR8	**CPX15014AA**	**CPX15064AA**
8	200	240	FR9	**CPX20014AA**	**CPX20064AA**
8	250	302	FR9	**CPX25014AA**	**CPX25064AA**
9	300	361	FR10	**CPX30014AA**	**CPX30064AA**
9	350	414	FR10	**CPX35014AA**	**CPX35064AA**
9	400	477	FR10	**CPX40014AA**	**CPX40064AA**
10	500	590	FR11	**CPX50014AA**	**CPX50064AA**
10	600	730	FR11	**CPX60014AA**	**CPX60064AA**
11	700	920	FR12	**CPX70014AA**	**CPX70064AA**
11	800	1030	FR12	**CPX80014AA**	**CPX80064AA**
Constant Torque Drive					
7	25	40	FR6	**CPX02514EA**	**CPX02564EA**
7	30	52	FR6	**CPX03014EA**	**CPX03064EA**
7	40	65	FR7	**CPX04014DA**	**CPX04064DA**
7	50	77	FR7	**CPX05014DA**	**CPX05064DA**
7	60	96	FR7	**CPX06014DA**	**CPX06064DA**
7	75	124	FR8	**CPX07514DA**	**CPX07564DA**
7	100	156	FR8	**CPX10014DA**	**CPX10064DA**
7	125	180	FR8	**CPX12514DA**	**CPX12564DA**
8	150	240	FR9	**CPX15014DA**	**CPX15064DA**
8	200	302	FR9	**CPX20014DA**	**CPX20064DA**
9	250	361	FR10	**CPX25014DA**	**CPX25064DA**
9	300	414	FR10	**CPX30014DA**	**CPX30064DA**
9	350	477	FR10	**CPX35014DA**	**CPX35064DA**
10	400	590	FR11	**CPX40014DA**	**CPX40064DA**
11	500	590	FR11	**CPX50014DA**	**CPX50064DA**
11	600	650	FR12	**CPX60014DA**	**CPX60064DA**
11	700	730	FR12	**CPX70014DA**	**CPX70064DA**

① See enclosure dimensions in **Table 9**.
② The 18-pulse Clean Power assembly includes a standard drive, door-mounted local/remote keypad and enclosure.

Table 9. CPX9000 Enclosure Dimensions

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

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

Options

Control/Communication Option Descriptions

Table 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 10V DC 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 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 – 10V DC 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 which converts a 3 – 15 psig pneumatic signal to either 0 – 8V DC or a 1 – 9V DC 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, 600V AC are provided for customer use. Bypass Options **RB** and **RA** include an Output Contactor as standard. This option includes a low VA 115V AC 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 .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 feet (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 2 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 2 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 10. Available Control/Communications Options (Continued)

Option	Description	Option Type
RA	**Manual HOA Bypass Controller** — The Manual HAND/OFF/AUTO (HOA) — 3-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. For applications up to 250 hp, an ***IT.*** Series IEC input contactor, an ***IT.*** Series IEC output contactor, and an ***IT.*** Series IEC starter with an electronic overload relay is included. For applications above 250 hp, an Advantage input contactor, an Advantage output contactor and an Advantage starter with electronic overload protection is included. The contactors are mechanically and electrically interlocked (see power diagram on **Page 18**).	Bypass
RB	**Manual IOB Bypass Controller** — The Manual INVERTER/OFF/BYPASS (IOB) — 3-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. For applications up to 250 hp, an ***IT.*** Series IEC input contactor, an ***IT.*** Series IEC output contactor, and an ***IT.*** Series IEC starter with an electronic overload relay is included. For applications above 250 hp, an Advantage input contactor, an Advantage output contactor and an Advantage starter with electronic overload protection is included. The contactors are mechanically and electrically interlocked (see power diagram on **Page 18**).	Bypass
RC	**Auto Transfer HOA Bypass Controller** – The Manual HAND/OFF/AUTO (HOA) — 3-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. For applications up to 250 hp, an ***IT.*** Series IEC input contactor, an ***IT.*** Series IEC output contactor, and an ***IT.*** Series IEC starter with an electronic overload relay is included. For applications above 250 hp, an Advantage input contactor, an Advantage output contactor and an Advantage starter with electronic overload protection is included. The contactors are mechanically and electrically interlocked (see power diagram on **Page 18**). 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
RD	**Auto Transfer IOB Bypass Controller** — The Auto INVERTER/OFF/BYPASS (IOB) — 3-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. For applications up to 250 hp, an ***IT.*** Series IEC input contactor, an ***IT.*** Series IEC output contactor, and an ***IT.*** Series IEC starter with an electronic overload relay is included. For applications above 250 hp, an Advantage input contactor, an Advantage output contactor and an Advantage starter with electronic overload protection is included. The contactors are mechanically and electrically interlocked (see power diagram on **Page 18**). 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 ***IT.*** Series reduced voltage soft starter to bypass assembly for soft starting in bypass mode.	Bypass
S7	**10" Expansion** — Expansion cabinet allows for special components, customer-supplied components or oversized cables. **NOTE:** Enclosure expansion rated NEMA Type 1 only.	Enclosure
S8	**20" 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 13**).

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.

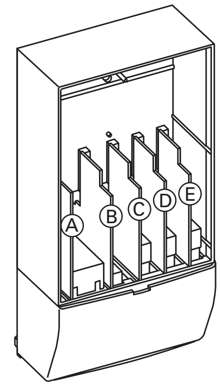

Figure 13. CPX9000 Series Option Boards

Table 11. Option Board Kits

Option Kit Description ②	Allowed Slot Locations ①	Field Installed	Factory Installed	SVX Ready Programs						
		Catalog Number	Option Designator	Basic	Local/ Remote	Standard	MSS	PID	Multi-P.	PFC
Standard I/O Cards (See Figure 13)										
2 RO (NC/NO)	B	**OPTA2**	—	X	X	X	X	X	X	X
6 DI, 1 DO, 2 AI, 1AO, 1 +10V DC ref, 2 ext +24V DC/ EXT +24V DC	A	**OPTA9**	—	X	X	X	X	X	X	X
Extended I/O Card Options										
6 DI, 1 ext +24V DC/EXT +24V DC	B, C, **D**, E	**OPTB1**	**B1**	—	—	—	—	—	X	X
1 RO (NC/NO), 1 RO (NO), 1 Therm	B, C, **D**, E	**OPTB2**	**B2**	—	—	—	—	—	X	X
1 AI (mA isolated), 2 AO (mA isolated), 1 ext +24V DC/EXT +24V DC	B, C, **D**, E	**OPTB4**	**B4**	X	X	X	X	X	X	X
3 RO (NO)	B, C, **D**, E	**OPTB5**	**B5**	—	—	—	—	—	X	X
1 ext +24V DC/EXT +24V DC, 3 Pt100	B, C, **D**, E	**OPTB8**	**B8**	—	—	—	—	—	—	—
1 RO (NO), 5 DI 42 – 240V AC Input	B,C, **D**, E	**OPTB9**	**B9**	—	—	—	—	—	X	X
Communication Cards ③										
Modbus	D, **E**	**OPTC2**	**C2**	X	X	X	X	X	X	X
Modbus TCP	D, **E**	**OPTCI**	**CI**	X	X	X	X	X	X	X
BACnet	D, **E**	**OPTCJ**	**CJ**	X	X	X	X	X	X	X
Johnson Controls N2	D, **E**	**OPTC2**	**CA**	—	—	—	—	—	—	—
Profibus DP	D, **E**	**OPTC3**	**C3**	X	X	X	X	X	X	X
LonWorks	D, **E**	**OPTC4**	**C4**	X	X	X	X	X	X	X
Profibus DP (D9 Connector)	D, **E**	**OPTC5**	**C5**	X	X	X	X	X	X	X
CanOpen (Slave)	D, **E**	**OPTC6**	**C6**	X	X	X	X	X	X	X
DeviceNet	D, **E**	**OPTC7**	**C7**	X	X	X	X	X	X	X
Modbus (D9 Type Connector)	D, **E**	**OPTC8**	**C8**	X	X	X	X	X	X	X
RS-232 with D9 Connection	D, **E**	**OPTD3**	**D3**	X	X	X	X	X	X	X

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 ISO11898 standard cables to be chosen for CAN bus should have a nominal impedance of 120Ω, and specific line delay of nominal 5 nS/m. 120Ω 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 2-wire twisted shielded cable with 2-wire bus power cable and drain. The baud rates used for communication include 125K baud, 250K baud and 500K baud.

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

Description	Specifications
Analog voltage, input	0 – ±10V, $R_i \geq 200$ kΩ
Analog current, input	0 (4) – 20 mA, $R_i = 250\Omega$
Digital Input	24V: “0” ≤ 10V, “1” ≥ 18V, $R_i > 5$ kΩ
Aux. voltage	24V (±20%), max. 50 mA
Reference voltage	10V ±3%, max. 10 mA
Analog current, output Analog voltage, output	0 (4) – 20 mA, $R_L = 500$ kΩ, resolution 10 bit, accuracy ≤ ±2% 0 (2) – 10V, $R_L \geq 1$ kΩ, resolution 10 bit, accuracy ≤ ±2%
Relay output Max. switching voltage Max. switching load Max. continuous load	 300V DC, 250V AC 8A/24V DC, .4A/300V DC, 2 kVA/250V AC 2A rms
Thermistor input	$R_{trip} = 4.7$ kΩ
Encoder input	24V: “0” ≤ 10V, “1” ≥18V, $R_i = 2.2$ kΩ 5V: “0” ≤ 2V, “1” ≥ 3V, $R_i = 330\Omega$

Dimensions

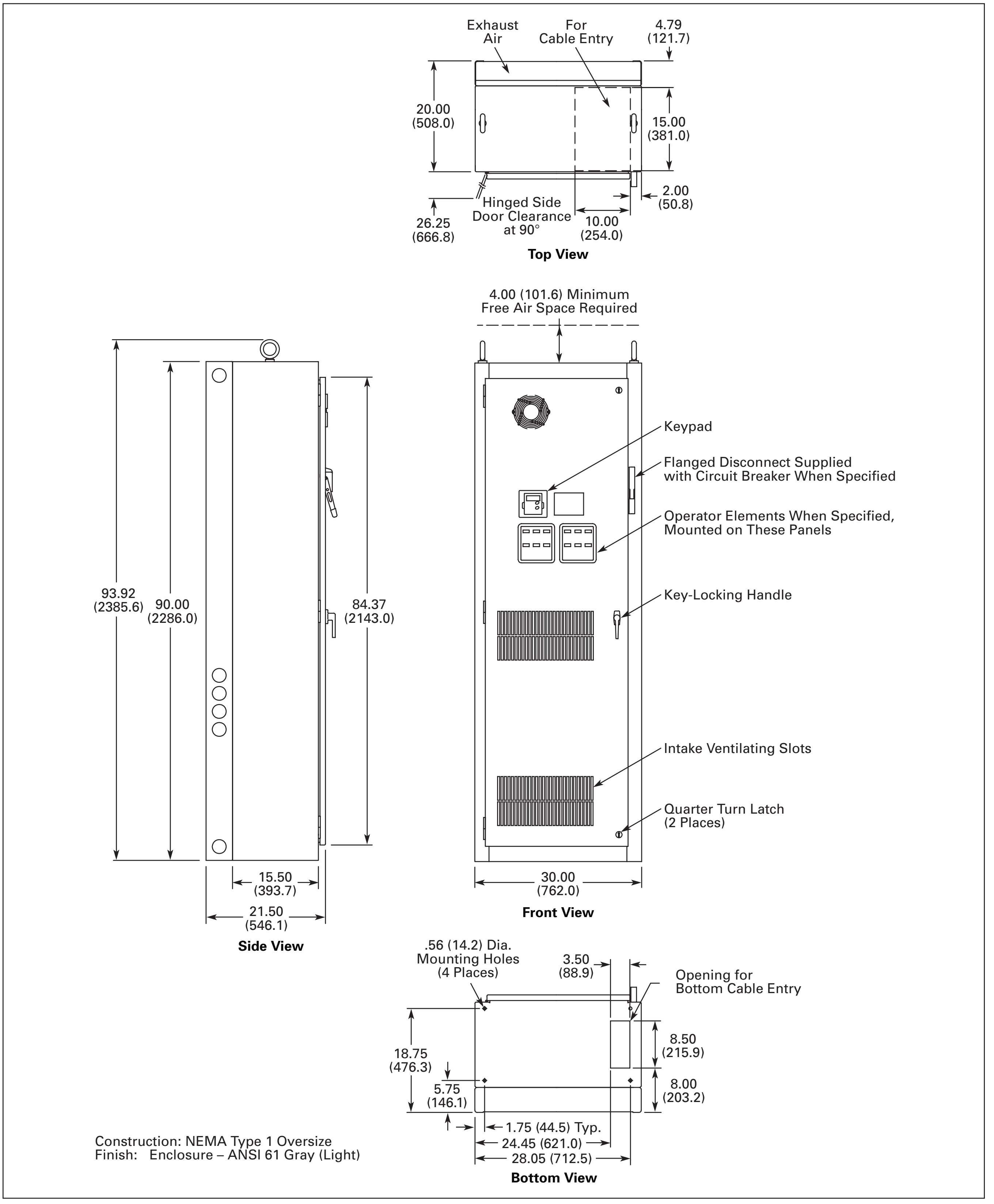

Figure 14. Enclosure Size 7, 25 – 150 hp VT/25 – 125 hp CT — Approximate Dimensions in Inches (mm)

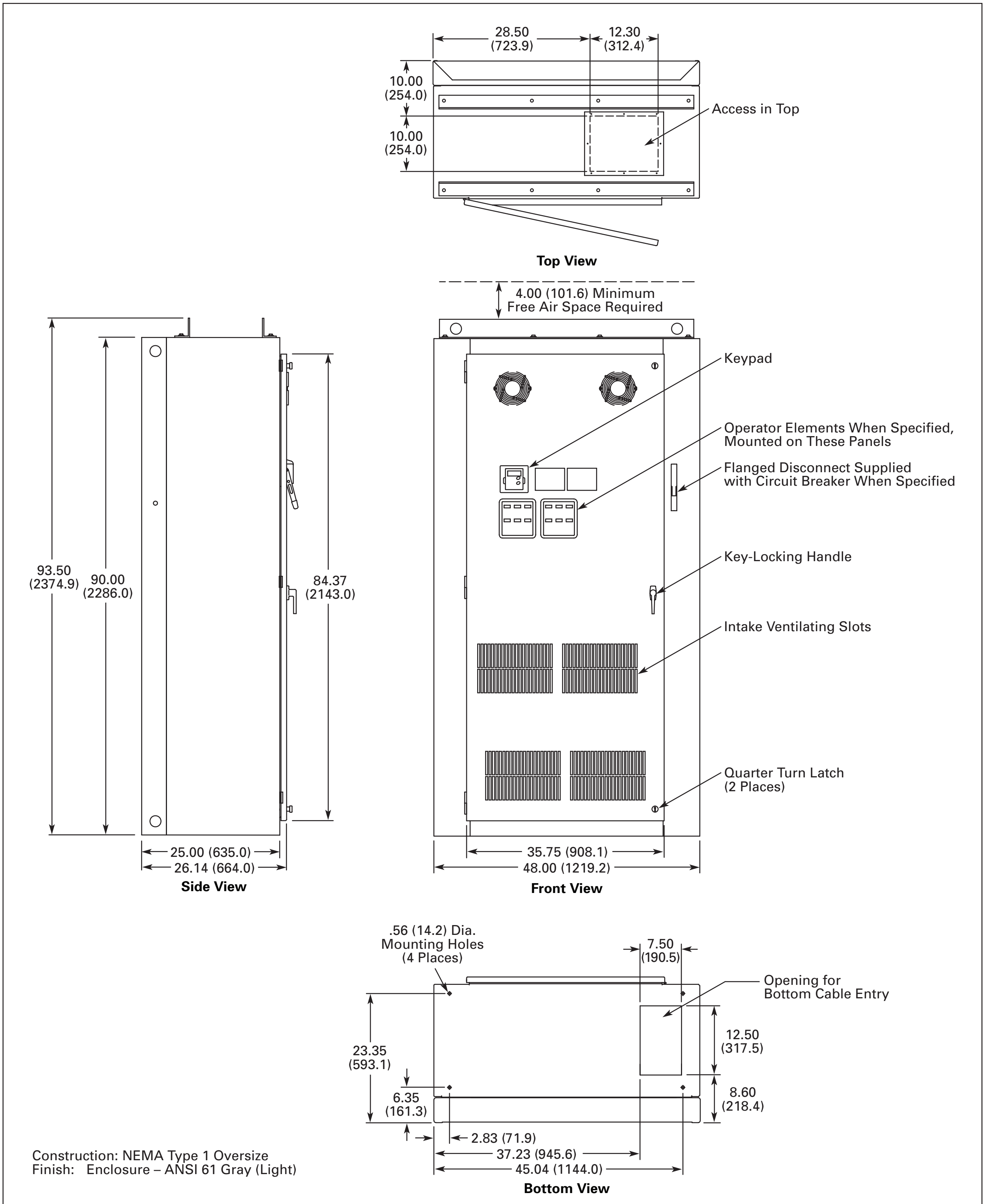

Figure 15. Enclosure Size 8, 150 – 200 hp CT/200 – 250 hp VT — Approximate Dimensions in Inches (mm)

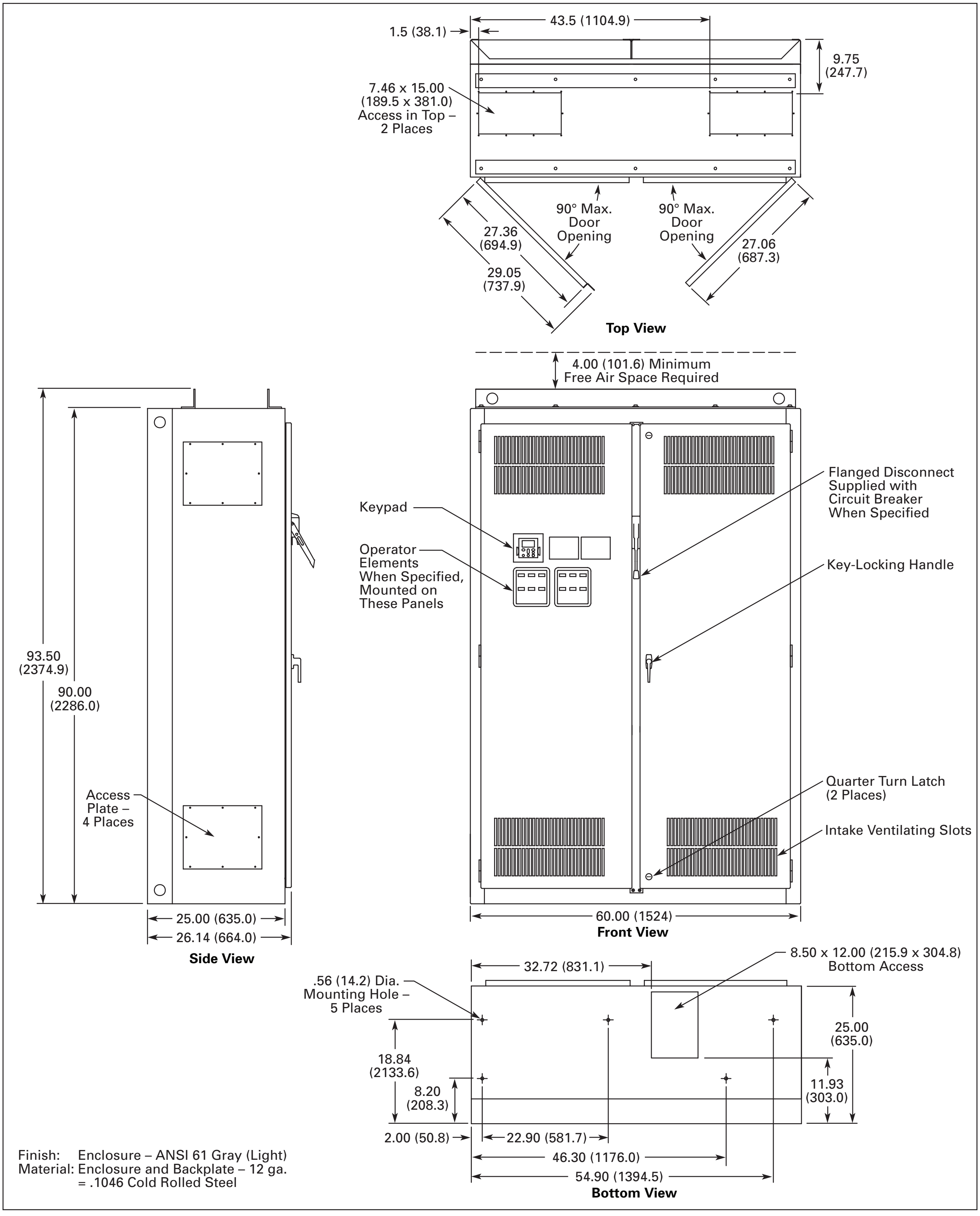

Figure 16. Enclosure Size 9, 250 – 350 hp CT/300 – 400 hp VT, Approximate Dimensions in Inches (mm)

Wiring Diagrams

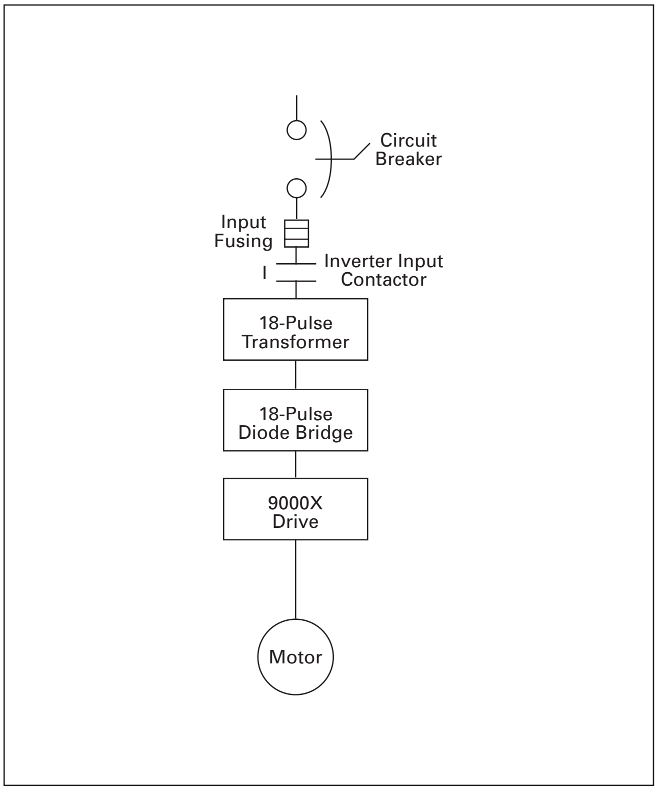

Figure 17. Power Diagram 25 – 250 hp VT/25 – 200 hp CT

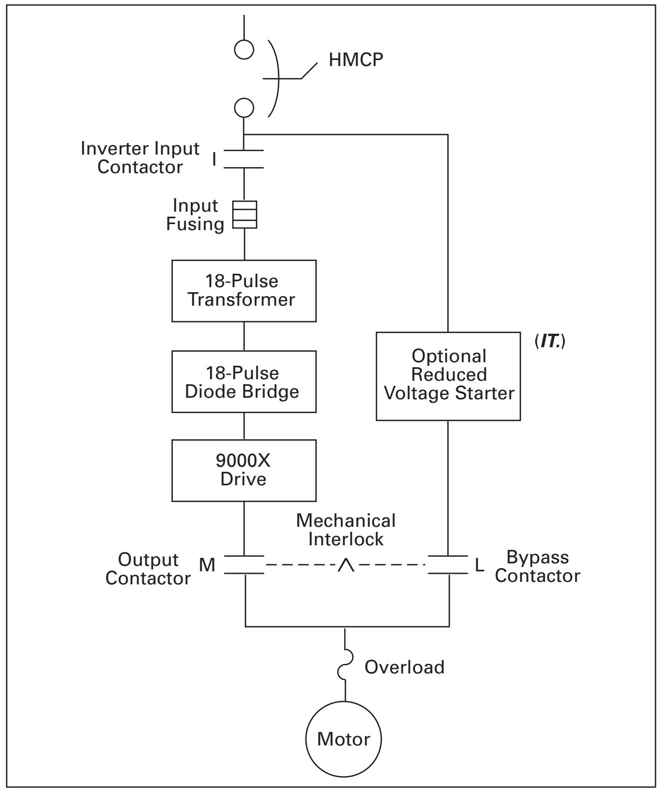

Figure 19. Power Diagram 25 – 250 hp VT/25 – 200 hp CT with Bypass

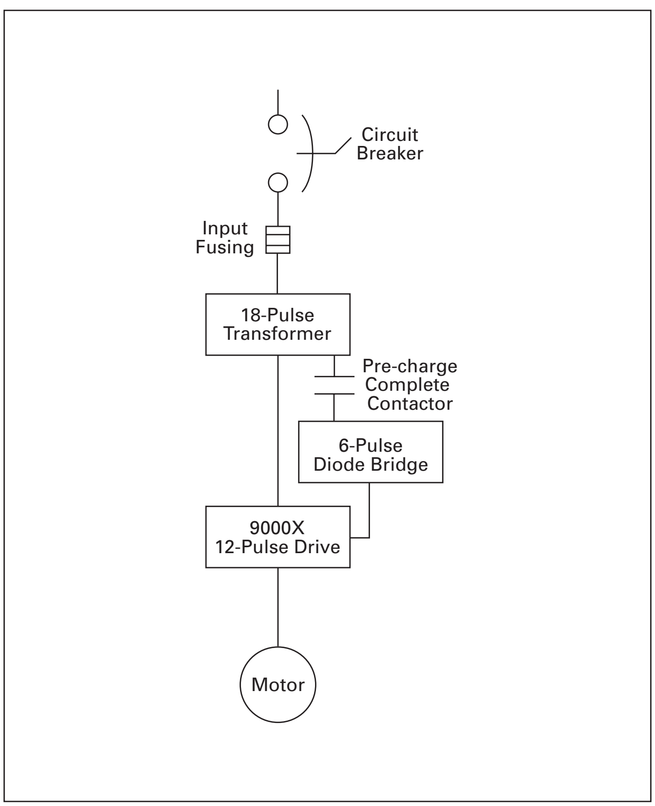

Figure 18. Power Diagram 300+ hp VT/250+ hp CT

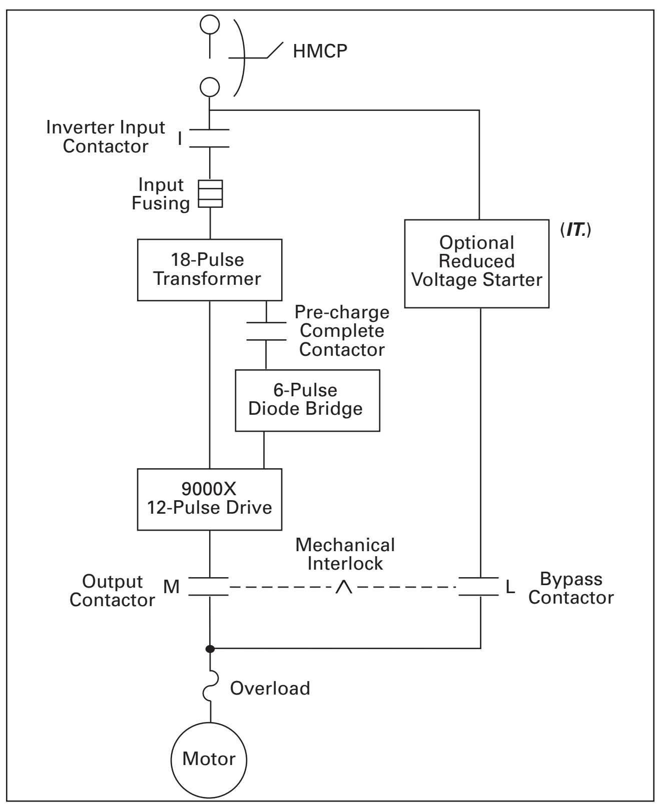

Figure 20. Power Diagram 300+ hp VT/250+ hp CT with Bypass

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