11100 / 1105 / 1110 / 1120 / 1130 / 1200 / 1230

Variable-Frequency AC Drives

Guide to Installation, Troubleshooting, and Maintenance

1 1/2 to 1,000 hp
(1.1 to 750 kW)

For revisions ECL 10 and above

Notices

The information contained in this manual is considered accurate to the best knowledge of the supplier at the time of publication. The manufacturer, however, assumes no liability for errors that may exist. The supplier reserves the right to change data and specifications without notice.

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Safety Information

Overview

This section states important safety information that must be followed when installing, operating, and servicing the drive. Study this information carefully before working on or with the unit. Failure to follow these instructions may lead to personal injury or death or to damage to the drive, motor, or driven equipment.

Additional safety instructions specific to the application software can be found in the application documentation. Please study and follow those instructions as well.

Conventions Used

The following notation conventions are used throughout this manual to indicate information important to personal safety or machine hazards.

Attention

Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.

General Precautions

Attention

Only qualified personnel with the proper skills, instruction, and familiarity with the drive and its applications should install, start up, operate, troubleshoot, and maintain the drive. You must be familiar with the electrical and mechanical components of the system to perform the procedures outlined in this manual. Failure to comply may result in personal injury, death, and/or equipment damage.

Attention

Failure to take proper precautions for electrical hazard could cause injury or death.

Attention

Failure to follow industry safety standards and instructions in this manual could damage the drive and void the manufacturer's warranty.

Attention

The drive may be sensitive to electrostatic discharge. Static precautions are required when servicing or repairing the unit.

Attention

If an aluminum electrolytic capacitor in the drive fails from a build-up of internal pressure, a safety vent will operate, spraying electrolyte vapor from the capacitor. If a capacitor vents, avoid contact with the liquid, avoid inhaling the vapors, and ventilate the area. If your skin comes in contact with the electrolyte, flush it immediately with cold water. If electrolyte gets in your eyes, immediately remove any contact lenses and flush the open eyes with plenty of clean water. If electrolyte is ingested, dilute it by drinking warm water and seek immediate medical attention.

Attention

Drives are intended for fixed, permanent connection to earthed three-phase supply mains. Use of EMC filters along with the equipment will increase leakage current in the protective conductor and may affect compatibility with residual-current-operated protective devices.

Attention

The drive provides solid-state motor overload protection. The level of protection is dependent upon the rating of the unit (given in Table 2-2) as well as the software overload specified by the user. Please refer to the application documentation for instructions on adjusting the overload.

Installation Precautions

Attention

An incorrectly installed or operated drive can result in damage to the equipment it controls. Make certain installation and operating specifications are followed.

Attention

To provide protection against electrical shock, drives must be mounted in an enclosure meeting at least the requirements of Protective Type IP20 (or NEMA equivalent) according to EN60529 and with top surfaces meeting at least the requirements of IP40 (or NEMA equivalent). It is recommended that a key or tool be required to open the enclosure and that enclosure doors be interlocked with the electrical supply disconnect.

Attention

The drive and associated equipment must be properly earth grounded.

Attention

Any site insulation tests must be performed before making electrical connections to the drive.

Attention

The drive is not equipped with a supply-disconnecting device. An external supply-disconnecting device must be provided to isolate incoming electrical supplies during installation and maintenance work. This device should comply with the requirements of EN 60204-1 as well as all applicable national and local regulations.

Application Precautions

Attention

Emergency stop devices shall be located at each operator control station and at other operating stations where emergency stop may be required. Control inputs and keypad motor-control functions do not generate an emergency stop of the motor and do not remove power that can cause hazardous conditions. Regardless of the operating state, the drive's motor output terminals may be at dangerous voltage levels whenever input power is applied and the bus is charged.

Attention

Drive functionality depends upon the application software installed. Some application software offers automatic restart functions that allow the unit to reset and resume operation after a fault. These functions must not be enabled when hazardous conditions might arise from such action. Certain features may present additional hazardous situations. Refer to the associated application documentation for further safety information.

Service Precautions

Attention

Always disconnect and lock out all electrical supplies before working on the drive or associated equipment. Do this before touching any electrical or mechanical components associated with the drive application.

Attention

High voltage may be present even when all electrical power supplies are disconnected. After switching off electrical power, wait at least 15 minutes for bus circuit capacitors to discharge before working on the drive or associated equipment. Use an appropriate voltmeter to further verify that capacitors are discharged before beginning work. Do not rely exclusively on the bus voltage indicator. Dangerous voltage levels may remain even when the indicator is off.

Attention

High voltage may be present at the motor output terminals (U, V, W) whenever input power is applied, regardless of whether the motor is moving or not.

Attention

Before energizing the motor, verify that there are no loose components associated with the drive train and that motor motion will not result in injury or damage to the equipment.

Safe Service Practices

Follow industry-recognized safety procedures:

- Use only one hand to hold test equipment probes
- Wear approved eye protection
- Stand on insulated material
- Use an isolated oscilloscope
- Keep unnecessary personnel out of the work area
- Never leave a drive cabinet open or unattended

1 About the Manual

1.1 Overview

This chapter describes the contents and intended audience of this document.

1.2 Contents

The manual provides the instructions and technical information necessary to install and maintain the hardware of Unico's 1000 family of AC drives. Specifically, the manual pertains to units listed in Table 1-1. The 1140 Variable-Voltage AC Drive is covered separately in publication 1140.40 (111-564).

Table 1-1—1000 Family

Drive	Description
1100	Variable-Frequency AC Drive
1105	Variable-Frequency AC Drive
1110	Phase-Converting AC Drive
1120	Modular AC Drive
1130	Line-Regenerative AC Drive
1200	Variable-Frequency AC Drive
1230	Line-Regenerative AC Drive

What's covered

- *Safety Instructions*, discusses safety hazards and procedures important to anyone working with the drive
- Chapter 2, *Product Overview*, tells how to receive the drive and provides an overview of its architecture, features, and specifications
- Chapter 3, *Mechanical Installation*, provides instructions on physical installation Chapter 4, *Electrical Installation*, explains the routine electrical connections
- Chapter 5, *Troubleshooting/Maintenance*, discusses troubleshooting and maintenance of the drive hardware

What's not covered

This manual does not address aspects of the drive that depend upon the application software. Please refer to the application documentation for the following:

- Application-specific control signal wiring and definitions
- Operator interface instructions
- Start-up procedure
- Detailed description of drive features and modes of operation
- Parameter descriptions
- Fault identification and troubleshooting

This manual is not intended to provide in-depth service instructions. For service beyond that described in this manual, please contact Unico or your representative.

1.2.1 Intended Audience

The manual is intended for anyone who will be installing and servicing the drive. Installation should be performed by qualified electrical personnel to ensure that correct electrical practices and applicable electrical codes are applied.

The audience is expected to have a basic knowledge of physical and electrical fundamentals, electrical wiring practices and components, and electrical schematics. No prior experience with the drive is presumed or required.

Follow instructions

You can prevent injury and damage to the drive or equipment by carefully following the procedures outlined in this manual.

Follow regulations

All electrical work should conform to the National Electrical Code as well as all state and local government regulations. Please familiarize yourself with these regulations.

Read both manuals first

Read this manual *and* the application manual entirely before installing the drive.

2 Product Overview

2.1 Overview

This chapter provides an overview of the 1000 family of drives. It gives instructions on unpacking, identifying, storing, and transporting a drive. It also familiarizes the user with the basic features, architecture, and specifications of the drives.

2.2 Unpacking

After opening the package, you should verify delivery and inspect the drive before installing, storing, or transporting the unit.

2.2.1 Lifting Instructions

Smaller drives are mounted on wooden supports and shipped in corrugated boxes, while the large drives are transported on skids. When unpacking a boxed drive, carefully follow the lifting instructions below.

Attention

The drive may weigh a considerable amount. To avoid the risk of personal injury and/or damage to the drive, two people should work in unison when lifting and maneuvering the unit. Follow industry prescribed safe-lifting practices at all times.

[1] **Remove protective holder**
Lift off the cardboard protector that holds the instruction manuals.

[2] **Remove screws**
Remove the four wood screws that secure the heat sink of the drive to the wooden shipping supports.

[3] **Lift by the heat sink**
Two people may be required to safely lift the drive from its box. Each person should stand at one end of the drive, facing the other. Using both hands, place your fingertips beneath the rim of the aluminum heat sink and lift carefully in unison.

Attention

To avoid damage, do not lift the drive by the keypad/display bracket or by the control modules.

2.2.2 Verify delivery

Check that you received the drive that was ordered as well as any options or accessories. Minimally, you should have received a drive and two manuals (this installation guide and an application guide). Contact your supplier regarding any discrepancies.

2.2.3 Inspect for damage

Inspect the drive for any damage that may have occurred during shipment. Remove the cover, if present, and visually examine the insides for obvious problems. If damage is found, do not operate the drive. Report the problem immediately to the supplier.

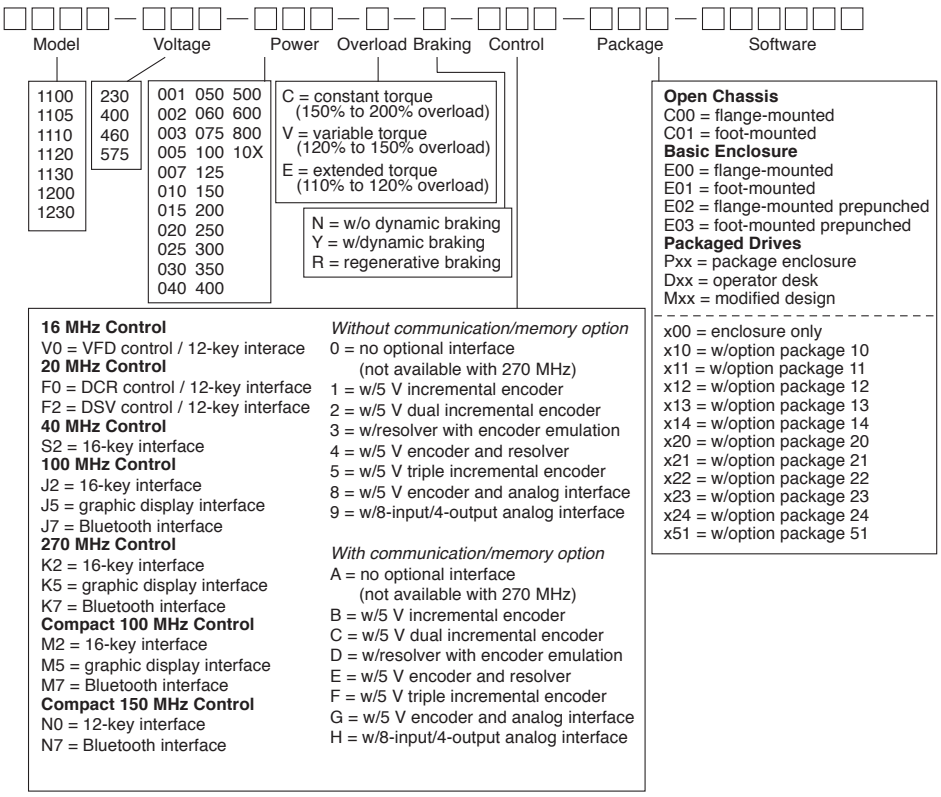
2.2.4 Storage/Transportation

If the drive must be stored or transported to another location before installation, verify that the ambient conditions are acceptable according to the environmental specifications given in Table 2-3. Choose a storage location that is clean, dry, and noncorrosive. Repack and store the drive in its original packaging.

2.2.5 Nameplate Identification

Drives are ordered using a model number similar to that shown in Figure 2-1. The model number identifies the drive type (1100, 1105, 1110, 1120, 1130, 1200, or 1230) and its configuration, including voltage, power, overload, control type, braking and packaging options, and application software. Each drive is labeled with an identification tag that indicates its part number, serial number, and input/output ratings.

Figure 2-1—Drive Model Number



2.3 Family Overview

The 1000 family of AC drives provides digital flux vector control of ordinary three-phase AC motors. The drives combine the latest insulated-gate-bipolar-transistor (IGBT), pulse-width modulation (PWM), and digital signal processor (DSP) technologies with digital-current-regulator (DCR) or digital-space-vector (DSV) control to deliver optimum motor performance, complete programmability, and simplicity of operation. Variable-frequency drive (VFD) operation is also available for cost-effective control of motor speed in simple applications.

The complete family is comprised of the 1100, 1105, 1110, 1120, 1130, 1200, and 1230 series of variable-frequency drives as well as the 1140 variable-voltage drive. These drives share a common architecture that provides a high degree of internal consistency. By combining this core drive topology with unique input sections, the 1000 family furnishes flexible, efficient, and cost-effective solutions to a variety of application needs. Table 2-1 summarizes the various models within the family. The 1140 is described in a separate publication.

Table 2-1—1000 Family Summary

Drive	Description	Input Voltages	Power Range	Input Operation
1100	Variable-Frequency AC Drive	230/460/575 V	1 1/2-600 hp	Three- or six-phase rectifier
1105	Variable-Frequency AC Drive	230/460/575 V	1 1/2-300 hp	Three- or six-phase rectifier
1110	Phase-Converting AC Drive	230/460 V	1 1/2-100 hp	Single-phase rectifier
1120	Modular AC Drive	230/460 V	1 1/2-200 hp	Rectified DC bus
1130	Line-Regenerative AC Drive	230/460/575 V	7 1/2-150 hp	Three-phase rectifier/inverter
1140	Variable-Voltage AC Drive	230/460/575 V	5-500 hp	Three-phase SCR control
1200	Variable-Frequency AC Drive	230/460 V	1 1/2-1000 hp	Three- or six-phase rectifier
1230	Line-Regenerative AC Drive	460 V	1 1/2-600 hp	Three-phase rectifier/inverter

2.3.1 Features

Performance Flexibility

The 1000 family accommodates a broad range of performance requirements. Units may be configured for constant-torque operation for heavy-duty cyclic loads, variable-torque operation for medium-duty requirements, or extended-torque operation for centrifugal loads such as fans and pumps. The drive operates in a transducerless vector control mode that does not require a feedback device and produces full torque to base speed with full starting torque. For demanding applications, an incremental encoder or resolver interface can be added for precise position, velocity, and torque regulation and improved dynamic performance. Dual- and triple-encoder interfaces are also available for position-following and dual-transducer applications. Variable-frequency control is alternately available for applications that do not require critical velocity or torque control.

Motor-Independent Design

The 1000 family drives operate any standard- or inverter-duty AC induction or synchronous motor, making it ideal for retrofits and new applications alike. A unique, proprietary digital current regulator (DCR) tunes the drive continuously in real time, eliminating the usual current-loop tuning process required by conventional drives. Digital space vector (DSV) control can be selected for reduced motor noise and low current ripple.

Auto Tuning

Once routine electrical connections have been made, simple-to-use auto-tuning features adjust virtually all motor- and load-dependent parameters. No motor maps are required. Simply enter basic motor information from the nameplate, and the advanced setup routines do the rest. The drive is completely tuned within minutes.

Control Options

Numerous control and interface options are available. The 16 MHz control module provides variable-frequency drive (VFD) control for simple applications. The 20 MHz and 40 MHz control modules are available in digital-current-regulator (DCR) and digital-space-vector (DSV) versions. The 100 MHz, 270 MHz, and Compact 100 MHz control modules provide for VFD, DCR, and DSV control. The Compact 150 MHz control module provides VFD and DSV control. Each control module provides digital and analog inputs and outputs as well as asynchronous serial communication capabilities. The 20 MHz, 40 MHz, 100 MHz, 270 MHz, and Compact 100 MHz modules also provide synchronous serial communication capabilities. The 100 MHz and 270 MHz modules include provision for an optional Anybus® module for communication using a variety of industry-standard protocols, while the 100 MHz, 270 MHz, and the Compact 100 MHz modules include provision(s) for a MaxStream™ module for wireless communication. Depending upon the control module, drives can accept motor and/or machine feedback with a single, dual, or triple incremental encoder interface, a resolver interface, or resolver and encoder interfaces. An optional analog interface module is also available for expanding the analog I/O capabilities of a drive. One of three keypad/display units is available, depending upon the application.

Application Software

A wide variety of software options is available to tailor a drive to its application, from a fully featured velocity/torque control for general purposes to a host of powerful programs pre-engineered for specific applications. Customization is possible with many programs using *UEdit*™, a Windows-based programming tool that allows users extend an application using IEC 1131 standard ladder diagrams and function blocks.

Braking Options

The 1000 family offers both dynamic and regenerative braking options. A dynamic braking IGBT allows motor braking energy to be dissipated in an external resistor. This dynamic braking control is included as standard on all 1120 drives and smaller 1105 and 1200 drives. It is optional on larger 1105 and 1200 drives and all 1100 and 1110 drives. Appropriately sized external braking resistors are required. The 1130 and 1230 line-regenerative drives provide true four-quadrant control without requiring dynamic braking. Energy generated by stopping the motor and load is put back onto the power grid rather than wasted as heat in a resistor.

Digital Setup, Easy Operation

A keypad and liquid crystal display provide a simple interface for setting and viewing operating parameters and diagnostics. All controller settings are made digitally for precision and repeatability. Readouts and fault messages are displayed in readily understandable language. A graphical display option provides on-board oscilloscope-type viewing of drive and system parameters.

Multiaxis Operation

A built-in high-speed synchronous communication port allows the motion of multiple slave drives to be precisely coordinated. With optional master/slave software, the velocity ratio and position phasing of the drives can also be controlled. Multiple motors can be operated in parallel from a single drive using optional variable-frequency control.

Power Quality

A built-in link choke on the 1100, 1105, and 1110 drives and the unique low-capacitance design of the 1200 provides near-unity overall power factor and low harmonic line currents at all motor speeds. High-power 1100, 1105, and 1200 drives also offer a six-phase (twelve-pulse) configuration for further minimizing line harmonics in critical applications. The 1130 and 1230 line-regenerative drives provide near-unity power factor for both motoring- and braking-type loads by using an IGBT bridge to control the flow of power into and out of the drive.

Protection and Advanced Diagnostics

Drives monitor their operating conditions and provide a comprehensive set of overload, short circuit, and other electronic protective features to ensure safe, reliable operation. Faults indications are displayed in plain language. A log maintains a history of fault occurrences and externally triggered events.

Serial Connectivity

An RS-422/485 serial interface is provided for connecting a drive to a process controller, communication network, or programmable controller. A variety of popular communication protocols is available. The 100 MHz and 270 MHz modules also accept an Anybus® module with numerous industry-standard protocol options, and the 100 MHz, 270 MHz, and Compact 100 MHz modules accept MaxStream module(s) for wireless communications. An RS-232 connection is also provided on 40 MHz, 100 MHz, 270 MHz, Compact 100 MHz, and Compact 150 MHz controllers for connecting a personal computer. The Compact 150 MHz module also provides a USB 2.0 port for asynchronous communications. Windows-based PCs can set up, monitor, and control a network of drives using optional DriveLink™ or UEdit™ software. Drive Archive™ and Drive Chart™ for the Palm OS make it easy to save and restore setups and capture charts using a handheld computer.

Packaging

Compact and rugged, drives are available either enclosed or as an open chassis for mounting inside an enclosure. Both versions can be foot-mounted to a wall or subplate or flange-mounted through a cutout to dissipate heat outside an enclosure. Standard packaged systems are also available that incorporate additional components within an enclosure.

2.3.2 Drive Architecture

The general function of the drive is to convert a fixed voltage and frequency from an electrical power source into a variable voltage and frequency for controlling an AC motor. The basic architecture of the 1100, 1105, and 1110 drives is shown in Figure 2-2, that of the 1120 drive in Figure 2-3, that of the 1130 and 1230 drives in Figure 2-4, and that of the 1200 in Figure 2-5.

A *rectifier section* is used on the 1100, 1105, 1110, and 1200 drives to convert the fixed AC line voltage into a DC bus voltage. The 1120 is a modular design intended for operating a number of units from a common DC bus. Low-power drives use a diode rectifier and resistors to charge the bus capacitors, which is then bypassed by a contact once the bus is up to full voltage. Medium- and high-power drives use silicon-controlled rectifiers (SCRs) to control the charging of the bus capacitors. High-power drives provide for optional twelve-pulse (six-phase) connection of the input to reduce harmonic currents. The 1110 drive is designed for single-phase operation using two, rather than three, AC line voltage terminals. A *rectifier control* coordinates the charging of the bus.

A *link choke* and *bus capacitors* in the 1100, 1105, and 1110 drives form a filter that smoothes the output of the rectifier section into a steady DC voltage. An optional *dynamic brake* device on these units allows regenerative energy from the load to be dissipated in an external resistor when the drive is braking. The link choke and dynamic brake device are normally part of the converter supplying the DC bus to 1120 units.

A *converter section* is used on the 1130 and 1230 drives to regulate power flow between the AC line and DC bus. The converter uses an insulated gate bipolar transistor (IGBT) bridge to rectify the AC line voltage into a DC bus voltage. This section also regenerates energy from the DC bus to the AC line when the drive is braking.

An *inverter section* consisting of six insulated gate bipolar transistors (IGBTs) is used to power an AC motor. This section can produce sine-wave motor voltages and currents of any desired amplitude by rapidly switching the IGBTs using a technique called pulse-width modulation (PWM). A *gate driver* is used to pass switching signals from the drive controller to the IGBTs.

Overall operation of the unit is regulated by a *drive control* that incorporates a digital signal processor (DSP) and a digital current regulator (DCR) or digital space vector (DSV) control. This high-speed digital control uses both voltage and current feedback to regulate the output to the motor. Optional *encoder* and *resolver interfaces* are available to provide closed-loop control of motor velocity and/or position. A dual encoder option is available to slave the motor to other sections of a machine or to reduce machine resonance using dual transducer control. Variable-frequency drive (VFD) operation is an option for controlling AC motors in simple applications.

A *keypad* and *display* on the control module provide access to operating and setup parameters. The control module also provides analog and digital inputs that can be used as input to and output from the drive. Serial communication channels are also available for connecting drives to process controllers, communication networks, programmable controllers, or personal computers.

Figure 2-2—Architecture of the 1100, 1105, and 1110 Drives

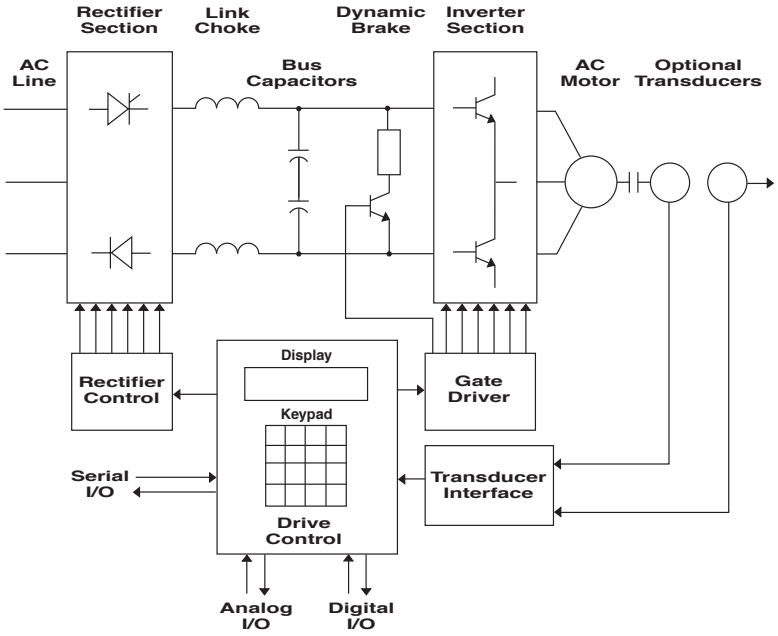


Figure 2-3—Architecture of the 1120 Drive

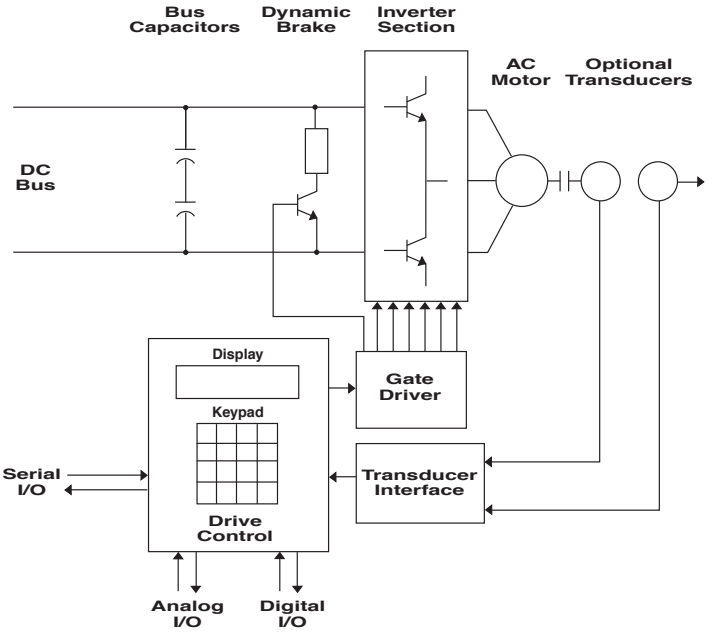


Figure 2-4—Architecture of the 1130 and 1230 Drives

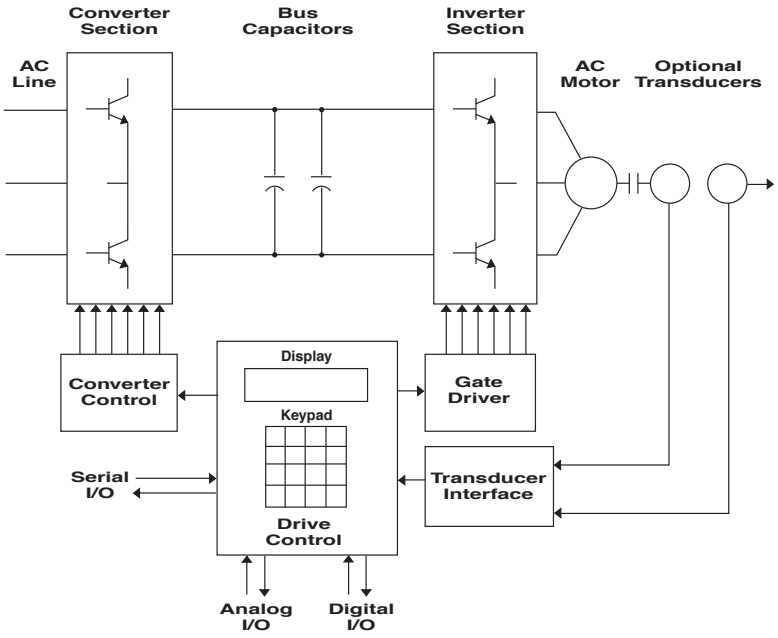
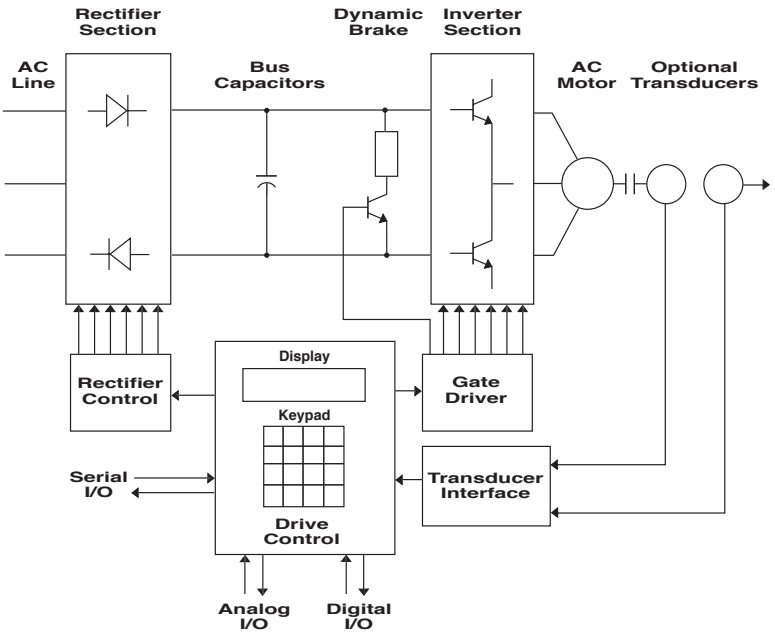


Figure 2-5—Architecture of the 1200 Drive



2.4 Specifications

Detailed drive specifications are provided in Table 2-2 through Table 2-14 below.

Table 2-2—Electrical Specifications

Input Supply

Line voltage:	200 to 240 V AC, three phase (1100, 1105, 1120, 1130, and 1200) 220 to 240 V AC, single-phase (1110) 380 to 480 V AC, three-phase (1100, 1105, 1120, 1130, 1200, and 1230) 440 to 480 V AC, single-phase (1110) 500 to 600 V AC, three-phase (1100, 1105, and 1130) Phase-sequence insensitive Overvoltage Category III (IEC 664-1)
Voltage tolerance:	–10% of minimum, +10% of maximum
Imbalance:	Maximum ±3% of nominal input voltage
Frequency:	47 to 65 Hz
Short circuit rating:	85,000 A_{rms} symmetrical
Power factor:	Displacement: 1.00 at all loads and speeds Overall: 0.99 at rated load (1230) 0.94 at rated load (1100, 1105, 1130, and 1200) 0.65 at rated load (1110)
Harmonic distortion:	(1230) Harmonics are below the limits defined in IEEE-519 for all I_{SC}/I_L. Each individual harmonic current fulfils IEE-519 table 10-3 for $I_{SC}/I_L \geq 20$. Current total harmonic distortion (THD) and each individual current harmonic fulfil IEC 61000-3-4 table 5.2 for $R_{SCE} \geq 66$. The values will be met if the supply network voltage is not distorted by other loads.

R_{sc}	THD Voltage (%)	THD Current (%)
20	4	4
100	0.8	5

Output Rating

Voltage:	Zero to input supply voltage, three-phase (1100, 1105, 1120, 1130, 1200, and 1230) Zero to 90% of input supply voltage, three-phase (1110)
Frequency:	Zero to 120 Hz for transducerless vector control Zero to 180 Hz for transducer-based vector control Zero to 300 Hz for variable-frequency control
Switching frequency:	16 MHz control: 1.0, 1.9, 3.9, 7.8, and 15.6 kHz (see Table 2-14) 20 MHz control: Programmable from 1.1 to 6.5 kHz (see Table 2-14) 40 MHz, 100 MHz, 270 MHz, Compact 100 MHz, and Compact 150 MHz controls: Programmable from 1.0 to 12.0 kHz (see Table 2-14)

Table 2-2—Electrical Specifications *(continued)*

Service Conditions			
Efficiency:	97% nominal at rated switching frequency		
Overload current (†):	*Torque*	*Overload (1 min)*	*Maximum*
	Constant	150% to 200% of rated	200% of rated
	Variable	120% to 150% of rated	140% to 160% of rated
	Extended (1100, 1105, 1120, 1130, 1200, 1230)	110% to 120% of rated	120% to 140% of rated

(†) Depending upon the application, the overload may reach the listed upper limit with a corresponding decrease in overload time. Refer to the application documentation for further information.

Table 2-3—Environmental Specifications

Operating Environment	
Temperature:	Control section: 32° to 131° F (0° to 55° C) Heat sink (standard): 32° to 104° F (0° to 40° C) Heat sink (derated): 32° to 122° F (0° to 50° C)
Relative humidity:	5% to 95%, noncondensing
Altitude:	0 to 3,300 ft (0 to 1,000 m) above sea level *Derate output power 1% per 330 ft (100 m) above 3,300 ft (1,000 m).*
Air pressure:	20.67" to 31.30" (70 to 106 kPa)
Vibration:	0.3 mm (2 to 9 Hz), 1 m/s^2 (9 to 200 Hz) sinusoidal (IEC 68-2-6)
Pollution:	Nonconductive pollution according to Pollution Degree 2 of IEC 664-1 *If the drive is to be used in a more polluted environment (Pollution Degree 3 or 4), suitable enclosures and air filtering or conditioning equipment must be used. To protect against dust ingress, an IP6x-rated enclosure (or NEMA equivalent) must be used.*
Contamination levels:	Class 3C2 for chemicals (IEC 721-3-3) Class 3S2 for dust (IEC 721-3-3)
Storage Environment	
Temperature:	–40° to 158° F (–40° to 70° C)
Relative humidity:	5% to 95%, noncondensing
Air pressure:	20.67" to 31.30" (70 to 106 kPa)
Transportation Environment	
Temperature:	–40° to 158° F (–40° to 70° C)
Relative humidity:	5% to 95%, noncondensing
Air pressure:	20.67" to 31.30" (70 to 106 kPa)

Table 2-4—Performance Specifications

Frequency Control (16 MHz control)	
Range:	Zero to base speed at full torque Base speed to 300 Hz at constant power
Resolution:	0.024% with analog input (12-bit) 0.1 Hz with digital input
Velocity Control (20, 40, 100, 270 MHz, Compact 100 MHz, and 150 MHz control)	
Range:	Zero to base speed at full torque Base speed to 180 Hz at constant power with transducer Base speed to 120 Hz at constant power without transducer
Regulation:	±0.001% of base speed, down to zero, with transducer ±0.5% of base speed, 2 Hz and above, without transducer
Torque Control (20, 40, 100, 270 MHz, Compact 100 MHz, and Compact 150 MHz control)	
Starting torque:	Constant torque: zero to 150% to 200% of rated Variable torque: zero to 120% to 150% of rated Extended torque: zero to 110% to 120% of rated (1100, 1105, 1120, 1130, 1200, and 1230)
Regulation:	±2.0% of maximum with transducer ±5.0% of maximum without transducer

Table 2-5—Processor/Memory Specifications

Central processing unit:	16 MHz control: 80C196 microprocessor
	20 and 40 MHz controls: 56002 digital signal processor (DSP)
	100 MHz amd Compact 100 MHz controls: 56309 digital signal processor (DSP)
	270 MHz control: 56321 digital signal processor (DSP)
	Compact 150 MHz control: TMS320F2812 digital signal processor (DSP)
Clock frequency:	16 MHz, 20 MHz, 40 MHz, 100 MHz, 150 MHz, or 270 MHz
Data memory:	16 MHz control: 2 kilobyte battery-backed static RAM
	20 MHz control: 16 kilobyte battery-backed static RAM
	40 MHz control: 32 kilobyte battery-backed static RAM
	100 MHz and Compact 100 MHz controls: 128 kilobyte battery-backed static RAM
	270 MHz control: 512 kilobyte battery-backed static RAM
	Compact 150 MHz control: 128 kilobyte battery-backed static RAM
	Memory expansion module: Accepts SD flash memory card up to 2 GB
Scratch pad memory:	16 MHz control: 256 byte high-speed RAM
	20 MHz control: 24 kilobyte high-speed RAM
	40 MHz control: 142 kilobyte high-speed RAM
	100 MHz, 270 MHz, and Compact 100 MHz controls: 1.5 megabyte high-speed RAM
	Compact 150 MHz control: 36 kilobyte high-speed RAM
Program memory:	16 MHz control: 64 kilobyte flash EPROM
	20 MHz control: 384 kilobyte flash EPROM
	40 MHz control: 1.5 megabyte flash EPROM
	100 MHz and Compact 100 MHz controls: 3.0 megabyte flash EPROM
	270 MHz control: 6.0 megabyte flash EPROM
	Compact 150 MHz control: 256 kilobyte flash EPROM

Table 2-6—Input/Output Specifications

Analog	
Inputs:	16 MHz and 20 MHz controls: Three (3) 12-bit analog inputs (±10 V DC, 0 to 10 V DC, and 0 to 20 mA)
	40 MHz, 100 MHz, 270 MHz, Compact 100 MHz, and Compact 150 MHz controls: Three (3) 12-bit analog inputs (±10 V DC or 0 to 20 mA)
	Analog Interface Module (optional): Eight (8) 12-bit analog inputs (0 to 10 V DC or 0 to 20 mA)
Outputs:	16 MHz and 20 MHz controls: Two (2) 12-bit analog outputs (±10 V DC)
	40 MHz, 100 MHz, 270 MHz, and Compact 100 MHz controls: Two (2) 12-bit analog outputs (±10 V DC and 0 to 20 mA)
	Compact 150 MHz control: Two (2) 10-bit analog outputs (±10 V DC and 0 to 20 mA)
	Analog Interface Module (optional): Four (4) 12-bit analog outputs (±10 V DC)
Digital	
Inputs:	16 MHz, 40 MHz, 100 MHz, 270 MHz, Compact 100 MHz, and Compact 150 MHz controls: Twelve (12) digital inputs (require sink of 1 mA to common)
	20 MHz control: Eleven (11) digital inputs (require sink of 1 mA to common)
	I/O Fanning Strip (optional): Provision for input converters rated 2.5 to 2.8 V DC @ 30 mA, 90 to 140 V AC @ 11 mA, and 180 to 270 V AC @ 5 mA
Outputs:	16 MHz and 20 MHz mixed I/O controls: Three (3) digital outputs (Form C contacts rated 125 V AC @ 5 A, Form A contact rated 125 V AC @ 5 A, and open-collector driver rated 24 V DC @ 500 mA)
	40 MHz, 100 MHz, 270 MHz, Compact 100 MHz, and Compact 150 MHz logic I/O controls: Six (6) digital outputs (open-collector driver rated 24 V DC @ 500 mA)
	I/O Fanning Strip (optional): Provision for output converters rated 5 to 60 V DC @ 3 A, 12 to 140 V AC @ 3 A, or 24 to 270 V AC @ 3 A; or for normally-open or normally-closed relay converters rated 250 V AC @ 8 A

Table 2-7—Serial Communication Specifications

Asynchronous	
Port(s):	16 MHz and 20 MHz controls: RS-422/485, isolated 40 MHz control: RS-232/422/485, isolated Auxiliary RS-422/485 100 MHz and 270 MHz controls: RS-232/422/485 Two (2) auxiliary RS-422/485 Compact 100 MHz control: RS-232/422/485 Auxiliary RS-422/485 Compact 150 MHz control: RS-232/422/485 USB 2.0
Baud rate:	Application dependent
Protocol:	Application dependent
Synchronous	
Port:	20 MHz, 40 MHz, 100 MHz, 270 MHz, and Compact 100 MHz controls: RS-485 for high-speed master/slave networking

Table 2-8—Communication Module Specifications

Interfaces:	100 MHz control: One (1) Anybus® communication provision One (1) Bluetooth® or MaxStream™ wireless communication provisions 270 MHz control: One (1) Anybus® communication provision Two (2) Bluetooth® or MaxStream™ wireless communication provisions Compact 100 MHz and Compact 150 MHz controls: One (1) Bluetooth® or MaxStream™ wireless communication provision
Anybus® options:	Anybus® CANopen communication module Anybus® CC-Link® communication module Anybus® ControlNet™ communication module Anybus® DeviceNet™ communication module Anybus® Ethernet communication module Anybus® Interbus communication module Anybus® LonWorks® communication module Anybus® Modbus® Plus communication module Anybus® Profibus DPV1 communication module Anybus® Profibus Master communication module
MaxStream™ options:	MaxStream™ 900 MHz wireless communication module MaxStream™ 2.4 GHz wireless communication module

Table 2-9—Encoder Interface Specifications

Internal supply:	5 V DC @ 250 mA
Channels:	100 MHz (323-397 and 323-547), 270 MHz, Compact 100 MHz (323-060), and Compact 150 MHz Control Modules: A, B, marker, reference
	Encoder Interface Module: A, B, marker
	Dual Encoder Interface Module: A, B, marker, reference
Allowable quadrature error:	±36°
Maximum input frequency:	250 kHz
Switching threshold:	200 mV
Input Impedance:	120 Ω
Differential input voltage:	±5 V
Common mode input voltage:	±5 V

Table 2-10—Resolver Interface Module with Encoder Emulation Specifications

Reference Output		
Frequency:	5 kHz	
Amplitude:	4 V_{rms}	
Feedback Input		
Sine/cosine amplitude:	2 V_{rms}	
Transformation ratio:	0.5	
Resolution	10- to 16-bit, programmable	
Maximum Recommended Speed	*Resolution*	*Speed*
	10-bit	50,000 rpm
	12-bit	12,000 rpm
	14-bit	3,000 rpm
	16-bit	800 rpm
Encoder Emulation		
Channels:	A, B, marker, feedback error	
Resolution:	*Resolver Resolution*	*Quadrature Output*
	10-bit	256 ppr
	12-bit	1,024 ppr
	14-bit	4,096 ppr
	16-bit	16,384 ppr

Table 2-11—Protection Specifications

• Ground fault	• Ambient overtemperature
• Motor phase-to-phase short circuit	• Power transistor fault (except 16 MHz control)
• DC bus overvoltage	• Logic power undervoltage (except 16 MHz control)
• DC bus undervoltage	• Memory malfunction
• Instantaneous overcurrent	• Processor not running fault (except 16 MHz control)
• Motor overload	
• Heat sink overtemperature	

Refer to the application documentation for additional protective features.

Table 2-12—Product Range

Input Voltage	Application		
	Constant-Torque	Variable-Torque	Extended-Torque
1100			
230 V AC	1 1/2-60 hp (1.1-45 kW)	2-75 hp (1.5-55 kW)	—
380 V AC	1 1/2-350 hp (1.1-262 kW)	2-400 hp (1.5-300 kW)	—
460 V AC	1 1/2-350 hp (1.1-262 kW)	2-400 hp (1.5-300 kW)	25-500 hp (18-375 kW)
575 V AC	1 1/2-400 hp (1.1-300 kW)	2-500 hp (1.5-375 kW)	40-600 hp (30-450 kW)
1105			
230 V AC	1 1/2-20 hp (1.1-15 kW)	2-25 hp (1.5-18 kW)	—
380 V AC	1 1/2-150 hp (1.1-110 kW)	2-200 hp (1.5-150 kW)	—
460 V AC	1 1/2-150 hp (1.1-110 kW)	2-200 hp (1.5-150 kW)	10-250 hp (7.5-185 kW)
575 V AC	1 1/2-200 hp (1.1-150 kW)	2-250 hp (1.5-185 kW)	10-300 hp (7.5-225 kW)
1110			
230 V AC	1 1/2-40 hp (1.1-30 kW)	2-50 hp (1.5-37 kW)	—
460 V AC	1 1/2-75 hp (1.1-55 kW)	2-100 hp (1.5-75 kW)	—
1120			
230 V AC	1 1/2-60 hp (1.1-45 kW)	2-75 hp (1.5-55 kW)	10-100 hp (7.5-75 kW)
460 V AC	1 1/2-125 hp (1.1-90 kW)	2-150 hp (1.5-110 kW)	10-200 hp (7.5-150 kW)
1130			
230 V AC	7 1/2-60 hp (5.5-45 kW)	10-75 hp (7.5-55 kW)	—
380 V AC	7 1/2-125 hp (5.5-90 kW)	10-150 hp (7.5-110 kW)	—
460 V AC	7 1/2-125 hp (5.5-90 kW)	10-150 hp (7.5-110 kW)	25-150 hp (18-110 kW)
575 V AC	7 1/2-125 hp (5.5-90 kW)	10-150 hp (7.5-110 kW)	25-150 hp (18-110 kW)
1200			
230 V AC	1 1/2-20 hp (1.1-15 kW)	2-25 hp (1.5-18 kW)	10-30 hp (7.5-22 kW)
380 V AC	1 1/2-600 hp (1.1-450 kW)	2-800 hp (1.5-600 kW)	—
460 V AC	1 1/2-600 hp (1.1-450 kW)	2-800 hp (1.5-600 kW)	10-1000 hp (7.5-750 kW)
1230			
460 V AC	1 1/2-400 hp (1.1-300 kW)	2-500 hp (1.5-375 kW)	20-600 hp (15-450 kW)

Table 2-13—Output Current Ratings

Power	Current	Constant Torque		Variable Torque		Extended Torque	
	Continuous	Overload	Maximum	Overload	Maximum	Overload	Maximum
hp (kW)	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}
230 V							
1 1/2 (1.1)	6.0	9.0	12.0	—	—	—	—
2 (1.5)	6.8	10.2	13.6	8.2	12.0	—	—
3 (2.2)	9.6	14.4	19.2	11.5	13.6	—	—
5 (3.7)	15.2	22.8	30.4	18.2	19.2	—	—
7 1/2 (5.5)	22.0	33.0	44.0	26.4	30.4	—	—
10 (7.5)	28.0	42.0	56.0	33.6	44.0	30.4	30.4
15 (11)	42.0	63.0	84.0	50.4	56.0	44.0	44.0
20 (15)	54.0	81.0	108.0	64.8	84.0	56.0	56.0
25 (18)	68.0	102.0	136.0	81.6	108.0	74.8	84.0
30 (22)	80.0	120.0	160.0	96.0	136.0	88.0	108.0
40 (30)	104.0	156.0	208.0	124.8	160.0	114.4	136.0
50 (37)	130.0	195.0	260.0	156.0	208.0	143.0	160.0
60 (45)	154.0	231.0	308.0	184.8	260.0	169.4	208.0
75 (55)	192.0	—	—	230.4	308.0	211.2	260.0
100 (75)	248.0	—	—	—	—	272.8	308.0

(continued)

The ratings provided in this table reflect standard overloads of 150% (CT), 120% (VT), and 110% (ET). Depending upon the application software, units may be operated at up to 200% (CT), 150% (VT), and 120% (ET) overload. To determine the maximum overload current for alternate VT and ET ratings, use the CT overload for the same power rating but limit it to the VT or ET maximum current. Refer to the application documentation for further information.

Table 2-13—Output Current Ratings *(continued)*

Power	Current	Constant Torque		Variable Torque	
	Continuous	Overload	Maximum	Overload	Maximum
hp (kW)	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}
380 V					
1 1/2 (1.1)	3.5	5.2	6.0	—	—
2 (1.5)	3.9	5.9	6.8	4.7	6.0
3 (2.2)	5.5	8.3	9.6	6.6	6.8
5 (3.7)	8.7	13.1	15.2	9.6	9.6
7 1/2 (5.5)	12.7	19.0	22.0	15.2	15.2
10 (7.5)	16.1	24.2	28.0	19.3	22.0
15 (11)	24.2	36.2	42.0	28.0	28.0
20 (15)	31.1	46.6	54.0	37.3	42.0
25 (18)	39.1	58.7	68.0	46.9	54.0
30 (22)	46.0	69.0	80.0	55.2	68.0
40 (30)	59.8	89.7	104.0	71.8	80.0
50 (37)	74.8	112.1	130.0	89.7	104.0
60 (45)	88.6	132.8	154.0	106.3	130.0
75 (55)	110.4	165.6	192.0	132.5	154.0
100 (75)	142.6	213.9	248.0	171.1	192.0
125 (90)	179.4	269.1	312.0	215.3	248.0
150 (110)	207.0	310.5	360.0	248.4	312.0
200 (150)	276.0	414.0	480.0	331.2	360.0

(continued)

Table 2-13—Output Current Ratings *(continued)*

Power	Current	Constant Torque		Variable Torque	
	Continuous	Overload	Maximum	Overload	Maximum
hp (kW)	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}
380 V					
1100:					
250 (185)	345.0	517.5	600.0	414.0	480.0
300 (225)	414.0	621.0	720.0	496.8	600.0
350 (262)	483.0	724.5	840.0	579.6	720.0
400 (300)	552.0	—	—	662.4	840.0
1200:					
250 (185)	345.0	517.5	600.0	414.0	480.0
300 (225)	414.0	621.0	720.0	496.8	600.0
400 (300)	552.0	828.0	960.0	662.4	720.0
500 (375)	690.0	1035.0	1200.0	828.0	960.0
600 (450)	828.0	1242.0	1440.0	993.6	1200.0
800 (600)	1104.0	—	—	1324.8	1440.0

(continued)

Table 2-13—Output Current Ratings *(continued)*

Power	Current	Constant Torque		Variable Torque		Extended Torque	
	Continuous	Overload	Maximum	Overload	Maximum	Overload	Maximum
hp (kW)	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}
460 V							
1 1/2 (1.1)	3.0	4.5	6.0	—	—	—	—
2 (1.5)	3.4	5.1	6.8	4.1	6.0	—	—
3 (2.2)	4.8	7.2	9.6	5.8	6.8	—	—
5 (3.7)	7.6	11.4	15.2	9.1	9.6	—	—
7 1/2 (5.5)	11.0	16.5	22.0	13.2	15.2	—	—
10 (7.5)	14.0	21.0	28.0	16.8	22.0	15.2	15.2
15 (11)	21.0	31.5	42.0	25.2	28.0	22.0	22.0
20 (15)	27.0	40.5	54.0	32.4	42.0	28.0	28.0
25 (18)	34.0	51.0	68.0	40.8	54.0	37.4	42.0
30 (22)	40.0	60.0	80.0	48.0	68.0	44.0	54.0
40 (30)	52.0	78.0	104.0	62.4	80.0	57.2	68.0
50 (37)	65.0	97.5	130.0	78.0	104.0	71.5	80.0
60 (45)	77.0	115.5	154.0	92.4	130.0	84.7	104.0
75 (55)	96.0	144.0	192.0	115.2	154.0	105.6	130.0
100 (75)	124.0	186.0	248.0	148.8	192.0	136.4	154.0
125 (90)	156.0	234.0	312.0	187.2	248.0	171.6	192.0
150 (110)	180.0	270.0	360.0	216.0	312.0	198.0	248.0
200 (150)	240.0	360.0	480.0	288.0	360.0	264.0	312.0

(continued)

Table 2-13—Output Current Ratings *(continued)*

Power	Current	Constant Torque		Variable Torque		Extended Torque	
	Continuous	Overload	Maximum	Overload	Maximum	Overload	Maximum
hp (kW)	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}
460 V							
1100:							
250 (185)	300.0	450.0	600.0	360.0	480.0	330.0	360.0
300 (225)	360.0	540.0	720.0	432.0	600.0	396.0	480.0
350 (262)	420.0	630.0	840.0	504.0	720.0	462.0	600.0
400 (300)	480.0	—	—	576.0	840.0	528.0	720.0
500 (375)	600.0	—	—	—	—	660.0	840.0
1200:							
250 (185)	300.0	450.0	600.0	360.0	480.0	330.0	360.0
300 (225)	360.0	540.0	720.0	432.0	600.0	396.0	480.0
400 (300)	480.0	720.0	960.0	576.0	720.0	528.0	600.0
500 (375)	600.0	900.0	1200.0	720.0	960.0	660.0	720.0
600 (450)	720.0	1080.0	1440.0	864.0	1200.0	792.0	960.0
800 (600)	960.0	—	—	1152.0	1440.0	990.0	1200.0
1000 (750)	1200.0	—	—	—	—	1320.0	1440.0

(continued)

Table 2-13—Output Current Ratings *(continued)*

Power	Current	Constant Torque		Variable Torque		Extended Torque	
	Continuous	Overload	Maximum	Overload	Maximum	Overload	Maximum
hp (kW)	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}	A_{rms}
575 V							
1 1/2 (1.1)	2.4	3.6	4.8	—	—	—	—
2 (1.5)	2.7	4.1	5.4	3.2	4.8	—	—
3 (2.2)	3.9	5.9	7.8	4.7	5.4	—	—
5 (3.7)	6.1	9.2	12.2	7.3	7.8	—	—
7 1/2 (5.5)	9.0	13.5	18.0	10.8	12.2	—	—
10 (7.5)	11.0	16.5	22.0	13.2	18.0	11.0	12.2
15 (11)	17.0	25.5	34.0	20.4	22.0	17.0	18.0
20 (15)	22.0	33.0	44.0	26.4	34.0	22.0	22.0
25 (18)	27.0	40.5	54.0	32.4	44.0	29.7	34.0
30 (22)	32.0	48.0	64.0	38.4	54.0	35.2	44.0
40 (30)	41.0	61.5	82.0	49.2	64.0	45.1	54.0
50 (37)	52.0	78.0	104.0	62.4	82.0	57.2	64.0
60 (45)	62.0	93.0	124.0	74.4	104.0	68.2	82.0
75 (55)	77.0	115.5	154.0	92.4	124.0	84.7	104.0
100 (75)	99.0	148.5	198.0	118.8	154.0	108.9	124.0
125 (90)	125.0	187.5	250.0	150.0	198.0	137.5	154.0
150 (110)	144.0	216.0	288.0	172.8	250.0	158.4	198.0
200 (150)	192.0	288.0	384.0	230.4	288.0	211.2	250.0
250 (185)	240.0	360.0	480.0	288.0	384.0	264.0	288.0
300 (225)	288.0	432.0	576.0	345.6	480.0	316.8	384.0
350 (262)	336.0	504.0	672.0	403.2	576.0	369.6	480.0
400 (300)	384.0	576.0	768.0	460.8	672.0	422.4	576.0
500 (375)	480.0	—	—	576.0	768.0	528.0	672.0
600 (450)	576.0	—	—	—	—	633.6	768.0

Table 2-14—Switching Frequencies

Power	CT	VT	ET
hp (kW)	*kHz*	*kHz*	*kHz*
230 V			
1 1/2 (1.1)	8.0	—	—
2 (1.5)	8.0	6.9	—
3 (2.2)	8.0	4.4	—
5 (3.7)	8.0	3.3	—
7 1/2 (5.5)	8.0	4.5	—
10 (7.5)	8.0	5.6	2.5 (†)
15 (11)	8.0	4.1	2.1 (†)
20 (15)	8.0	5.9	2.0 (†)
25 (18)	8.0	6.3	4.0
30 (22)	8.0	6.7	5.1
40 (30)	8.0	5.8	4.7
50 (37)	8.0	6.4	3.9
60 (45)	6.0	6.8	5.2
75 (55)	—	4.4	5.2
100 (75)	—	—	2.5 (†)

(continued)

(†) Digital space vector (DSV) control must be used to achieve switching frequencies less than 3.2 kHz.

Table 2-14—Switching Frequencies *(continued)*

Power	CT	VT
hp (kW)	*kHz*	*kHz*
380 V		
1 1/2 (1.1)	5.5	—
2 (1.5)	5.5	4.9
3 (2.2)	5.5	3.5
5 (3.7)	5.5	2.9 (†)
7 1/2 (5.5)	5.5	3.6
10 (7.5)	5.5	4.2
15 (11)	5.5	3.4
20 (15)	5.5	4.3
25 (18)	5.5	4.6
30 (22)	5.5	4.8
40 (30)	5.5	4.3
50 (37)	5.5	4.6
60 (45)	5.5	4.8
75 (55)	5.5	4.5
100 (75)	3.5	4.3
125 (90)	3.5	2.8 (†)
150 (110)	3.5	3.0 (†)
200 (150)	3.5	2.4 (†)
250 (185)	—	2.8 (†)

(continued)

Table 2-14—Switching Frequencies *(continued)*

Power	CT	VT
hp (kW)	*kHz*	*kHz*
380 V		
1100:		
250 (185)	3.5	—
300 (225)	3.5	3.0 (†)
350 (262)	3.5	3.2
400 (300)	—	3.1 (†)
1200:		
250 (185)	3.5	—
300 (225)	3.5	2.8 (†)
400 (300)	3.5	2.4 (†)
500 (375)	3.5	2.8 (†)
600 (450)	3.5	2.8 (†)
800 (600)	—	2.4 (†)

(continued)

Table 2-14—Switching Frequencies *(continued)*

Power	CT	VT	ET
hp (kW)	*kHz*	*kHz*	*kHz*
460 V			
1 1/2 (1.1)	6.0	—	—
2 (1.5)	6.0	5.4	—
3 (2.2)	6.0	4.0	—
5 (3.7)	6.0	3.3	—
7 1/2 (5.5)	6.0	4.0	—
10 (7.5)	6.0	4.6	2.8 (†)
15 (11)	6.0	3.8	2.6 (†)
20 (15)	6.0	4.8	2.5 (†)
25 (18)	6.0	5.0	3.7
30 (22)	6.0	5.3	4.4
40 (30)	6.0	4.7	4.1
50 (37)	6.0	5.1	3.7
60 (45)	6.0	5.3	4.4
75 (55)	6.0	4.9	4.4
100 (75)	4.0	4.7	3.7
125 (90)	4.0	3.3	3.7
150 (110)	4.0	3.5	2.8 (†)
200 (150)	4.0	2.9 (†)	2.5 (†)
250 (185)	—	3.2	2.0 (†)
300 (225)	—	—	2.6 (†)

(continued)

Table 2-14—Switching Frequencies *(continued)*

Power	CT	VT	ET
hp (kW)	*kHz*	*kHz*	*kHz*
460 V			
1100:			
250 (185)	4.0	—	—
300 (225)	4.0	3.5	—
350 (262)	4.0	3.7	3.1 (†)
400 (300)	—	3.6	3.4
500 (375)	—	—	2.9 (†)
1200:			
250 (185)	4.0	—	—
300 (225)	4.0	3.3	—
400 (300)	4.0	2.9 (†)	2.2 (†)
500 (375)	4.0	3.2	2.0 (†)
600 (450)	4.0	3.3	2.6 (†)
800 (600)	—	2.9 (†)	2.2 (†)
1000 (750)	—	—	2.0 (†)

(continued)

Table 2-14—Switching Frequencies *(continued)*

Power	CT	VT	ET
hp (kW)	*kHz*	*kHz*	*kHz*
575 V			
1 1/2 (1.1)	4.0	—	—
2 (1.5)	4.0	3.6	—
3 (2.2)	4.0	2.6 (†)	—
5 (3.7)	4.0	2.1 (†)	—
7 1/2 (5.5)	4.0	2.6 (†)	—
10 (7.5)	4.0	3.0 (†)	1.8 (†)
15 (11)	4.0	2.4 (†)	1.6 (†)
20 (15)	4.0	3.1 (†)	1.6 (†)
25 (18)	4.0	3.3	2.4 (†)
30 (22)	4.0	3.5	2.9 (†)
40 (30)	4.0	3.1 (†)	2.7 (†)
50 (37)	4.0	3.4	2.4 (†)
60 (45)	4.0	3.5	2.9 (†)
75 (55)	4.0	3.3	2.9 (†)
100 (75)	3.0 (†)	3.1 (†)	2.4 (†)
125 (90)	3.0 (†)	2.5 (†)	2.4 (†)
150 (110)	3.0 (†)	2.7 (†)	2.1 (†)
200 (150)	3.0 (†)	2.2 (†)	2.0 (†)
250 (185)	3.0 (†)	2.5 (†)	1.7 (†)
300 (225)	3.0 (†)	2.7 (†)	2.1 (†)
350 (262)	3.0 (†)	2.8 (†)	2.4 (†)
400 (300)	—	2.7 (†)	2.6 (†)
500 (375)	—	—	2.3 (†)

3 Mechanical Installation

3.1 Overview

Proper mechanical installation of the drive is essential for safe, reliable operation and to simplify electrical wiring and maintenance. This chapter provides information and instructions for determining the best mounting location, selecting an enclosure, planning a layout, and installing the unit.

3.2 Forms

Drives are classified into twelve different *forms* according to their physical size and construction. These forms correspond, for the most part, to different heat sink sizes and sometimes to different box sizes or mounting methods. Refer to Table 3-3 through Table 3-8 near the end of this chapter to determine the form of a unit based upon its voltage, torque, and power ratings.

3.3 Installation Site Considerations

It is important to chose a mounting location that protects the drive from harmful environmental conditions while, at the same time, safeguarding personnel from the dangerous voltages of the drive system.

3.3.1 Enclosure

A drive can be supplied either as an unmounted open chassis, an unmounted enclosed unit, or mounted within a larger enclosure as part of a packaged drive system incorporating additional components. Open-chassis (IP00) units must be mounted inside an enclosure for safety. The integral enclosures provided with Form 9N, 12N, 13N, 17N, and 17X drives provide NEMA 3R (IP23) protection and can be converted to NEMA 4 (IP66) using the solid gland plate provided with the enclosure. Form 13, 17, 22X, 30, 34, 34X, 48, and 48X enclosures provide NEMA 1 (IP20) protection. Both open-chassis and enclosed versions of all models may be either foot- or flange-mounted.

Figure 3-1 through Figure 3-5 provide the physical dimensions and mechanical layouts of the drives. Refer to these figures when planning your layout. For simplicity, only the dimensions of enclosed drives are shown. Chassis units occupy approximately the same space.

Attention

To provide protection against electrical shock, chassis units must be mounted in an enclosure meeting at least the requirements of Protective Type IP20 (or NEMA equivalent) according to EN60529 and with top surfaces meeting at least the requirements of IP40 (or NEMA equivalent). It is recommended that a key or tool be required to open the enclosure and that enclosure doors be interlocked with the electrical supply disconnect.

3.3.2 Operating Environment

The drive should be mounted in an environment that is free from corrosive and volatile vapors, dust and particles, mechanical shock, excessive vibration, water or excessive moisture, and temperature extremes. The required ambient operating conditions are specified in Table 2-3.

3.3.3 Cooling

Thermal management techniques may be necessary to keep the drive operating within required temperature specifications, particularly when units are installed within confined spaces. Drives cool themselves using fans that circulate air across a heat sink. Air can be drawn from either inside the enclosure or outside, depending upon the mounting configuration. Some applications may require additional ventilating or cooling equipment.

3.3.3.1 Thermal Load

If the drive is to be installed in a separate enclosure, its thermal load must be considered. The total power dissipated by each drive is given in Table 3-10 (1100, 1105, and 1130 drives), Table 3-11 (1110 drives), Table 3-12 (1120 drives), Table 3-13 (1200 drives), and Table 3-14 (1230 drives) at the end of this chapter. Dissipation figures are provided for the control section and heat sink independently since the heat sink can be mounted externally to the enclosure. Use this information, in conjunction with the enclosure manufacturer's recommendations, to size the enclosure and to determine cooling airflow requirements. Power dissipation of units operating on 380 V power lines is the same as that listed for 460 V.

3.3.3.2 Air Circulation

Air circulation can be controlled by selecting the mounting configuration. Foot-mounted drives stand away from the mounting surface and pull ambient air from behind the unit to cool the heat sink. Flange-mounted drives dissipate heat outside an enclosure by allowing the heat sink to protrude through a cutout in the enclosure wall. The smallest units, which do not have finned heat sinks, must be flush mounted. Refer to Section 3.5 for mounting instructions.

3.4 Layout Considerations

The following information should be considered when planning a mechanical layout.

3.4.1 Dimensions and Weights

The physical dimensions of each drive are provided in Figure 3-1 through Figure 3-5. The approximate weight of each unit is given in Table 3-3 through Table 3-9.

Attention

Make certain that the mounting surface is strong enough to support the weight of all components to be mounted on it.

3.4.2 Space Requirements

Sufficient space must be provided around each drive for cooling airflow, access to electrical connections, and maintenance. Minimum recommended clearances above and below, to the side of, and behind the heat sink and fans of the various units are indicated in Table 3-1. If multiple drives are to be installed adjacent to each other, allow twice the indicated clearances between units. Be sure to also leave enough clearance for removing and replacing the cover during installation and servicing.

Table 3-1—Minimum Mounting Clearances

Form	Vertical	Horizontal	Behind
	in (mm)	*in (mm)*	*in (mm)*
13, 13N, 17, 17N, 17X, and 30	6.00" (152)	3.00" (76)	1.13" (29)
48 and 48X	3.00" (76)	6.00" (152)	2.25" (57)
9N and 12N	6.00" (152)	3.00" (76)	—
22X, 34, and 34X	3.00" (76)	6.00" (152)	2.25" (57)

3.4.3 Orientation

Drives must be mounted upright (so that the cover label reads correctly) to permit proper cooling airflow. Under no circumstances should units be installed upside down or on their sides in an attempt to change the direction of airflow or to facilitate wiring.

Position the drive so that its keypad/display can be accessed comfortably by the operator. The average adult is 5' 6" (168 cm) tall, so mount accordingly if possible.

3.4.4 Cable Routing

Separate electrical conduits are required for incoming power, output to the motor, and control wiring.

3.5 Installation Procedure

Both chassis and enclosed drives can be either foot- or flange-mounted. Figure 3-1 through Figure 3-5 provide the physical dimensions and mechanical layouts of the units. Refer to these figures when planning your layout.

Attention

Make certain that the mounting surface is secure before mounting the drive. Equipment damage could result from an improperly mounted unit.

Attention

Exercise care during installation to prevent metal shavings, conduit knockouts, and other debris from falling into the unit(s). Personal injury and/or equipment damage could result.

Attention

The drive may weigh a considerable amount. To avoid the risk of personal injury and/or damage to the drive, two or more people should work in unison when lifting and maneuvering a unit. Follow industry prescribed safe lifting practices at all times.

3.5.1 Foot Mounting

A drive may be foot-mounted to a subpanel inside an enclosure or directly to an enclosure wall. Mounting feet are provided with Form 12N 1105 and 1120 drives and all Form 9N 1200 drives. Feet are available as a factory-installed option with Form 17N, 30, and 34 1105 drives, Form 17 1120 drives, Form 13N, 17X, and 48X 1230 drives, and all 1100, 1110, and 1130 drives. Optional foot-mounting brackets are available with Form 22X 1230 drives. Mounting feet and brackets keep the heat sink and fans, if so supplied, the proper distance from the mounting surface. Certain low-power Form 13 models do not have finned heat sinks and, therefore, cannot accept feet. These models must be mounted flush with the surface.

Mount Form 13, 13N, 17, 17N, 17X, and 30 drives using four 1/4" (6 mm) bolts or studs with nuts. Mount Form 34, 34X, 48 and 48X drives using four 3/8" (10 mm) bolts or studs with nuts. Attach the top feet first to suspend the drive, then secure the bottom feet. Mount Form 9N and 12N drives using four #10 (5 mm) bolts or studs with nuts. Attach the bottom feet first, then secure the the top feet. Refer to the flange-mounting diagrams for hole locations.

Form 22X drives may be foot-mounted to a subpanel inside an enclosure or directly to an enclosure wall using the optional 709-628 foot-mounting bracket kit. Attach the brackets first to the mounting surface using 5/16" (8 mm) bolts or studs, then mount the drive unit to the protruding 5/16"–18 x 3/4" studs.

3.5.2 Flush Mounting (Form 22X)

Form 22X drives may be flush mounted to a subpanel inside an enclosure or directly to an enclosure wall. The units require a cutout in the panel or enclosure wall to allow air to vent out the back. Allow clearance behind the cutout for airflow as recommended in Table 3-1. Mount the drives using at least six 5/16" (8 mm) bolts or studs. Rest the bottom mounting slots on the bolts or studs while securing the top.

3.5.3 Flange Mounting

A drive may also be flange-mounted with its heat sink protruding through a cutout in the enclosure wall. This allows heat to be dissipated outside the enclosure. A mounting flange is provided with 1100, 1110, and 1130 drives, with Form 17N, 30, and 34 1105 drives, and with Form 17 1120 drives. It is available as a factory-installed option with Form 12N 1105 and 1120 drives and Form 9N 1200 drives. Factory-installed mounting adapters are also available for reusing existing cutouts when retrofitting certain units (see Table 3-2). Allow the recommended clearance behind the heat sink and fans for airflow (see Table 3-1). Certain low-power Form 13 models do not have finned heat sinks and must be mounted flush with the surface.

Mount Form 9N, 12N, 13, 17, 17N, 17X, and 30 drives using #10 (5 mm) bolts or studs with nuts. The number of bolts or studs required varies with the size of the drive. Form 22X drives use sixteen #10 (5 mm) studs through the holes in the heat sink flange. The corner studs of each unit must pass through the console; others may be welded. Form 34, 34X, 48, and 48X drives have 1/4"-20 mounting studs protruding through both sides of the heat sink that require (12) 5/16" (8 mm) mounting holes. Secure the unit across the top and bottom using six additional 1/4" (6 mm) bolts with nuts. Refer to the flange-mounting diagrams for hole locations and cutout dimensions. Retrofit adapters use the same hole patterns as the drives they replace. Chassis units are designed to provide NEMA 4 (IP66) integrity when flange-mounted inside a suitable NEMA 4 enclosure using the gasket provided.

Table 3-2—Flange-Mounting Retrofit Adapters

Form	Part Number	Description
9N	711-556	Adapter for mounting drive within cutout for Form 13 and 13N drives
9N	711-557	Adapter for mounting drive within cutout for Form 17, 17N, and 17X drives
12N	708-520	Adapter for mounting drive within cutout for Form 17, 17N, and 17X drives
17, 17N, and 17X	709-623	Adapter for mounting drive within cutout for Form 30 drive

3.6 Mounting the I/O Fanning Strip

The optional I/O fanning strip is generally mounted beneath the drive. Attach the strip from behind the mounting surface using nuts to secure the four #6-32 standoff screws.

Figure 3-1—Form 9N Mounting Dimensions (1200 Drive)

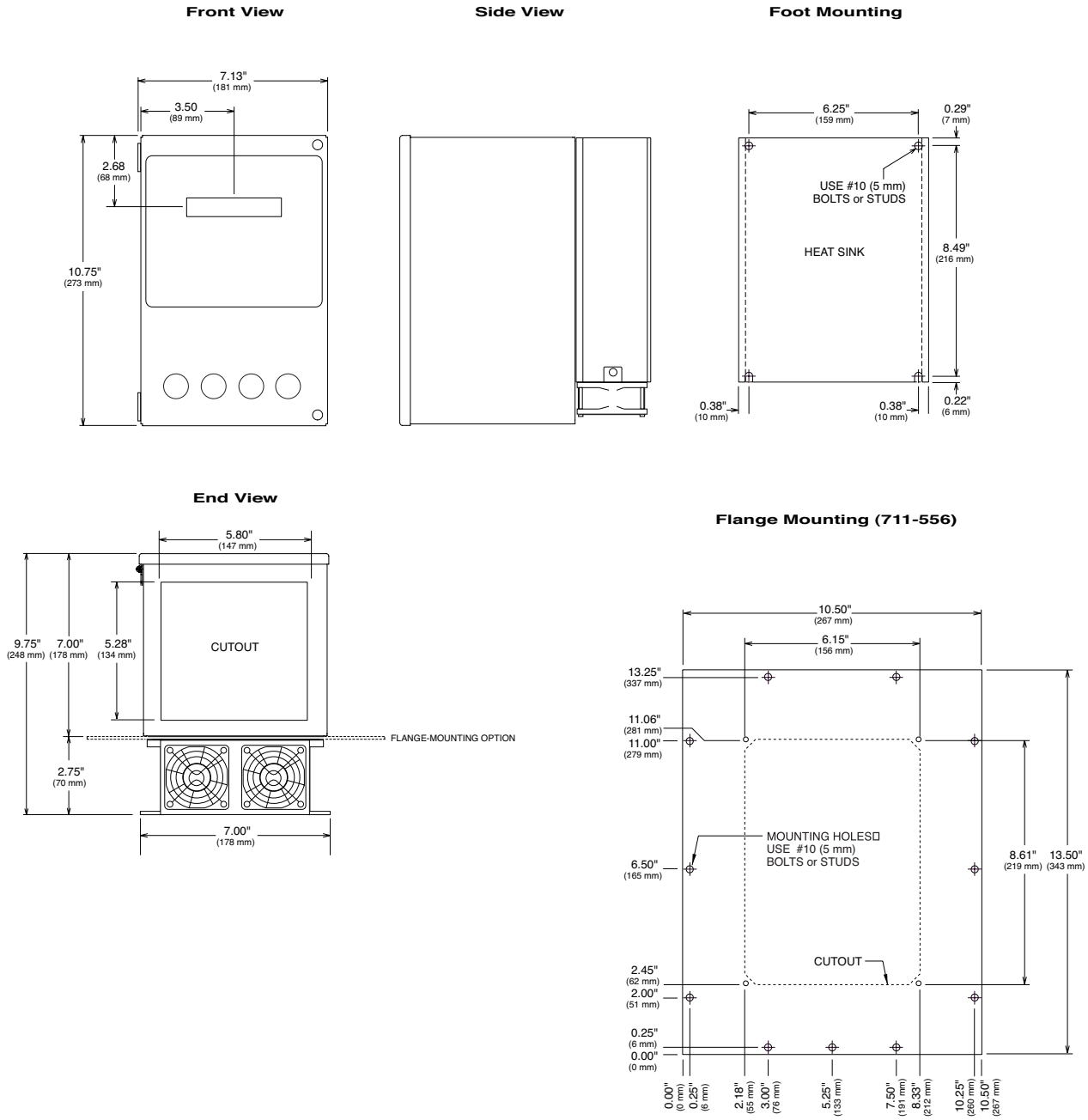
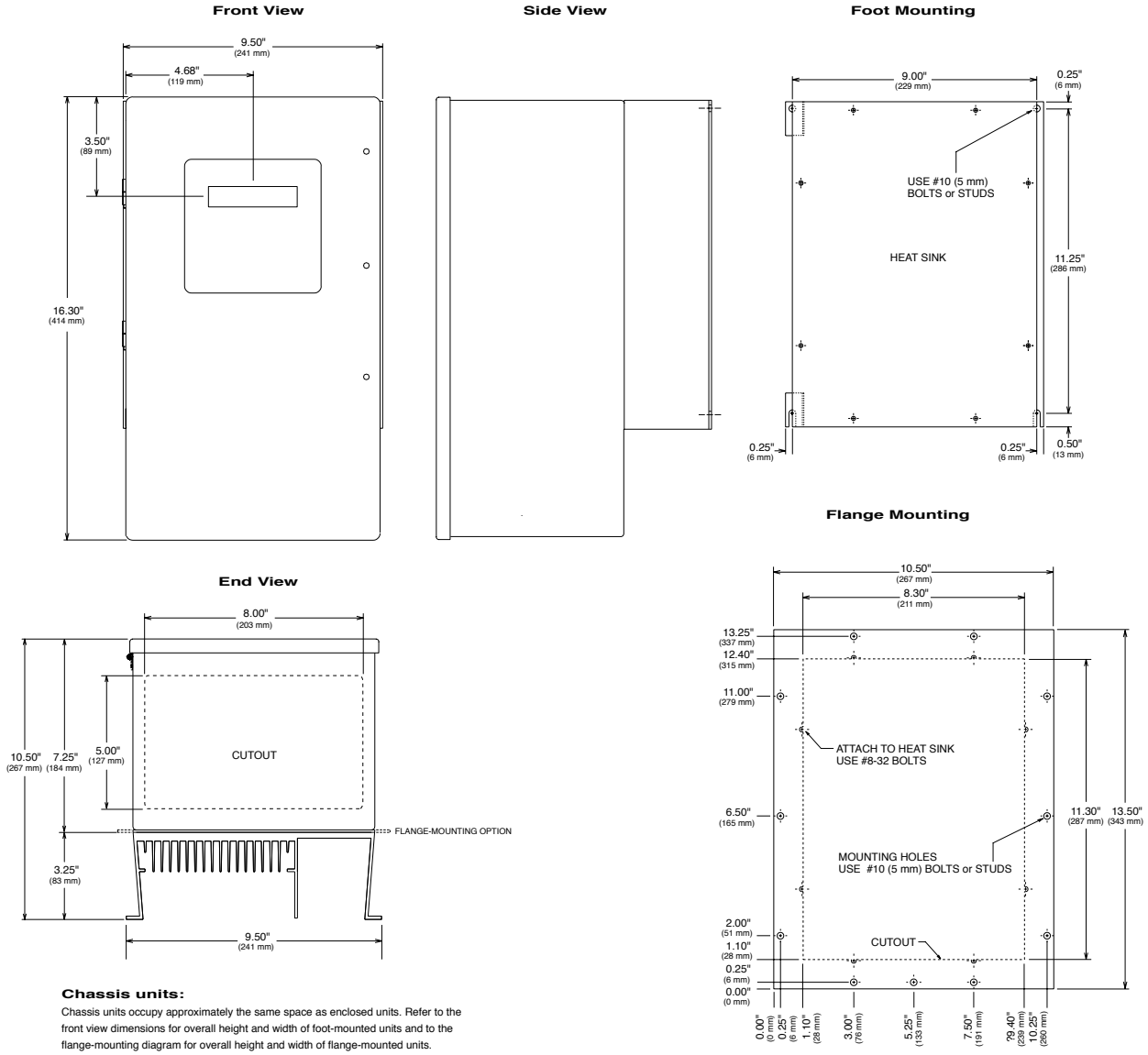


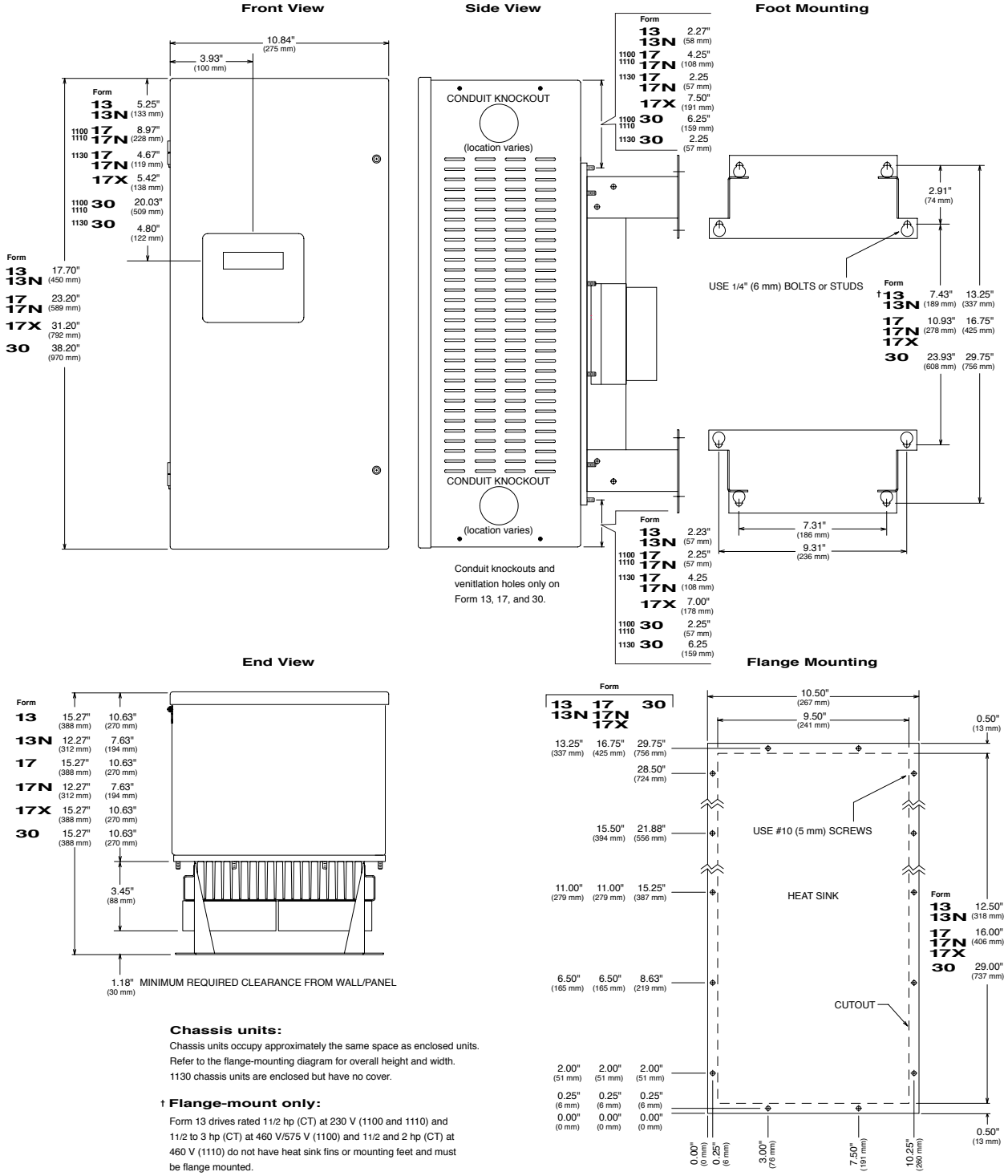
Figure 3-2—Form 12N Mounting Dimensions (1105 and 1120 Drives)



Chassis units:

Chassis units occupy approximately the same space as enclosed units. Refer to the front view dimensions for overall height and width of foot-mounted units and to the flange-mounting diagram for overall height and width of flange-mounted units.

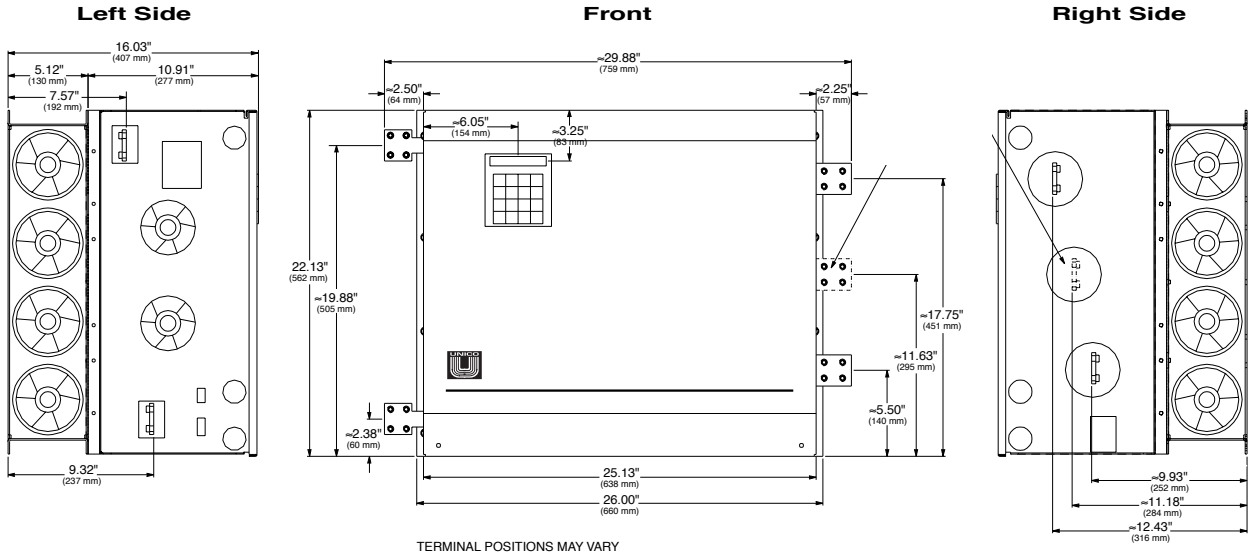
Figure 3-3—Form 13, 13N, 17, 17N, 17X, and 30 Mounting Dimensions (1100, 1105, 1110, 1120, 1130, 1200, and 1230 Drives)



Chassis units:
Chassis units occupy approximately the same space as enclosed units. Refer to the flange-mounting diagram for overall height and width. 1130 chassis units are enclosed but have no cover.

† **Flange-mount only:**
Form 13 drives rated 1 1/2 hp (CT) at 230 V (1100 and 1110) and 1 1/2 to 3 hp (CT) at 460 V/575 V (1100) and 1 1/2 and 2 hp (CT) at 460 V (1110) do not have heat sink fins or mounting feet and must be flange mounted.

Figure 3-4—Form 22X Mounting Dimensions (1230 Drive)



TERMINAL POSITIONS MAY VARY

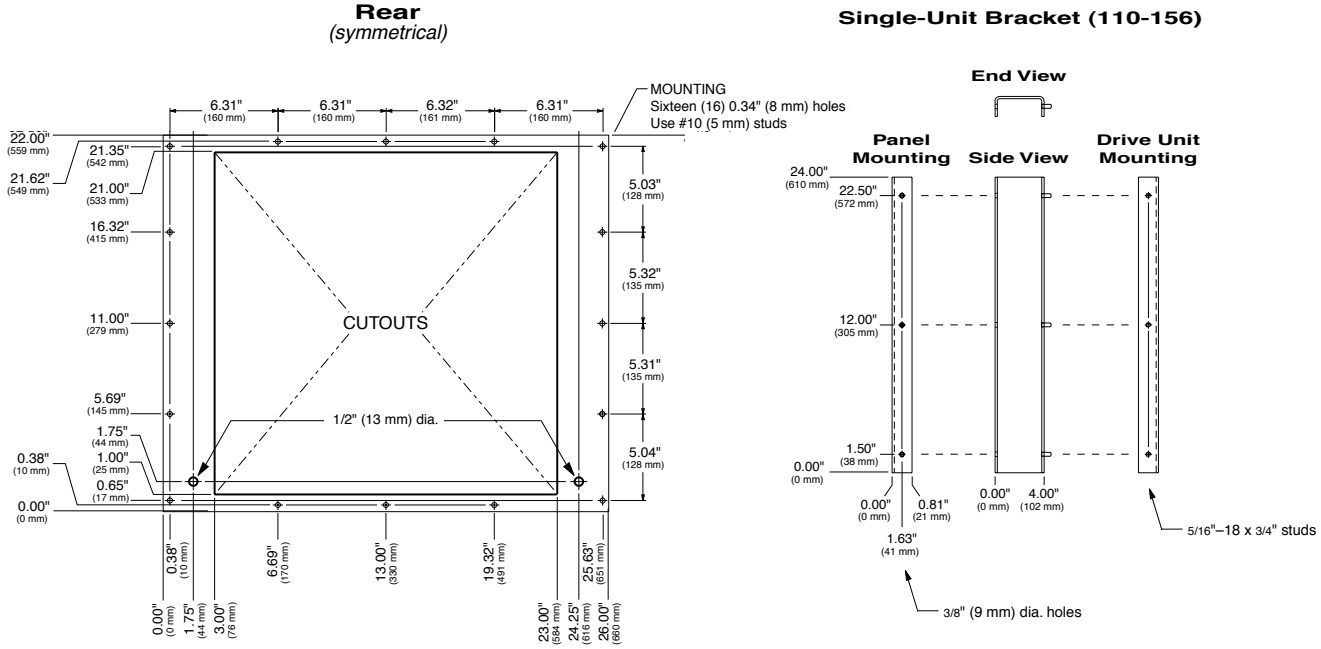
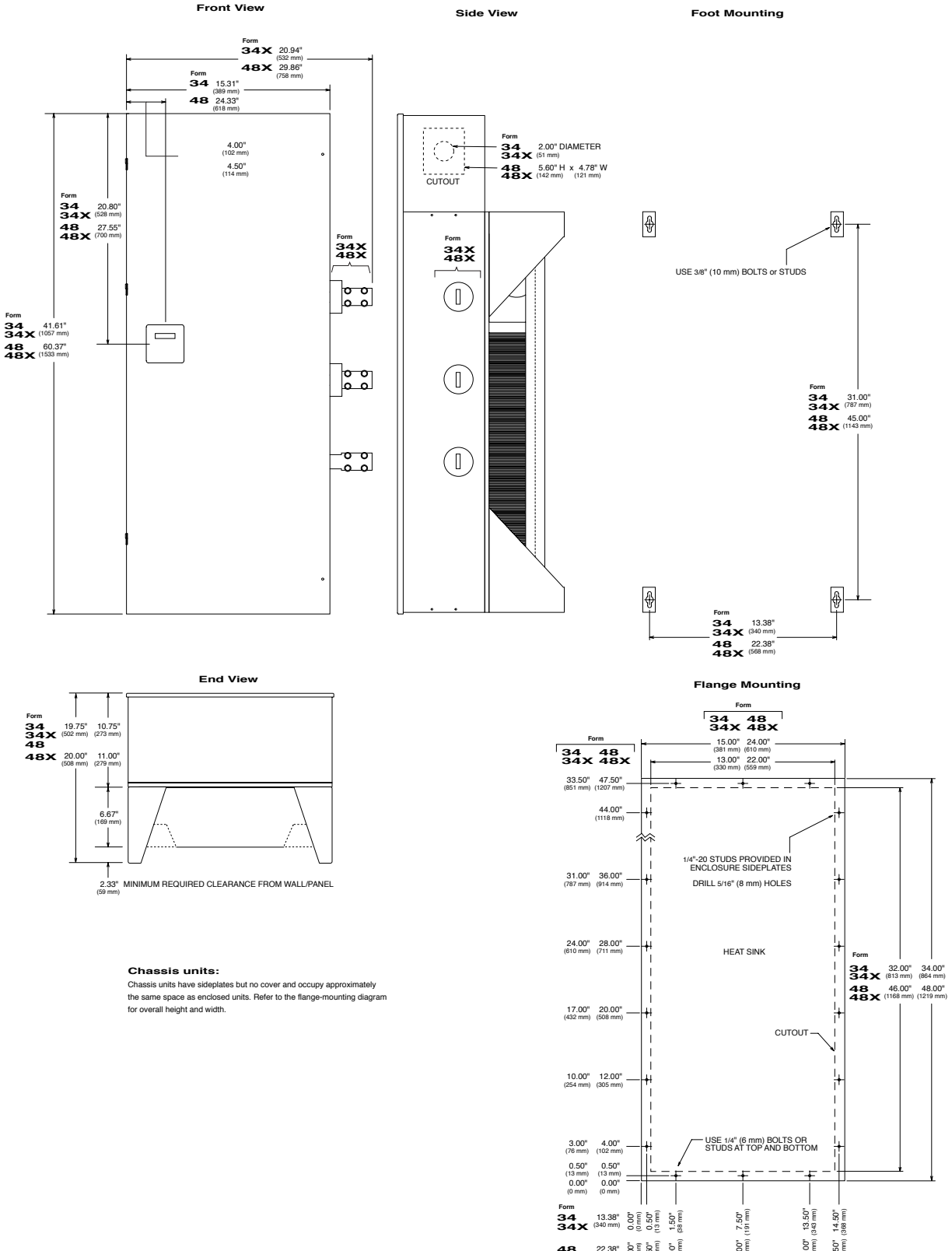


Figure 3-5—Form 34, 34X, 48, and 48X Mounting Dimensions (1100, 1105, 1200, and 1230 Drives)



Chassis units:
Chassis units have sideplates but no cover and occupy approximately the same space as enclosed units. Refer to the flange-mounting diagram for overall height and width.

Table 3-3—1100 Drive Forms / Weights

Power			Form	Weights	
CT	**VT**	**ET**		**Chassis**	**Enclosed**
hp (kW)	*hp (kW)*	*hp (kW)*		*lb (kg)*	*lb (kg)*
230 V					
1 1/2–7 1/2 (1.1-5.5)	2–10 (1.5-7.5)	—	13	30 (14)	45 (20)
10–30 (7.5-22)	25–40 (18-30)	—	17	55 (25)	70 (32)
40–60 (30-45)	50–75 (37-55)	—	30	105 (48)	130 (59)
460 V					
1 1/2–5 (1.1–3.7)	2–7 1/2 (1.5-5.5)	—	13	30 (14)	45 (20)
7 1/2–50 (5.5-37)	10–60 (7.5-45)	25–75 (18-55)	17	55 (25)	70 (32)
60–125 (45-90)	75–150 (55-110)	100–150 (75-110)	30	105 (48)	130 (59)
150–250 (110-185)	200-300 (150-225)	250–350 (185-262)	48	400 (181)	450 (204)
300–350 (225-262)	350-400 (262-300)	400–500 (300-375)	48	500 (227)	550 (249)
575 V					
1 1/2–5 (1.1–3.7)	2–7 1/2 (1.5-5.5)	—	13	30 (14)	45 (20)
7 1/2–60 (7.5-45)	10–75 (7.5-55)	25–100 (18-75)	17	55 (25)	70 (32)
75–125 (55-90)	100–150 (75-110)	125–150 (90-110)	30	105 (48)	130 (59)
150–300 (110-225)	200-350 (150-262)	250–400 (185-300)	48	400 (181)	450 (204)
350–400 (262-300)	400-500 (300-375)	500–600 (375-450)	48	500 (227)	550 (249)

Table 3-4—1105 Drive Forms / Weights

Power			Form	Weights	
CT	**VT**	**ET**		**Chassis**	**Enclosed**
hp (kW)	*hp (kW)*	*hp (kW)*		*lb (kg)*	*lb (kg)*
230 V					
1 1/2–3 (1.1-2.2)	2–5 (1.5-3.7)	—	12N	15 (7)	25 (11)
5–20 (3.7-15)	7 1/2–25 (5.5-18)	—	12N	20 (9)	30 (14)
460 V					
1 1/2–5 (1.1-3.7)	2–7 1/2 (1.5-5.5)	10 (7.5)	12N	15 (7)	25 (11)
7 1/2–20 (5.5-15)	10–25 (7.5-18)	15–30 (11-22)	12N	20 (9)	30 (14)
25–40 (18-30)	30–50 (22-37)	40–60 (30-45)	17N	40 (18)	50 (23)
50–100 (37-75)	60–125 (45-90)	75–150 (55-110)	30	100 (45)	125 (57)
125–150 (90-110)	150–200 (110-150)	200–250 (150-185)	34	260 (118)	290 (132)
575 V					
1 1/2–10 (1.1-7.5)	2–15 (1.5-11)	10–20 (7.5-15)	12N	15 (7)	25 (11)
15–40 (11-30)	20–50 (15-37)	25–60 (18-45)	17N	40 (18)	50 (23)
50–100 (37-75)	60–125 (45-90)	75–150 (55-110)	30	100 (45)	125 (57)
125–200 (90-150)	150–250 (110-185)	200–300 (150-225)	34	260 (118)	290 (132)

Table 3-5—1110 Drive Forms / Weights

Power		Form	Weights	
CT	**VT**		**Chassis**	**Enclosed**
hp (kW)	*hp (kW)*		*lb (kg)*	*lb (kg)*
230 V				
1 1/2–3 (1.1-2.2)	2–5 (1.5-3.7)	13	30 (14)	45 (20)
5–20 (5.5-15)	7 1/2–25 (7.5-18)	17	40 (18)	60 (27)
25 (18)	30 (22)	17	50 (23)	70 (32)
30–40 (22-30)	40–50 (30-37)	30	100 (45)	125 (57)
460 V				
1 1/2–5 (1.1–3.7)	2–7 1/2 (1.5-5.5)	13	30 (14)	45 (20)
7 1/2–20 (5.5-15)	10–25 (7.5-18)	17	40 (18)	60 (27)
25–40 (18-30)	30–50 (22-37)	17	50 (23)	70 (32)
50–75 (37-55)	60–100 (45-75)	30	100 (45)	125 (57)

Table 3-6—1120 Drive Forms / Weights

Power			Form	Weights	
CT	**VT**	**ET**		**Chassis**	**Enclosed**
hp (kW)	*hp (kW)*	*hp (kW)*		*lb (kg)*	*lb (kg)*
230 V					
1 1/2–3 (1.1-2.2)	2–5 (1.5-3.7)	—	12N	15 (7)	25 (11)
5–20 (3.7-15)	7 1/2–25 (5.5-18)	10–30 (7.5-22)	12N	20 (9)	30 (14)
25–60 (18-45)	30–75 (22-55)	40–100 (30-75)	17	50 (23)	70 (32)
460 V					
1 1/2–5 (1.1-3.7)	2–7 1/2 (1.5-5.5)	10 (7.5)	12N	15 (7)	25 (11)
7 1/2–40 (5.5-30)	10–50 (7.5-37)	15–60 (11-45)	12N	20 (9)	30 (14)
50–125 (37-90)	60–150 (45-110)	75–200 (55-150)	17	50 (23)	70 (32)

Table 3-7—1130 Drive Forms / Weights

Power			Form	Weights	
CT	**VT**	**ET**		**Chassis**	**Enclosed**
hp (kW)	*hp (kW)*	*hp (kW)*		*lb (kg)*	*lb (kg)*
230 V					
7 1/2–20 (5.5-15)	10–25 (7.5-18)	—	17	55 (25)	75 (34)
25–30 (18-22)	30–40 (22-30)	—	17	65 (29)	80 (36)
40–60 (30-45)	50–75 (37-55)	—	30	120 (54)	145 (66)
460 V					
7 1/2–20 (5.5-15)	10–25 (7.5-18)	25-30 (18-22)	17	55 (25)	75 (34)
25–50 (18-37)	30–60 (22-45)	40-75 (30-55)	17	65 (29)	80 (36)
60–125 (45-90)	75–150 (55-110)	100-150 (75-110)	30	120 (54)	145 (66)
575 V					
7 1/2–20 (5.5-15)	10–25 (7.5-18)	25-30 (18-22)	17	55 (25)	75 (34)
25–50 (18-37)	30–60 (22-45)	40-75 (30-55)	17	65 (29)	80 (36)
60–125 (45-90)	75–150 (55-110)	100-150 (75-110)	30	120 (54)	145 (66)

Table 3-8—1200 Drive Forms / Weights

Power			Form	Weights	
CT	**VT**	**ET**		**Chassis**	**Enclosed**
hp (kW)	*hp (kW)*			*lb (kg)*	*lb (kg)*
230 V					
1 1/2–7 1/2 (1.1-5.5)	2–10 (1.5-7.5)	10–15 (7.5-11)	9N	10 (5)	15 (7)
10–15 (7.5-11)	15–20 (11-15)	20–25 (15-18)	13N	25 (11)	35 (16)
20 (15)	25 (18)	30 (22)	17N	35 (16)	45 (20)
460 V					
1 1/2–15 (1.1-11)	2–20 (1.5-15)	10–25 (7.5-18)	9N	10 (5)	15 (7)
20–30 (15-22)	25–40 (18-30)	30–50 (22-37)	13N	25 (11)	35 (16)
40 (30)	50 (37)	60 (45)	17N	35 (16)	45 (20)
50–100 (37-75)	60–125 (45-90)	75–150 (55-110)	17X	50 (23)	70 (32)
125–250 (90-185)	150–300 (110-225)	200–400 (150-300)	34X	150 (68)	190 (86)
300–600 (225-450)	400–800 (300-600)	500–1000 (375-750)	48X	500 (227)	565 (256)

Table 3-9—1230 Drive Forms / Weights

Power			Form	Weights	
CT	**VT**	**ET**		**Chassis**	**Enclosed**
hp (kW)	*hp (kW)*			*lb (kg)*	*lb (kg)*
460 V					
1 1/2–15 (1.1-11)	2–20 (1.5-15)	20–25 (15-18)	13N	25 (11)	35 (16)
20–100 (15-75)	25–125 (18-90)	30–150 (22-110)	17X	50 (23)	70 (32)
125–250 (90-185)	150–300 (110-225)	200–400 (150-300)	22X	200 (91)	—
300–400 (225-300)	400–500 (300-375)	500–600 (375-450)	48X	500 (227)	565 (256)

Table 3-10—1100, 1105, and 1130 Power Dissipation

Power			Dissipation		
CT	**VT**	**ET**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
230 V					
1 1/2 (1.1)	2 (1.5)	—	0.042	0.054	0.095
2 (1.5)	3 (2.2)	—	0.043	0.062	0.105
3 (2.2)	5 (3.7)	—	0.048	0.088	0.136
5 (3.7)	7 1/2 (5.5)	10 (7.5)	0.054	0.140	0.194
7 1/2 (5.5)	10 (7.5)	15 (11)	0.063	0.204	0.266
10 (7.5)	15 (11)	20 (15)	0.072	0.261	0.333
15 (11)	20 (15)	25 (18)	0.095	0.392	0.487
20 (15)	25 (18)	30 (22)	0.111	0.506	0.617
25 (18)	30 (22)	40 (30)	0.127	0.637	0.764
30 (22)	40 (30)	50 (37)	0.151	0.751	0.902
40 (30)	50 (37)	60 (45)	0.184	0.979	1.163
50 (37)	60 (45)	75 (55)	0.214	1.224	1.438
60 (45)	75 (55)	100 (75)	0.247	1.452	1.699
460 V					
1 1/2 (1.1)	2 (1.5)	—	0.042	0.040	0.082
2 (1.5)	3 (2.2)	—	0.043	0.046	0.089
3 (2.2)	5 (3.7)	—	0.046	0.065	0.111
5 (3.7)	7 1/2 (5.5)	10 (7.5)	0.054	0.104	0.158
7 1/2 (5.5)	10 (7.5)	15 (11)	0.062	0.151	0.212
10 (7.5)	15 (11)	20 (15)	0.071	0.193	0.264
15 (11)	20 (15)	25 (18)	0.087	0.289	0.376
20 (15)	25 (18)	30 (22)	0.102	0.373	0.475
25 (18)	30 (22)	40 (30)	0.117	0.469	0.586
30 (22)	40 (30)	50 (37)	0.142	0.553	0.695
40 (30)	50 (37)	60 (45)	0.173	0.720	0.893
50 (37)	60 (45)	75 (55)	0.203	0.901	1.104

(continued)

Table 3-10—1100, 1105, and 1130 Power Dissipation *(continued)*

Power			Dissipation		
CT	**VT**	**ET**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
460 V					
60 (45)	75 (55)	100 (75)	0.241	1.068	1.309
75 (55)	100 (75)	125 (90)	0.289	1.332	1.621
100 (75)	125 (90)	150 (110)	0.364	1.725	2.089
125 (90)	150 (110)	200 (150)	0.448	2.169	2.617
150 (110)	200 (150)	250 (185)	0.225	3.062	3.287
200 (150)	250 (185)	300 (225)	0.275	3.999	4.274
250 (185)	300 (225)	350 (262)	0.325	4.937	5.262
300 (225)	350 (262)	400 (300)	0.375	5.874	6.249
350 (262)	400 (300)	500 (375)	0.425	6.811	7.236
575 V					
1 1/2 (1.1)	2 (1.5)	—	0.042	0.039	0.081
2 (1.5)	3 (2.2)	—	0.043	0.045	0.088
3 (2.2)	5 (3.7)	—	0.046	0.065	0.111
5 (3.7)	7 1/2 (5.5)	10 (7.5)	0.054	0.102	0.156
7 1/2 (5.5)	10 (7.5)	15 (11)	0.062	0.150	0.212
10 (7.5)	15 (11)	20 (15)	0.071	0.185	0.256
15 (11)	20 (15)	25 (18)	0.087	0.285	0.372
20 (15)	25 (18)	30 (22)	0.102	0.369	0.471
25 (18)	30 (22)	40 (30)	0.117	0.454	0.571
30 (22)	40 (30)	50 (37)	0.142	0.538	0.680
40 (30)	50 (37)	60 (45)	0.173	0.692	0.865
50 (37)	60 (35)	75 (55)	0.203	0.876	1.079
60 (45)	75 (55)	100 (75)	0.241	1.046	1.287
75 (55)	100 (75)	125 (90)	0.289	1.299	1.588
100 (75)	125 (90)	150 (110)	0.364	1.675	2.039
125 (90)	150 (110)	200 (150)	0.448	2.113	2.561
150 (110)	200 (150)	250 (185)	0.225	2.992	3.217

(continued)

Table 3-10—1100, 1105, and 1130 Power Dissipation *(continued)*

Power			Dissipation		
CT	**VT**	**ET**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
575 V					
200 (150)	250 (185)	300 (225)	0.275	3.906	4.181
250 (185)	300 (225)	350 (262)	0.325	4.819	5.144
300 (225)	350 (262)	400 (300)	0.375	5.733	6.108
350 (262)	400 (300)	500 (375)	0.425	6.647	7.072
400 (300)	500 (375)	600 (450)	0.475	7.561	8.036

Table 3-11—1110 Power Dissipation

Power		Dissipation		
CT	**VT**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*kW*	*kW*	*kW*
230 V				
1 1/2 (1.1)	2 (1.5)	0.045	0.054	0.098
2 (1.5)	3 (2.2)	0.049	0.062	0.111
3 (2.2)	5 (3.7)	0.054	0.088	0.142
5 (3.7)	7 1/2 (5.5)	0.065	0.140	0.205
7 1/2 (5.5)	10 (7.5)	0.080	0.204	0.283
10 (7.5)	15 (11)	0.100	0.261	0.361
15 (11)	20 (15)	0.126	0.392	0.518
20 (15)	25 (18)	0.152	0.506	0.658
25 (18)	30 (22)	0.186	0.637	0.823
30 (22)	40 (30)	0.214	0.751	0.965
40 (30)	50 (37)	0.264	0.979	1.243

(continued)

Table 3-11—1110 Power Dissipation *(continued)*

Power		Dissipation		
CT	VT	Control	Heat Sink	Total
hp (kW)	*hp (kW)*	*kW*	*kW*	*kW*
460 V				
1 1/2 (1.1)	2 (1.5)	0.045	0.040	0.085
2 (1.5)	3 (2.2)	0.047	0.046	0.093
3 (2.2)	5 (3.7)	0.054	0.065	0.119
5 (3.7)	7 1/2 (5.5)	0.064	0.104	0.168
7 1/2 (5.5)	10 (7.5)	0.079	0.151	0.229
10 (7.5)	15 (11)	0.092	0.193	0.285
15 (11)	20 (15)	0.117	0.289	0.406
20 (15)	25 (18)	0.142	0.373	0.515
25 (18)	30 (22)	0.177	0.469	0.646
30 (22)	40 (30)	0.203	0.553	0.756
40 (30)	50 (37)	0.253	0.720	0.973
50 (37)	60 (45)	0.311	0.901	1.212
60 (45)	75 (55)	0.364	1.068	1.432
75 (55)	100 (75)	0.439	1.332	1.771

Table 3-12—1120 Power Dissipation

Power			Dissipation		
CT	VT	ET	Control	Heat Sink	Total
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
230 V					
1 1/2 (1.1)	2 (1.5)	—	0.039	0.042	0.080
2 (1.5)	3 (2.2)	—	0.039	0.047	0.086
3 (2.2)	5 (3.7)	—	0.042	0.067	0.109
5 (3.7)	7 1/2 (5.5)	10 (7.5)	0.044	0.106	0.150
7 1/2 (5.5)	10 (7.5)	15 (11)	0.048	0.153	0.201
10 (7.5)	15 (11)	20 (15)	0.052	0.195	0.247
15 (11)	20 (15)	25 (18)	0.065	0.292	0.357

(continued)

Table 3-12—1120 Power Dissipation *(continued)*

Power			Dissipation		
CT	**VT**	**ET**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
230 V					
20 (15)	25 (18)	30 (22)	0.071	0.376	0.447
25 (18)	30 (22)	40 (30)	0.077	0.473	0.550
30 (22)	40 (30)	50 (37)	0.091	0.557	0.648
40 (30)	50 (37)	60 (45)	0.104	0.724	0.828
50 (37)	60 (45)	75 (55)	0.114	0.905	1.019
60 (45)	75 (55)	100 (75)	0.127	1.072	1.199
460 V					
1 1/2 (1.1)	2 (1.5)	—	0.039	0.034	0.073
2 (1.5)	3 (2.2)	—	0.039	0.039	0.078
3 (2.2)	5 (3.7)	—	0.040	0.055	0.095
5 (3.7)	7 1/2 (5.5)	10 (7.5)	0.044	0.087	0.131
7 1/2 (5.5)	10 (7.5)	15 (11)	0.047	0.125	0.172
10 (7.5)	15 (11)	20 (15)	0.051	0.160	0.211
15 (11)	20 (15)	25 (18)	0.057	0.239	0.296
20 (15)	25 (18)	30 (22)	0.062	0.308	0.370
25 (18)	30 (22)	40 (30)	0.067	0.388	0.455
30 (22)	40 (30)	50 (37)	0.082	0.456	0.538
40 (30)	50 (37)	60 (45)	0.093	0.593	0.686
50 (37)	60 (35)	75 (55)	0.103	0.741	0.844
60 (45)	75 (55)	100 (75)	0.121	0.878	0.999
75 (55)	100 (75)	125 (90)	0.139	1.094	1.233
100 (75)	125 (90)	150 (110)	0.164	1.414	1.578
125 (90)	150 (110)	200 (150)	0.198	1.778	1.976

Table 3-13—1200 Power Dissipation

Power			Dissipation		
CT	**VT**	**ET**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
230 V					
1 1/2 (1.1)	2 (1.5)	—	0.037	0.054	0.090
2 (1.5)	3 (2.2)	—	0.037	0.062	0.099
3 (2.2)	5 (3.7)	—	0.045	0.088	0.133
5 (3.7)	7 1/2 (5.5)	10 (7.5)	0.047	0.140	0.187
7 1/2 (5.5)	10 (7.5)	15 (11)	0.051	0.204	0.254
10 (7.5)	15 (11)	20 (15)	0.052	0.261	0.313
15 (11)	20 (15)	25 (18)	0.065	0.392	0.457
20 (15)	25 (18)	30 (22)	0.071	0.506	0.577
460 V					
1 1/2 (1.1)	2 (1.5)	—	0.037	0.040	0.077
2 (1.5)	3 (2.2)	—	0.037	0.046	0.083
3 (2.2)	5 (3.7)	—	0.038	0.065	0.103
5 (3.7)	7 1/2 (5.5)	10 (7.5)	0.040	0.104	0.144
7 1/2 (5.5)	10 (7.5)	15 (11)	0.050	0.151	0.200
10 (7.5)	15 (11)	20 (15)	0.052	0.193	0.245
15 (11)	20 (15)	25 (18)	0.058	0.289	0.347
20 (15)	25 (18)	30 (22)	0.062	0.373	0.435
25 (18)	30 (22)	40 (30)	0.067	0.469	0.536
30 (22)	40 (30)	50 (37)	0.082	0.553	0.635
40 (30)	50 (37)	60 (45)	0.093	0.720	0.813
50 (37)	60 (45)	75 (55)	0.103	0.901	1.004
60 (45)	75 (55)	100 (75)	0.121	1.068	1.189
75 (55)	100 (75)	125 (90)	0.139	1.332	1.471
100 (75)	125 (90)	150 (110)	0.164	1.725	1.889
125 (90)	150 (110)	200 (150)	0.198	2.169	2.367
150 (110)	200 (150)	250 (185)	0.253	2.512	2.765

(continued)

Table 3-13—1200 Power Dissipation *(continued)*

Power			Dissipation		
CT	**VT**	**ET**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
460 V					
200 (150)	250 (185)	300 (225)	0.275	3.599	3.874
250 (185)	300 (225)	400 (300)	0.325	4.437	4.762
300 (225)	400 (300)	500 (375)	0.375	5.274	5.649
400 (300)	500 (375)	600 (450)	0.475	6.949	7.424
500 (375)	600 (450)	800 (600)	0.575	8.624	9.199
600 (450)	800 (600)	1000 (750)	0.675	10.298	10.973

Table 3-14—1230 Power Dissipation

Power			Dissipation		
CT	**VT**	**ET**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
460 V					
1 1/2 (1.1)	2 (1.5)	—	0.074	0.080	0.154
2 (1.5)	3 (2.2)	—	0.074	0.092	0.166
3 (2.2)	5 (3.7)	—	0.076	0.130	0.206
5 (3.7)	7 1/2 (5.5)	—	0.080	0.208	0.288
7 1/2 (5.5)	10 (7.5)	—	0.100	0.302	0.400
10 (7.5)	15 (11)	20 (15)	0.104	0.386	0.490
15 (11)	20 (15)	25 (18)	0.116	0.578	0.694
20 (15)	25 (18)	30 (22)	0.124	0.746	0.870
25 (18)	30 (22)	40 (30)	0.134	0.938	1.072
30 (22)	40 (30)	50 (37)	0.164	1.106	1.270
40 (30)	50 (37)	60 (45)	0.186	1.440	1.626
50 (37)	60 (45)	75 (55)	0.206	1.802	2.008
60 (45)	75 (55)	100 (75)	0.242	2.136	2.378
75 (55)	100 (75)	125 (90)	0.278	2.664	2.942
100 (75)	125 (90)	150 (110)	0.328	3.450	3.778

(continued)

Table 3-14—1230 Power Dissipation *(continued)*

Power			Dissipation		
CT	**VT**	**ET**	**Control**	**Heat Sink**	**Total**
hp (kW)	*hp (kW)*	*hp (kW)*	*kW*	*kW*	*kW*
460 V					
125 (90)	150 (110)	200 (150)	0.396	4.338	4.734
150 (110)	200 (150)	250 (185)	0.506	5.024	5.530
200 (150)	250 (185)	300 (225)	0.550	7.198	7.748
250 (185)	300 (225)	400 (300)	0.650	8.874	9.524
300 (225)	400 (300)	500 (375)	0.750	10.548	11.298
400 (300)	500 (375)	600 (450)	0.950	13.898	14.848

4 Electrical Installation

4.1 Overview

This chapter explains the electrical installation of the drive. It covers grounding, input power, motor output, dynamic braking, bus connections, and basic control connections. Since control signals vary from application to application, specific wiring instructions are discussed in the application documentation.

4.2 Wiring Requirements

Follow the instructions below to ensure safe, reliable electrical connections.

4.2.1 Standards and Codes

All wiring must conform to applicable local and national codes.

Attention

The supplier cannot assume responsibility for compliance or noncompliance to any code governing the proper installation of this unit. The following information is intended only as a guide for proper installation. All wiring must conform to the National Electrical Code (NEC), described in publication NFPA No. 70. Local codes may overrule this information.

4.2.2 Conductors

Size conductors according to the National Electrical Code (NEC) based upon the required current-carrying capacity. All wires should be stranded copper with a rating of 167° F (75° C) or higher.

Wires terminating in terminal blocks must meet the gauge limitations of the terminal as well. Acceptable wire sizes for ground and power connection terminals are specified in Table 4-4 through Table 4-9 and for control signal connection terminals in Table 4-19.

Wires terminating at studs or bolts must use ring lugs to provide a solid connection. Use UL-approved lugs suitable for the currents required. For these connections, Table 4-4 through Table 4-9 list the stud or bolt size rather than the acceptable wire size.

4.2.3 Tightening Torque

Tighten connections by applying the recommended tightening torque listed in Table 4-4 through Table 4-10 (for ground and power connections) and in Table 4-19 and (for control signal connections). Use a torque wrench to ensure that connections are properly tightened.

4.3 Insulation Tests

Any site insulation tests must be performed before making electrical connections to the drive. These tests should conform to all applicable national and local codes. A suggested procedure for checking installation insulation is outlined below.

Attention

Before performing the insulation tests, make certain that the drive is disconnected from the input power (S, T or R, S, T or R1, R2, S1, S2, T1, T2). Also verify that the motor cable is disconnected from drive output terminals (U, V, W) and from the motor.

- Measure the insulation resistance of the motor between the phases and between each phase and protective ground. The voltage range of the meter must be at least equal to the line voltage but not higher than 1,000 V. The insulation resistance must be greater than 1 MΩ.
- Measure the insulation resistance of the motor cable between the phases and between each phase and protective ground. The insulation resistance must be greater than 1 MΩ.

4.4 Ground Connections

Proper grounding procedures are essential to the safe, successful operation of the drive. Careful attention to these procedures can prevent electrical noise from disrupting drive operation.

The drive, power supply, motor, and control circuits should all share a common earth ground. Refer to the appropriate connection diagram as listed in Table 4-1 below. Refer to Section 4.2 for wiring requirements. Ground connection terminal specifications for the various drives are provided in the tables summarized in Table 4-1.

PE

Ground terminal designation

Ground terminals are designated by the IEC symbol at left, by PE (protective earth), or both. Such terminals are internally connected and tied to the chassis or enclosure. They are intended for connecting both the protective earth ground electrode as well as any external protective grounding conductors.

Table 4-1—Power/Ground Connection Tables

Drive	Connection Diagram	Terminal Specifications
1100	Figure 4-1	Table 4-4
1105	Figure 4-2	Table 4-5
1110	Figure 4-4	Table 4-6
1120	Figure 4-5	Table 4-7
1130	Figure 4-6	Table 4-8
1200	Figure 4-7	Table 4-9
1230	Figure 4-8	Table 4-10

4.4.1 Ground the drive

The ground terminals (PE) of the drive should be connected to either a grounding electrode buried in the earth or a suitable plant ground with a solid connection to earth ground. The ground connector should be an electrode conductor or bonding jumper of sufficient capacity.

Refer to Publication NFPA No. 70, Article 250, and to the IEEE "greenbook" for details on grounding and grounding electrodes.

4.4.2 Ground the Power Supply

The incoming power supply must be earth grounded for ground fault protection.

4.4.3 Ground the Motor and Transducer

The motor case and encoder or resolver case, if present, must also be earth grounded. To minimize electrical noise emissions, it is recommended that a ground lead from the motor case return with the motor stator leads to the drive ground terminals.

4.4.4 Connect the Control Grounds

Connect the logic commons of the various low-voltage control circuits and any external control circuits to the drive ground.

4.5 Input Power Supply

The 1100, 1105, 1110, 1130, 1200, and 1230 drives must be connected to the input power supply. Fuses or a circuit breaker must be used to protect the unit from short circuits. A line reactor or isolation transformer may also be necessary to condition the power source.

Attention

- Do not supply input voltages higher than that specified. Higher input voltages may damage the drive.
- Input power (S, T or R, S, T or R1, R2, S1, S2, T1, T2) should be able to supply at least 1.5 times the inverter capacity.
- Do not connect supply input voltage (S, T or R, S, T or R1, R2, S1, S2, T1, T2) to output terminals (U, V, W).
- Do not use power factor correction capacitors on the input or the output.
- Do not run or stop the inverter by applying and removing power. Use only the keypad, digital inputs, or serial commands to operate the drive.
- Do not perform the Megger test.

Attention

The drive is not equipped with a supply-disconnecting device. An external supply-disconnecting device must be provided to isolate incoming electrical supplies during installation and maintenance work. This supply-disconnecting device should comply with all applicable national and local codes.

Attention

High voltage may be present even when all electrical power supplies are disconnected. After switching off electrical power, wait at least 15 minutes for bus circuit capacitors to discharge before working on the drive or associated equipment. Use an appropriate voltmeter to further verify that capacitors are discharged before beginning work. Do not rely exclusively on the bus voltage indicator. Dangerous voltage levels may remain even when the indicator is off.

4.5.1 Power Source Conditioning

The use of an AC line reactor and/or isolation transformer is recommended under certain circumstances. The drive is designed for direct connection to AC lines of the correct voltage and impedance. Use the guidelines that follow to determine whether an isolation transformer or line reactor is required. Refer to Table 4-13 for isolation transformer sizing specifications and to Table 4-14 through Table 4-16 for line reactor sizing specifications for three-phase connections. When using a single-phase input, select a line reactor based upon the input current requirements of the 1110 drive as specified in Table 4-12. You may purchase isolation transformers and line reactors directly from Unico. Contact the factory for more information.

Impedance mismatch

Input lines must have a minimum impedance of 1% relative to the rated input kVA of the drive (assume the drive's horsepower rating is approximately equal to its kVA rating). If the line has a lower impedance, a line reactor or isolation transformer must be added ahead of the drive to increase line impedance. If line impedance is too low, transient voltage spikes or interruptions can create excessive current spikes that may cause nuisance input fuse blowing and may damage the drive. Generally, if the kVA capacity of the AC line is greater than four times the rated power of the motor (in horsepower), an isolation transformer or AC line reactor should be used.

No neutral or referenced phase

If the AC input power system does not have a neutral or one phase referenced to ground, an isolation transformer with the neutral of the secondary grounded is highly recommended. If the line-to-ground voltages on any phase exceed 125% of the nominal line-to-line voltage, an isolation transformer with the neutral of the secondary grounded is always required.

Transient power interruptions or voltage spikes

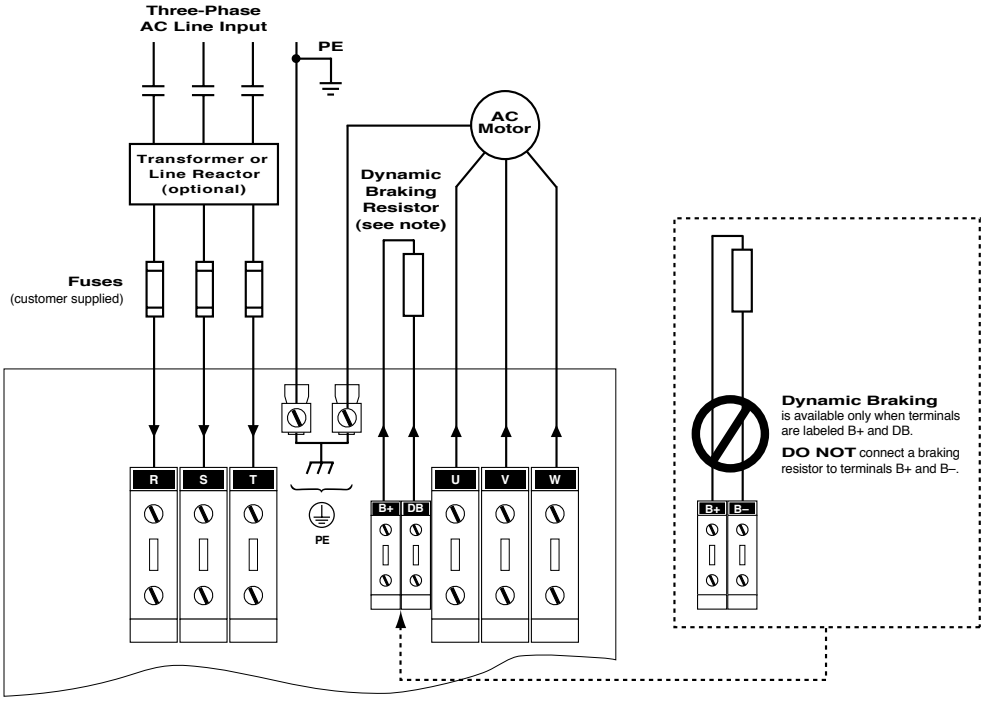
If the AC line frequency experiences transient power interruptions or significant voltage spikes, an isolation transformer or AC line reactor must be installed. The drive can be damaged by extreme voltage and current spikes.

Power factor correction capacitors

If the AC line supplying the drive has power factor correction capacitors that are switched in and out, an isolation transformer or AC line reactor must be installed between the drive and the capacitors. The drive can be damaged by the extreme voltage and current spikes caused by capacitor switching. If the capacitors are permanently connected and not switched, the guideline for impedance mismatch applies.

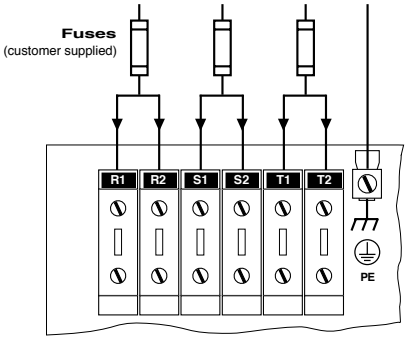
Figure 4-1—1100 Power and Grounding Connections

Forms 13, 17, and 30 (to 100 hp CT)

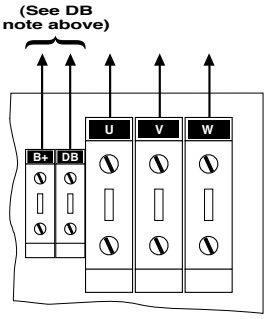


Forms 30 (125 hp CT) and 48

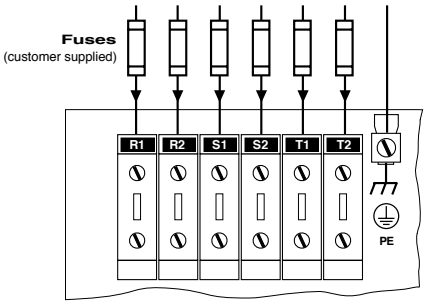
Three-Phase Input (Six-Pulse Operation)
125 hp (CT)



Drive Output
150 hp (CT) 460 V and
150 to 200 hp (CT) 575 V



Six-Phase Input (Twelve-Pulse Operation)
150 to 400 hp (CT)



Drive Output
125 hp / 200 to 350 hp (CT) 460 V and
125 hp / 250 to 400 hp (CT) 575 V

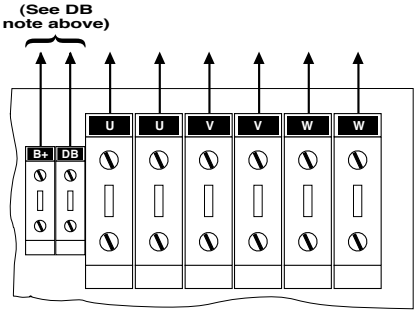
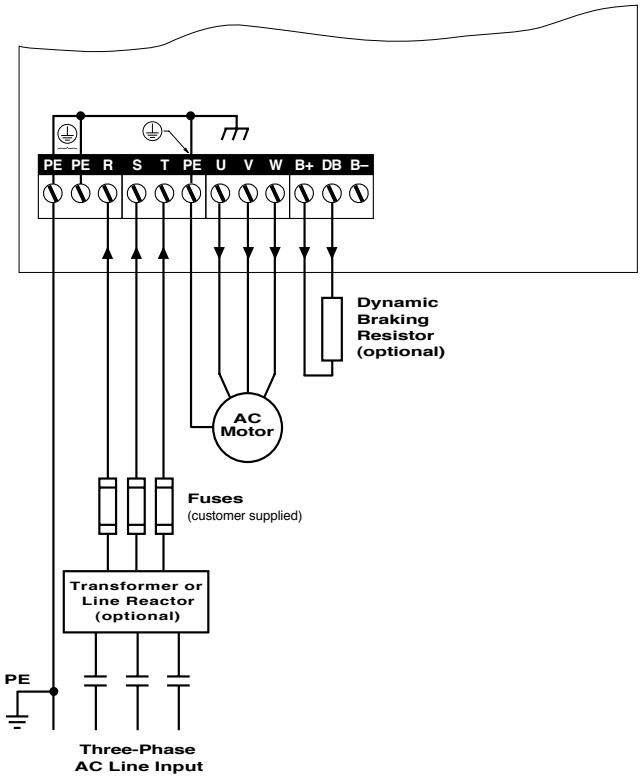


Figure 4-2—1105 Power and Grounding Connections

Form 12N



Form 17N

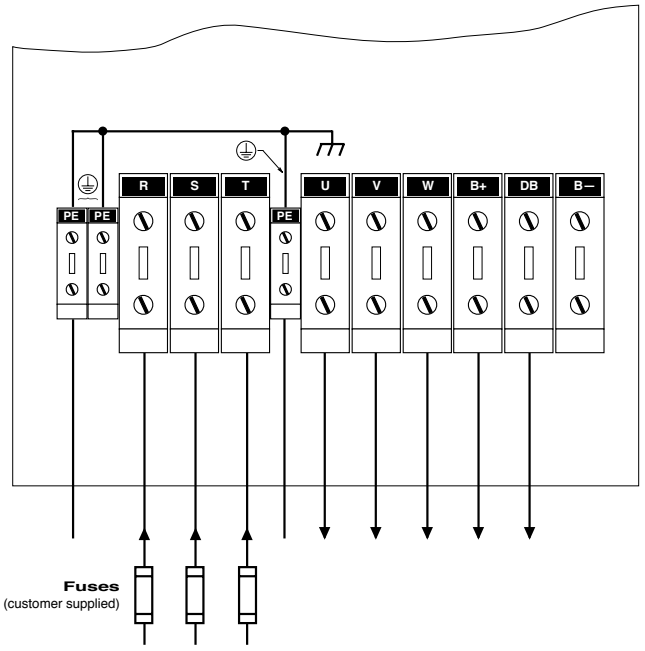
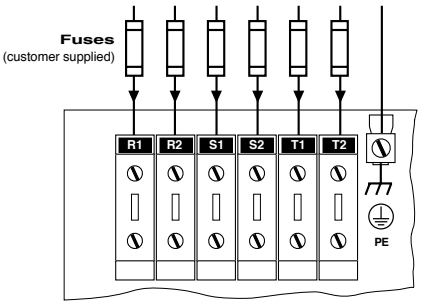


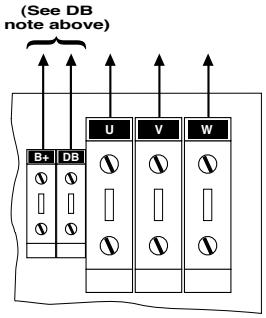
Figure 4-3—1105 Power and Grounding Connections *(continued)*

Forms 30 and 34

Six-Phase Input (Twelve-Pulse Operation)
50 to 150 hp (CT) 460 V and
50 to 200 hp (CT) 575 V



Drive Output
50 to 100 hp (CT) 460 V and 575 V



Drive Output
125 to 150 hp (CT) 460 V and
125 to 200 hp (CT) 575 V

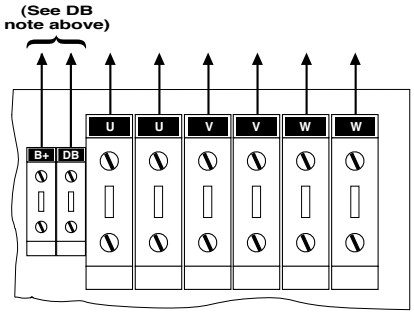


Figure 4-4—1110 Power and Grounding Connections

Forms 13, 17, and 30

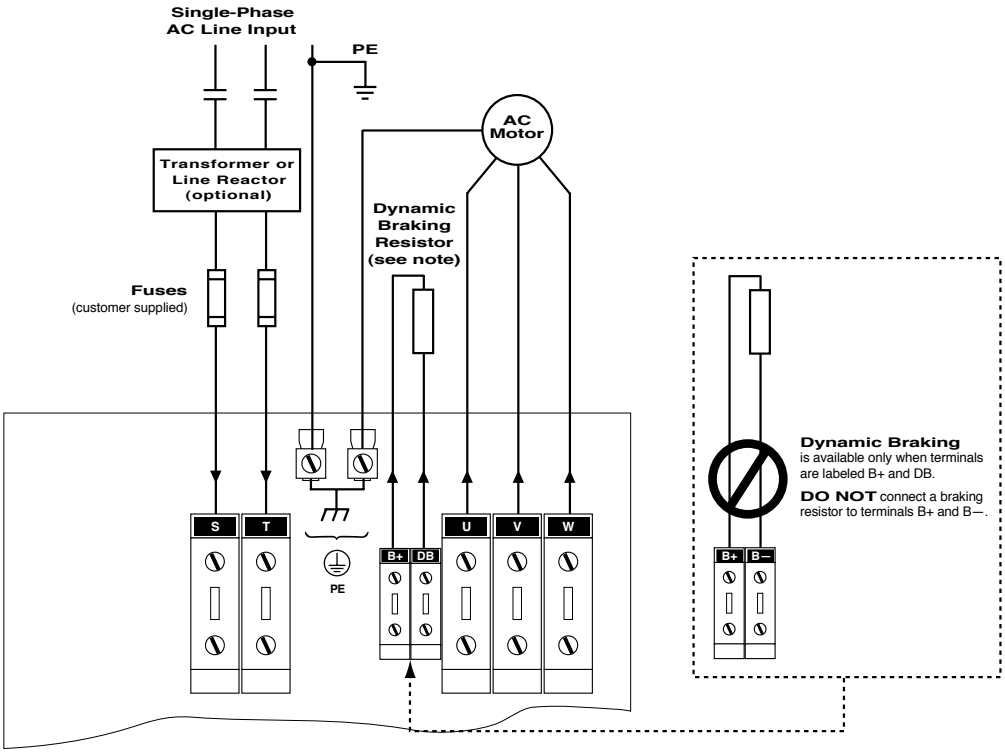
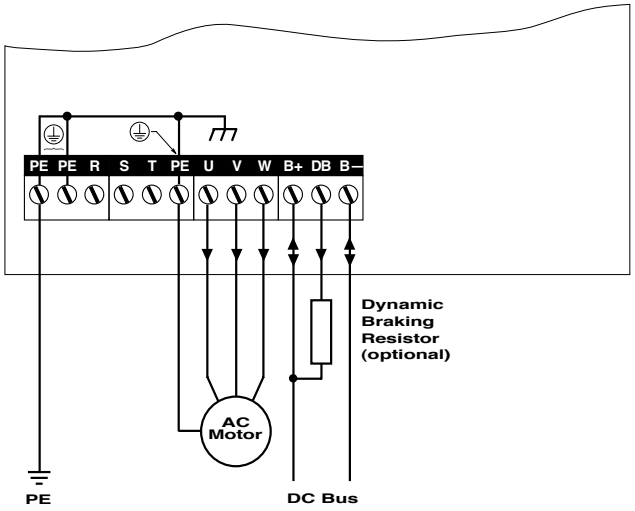


Figure 4-5—1120 Power and Grounding Connections

Form 12N



Form 17

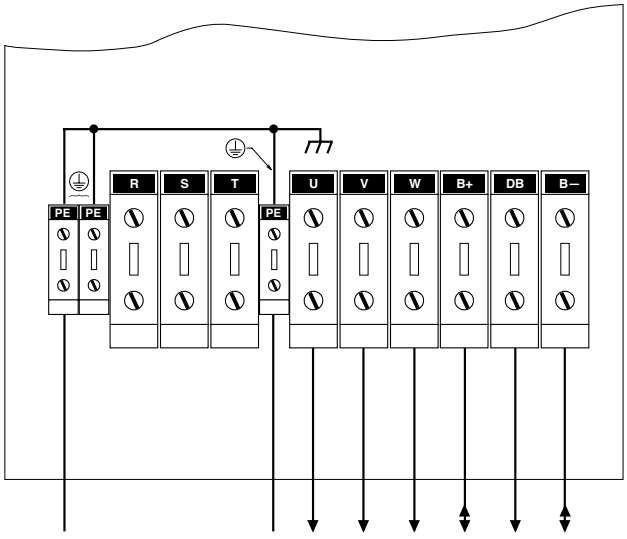
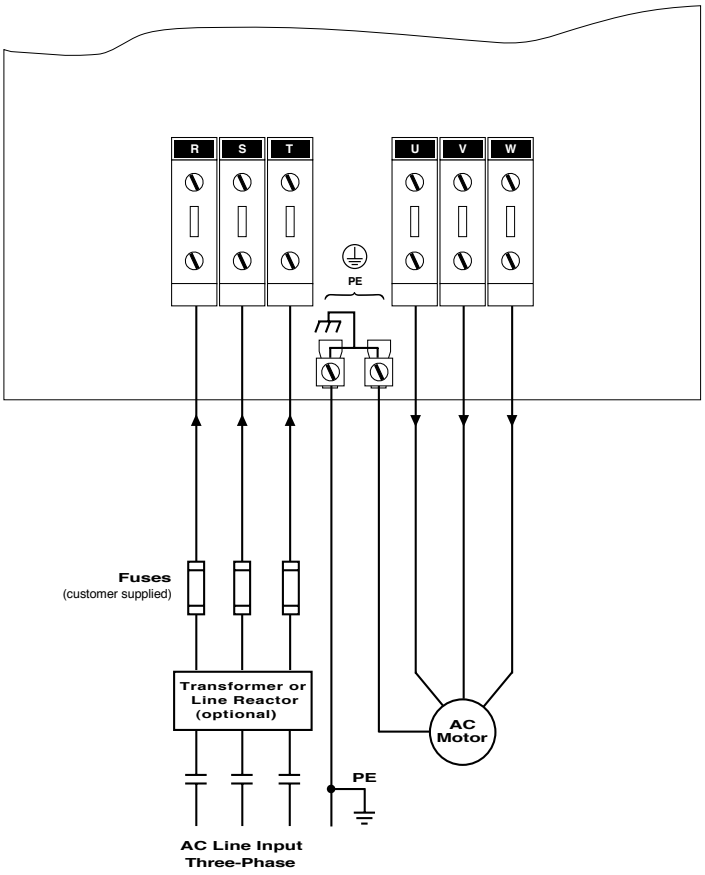


Figure 4-6—1130 Power and Grounding Connections

Forms 17 and 30 (to 50 hp CT 230 V, to 100 hp CT 460V and 575 V)



Form 30 (60 hp CT 230 V, 125 hp CT 460 V and 575 V)

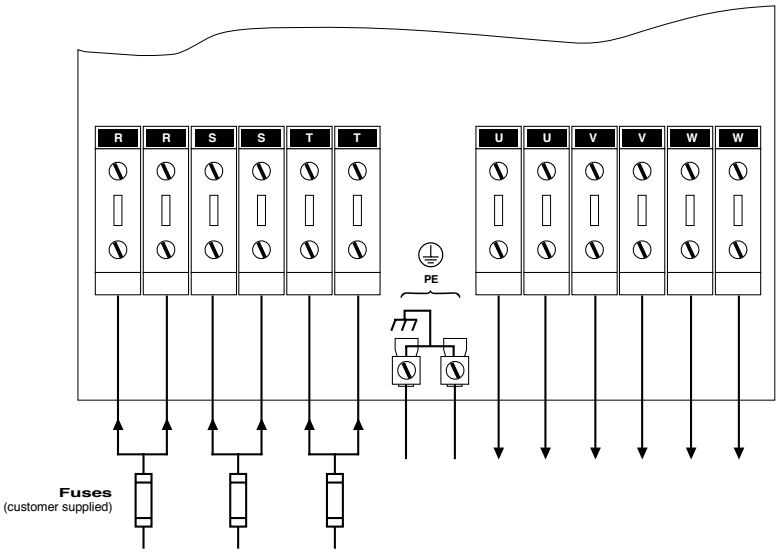


Figure 4-7—1200 Power and Grounding Connections

Form 9N

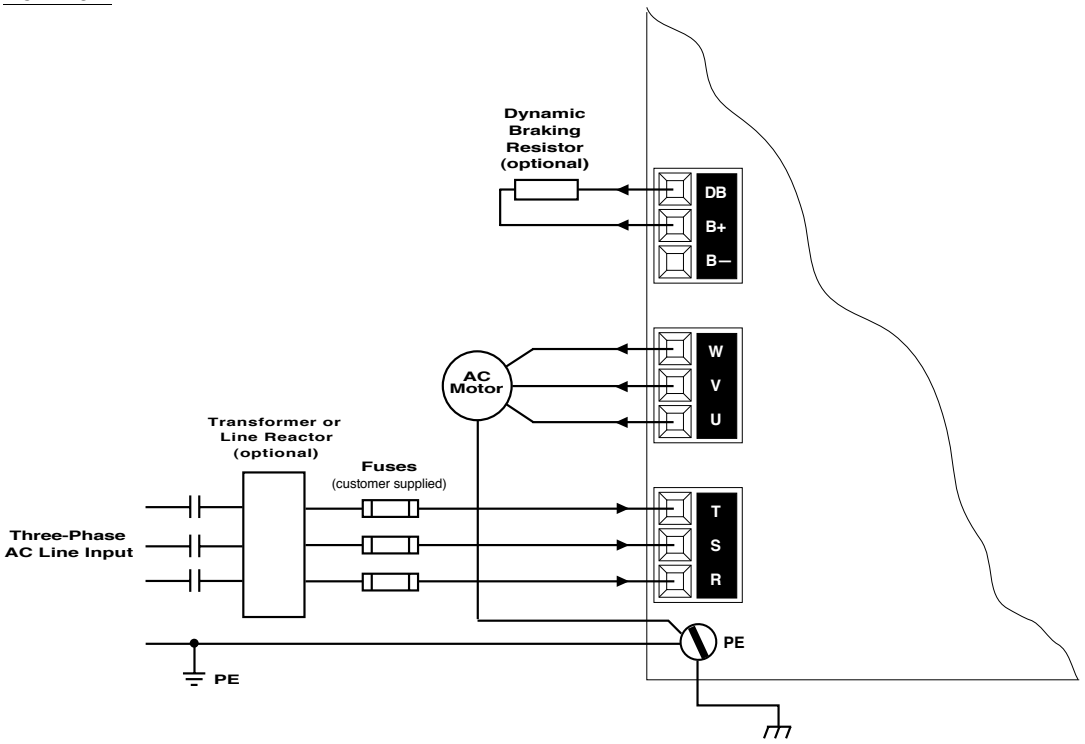
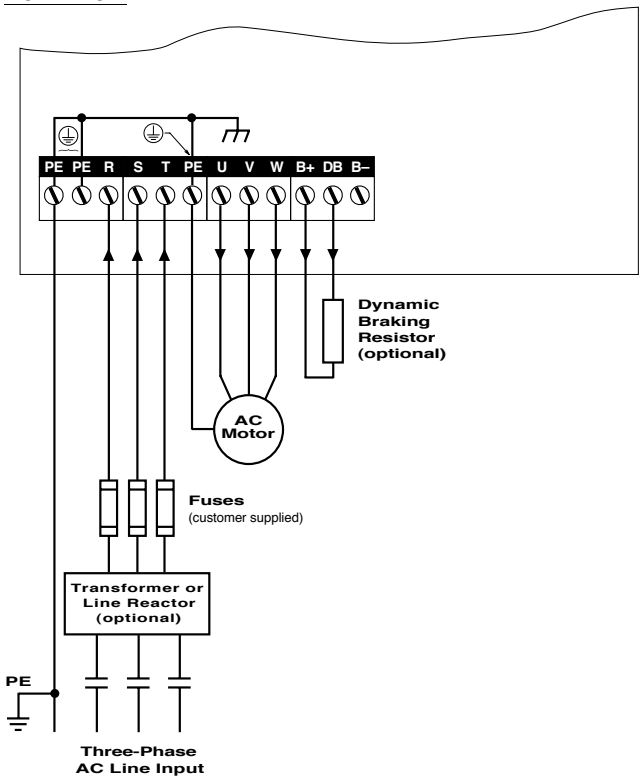


Figure 4-7—1200 Power and Grounding Connections *(continued)*

Form 13N



Form 17N

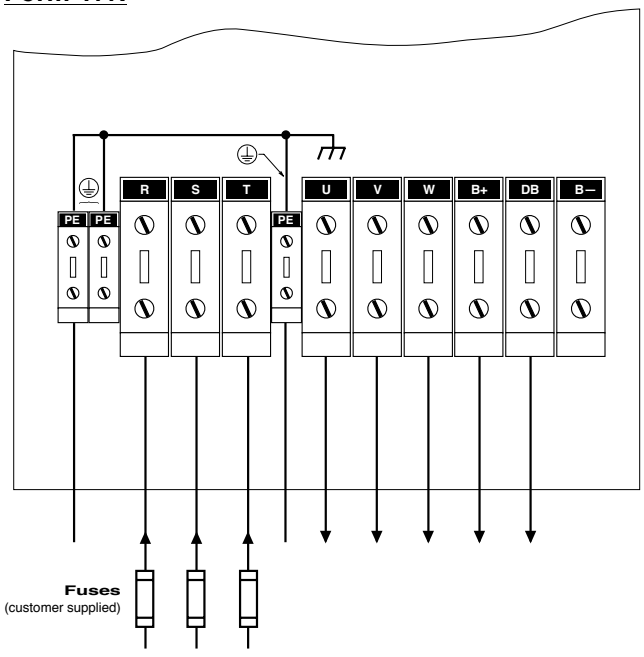


Figure 4-7—1200 Power and Grounding Connections *(continued)*

Form 17X

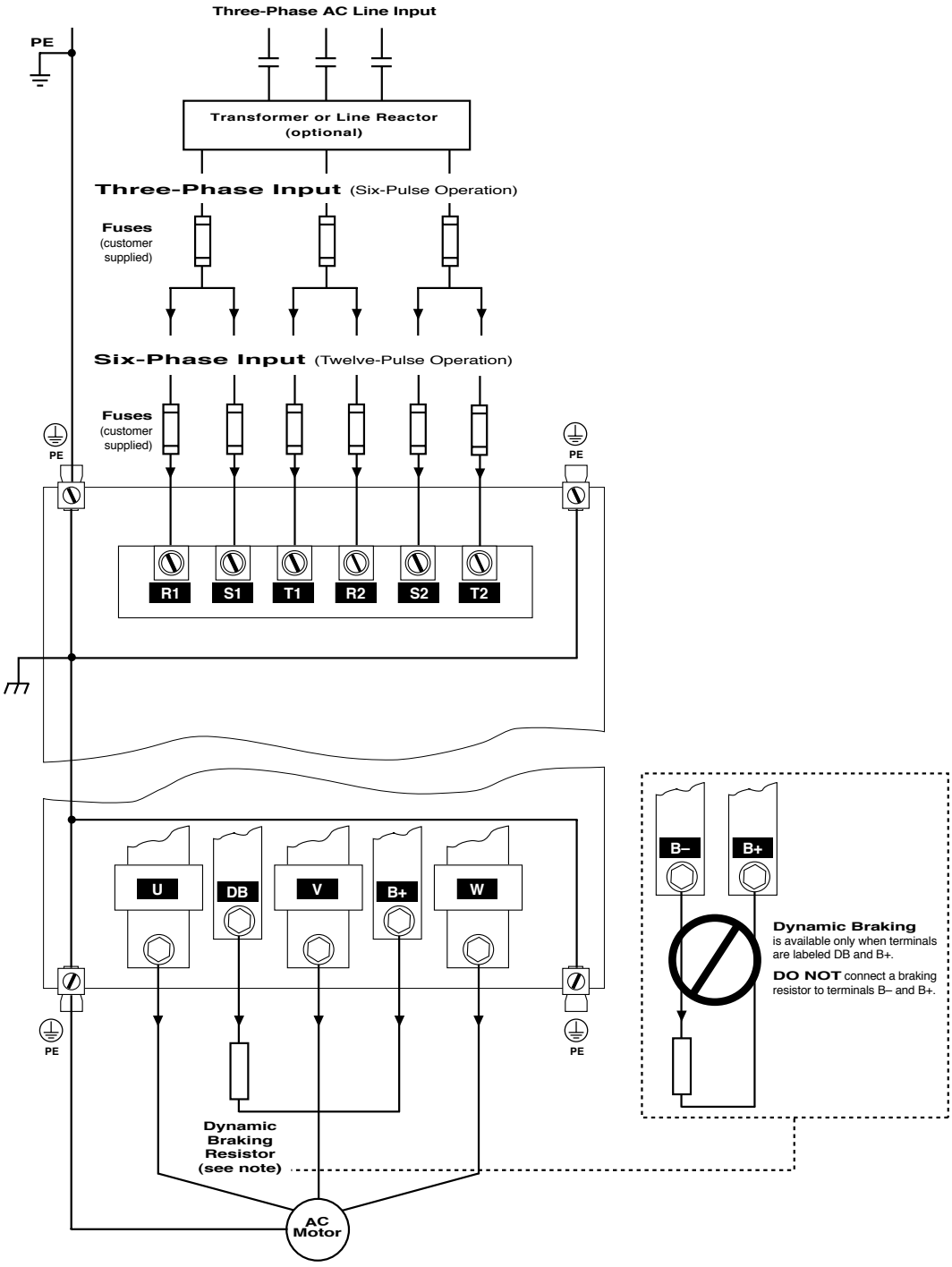


Figure 4-7—1200 Power and Grounding Connections *(continued)*

Form 34X

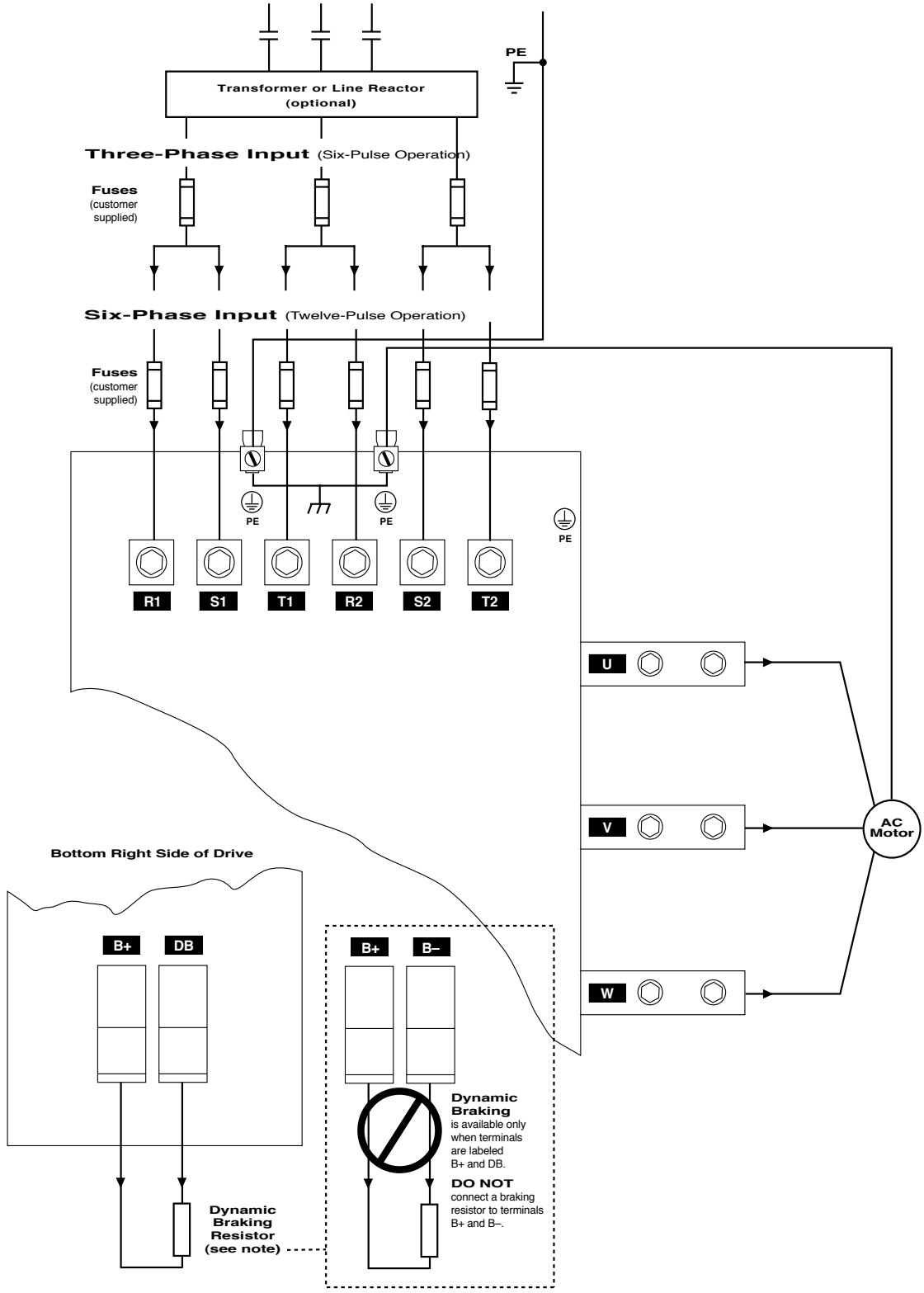


Figure 4-7—1200 Power and Grounding Connections *(continued)*

Form 48X

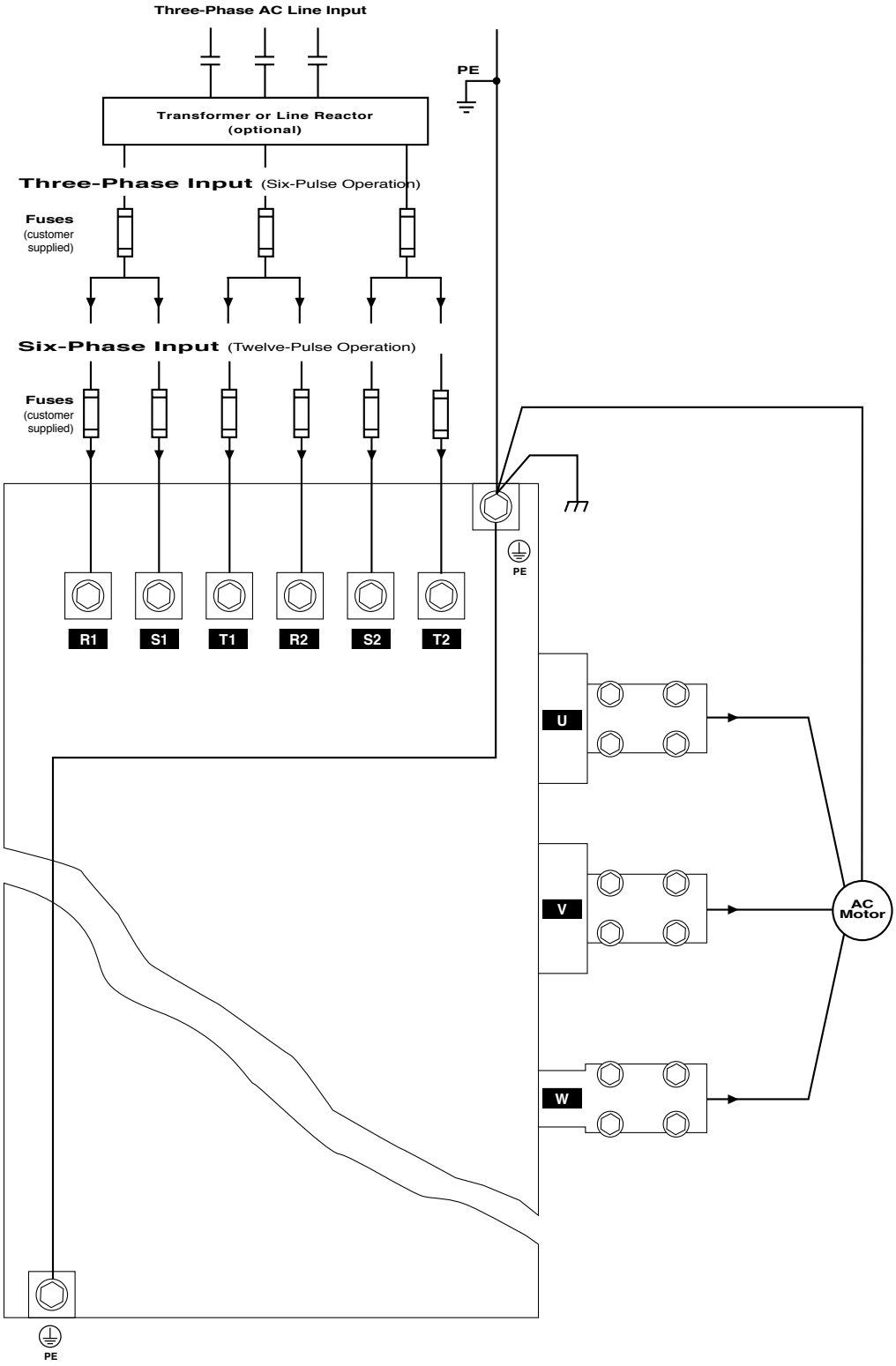


Figure 4-8—1230 Power and Grounding Connections

Form 13N

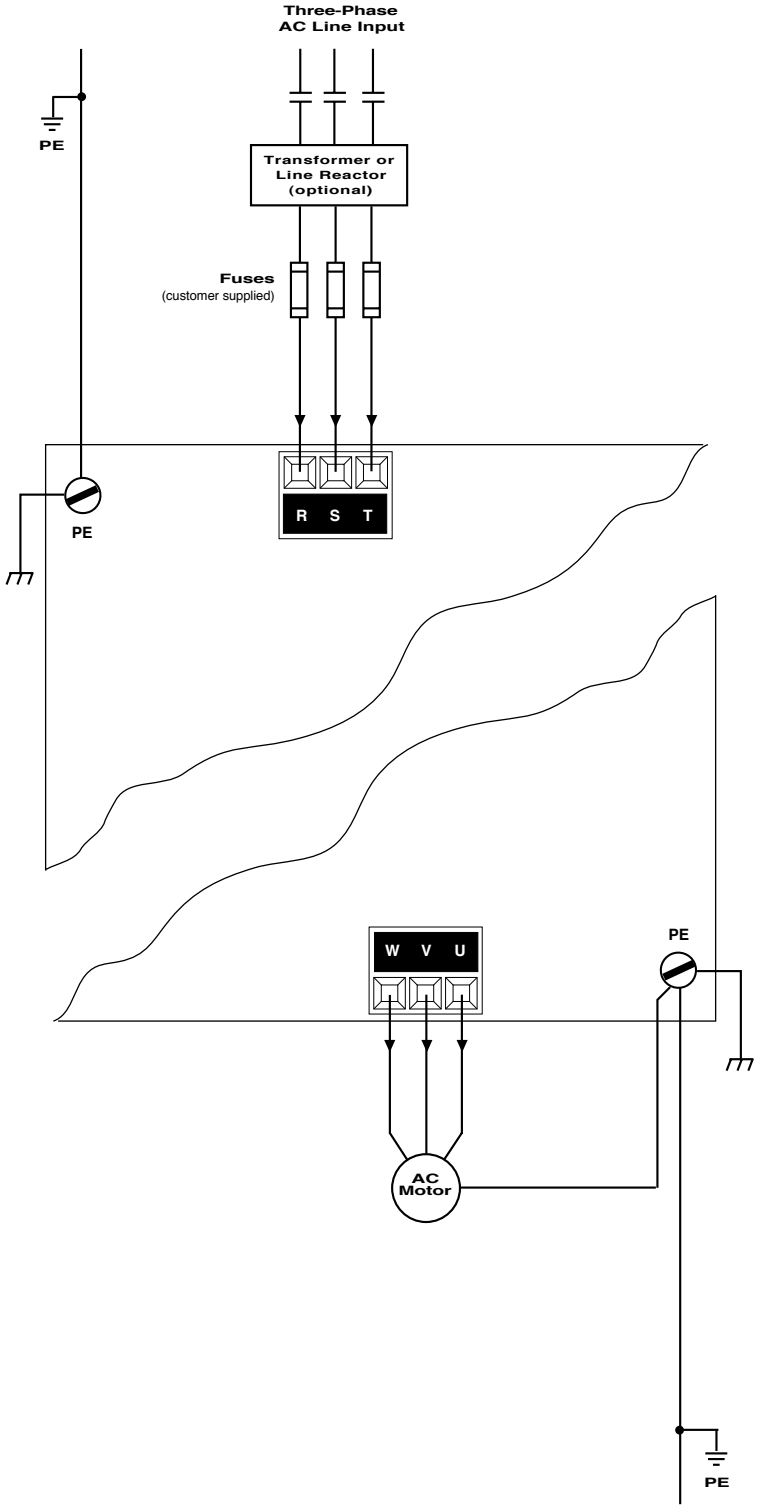
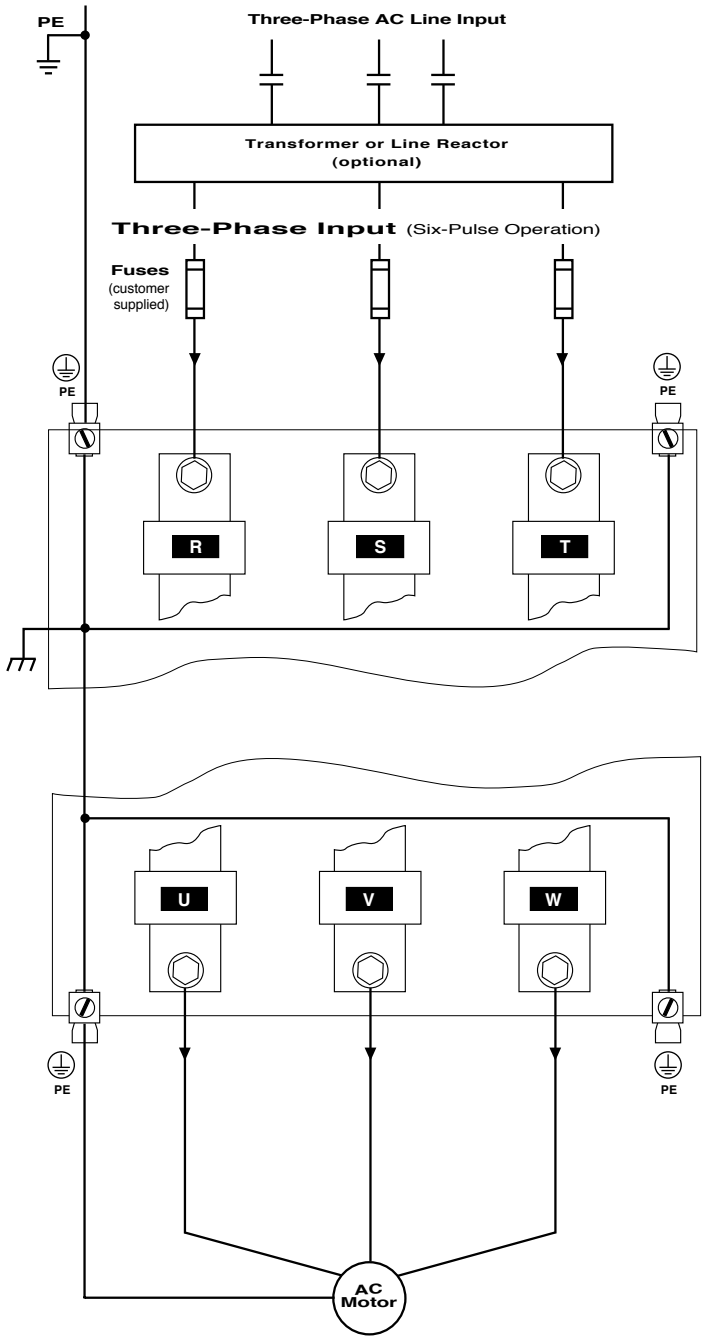


Figure 4-8—1230 Power and Grounding Connections *(continued)*

Form 17X



4.5.2 Connect the Power Supply

Connect the line power supply leads to the 1100, 1105, 1110, 1130, 1200, and 1230 drives using the appropriate connection diagram as listed in Table 4-1. Depending upon the drive model and its power rating, the drive may accept either a single-phase (S, T), a three-phase (R, S, T), or a six-phase (R1, R2, S1, S2, T1, T2) input. If six-phase (12-pulse) operation is unnecessary, six-phase drives may also be configured for three-phase (six-pulse) operation. Refer to the appropriate connection diagram as listed in Table 4-1. Input connection terminal specifications for the various drives are provided in the tables summarized in Table 4-1. Large drives use double terminals (indicated by x2) to accommodate the maximum required currents. High-power drive sizes provide for optional six-phase (12-pulse) connection and, therefore, also have double terminals (indicated x2). Refer to Section 4.2 for wiring requirements. The inverter is phase-sequence insensitive, so the input leads may be connected in any order. Make certain that AC power inputs are routed separately from control signals.

4.5.3 Input Protection

The 1100, 1105, 1110, 1130, 1200, and 1230 drives must be protected from short circuits using either a circuit breaker or fusing.

Fuses are not supplied with the unit and must be provided externally. Fuse recommendations and specifications are provided in
Table 4-11 (1100, 1105, 1130, 1200, and 1230 drives) and Table 4-12 (1110 drives). Select fuses according to the power of the application, not necessarily according to the drive rating. For example, a drive rated 40 hp CT can also be applied at 50 hp VT or 60 hp ET, depending upon the overload requirements of the application. The nominal ratings of the drive can be found on the rating label. Fuse recommendations differ for single-, three-, and six-phase configurations. The recommended fuse ratings for the six-phase (twelve-pulse) connections are 60% of those listed for the three-phase (six-pulse) connection in
Table 4-11.

Fuses from other manufacturers may be used as long as they meet the specifications given. Semiconductor fuses provide the highest level of protection and are recommended. UL-listed drives must use UL-recognized fuses under category JFHR2. For help in locating additional UL-recognized fuse manufacturers, please contact the factory.

If a circuit breaker is to be used, refer to
Table 4-11 (1100, 1105, 1130, 1200, and 1230 drives) or Table 4-12 (1110 drives) to determine the proper current rating using the input current and applying a margin of approximately 33%. You may purchase a circuit breaker directly from Unico. Contact the factory directly for more information.

4.6 Connect the Motor

Connect the motor leads using the appropriate connection diagram as listed in Table 4-1. Motor output terminal specifications for the various drives are provided in the tables summarized in Table 4-1. High-power drives have two terminals per motor phase (indicated x2) to provide for convenient wire gauges. Refer to Section 4.2 for wiring requirements. Use of a metal-jacketed motor cable is recommended to minimize noise emissions. Refer to Table 2-13 to determine the output current rating of the drive.

If the motor has a transducer, the motor leads may be connected in any order and the drive will determine the correct phasing accordingly. If the motor does not have a

transducer, you may have to rephase it during start-up. Refer to the application documentation for further information.

High-frequency voltage switching on these connections necessitates care to minimize electrical noise interference. Make certain that motor outputs are routed separately from control signals and AC input power and that control signals are appropriately shielded.

4.7 Connect the Dynamic Braking Resistor

Dynamic braking control for use with an external resistor is included on Form 12N and 17N 1105 drives, on all 1120 drives, and on Form 9N and 13N 1200 drives. It is optionally available on other 1105 drives, on Form 17X and 34X 1200 drives, and on all 1100 and 1110 drives. Drives with optional braking control have terminals labeled B+ and DB. Units having only B+ and B– with no DB terminal do not feature dynamic braking.

Connect the braking resistor to the B+ and DB terminals using the appropriate connection diagram as listed in Table 4-1. Dynamic braking terminal specifications for the various drives are provided in the tables summarized in Table 4-1. Refer to Section 4.2 for wiring requirements.

Dynamic braking resistors are available from the factory or you may supply your own. Resistors are sized to give a braking torque of either 100% of rated constant torque with integral control or 100%, 150%, or 200% of rated constant torque with optional control. Resistors with a capacity of 5%, 10%, or 20% of the associated drive constant-torque power rating. Consult the factory for other combinations. If providing your own resistor, size it according to Table 4-17, which lists recommended values for providing a braking torque of 100% of rated constant torque with integral braking control and 150% with optional braking control. Make certain braking resistors provide at least the minimum resistance specified in Table 4-18 to accommodate braking device current limitations. Consult the factory for sizing assistance.

Attention

The braking resistor should be mounted in a well-ventilated area. Avoid placing it in a location where heat could cause injury or property damage. The resistor should be housed in a metal enclosure to shield neighboring equipment from electromagnetic emissions. If it is mounted outside of the enclosure, a guard should be constructed to prevent accidental contact.

Attention

Do not connect any kind of power supply to the dynamic braking resistor terminals. Do not connect a resistor rated less than specified.

4.8 Bus Connections

The drive bus can be connected externally for sharing energy between units or for storing energy in a capacitor bank. Bus connections are available on 1100 and 1110 drives without optional braking control, on low-power 1105 drives and higher-power 1105 drives without braking control, and on all 1120, 1130 drives, and 1200 drives. Units having bus connections provide terminals labeled B+ and B–.

Connect the B+ and B– terminals of the 1120 drive to the common DC bus using the appropriate connection diagram as listed in Table 4-1. Bus terminal specifications for the 1120 drive are provided in the tables summarized in Table 4-1. Use the bus current information listed in Table 4-3 to determine proper wire sizing. Nominal bus voltages are provided in Table 4-2. Refer to Section 4.2 for wiring requirements.

Attention

High voltage may be present even when all electrical power supplies are disconnected. After switching off electrical power, wait at least 15 minutes for bus circuit capacitors to discharge before working on the drive or associated equipment. Use an appropriate voltmeter to further verify that capacitors are discharged before beginning work. Do not rely exclusively on the bus voltage indicator. Dangerous voltage levels may remain even when the indicator is off.

4.8.1 Common-Bus Operation

The buses of multiple drives can be interconnected in certain applications to enable motoring and braking energies to circulate between units. The 1120 drive is intended for multidrive operation from a common bus. Consult the factory for assistance in using a common-bus connection with other drives.

Table 4-2—Nominal Bus Voltages

Input Power	Bus Voltage
230 V AC	311 V DC
380 V AC	513 V DC
460 V AC	621 V DC
575 V AC	776 V DC

Table 4-3—DC Bus Currents

Power	230 V	380 V	460 V
hp (kW)	A_{dc}	A_{dc}	A_{dc}
1 1/2 (1.1)	4.9	2.8	2.5
2 (1.5)	6.1	3.5	3.0
3 (2.2)	8.9	5.1	4.4
5 (3.7)	14.4	8.3	7.2
7 1/2 (5.5)	21.2	12.2	10.6
10 (7.5)	27.6	15.9	13.8
15 (11)	41.4	23.8	20.7
20 (15)	54.2	31.2	27.1
25 (18)	68.0	39.1	34.0
30 (22)	80.8	46.5	40.4
40 (30)	106.4	61.2	53.2
50 (37)	133.0	76.5	66.5
60 (45)	158.6	91.2	79.3
75 (55)	198.0	113.8	99.0
100 (75)	259.8	149.4	129.9
125 (90)	—	187.3	162.9
150 (110)	—	220.4	191.7
200 (150)	—	293.9	255.6
250 (185)	—	367.4	319.5
300 (225)	—	440.9	383.4
350 (262)	—	514.4	447.3
400 (300)	—	587.9	511.2
500 (375)	—	734.8	639.0
600 (450)	—	881.8	766.8
800 (600)	—	1175.8	1022.4
1000 (750)	—	—	1278.0

Table 4-4—1100 Ground and Power Terminal Specifications

Power			Terminal							
			Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
			(PE)		(R, S, T or R1, R2, S1, S2, T1, T2)		(U, V, W)		(B+, DB or B+, B–)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*
230 V										
1 1/2 (1.1)	2 (1.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
2 (1.5)	3 (2.2)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
3 (2.2)	5 (3.7)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
5 (3.7)	7 1/2 (5.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
7 1/2 (5.5)	10 (7.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
10 (7.5)	15 (11)	—	12–1 (3.3-42)	200 (23)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
15 (11)	20 (15)	—	12–1 (3.3-42)	200 (23)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
20 (15)	25 (18)	—	12–1 (3.3-42)	200 (23)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
25 (18)	30 (22)	—	12–1 (3.3-42)	200 (23)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
30 (22)	40 (30)	—	12–1 (3.3-42)	200 (23)	4–2/0 (21-67)	53.4–62.3 (6.0-7.0)	4–2/0 (21-67)	53.4–62.3 (6.0-7.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
40 (30)	50 (37)	—	12–1 (3.3-42)	200 (23)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
50 (37)	60 (45)	—	12–1 (3.3-42)	200 (23)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)
60 (45)	75 (55)	—	12–1 (3.3-42)	200 (23)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)
460 V										
1 1/2 (1.1)	2 (1.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
2 (1.5)	3 (2.2)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
3 (2.2)	5 (3.7)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
5 (3.7)	7 1/2 (5.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
7 1/2 (5.5)	10 (7.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
10 (7.5)	15 (11)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
15 (11)	20 (15)	25 (18)	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
20 (15)	25 (18)	30 (22)	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
25 (18)	30 (22)	40 (30)	12–1 (3.3-42)	200 (23)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)

(continued)

Table 4-4—1100 Ground and Power Terminal Specifications *(continued)*

Power			Terminal							
			Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
			(PE)		(R, S, T or R1, R2, S1, S2, T1, T2)		(U, V, W)		(B+, DB or B+, B–)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*
460 V										
30 (22)	40 (30)	50 (37)	12–1 (3.3-42)	200 (23)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
40 (30)	50 (37)	60 (45)	12–1 (3.3-42)	200 (23)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
50 (37)	60 (45)	75 (55)	12–1 (3.3-42)	200 (23)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
60 (45)	75 (55)	100 (75)	12–1 (3.3-42)	200 (23)	4–2/0 (21-67)	53.4–62.3 (6.0-7.0)	4–2/0 (21-67)	53.4–62.3 (6.0-7.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
75 (55)	100 (75)	125 (90)	12–1 (3.3-42)	200 (23)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
100 (75)	125 (90)	150 (110)	12–1 (3.3-42)	200 (23)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
125 (90)	150 (110)	—	12–1 (3.3-42)	200 (23)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)
150 (110)	200 (150)	250 (185)	12–1 (3.3-42)	200 (23)	2–4/0 (x2) (34-107)	133–177 (15-20)	2/0–500 (67-253)	221-266 (25-30)	6–1/0 (13-53)	53.1–70.9 (6.0-8.0)
200 (150)	250 (185)	300 (225)	12–1 (3.3-42)	200 (23)	2–300 (x2) (34-152)	221–266 (25-30)	2–4/0 (x2) (34-107)	133–177 (15-20)	6–1/0 (13-53)	53.1–70.9 (6.0-8.0)
250 (185)	300 (225)	350 (262)	12–1 (3.3-42)	200 (23)	2–300 (x2) (34-152)	221–266 (25-30)	2–300 (x2) (34-152)	221–266 (25-30)	2–4/0 (34-107)	133–177 (15-20)
300 (225)	350 (262)	400 (300)	12–1 (3.3-42)	200 (23)	2/0–500 (x2) (67-253)	221–266 (25-30)	2/0–500 (x2) (67-253)	221–266 (25-30)	2–4/0 (34-107)	133–177 (15-20)
350 (262)	400 (300)	500 (375)	12–1 (3.3-42)	200 (23)	2/0–500 (x2) (67-253)	221–266 (25-30)	2/0–500 (x2) (67-253)	221–266 (25-30)	2–4/0 (34-107)	133–177 (15-20)
575 V										
1 1/2 (1.1)	2 (1.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
2 (1.5)	3 (2.2)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
3 (2.2)	5 (3.7)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
5 (3.7)	7 1/2 (5.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
7 1/2 (5.5)	10 (7.5)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
10 (7.5)	15 (11)	—	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
15 (11)	20 (15)	25 (18)	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
20 (15)	25 (18)	30 (22)	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
25 (18)	30 (22)	40 (30)	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
30 (22)	40 (30)	50 (37)	12–1 (3.3-42)	200 (23)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)

(continued)

Table 4-4—1100 Ground and Power Terminal Specifications *(continued)*

Power			Terminal							
			Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
			(PE)		(R, S, T or R1, R2, S1, S2, T1, T2)		(U, V, W)		(B+, DB or B+, B–)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
575 V										
40 (30)	50 (37)	60 (45)	12–1 (3.3-42)	200 (23)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
50 (37)	60 (45)	75 (55)	12–1 (3.3-42)	200 (23)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
60 (45)	75 (55)	100 (75)	12–1 (3.3-42)	200 (23)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
75 (55)	100 (75)	125 (90)	12–1 (3.3-42)	200 (23)	4–2/0 (21-67)	53.4–62.3 (6.0-7.0)	4–2/0 (21-67)	53.4–62.3 (6.0-7.0)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
100 (75)	125 (90)	150 (110)	12–1 (3.3-42)	200 (23)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	20–6 (0.5-13)	10.6–12.4 (1.2-1.4)
125 (90)	150 (110)	—	12–1 (3.3-42)	200 (23)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)
150 (110)	200 (150)	250 (185)	12–1 (3.3-42)	200 (23)	2–4/0 (x2) (34-107)	133–177 (15-20)	2/0–500 (x2) (67-253)	221–266 (25-30)	6–1/0 (13-53)	53.1–70.9 (6.0-8.0)
200 (150)	250 (185)	300 (225)	12–1 (3.3-42)	200 (23)	2–4/0 (x2) (34-107)	133–177 (15-20)	2/0–500 (x2) (67-253)	221–266 (25-30)	6–1/0 (13-53)	53.1–70.9 (6.0-8.0)
250 (185)	300 (225)	350 (262)	12–1 (3.3-42)	200 (23)	2–4/0 (x2) (34-107)	133–177 (15-20)	2–4/0 (x2) (34-107)	133–177 (15-20)	6–1/0 (13-53)	53.1–70.9 (6.0-8.0)
300 (225)	350 (262)	400 (300)	12–1 (3.3-42)	200 (23)	2–300 (x2) (34-152)	221–266 (25-30)	2–300 (x2) (34-152)	221–266 (25-30)	2–4/0 (34-107)	133–177 (15-20)
350 (262)	400 (300)	500 (375)	12–1 (3.3-42)	200 (23)	2/0–500 (x2) (67-253)	221–266 (25-30)	2/0–500 (x2) (67-253)	221–266 (25-30)	2–4/0 (34-107)	133–177 (15-20)
400 (300)	500 (375)	600 (450)	12–1 (3.3-42)	200 (23)	2/0–500 (x2) (67-253)	221–266 (25-30)	2/0–500 (x2) (67-253)	221–266 (25-30)	2–4/0 (34-107)	133–177 (15-20)

Table 4-5—1105 Ground and Power Terminal Specifications

Power			Terminal							
			Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
			(PE, SH)		(R, S, T)		(U, V, W)		(B+, DB, B–)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
230 V										
1 1/2 (1.1)	2 (1.5)	—	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)
2 (1.5)	3 (2.2)	—	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)
3 (2.2)	5 (3.7)	—	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)
5 (3.7)	7 1/2 (5.5)	—	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
7 1/2 (5.5)	10 (7.5)	—	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
10 (7.5)	15 (11)	—	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
15 (11)	20 (15)	—	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
20 (15)	25 (18)	—	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
460 V										
1 1/2 (1.1)	2 (1.5)	—	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)
2 (1.5)	3 (2.2)	—	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)
3 (2.2)	5 (3.7)	—	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)
5 (3.7)	7 1/2 (5.5)	10 (7.5)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)	24–10 (0.2-5.3)	4.4–5.3 (0.5-0.6)
7 1/2 (5.5)	10 (7.5)	15 (11)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
10 (7.5)	15 (11)	20 (15)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
15 (11)	20 (15)	25 (18)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
20 (15)	25 (18)	30 (22)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
25 (18)	30 (22)	40 (30)	20–6 (0.5-13)	10.6–12.3 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)
30 (22)	40 (30)	50 (37)	20–6 (0.5-13)	10.6–12.3 (1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)
40 (30)	50 (37)	60 (45)	20–6 (0.5-13)	10.6–12.3 (1.4)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.4)
50 (37)	60 (45)	75 (55)	12–1 (3.3-42)	200 (23)	20–6 (x2) (0.5-13)	10.6–12.4 (1.4)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.4)
60 (45)	75 (55)	100 (75)	12–1 (3.3-42)	200 (23)	18–6 (x2) (0.8-13)	10.6–12.4 (1.2-1.4)	4–2/0 (21-67)	53.4–62.3 (6.0-7.0)	20–6 (0.5-13)	10.6–12.4 (1.4)
75 (55)	100 (75)	125 (90)	12–1 (3.3-42)	200 (23)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	20–6 (0.5-13)	10.6–12.4 (1.4)

(continued)

Table 4-5—1105 Ground and Power Terminal Specifications *(continued)*

Power			Terminal							
			Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
			(PE)		(R, S, T or R1, R2, S1, S2, T1, T2)		(U, V, W)		(B+, DB, B–)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
460 V										
100 (75)	125 (90)	150 (110)	12–1 (3.3-42)	200 (23)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	20–6 (13)	10.6–12.4 (1.4)
125 (90)	150 (110)	200 (150)	12–1 (3.3-42)	200 (23)	4–2/0 (x2) (21-67)	53.4–62.3 (6.0-7.0)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)
150 (110)	200 (150)	250 (185)	12–1 (3.3-42)	200 (23)	4–4/0 (x2) (21-107)	75.3–84.1 (8.5-9.5)	4–4/0 (x2) (21-107)	75.3–84.1 (8.5-9.5)	10–1/0 (5.3-53)	24.9-26.7 (2.8-3.0)
575 V										
1 1/2 (1.1)	2 (1.5)	—	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
2 (1.5)	3 (2.2)	—	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
3 (2.2)	5 (3.7)	—	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
5 (3.7)	7 1/2 (5.5)	10 (7.5)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
7 1/2 (5.5)	10 (7.5)	15 (11)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
10 (7.5)	15 (11)	20 (15)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)	18–4 (0.8-21)	16 (1.8)
15 (11)	20 (15)	25 (18)	20–6 (0.5-13)	10.6–12.3 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)
20 (15)	25 (18)	30 (22)	20–6 (0.5-13)	10.6–12.3 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)
25 (18)	30 (22)	40 (30)	20–6 (0.5-13)	10.6–12.3 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)
30 (22)	40 (30)	50 (37)	20–6 (0.5-13)	10.6–12.3 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)
40 (30)	50 (37)	60 (45)	20–6 (0.5-13)	10.6–12.3 (1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)	20–6 (0.5-13)	10.6–12.4 (1.4)
50 (37)	60 (45)	75 (55)	12–1 (3.3-42)	200 (23)	20–6 (x2) (0.5-13)	10.6–12.4 (1.4)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.4)
60 (45)	75 (55)	100 (75)	12–1 (3.3-42)	200 (23)	18–6 (x2) (0.8-13)	10.6–12.4 (1.2-1.4)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)	20–6 (0.5-13)	10.6–12.4 (1.4)
75 (55)	100 (75)	125 (90)	12–1 (3.3-42)	200 (23)	18–6 (x2) (0.8-13)	10.6–12.4 (1.2-1.4)	4–2/0 (21-67)	53.4–62.3 (6.0-7.0)	20–6 (0.5-13)	10.6–12.4 (1.4)
100 (75)	125 (90)	150 (110)	12–1 (3.3-42)	200 (23)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	4–4/0 (21-107)	75.3–84.1 (8.5-9.5)	20–6 (0.5-13)	10.6–12.4 (1.4)
125 (90)	150 (110)	200 (150)	12–1 (3.3-42)	200 (23)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)
150 (110)	200 (150)	250 (185)	12–1 (3.3-42)	200 (23)	4–2/0 (x2) (21-67)	53.4–62.3 (6.0-7.0)	10–1/0 (x2) (5.3-53)	24.9–26.7 (2.8-3.0)	18–6 (0.8-13)	10.6–12.4 (1.2-1.4)
200 (150)	250 (185)	300 (225)	12–1 (3.3-42)	200 (23)	4–4/0 (x2) (21-107)	75.3–84.1 (8.5-9.5)	4–4/0 (x2) (21-107)	75.3–84.1 (8.5-9.5)	10–1/0 (5.3-53)	24.9–26.7 (2.8-3.0)

Table 4-6—1110 Ground and Power Terminal Specifications

Power		Terminal							
		Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
		(PE)		(S, T)		(U, V, W)		(B+, DB or B+, B–)	
CT	VT	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
230 V									
1 1/2 (1.1)	2 (1.5)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
2 (1.5)	3 (2.2)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
3 (2.2)	5 (3.7)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
5 (3.7)	7 1/2 (5.5)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
7 1/2 (5.5)	10 (7.5)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
10 (7.5)	15 (11)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
15 (11)	20 (15)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	4 (16)	12 (1.4)	6 (13)	12 (1.4)
20 (15)	25 (18)	6 (x2) (13)	12 (1.4)	1/0 (x2) (35)	25 (2.8)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)
25 (18)	30 (22)	6 (x2) (13)	12 (1.4)	1/0 (x2) (35)	25 (2.8)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)
30 (22)	40 (30)	2 (x2) (33)	15 (1.8)	4/0 (x2) (95)	150 (17)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)
40 (30)	50 (37)	2 (x2) (33)	15 (1.8)	4/0 (x2) (95)	150 (17)	4/0 (95)	50 (5.6)	4 (16)	12 (1.4)
460 V									
1 1/2 (1.1)	2 (1.5)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
2 (1.5)	3 (2.2)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
3 (2.2)	5 (3.7)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
5 (3.7)	7 1/2 (5.5)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
7 1/2 (5.5)	10 (7.5)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
10 (7.5)	15 (11)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
15 (11)	20 (15)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
20 (15)	25 (18)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
25 (18)	30 (22)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	4 (16)	12 (1.4)	6 (13)	12 (1.4)

(continued)

Table 4-6—1110 Ground and Power Terminal Specifications ***(continued)***

Power		Terminal							
		Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
		(PE)		(S, T)		(U, V, W)		(B+, DB or B+, B–)	
CT	VT	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
460 V									
30 (22)	40 (30)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)
40 (30)	50 (37)	6 (x2) (13)	12 (1.4)	1/0 (x2) (35)	25 (2.8)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)
50 (37)	60 (45)	2 (x2) (33)	15 (1.8)	4/0 (95)	150 (17)	1/0 (35)	25 (2.8)	6 (13)	12 (1.4)
60 (45)	75 (55)	2 (x2) (33)	15 (1.8)	4/0 (x2) (95)	150 (17)	4/0 (95)	50 (5.6)	6 (13)	12 (1.4)
75 (55)	100 (75)	2 (x2) (33)	15 (1.8)	4/0 (x2) (95)	150 (17)	4/0 (95)	50 (5.6)	6 (13)	12 (1.4)

Table 4-7—1120 Ground and Power Terminal Specifications

Power			Terminal					
			Ground (PE)		Bus (B+, B–)		Motor Output (U, V, W)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
230 V								
1 1/2 (1.1)	2 (1.5)	—	*Consult factory*					
2 (1.5)	3 (2.2)	—						
3 (2.2)	5 (3.7)	—	*Consult factory*					
5 (3.7)	7 1/2 (5.5)	10 (7.5)						
7 1/2 (5.5)	10 (7.5)	15 (11)	*Consult factory*					
10 (7.5)	15 (11)	20 (15)						
15 (11)	20 (15)	25 (18)	*Consult factory*					
20 (15)	25 (18)	30 (22)						
25 (18)	30 (22)	40 (30)	*Consult factory*					
30 (22)	40 (30)	50 (37)						
40 (30)	50 (37)	60 (45)	*Consult factory*					
50 (37)	60 (45)	75 (55)						
60 (45)	75 (55)	100 (75)	*Consult factory*					
460 V								
1 1/2 (1.1)	2 (1.5)	—	*Consult factory*					
2 (1.5)	3 (2.2)	—						
3 (2.2)	5 (3.7)	—	*Consult factory*					
5 (3.7)	7 1/2 (5.5)	10 (7.5)						
7 1/2 (5.5)	10 (7.5)	15 (11)	*Consult factory*					
10 (7.5)	15 (11)	20 (15)						
15 (11)	20 (15)	25 (18)	*Consult factory*					
20 (15)	25 (18)	30 (22)						
25 (18)	30 (22)	40 (30)	*Consult factory*					
30 (22)	40 (30)	50 (37)						

(continued)

Table 4-7—1120 Ground and Power Terminal Specifications ***(continued)***

Power			Terminal					
			Ground (PE)		Bus (B+, B–)		Motor Output (U, V, W)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
460 V								
40 (30)	50 (37)	60 (45)	*Consult factory*					
50 (37)	60 (45)	75 (55)						
60 (45)	75 (55)	100 (75)	*Consult factory*					
75 (55)	100 (75)	125 (90)						
100 (75)	125 (90)	150 (110)	*Consult factory*					
125 (90)	150 (110)	200 (150)						

Table 4-8—1130 Ground and Power Terminal Specifications

Power			Terminal					
			Ground (PE)		AC Line Input (R, S, T)		Motor Output (U, V, W)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
230 V								
7 1/2 (5.5)	10 (7.5)	—	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
10 (7.5)	15 (11)	—	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
15 (11)	20 (15)	—	6 (x2) (13)	12 (1.4)	4 (16)	12 (1.4)	4 (16)	12 (1.4)
20 (15)	25 (18)	—	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	1/0 (35)	25 (2.8)
25 (18)	30 (22)	—	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	1/0 (35)	25 (2.8)
30 (22)	40 (30)	—	2 (x2) (33)	15 (1.8)	1/0 (35)	25 (2.8)	1/0 (35)	25 (2.8)
40 (30)	50 (37)	—	2 (x2) (33)	15 (1.8)	2/0 (70)	50 (5.6)	2/0 (70)	50 (5.6)
50 (37)	60 (45)	—	2 (x2) (33)	15 (1.8)	4/0 (95)	150 (17)	4/0 (95)	150 (17)
60 (45)	75 (55)	—	2 (x2) (33)	15 (1.8)	1/0 (x2) (35)	25 (2.8)	1/0 (x2) (35)	25 (2.8)
460 V								
7 1/2 (5.5)	10 (7.5)	—	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
10 (7.5)	15 (11)	—	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
15 (11)	20 (15)	25 (18)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
20 (15)	25 (18)	30 (22)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
25 (18)	30 (22)	40 (30)	6 (x2) (13)	12 (1.4)	4 (16)	12 (1.4)	4 (16)	12 (1.4)
30 (22)	40 (30)	50 (37)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	1/0 (35)	25 (2.8)
40 (30)	50 (37)	60 (45)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	1/0 (35)	25 (2.8)
50 (37)	60 (45)	75 (55)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	1/0 (35)	25 (2.8)
60 (45)	75 (55)	100 (75)	2 (x2) (33)	15 (1.8)	2/0 (70)	50 (5.6)	2/0 (70)	50 (5.6)
75 (55)	100 (75)	125 (90)	2 (x2) (33)	15 (1.8)	4/0 (95)	150 (17)	4/0 (95)	150 (17)
100 (75)	125 (90)	150 (110)	2 (x2) (33)	15 (1.8)	4/0 (95)	150 (17)	4/0 (95)	150 (17)
125 (90)	150 (110)	200 (150)	2 (x2) (33)	15 (1.8)	2/0 (x2) (70)	50 (5.6)	2/0 (x2) (70)	50 (5.6)

(continued)

Table 4-8—1130 Ground and Power Terminal Specifications *(continued)*

Power			Terminal					
			Ground (PE)		AC Line Input (R, S, T)		Motor Output (U, V, W)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
575 V								
7 1/2 (5.5)	10 (7.5)	—	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
10 (7.5)	15 (11)	—	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
15 (11)	20 (15)	25 (18)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
20 (15)	25 (18)	30 (22)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
25 (18)	30 (22)	40 (30)	6 (x2) (13)	12 (1.4)	6 (13)	12 (1.4)	6 (13)	12 (1.4)
30 (22)	40 (30)	50 (37)	6 (x2) (13)	12 (1.4)	4 (16)	12 (1.4)	4 (21)	12 (1.4)
40 (30)	50 (37)	60 (45)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	1/0 (54)	25 (2.8)
50 (37)	60 (45)	75 (55)	6 (x2) (13)	12 (1.4)	1/0 (35)	25 (2.8)	1/0 (54)	25 (2.8)
60 (45)	75 (55)	100 (75)	2 (x2) (33)	15 (1.8)	1/0 (35)	25 (2.8)	1/0 (54)	25 (2.8)
75 (55)	100 (75)	125 (90)	2 (x2) (33)	15 (1.8)	2/0 (70)	50 (5.6)	2/0 (67)	50 (5.6)
100 (75)	125 (90)	150 (110)	2 (x2) (33)	15 (1.8)	4/0 (95)	150 (17)	4/0 (107)	150 (17)
125 (90)	150 (110)	200 (150)	2 (x2) (33)	15 (1.8)	1/0 (x2) (35)	25 (2.8)	1/0 (x2) (54)	25 (2.8)

Table 4-9—1200 Ground and Power Terminal Specifications

Power			Terminal							
			Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
			(PE)		(R, S, T or R1, R2, S1, S2, T1, T2)		(U, V, W)		(B+, DB or B+, B–)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*	*AWG (mm²)*	*in•lb (Nm)*
230 V										
1 1/2 (1.1)	2 (1.5)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
2 (1.5)	3 (2.2)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
3 (2.2)	5 (3.7)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
5 (3.7)	7 1/2 (5.5)	10 (7.5)	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
7 1/2 (5.5)	10 (7.5)	15 (11)	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
10 (7.5)	15 (11)	20 (15)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)
15 (11)	20 (15)	25 (18)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)
20 (15)	25 (18)	30 (22)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	10–1 (5.3-42)	24.9–26.7 (2.8-3.0)	10–1 (5.3-42)	24.9–26.7 (2.8-3.0)	10–1 (5.3-42)	24.9–26.7 (2.8-3.0)
460 V										
1 1/2 (1.1)	2 (1.5)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
2 (1.5)	3 (2.2)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
3 (2.2)	5 (3.7)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
5 (3.7)	7 1/2 (5.5)	10 (7.5)	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
7 1/2 (5.5)	10 (7.5)	15 (11)	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
10 (7.5)	15 (11)	20 (15)	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
15 (11)	20 (15)	25 (18)	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
20 (15)	25 (18)	30 (22)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)
25 (18)	30 (22)	40 (30)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)
30 (22)	40 (30)	50 (37)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)
40 (30)	50 (37)	60 (45)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	10–1 (5.3-42)	24.9–26.7 (2.8-3.0)	10–1 (5.3-42)	24.9–26.7 (2.8-3.0)	10–1 (5.3-42)	24.9–26.7 (2.8-3.0)
50 (37)	60 (45)	75 (55)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	6–2/0 (10-67)	50 (5.6)	4–4/0 (16-107)	216 (24)	8–3/0 (8.4-85)	216 (24)
60 (45)	75 (55)	100 (75)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	6–2/0 (10-67)	50 (5.6)	4–4/0 (16-107)	216 (24)	8–3/0 (8.4-85)	216 (24)
75 (55)	100 (75)	125 (90)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	6–2/0 (10-67)	50 (5.6)	4–4/0 (16-107)	216 (24)	8–3/0 (8.4-85)	216 (24)

(continued)

Table 4-9—1200 Ground and Power Terminal Specifications ***(continued)***

Power			Terminal							
			Ground		AC Line Input		Motor Output		Dynamic Braking or Bus	
			(PE)		(R, S, T or R1, R2, S1, S2, T1, T2)		(U, V, W)		(B+, DB or B+, B–)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
460 V										
100 (75)	125 (90)	150 (110)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	6–2/0 (10-67)	50 (5.6)	4–4/0 (16-107)	216 (24)	8–3/0 (8.4-85)	216 (24)
125 (90)	150 (110)	200 (150)	2–1/0 (34-53)	200 (23)	3–350 (27-177)	375 (42)	3/0–500 (85-253)	216 (24)	6–1/0 (13-53)	53-71 (6.0-8.0)
150 (110)	200 (150)	250 (185)	2–1/0 (34-53)	200 (23)	3–350 (27-177)	375 (42)	3/0–500 (85-253)	216 (24)	6–1/0 (13-53)	53-71 (6.0-8.0)
200 (150)	250 (185)	300 (225)	2–1/0 (34-53)	200 (23)	3–350 (27-177)	375 (42)	3/0–500 (85-253)	216 (24)	6–1/0 (13-53)	53-71 (6.0-8.0)
250 (185)	300 (225)	400 (300)	2–1/0 (34-53)	200 (23)	3–350 (27-177)	375 (42)	3/0–500 (85-253)	216 (24)	6–1/0 (13-53)	53-71 (6.0-8.0)
300 (225)	400 (300)	500 (375)	4/0–350 (107-177)	375 (42)	10–1 (5.3-42)	95.4–111 (11-13)	4/0–600 (107-304)	372 (42)	—	—
400 (300)	500 (375)	600 (450)	4/0–350 (107-177)	375 (42)	10–1 (5.3-42)	95.4–111 (11-13)	4/0–600 (107-304)	372 (42)	—	—
500 (375)	600 (450)	800 (600)	4/0–350 (107-177)	375 (42)	10–1 (5.3-42)	95.4–111 (11-13)	4/0–600 (107-304)	372 (42)	—	—
600 (450)	800 (600)	1000 (750)	4/0–350 (107-177)	375 (42)	10–1 (5.3-42)	95.4–111 (11-13)	4/0–600 (107-304)	372 (42)	—	—

Table 4-10—1230 Ground and Power Terminal Specifications

Power			Terminal					
			Ground (PE)		AC Line Input (R, S, T)		Motor Output (U, V, W)	
CT	VT	ET	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque	Acceptable Wire Sizes	Tightening Torque
hp (kW)	*hp (kW)*	*hp (kW)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*	*AWG (mm^2)*	*in•lb (Nm)*
460 V								
1 1/2 (1.1)	2 (1.5)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
2 (1.5)	3 (2.2)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
3 (2.2)	5 (3.7)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
5 (3.7)	7 1/2 (5.5)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
7 1/2 (5.5)	10 (7.5)	—	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
10 (7.5)	15 (11)	20 (15)	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
15 (11)	20 (15)	25 (18)	14–6 (2.1-13)	25 (2.8)	20–6 (0.5-13)	15–16 (1.8-1.8)	20–6 (0.5-13)	15–16 (1.8-1.8)
20 (15)	25 (18)	30 (22)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)
25 (18)	30 (22)	40 (30)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)
30 (22)	40 (30)	50 (37)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)	14–4 (2.1-16)	20 (2.3)
40 (30)	50 (37)	60 (45)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	10–1 (5.3-42)	24.9–26.7 (2.8-3.0)	10–1 (5.3-42)	24.9–26.7 (2.8-3.0)
50 (37)	60 (45)	75 (55)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	4–4/0 (16-107)	216 (24)	4–4/0 (16-107)	216 (24)
60 (45)	75 (55)	100 (75)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	4–4/0 (16-107)	216 (24)	4–4/0 (16-107)	216 (24)
75 (55)	100 (75)	125 (90)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	4–4/0 (16-107)	216 (24)	4–4/0 (16-107)	216 (24)
100 (75)	125 (90)	150 (110)	14–6 (2.1-13)	10.5–12.4 (1.2-1.4)	4–4/0 (16-107)	216 (24)	4–4/0 (16-107)	216 (24)
125 (90)	150 (110)	200 (150)	2–1/0 (34-53)	200 (23)	3/0–500 (85-253)	216 (24)	3/0–500 (85-253)	216 (24)
150 (110)	200 (150)	250 (185)	2–1/0 (34-53)	200 (23)	3/0–500 (85-253)	216 (24)	3/0–500 (85-253)	216 (24)
200 (150)	250 (185)	300 (225)	2–1/0 (34-53)	200 (23)	3/0–500 (85-253)	216 (24)	3/0–500 (85-253)	216 (24)
250 (185)	300 (225)	400 (300)	2–1/0 (34-53)	200 (23)	3/0–500 (85-253)	216 (24)	3/0–500 (85-253)	216 (24)
300 (225)	400 (300)	500 (375)	4/0–350 (107-177)	375 (42)	4/0–600 (107-304)	372 (42)	4/0–600 (107-304)	372 (42)
400 (300)	500 (375)	600 (450)	4/0–350 (107-177)	375 (42)	4/0–600 (107-304)	372 (42)	4/0–600 (107-304)	372 (42)

Table 4-11—1100, 1105, 1130, 1200, and 1230 Fuse Specifications

Rated Power	Input Current	Fuse Current	Fuse Voltage	Recommended Semiconductor Fuse	
hp (kW)	*A_{rms}*	*A_{rms}*	*V_{rms}*	*Manufacturer*	*Part Number*
230 V					
1 1/2 (1.1)	4.2	10	250	Bussman	FWX 10A14F
2 (1.5)	5.1	10	250	Bussman	FWX 10A14F
3 (2.2)	7.5	10	250	Bussman	FWX 10A14F
5 (3.7)	12.1	20	250	Bussman	FWX 20A14F
7 1/2 (5.5)	17.8	25	250	Bussman	FWX 25A14F
10 (7.5)	23.2	30	250	Bussman	FWX 30A14F
15 (11)	34.9	50	250	Bussman	FWX 50A
20 (15)	45.7	60	250	Bussman	FWX 60A
25 (18)	57.3	80	250	Bussman	FWX 80A
30 (22)	68.1	90	250	Bussman	FWX 90A
40 (30)	89.6	125	250	Bussman	FWX 125A
50 (37)	112.0	150	250	Bussman	FWX 150A
60 (45)	133.6	175	250	Bussman	FWX 175A
75 (55)	166.7	225	250	Bussman	FWX 225A
380 V					
1 1/2 (1.1)	2.4	4	500	Bussman	FWH 4A14F
2 (1.5)	2.9	4	500	Bussman	FWH 4A14F
3 (2.2)	4.3	6	500	Bussman	FWH 6A14F
5 (3.7)	7.0	10	500	Bussman	FWH 10A14F
7 1/2 (5.5)	10.3	15	500	Bussman	FWH 15A14F
10 (7.5)	13.4	20	500	Bussman	FWH 20A14F
15 (11)	20.1	25	500	Bussman	FWH 25A14F
20 (15)	26.3	35	500	Bussman	FWH 35B
25 (18)	32.9	45	500	Bussman	FWH 45B
30 (22)	39.1	50	500	Bussman	FWH 50B
40 (30)	51.5	70	500	Bussman	FWH 70B

(continued)

Table 4-11—1100, 1105, 1130, 1200, and 1230 Fuse Specifications
(continued)

Rated Power	Input Current	Fuse Current	Fuse Voltage	Recommended Semiconductor Fuse	
hp (kW)	*A_{rms}*	*A_{rms}*	*V_{rms}*	*Manufacturer*	*Part Number*
380 V					
50 (37)	64.4	90	500	Bussman	FWH 90B
60 (45)	76.8	100	500	Bussman	FWH 100B
75 (55)	95.9	125	500	Bussman	FWH 125B
100 (75)	125.8	175	500	Bussman	FWH 175B
125 (90)	157.8	225	500	Bussman	FWH 225B
150 (110)	185.6	250	500	Bussman	FWH 250A
200 (150)	247.5	325	500	Bussman	FWH 325A
250 (185)	309.4	400	500	Bussman	FWH 400A
300 (225)	371.3	500	500	Bussman	FWH 500A
350 (262)	433.2	600	500	Bussman	FWH 600A
400 (300)	495.1	700	500	Bussman	FWH 700A
500 (375)	618.8	800	500	Bussman	FWP 800A
460 V					
1 1/2 (1.1)	2.1	3	500	Bussman	FWH 3A14F
2 (1.5)	2.6	4	500	Bussman	FWH 4A14F
3 (2.2)	3.7	5	500	Bussman	FWH 5A14F
5 (3.7)	6.1	10	500	Bussman	FWH 10A14F
7 1/2 (5.5)	8.9	12	500	Bussman	FWH 12A14F
10 (7.5)	11.6	15	500	Bussman	FWH 15A14F
15 (11)	17.4	25	500	Bussman	FWH 25A14F
20 (15)	22.8	30	500	Bussman	FWH 30A14F
25 (18)	28.6	40	500	Bussman	FWH 40B
30 (22)	34.0	45	500	Bussman	FWH 45B
40 (30)	44.8	60	500	Bussman	FWH 60B
50 (37)	56.0	80	500	Bussman	FWH 80B
60 (45)	66.8	90	500	Bussman	FWH 90B

(continued)

Table 4-11—1100, 1105, 1130, 1200, and 1230 Fuse Specifications *(continued)*

Rated Power	Input Current	Fuse Current	Fuse Voltage	Recommended Semiconductor Fuse	
hp (kW)	*A_{rms}*	*A_{rms}*	*V_{rms}*	*Manufacturer*	*Part Number*
460 V					
75 (55)	83.4	125	500	Bussman	FWH 125B
100 (75)	109.4	150	500	Bussman	FWH 150B
125 (90)	137.2	200	500	Bussman	FWH 200B
150 (110)	161.4	225	500	Bussman	FWH 225A
200 (150)	215.2	300	500	Bussman	FWH 300A
250 (185)	269.1	350	500	Bussman	FWH 350A
300 (225)	322.9	450	500	Bussman	FWH 450A
350 (262)	376.7	500	500	Bussman	FWH 500A
400 (300)	430.5	600	500	Bussman	FWH 600A
500 (375)	538.1	700	500	Bussman	FWH 700A
600 (450)	645.7	1,000	500	Bussman	FWH 1000A
800 (600)	861.0	1,200	500	Bussman	FWH 1200A
1000 (750)	1076.2	1,400	500	Bussman	FWH 1400A
575 V					
1 1/2 (1.1)	1.7	3	700	Bussman	FWP 3A14F
2 (1.5)	2.0	3	700	Bussman	FWP 3A14F
3 (2.2)	3.0	4	700	Bussman	FWP 4A14F
5 (3.7)	4.9	10	700	Bussman	FWP 10A14F
7 1/2 (5.5)	7.2	10	700	Bussman	FWP 10A14F
10 (7.5)	9.2	15	700	Bussman	FWP 15A14F
15 (11)	14.0	20	700	Bussman	FWP 20A14F
20 (15)	18.4	25	700	Bussman	FWP 25A14F
25 (18)	22.8	30	700	Bussman	FWP 30A14F
30 (22)	27.2	40	700	Bussman	FWP 40B
40 (30)	35.6	50	700	Bussman	FWP 50B
50 (37)	44.8	60	700	Bussman	FWP 60B

(continued)

Table 4-11—1100, 1105, 1130, 1200, and 1230 Fuse Specifications *(continued)*

Rated Power	Input Current	Fuse Current	Fuse Voltage	Recommended Semiconductor Fuse	
hp (kW)	*A_{rms}*	*A_{rms}*	*V_{rms}*	*Manufacturer*	*Part Number*
575 V					
60 (45)	53.6	70	700	Bussman	FWP 70B
75 (55)	66.8	90	700	Bussman	FWP 90B
100 (75)	87.4	125	700	Bussman	FWP 125B
125 (90)	109.8	150	700	Bussman	FWP 150B
150 (110)	129.1	175	700	Bussman	FWP 175B
200 (150)	172.2	225	700	Bussman	FWP 225A
250 (185)	215.2	300	700	Bussman	FWP 300A
300 (225)	258.3	350	700	Bussman	FWP 350A
350 (262)	301.3	400	700	Bussman	FWP 400A
400 (300)	344.4	450	700	Bussman	FWP 450A
500 (375)	430.5	600	700	Bussman	FWP 600A
600 (450)	516.6	700	700	Bussman	FWP 700A

Table 4-12—1110 Fuse Specifications

Rated Power	Input Current	Fuse Current	Fuse Voltage	Recommended Semiconductor Fuse	
hp (kW)	A_{rms}	A_{rms}	V_{rms}	*Manufacturer*	*Part Number*
230 V					
1 1/2 (1.1)	9.4	15	250	Bussman	FWX 15A14F
2 (1.5)	11.6	15	250	Bussman	FWX 15A14F
3 (2.2)	16.9	25	250	Bussman	FWX 25A14F
5 (3.7)	27.4	35	250	Bussman	FWX 35A
7 1/2 (5.5)	40.3	50	250	Bussman	FWX 50A
10 (7.5)	52.6	70	250	Bussman	FWX 70A
15 (11)	78.8	100	250	Bussman	FWX 100A
20 (15)	103.2	150	250	Bussman	FWX 150A
25 (18)	129.5	175	250	Bussman	FWX 175A
30 (22)	153.9	200	250	Bussman	FWX 200A
40 (30)	202.6	275	250	Bussman	FWX 275A
50 (37)	253.2	350	250	Bussman	FWX 350A
460 V					
1 1/2 (1.1)	4.7	10	500	Bussman	FWH 10A14F
2 (1.5)	5.8	10	500	Bussman	FWX 10A14F
3 (2.2)	8.4	15	500	Bussman	FWX 15A14F
5 (3.7)	13.7	20	500	Bussman	FWX 20A14F
7 1/2 (5.5)	20.2	25	500	Bussman	FWX 25A14F
10 (7.5)	26.3	35	500	Bussman	FWH 35B
15 (11)	39.4	50	500	Bussman	FWH 50B
20 (15)	51.6	70	500	Bussman	FWH 70B
25 (18)	64.7	90	500	Bussman	FWH 90B
30 (22)	76.9	100	500	Bussman	FWH 100B
40 (30)	101.3	150	500	Bussman	FWH 150B
50 (37)	126.6	175	500	Bussman	FWH 175B
60 (45)	150.9	200	500	Bussman	FWH 200B
75 (55)	188.4	250	500	Bussman	FWH 250A
100 (75)	247.3	325	500	Bussman	FWH 325A

Table 4-13—Isolation Transformer Ratings

Power	Single-Phase (†)	Three- or Six-Phase
hp (kW)	*kVA*	*kVA*
1 1/2 (1.1)	1 1/2	3
2 (1.5)	1 1/2	3
3 (2.2)	2	5
5 (3.7)	3	7 1/2
7 1/2 (5.5)	5	11
10 (7.5)	7 1/2	15
15 (11)	10	20
20 (15)	15	27
25 (18)	15	34
30 (22)	25	40
40 (30)	25	51
50 (37)	37 1/2	63
60 (45)	37 1/2	75
75 (55)	50	93
100 (75)	75	118
125 (90)	—	145
150 (110)	—	175
200 (150)	—	220
250 (185)	—	275
300 (225)	—	330
350 (262)	—	365
400 (300)	—	440
500 (375)	—	550
600 (450)	—	660
800 (600)	—	880
1000 (750)	—	1100

(†) Drive power rating is based upon use as a 230 V-to-460 V autotransformer.

Table 4-14—Three-Phase Line Reactor Ratings (230 V)

Power	Current	Inductance	
		3.0% Impedance	5.0% Impedance
hp (kW)	*A_{rms}*	*mH*	*mH*
1 1/2 (1.1)	8	3.000	5.000
2 (1.5)	8	1.500	3.000
3 (2.2)	12	1.300	2.500
5 (3.7)	18	0.800	1.500
7 1/2 (5.5)	25	0.500	1.200
10 (7.5)	35	0.400	0.800
15 (11)	45 / 55	0.300	0.500
20 (15)	55	0.250	0.500
25 (18)	80	0.200	0.400
30 (22)	80	0.200	0.230
40 (30)	110	0.100	0.180
50 (37)	130 / 160	0.100	0.200
60 (45)	160	0.080	0.150
75 (55)	200	0.055	0.110

Table 4-15—Three-Phase Line Reactor Ratings (460 V)

Power	Current	Inductance	
		3.0% Impedance	5.0% Impedance
hp (kW)	*A_{rms}*	*mH*	*mH*
1 1/2 (1.1)	2	9.100	12.000
2 (1.5)	4	6.500	12.000
3 (2.2)	8	5.000	7.500
5 (3.7)	8	3.000	5.000
7 1/2 (5.5)	12	2.500	4.200
10 (7.5)	18	1.500	2.500
15 (11)	25	1.200	2.000
20 (15)	35	0.800	1.700
25 (18)	35	0.800	1.200
30 (22)	45	0.700	1.200
40 (30)	55	0.500	0.850
50 (37)	80	0.400	0.700
60 (45)	80	0.400	0.700
75 (55)	110	0.300	0.450
100 (75)	130	0.200	0.300
125 (90)	160	0.150	0.230
150 (110)	200	0.110	0.240
200 (150)	250	0.090	0.150
250 (185)	320	0.075	0.130
300 (225)	400	0.061	0.110
350 (262)	500	0.050	0.085
400 (300)	500	0.050	0.085
500 (375)	600	0.040	0.065
600 (450)	750	0.031	0.050

Table 4-16—Three-Phase Line Reactor Ratings (575 V)

Power	Current	Inductance	
		3.0% Impedance	5.0% Impedance
hp (kW)	*A_{rms}*	*mH*	*mH*
1 1/2 (1.1)	2	12.000	20.000
2 (1.5)	4	12.000	22.000
3 (2.2)	4	9.100	12.000
5 (3.7)	8	5.000	7.500
7 1/2 (5.5)	12	3.100	5.100
10 (7.5)	12	2.500	4.200
15 (11)	18	1.500	2.500
20 (15)	25	1.200	2.000
25 (18)	35	1.200	1.700
30 (22)	35	0.800	1.700
40 (30)	45	0.700	1.200
50 (37)	55	0.500	0.850
60 (45)	80	0.400	0.700
75 (55)	80	0.400	0.700
100 (75)	110	0.300	0.450
125 (90)	130	0.200	0.370
150 (110)	160	0.230	0.320
200 (150)	200	0.190	0.240
250 (185)	250	0.150	0.190
300 (225)	320	0.096	0.160
350 (262)	400	0.082	0.140
400 (300)	400	0.082	0.140
500 (375)	500	0.057	0.096
600 (450)	600	0.048	0.080

Table 4-17—Dynamic Braking Resistor Ratings

Power	100% Braking			150% Braking			200% Braking			Duty Cycle / Power		
	230 V	460 V	575 V	230 V	460 V	575 V	230 V	460 V	575 V	5%	10%	20%
hp (kW)	*Ω*	*Ω*	*Ω*	*Ω*	*Ω*	*Ω*	*Ω*	*Ω*	*Ω*	*W*	*W*	*W*
1 1/2 (1.1)	96.2	384.6	595.2	64.1	256.4	396.8	48.1	192.3	297.6	51	101	203
2 (1.5)	73.5	294.1	463.0	49.0	196.1	308.6	36.8	147.1	231.5	68	135	270
3 (2.2)	52.1	208.3	320.5	34.7	138.9	213.7	26.0	104.2	160.3	101	203	405
5 (3.7)	32.9	131.6	204.9	21.9	87.7	136.6	16.5	65.8	102.5	169	338	675
7 1/2 (5.5)	22.7	90.9	138.9	15.2	60.6	92.6	11.4	45.5	69.4	253	506	1013
10 (7.5)	17.9	71.4	113.6	11.9	47.6	75.8	8.9	35.7	56.8	338	675	1350
15 (11)	11.9	47.6	73.5	7.9	31.7	49.0	6.0	23.8	36.8	506	1013	2025
20 (15)	9.3	37.0	56.8	6.2	24.7	37.9	4.6	18.5	28.4	675	1350	2700
25 (18)	7.4	29.4	46.3	4.9	19.6	30.9	3.7	14.7	23.1	844	1688	3375
30 (22)	6.3	25.0	39.1	4.2	16.7	26.0	3.1	12.5	19.5	1013	2025	4050
40 (30)	4.8	19.2	30.5	3.2	12.8	20.3	2.4	9.6	15.2	1350	2700	5400
50 (37)	3.9	15.4	24.0	2.6	10.3	16.0	1.9	7.7	12.0	1688	3375	6750
60 (45)	3.3	13.0	20.2	2.2	8.7	13.4	1.6	6.5	10.1	2025	4050	8100
75 (55)	2.6	10.4	16.2	1.7	6.9	10.8	1.3	5.2	8.1	2531	5063	10125
100 (75)	—	8.1	12.6	—	5.4	8.4	—	4.0	6.3	3375	6750	13500
125 (90)	—	6.4	10.0	—	4.3	6.7	—	3.2	5.0	4219	8438	16875
150 (110)	—	5.6	8.7	—	3.7	5.8	—	2.8	4.3	5063	10125	20250
200 (150)	—	4.2	6.5	—	2.8	4.3	—	2.1	3.3	6750	13500	27000
250 (185)	—	3.3	5.2	—	2.2	3.5	—	1.7	2.6	8438	16875	33750
300 (225)	—	2.8	4.3	—	1.9	2.9	—	1.4	2.2	10125	20250	40500
350 (262)	—	2.4	2.5	—	1.6	2.5	—	1.2	1.9	11812	23625	47250
400 (300)	—	2.1	2.2	—	1.4	2.2	—	1.0	1.6	13500	27000	54000
500 (375)	—	1.7	1.7	—	1.1	1.7	—	0.83	1.3	16875	33750	67500
600 (450)	—	1.4	1.5	—	0.93	1.5	—	0.69	1.1	20250	40500	81000

Consult the factory for dynamic braking duty cycles greater than 20%.

Table 4-18—Minimum Braking Resistance

Power	1100 1105 (w/optional DB) 1110			1105 (w/integral DB)			1120		1200	
CT	**230 V**	**460 V**	**575 V**	**230 V**	**460 V**	**575 V**	**230 V**	**460 V**	**230 V**	**460 V**
hp (kW)	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω
1 1/2 (1.1)	48.1	192.3	297.6	48.1	192.3	297.6	48.1	192.3	26.7	53.3
2 (1.5)	36.8	147.1	231.5	40.0	147.1	231.5	40.0	147.1	26.7	53.3
3 (2.2)	26.0	104.2	160.3	40.0	104.2	160.3	40.0	104.2	26.7	53.3
5 (3.7)	16.5	65.8	102.5	26.7	80.0	102.5	26.7	80.0	26.7	53.3
7 1/2 (5.5)	11.4	45.5	69.4	13.3	53.3	69.4	13.3	53.3	13.3	53.3
10 (7.5)	8.9	35.7	56.8	13.3	53.3	56.8	13.3	53.3	8.9	53.3
15 (11)	6.0	23.8	36.8	8.0	32.0	36.8	8.0	32.0	6.0	32.0
20 (15)	5.3	18.5	28.4	8.0	18.5	28.4	8.0	18.5	5.3	18.5
25 (18)	5.3	16.0	23.1	—	16.0	23.1	5.3	16.0	—	16.0
30 (22)	5.3	12.5	19.5	—	16.0	19.5	5.3	16.0	—	16.0
40 (30)	2.4	10.7	15.2	—	16.0	15.2	2.4	16.0	—	16.0
50 (37)	2.0	10.7	13.3	—	10.7	13.3	2.0	10.7	—	10.7
60 (45)	2.0	6.5	10.1	—	6.5	10.1	2.0	6.5	—	6.5
75 (55)	—	5.2	8.1	—	5.2	8.1	—	5.2	—	5.2
100 (75)	—	4.0	6.3	—	4.0	6.3	—	4.0	—	4.0
125 (90)	—	4.0	5.0	—	4.0	5.0	—	4.0	—	4.0
150 (110)	—	2.8	4.3	—	2.8	4.3	—	—	—	2.8
200 (150)	—	2.7	3.3	—	—	3.3	—	—	—	2.7
250 (185)	—	2.0	2.6	—	—	—	—	—	—	2.0
300 (225)	—	2.0	2.5	—	—	—	—	—	—	—
350 (262)	—	1.3	1.9	—	—	—	—	—	—	—
400 (300)	—	—	1.7	—	—	—	—	—	—	—

4.9 Control Signal Connections

Each drive accepts one of several different types of control modules, and each control module accepts one of several associated option modules. The wiring of these modules is similar. Any differences are noted in the tables and figures below.

The drive accepts a variety of analog and digital inputs and outputs, synchronous and aysnchronous serial communications, and optional encoder or resolver feedback. The 100 MHz control module also accommodates optional Anybus® serial communications, and the 100 Mhz and Compact 100 MHz control modules provide a MaxStream™ wireless communication option. These external signals are connected both to terminals and telephone-type jacks on the control module and to terminals on the optional encoder, resolver, Anybus®, MaxStream™ , and analog interface modules that mount on the control module. The general layout of external control connections is shown in Figure 4-9 through Figure 4-11. Control signal terminal specifications are given in Table 4-19. Refer to Section 4.2 for wiring requirements.

Table 4-19—Control Signal Terminal Specifications

Connection	Maximum Wire Size *AWG (mm^2)*	Tightening Torque *in•lb (Nm)*
Control Modules		
TB1 and TB2	14 (2.1)	7.0 (0.79)
CON19 (optional on 100 MHz control) and CON23 (270 MHz control)	14 (2.1)	4.0 (0.45)
CON16 (optional on Compact 100 MHz control) and CON15 (optional on Compact 150 MHz control)	16 (1.3)	1.9 (0.22)
Encoder Interface Modules *(optional)*		
CON2 (single and dual), CON3 (dual)	14 (2.1)	4.5 (0.51)
Resolver Interface Module with Encoder Emulation *(optional)*		
CON2, CON3	16 (1.3)	4.5 (0.51)
Analog Interface Module *(optional)*		
CON2	16 (1.3)	2.2 (0.25)
I/O Fanning Strip *(optional)*		
CON3, CON4	14 (2.1)	7.0 (0.79)
Anybus® Serial Communication Module *(optional)* ***MaxStream™ Wireless Communication Module*** *(optional)*		
All connections	*Refer to manufacturer's instruction manual*	

4.9.1 Wiring Precautions

Observe the following precautions when wiring control signals:

- When disconnecting wires from the screw terminals, completely loosen the screws before pulling out the wires
- Tie shields to Logic Common at one end only
- Twist differential (±) current input signals together

Figure 4-9—Control Module Connectors (16 MHz)

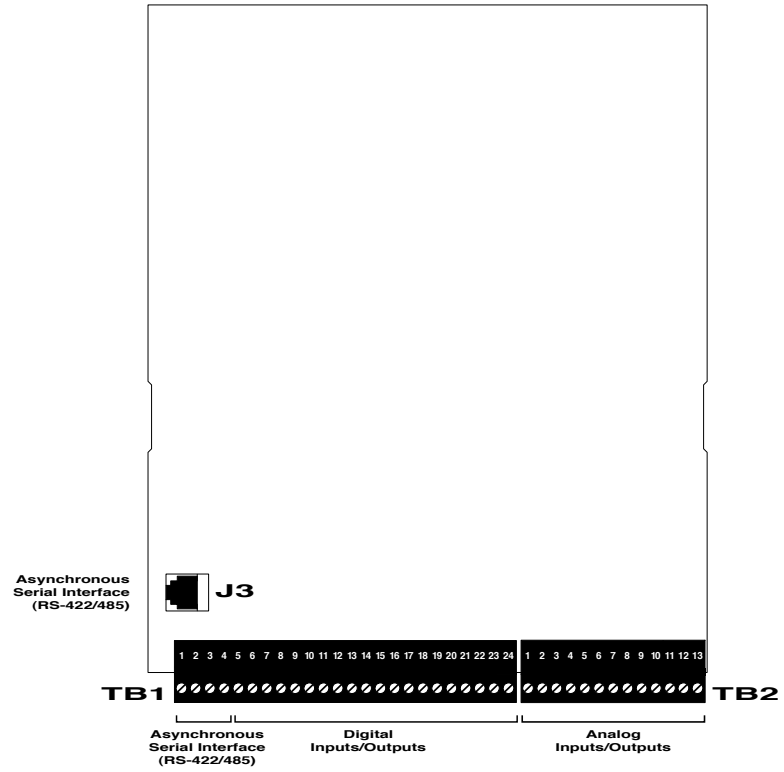


Figure 4-10—Control Module Connectors (20 and 40 MHz)

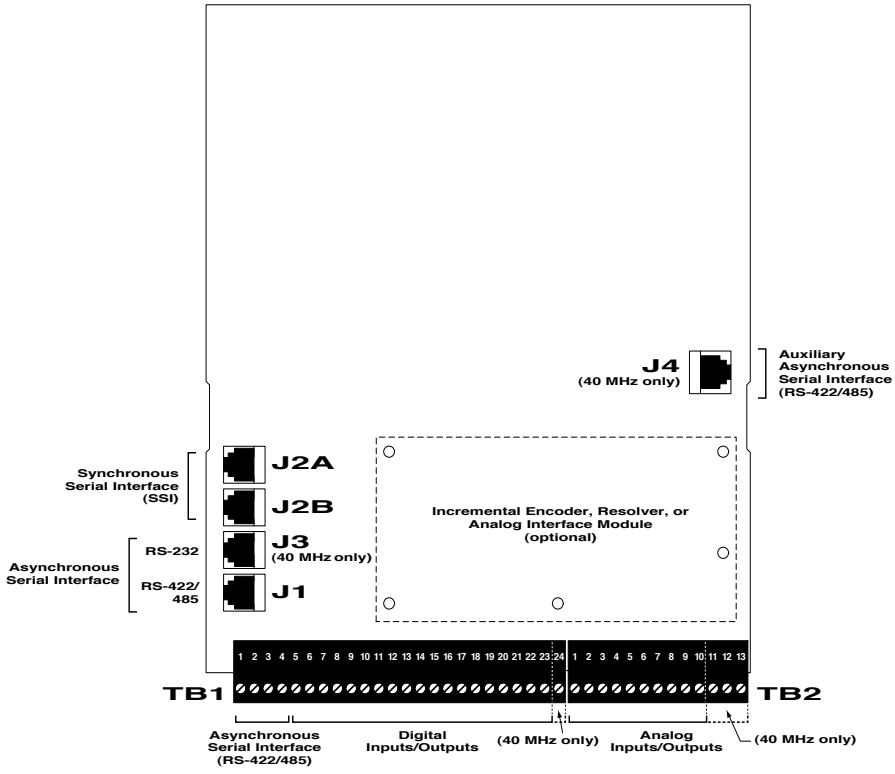


Figure 4-11—Control Module Connectors (100 MHz)

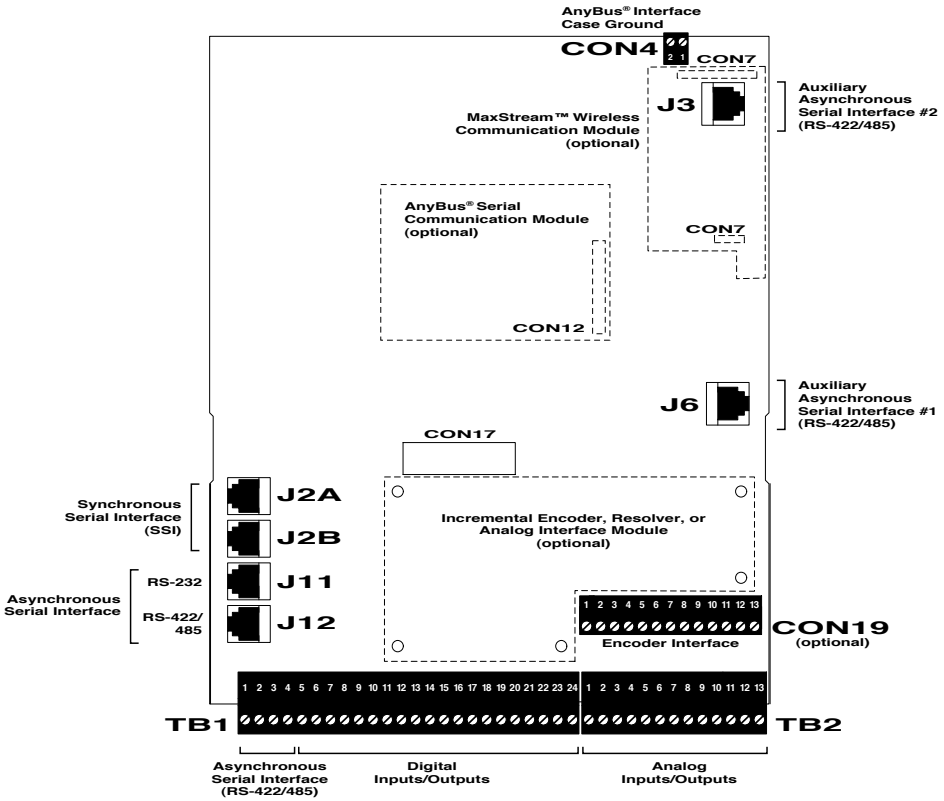


Figure 4-12—Control Module Connectors (270 MHz)

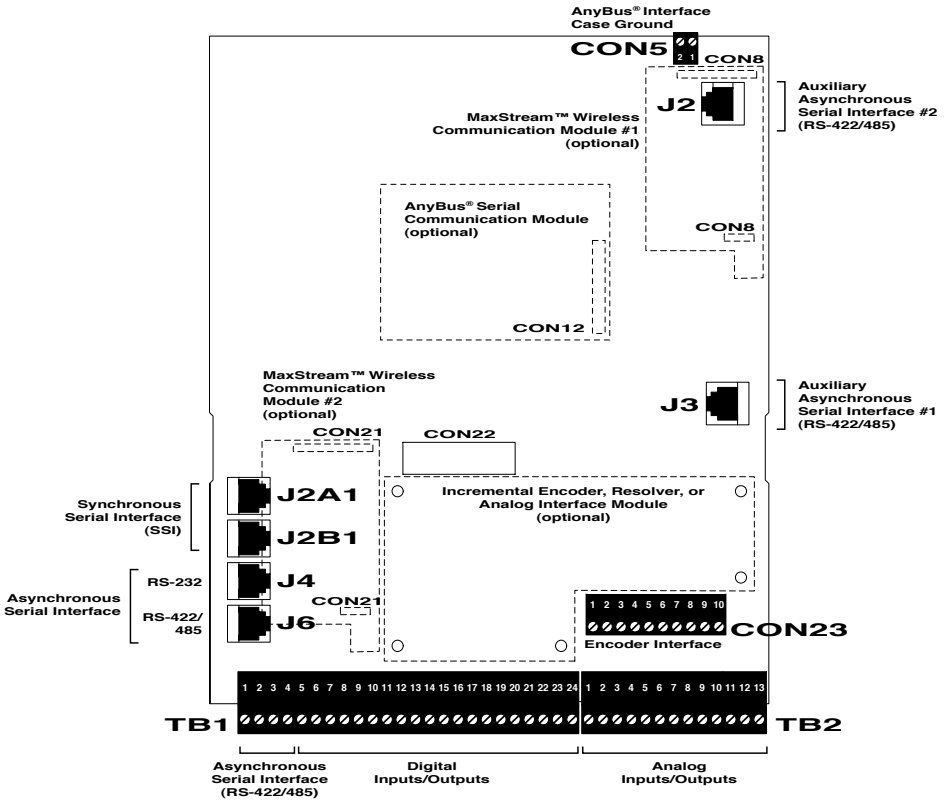
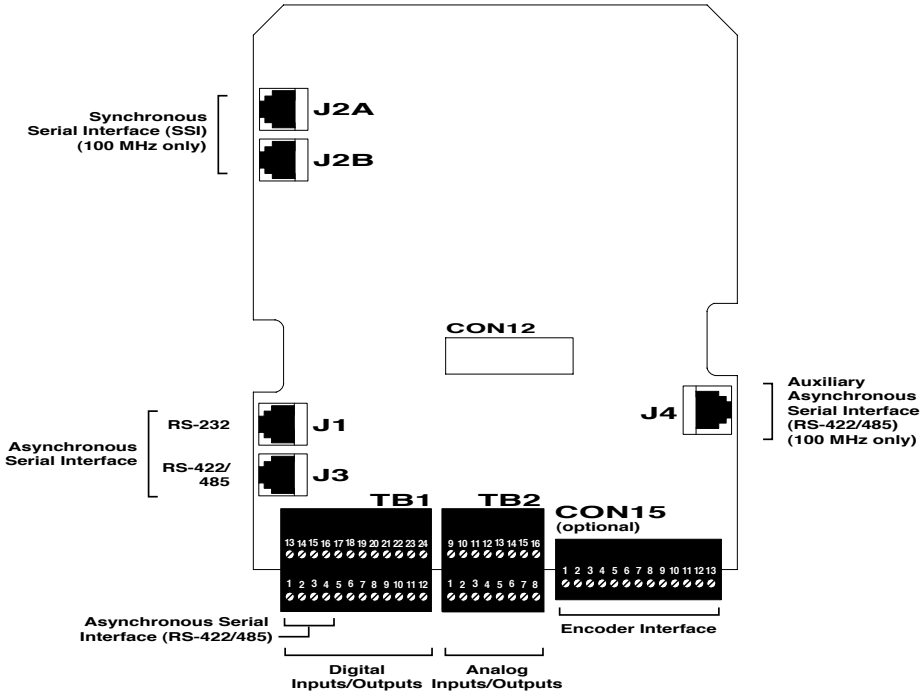


Figure 4-13—Control Module Connectors (Compact 100 MHz and Compact 150 MHz)



4.9.2 Digital I/O Connections (TB1)

Digital inputs and outputs are connected at terminal block TB1 on the control module. Refer to Table 4-21 for general connection descriptions and specifications. The specific functionality of each input and output is determined by the application software. Refer to the application documentation for complete descriptions.

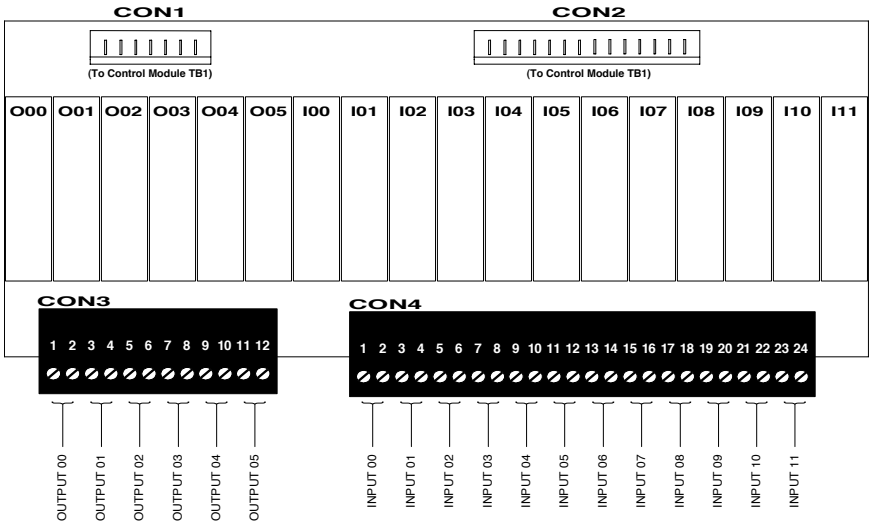
An optional I/O fanning strip and plug-in converter modules may be used with the 40 MHz, 100 MHz, 270 MHz, Compact 100 MHz, and Compact 150 MHz controllers with logic-type I/O to interface with AC and DC circuits of various voltages. The fanning strip may be populated with up to 12 input converters and six output converters. Table 4-20 lists the converters that are available and their voltage ranges. Refer to Figure 4-14 for the fanning strip layout and connections. Jumpers supplied with the fanning strip may be used in lieu of converters to pass selected I/O directly from the drive to the fanning strip.

Connect the fanning strip to the control module using the 203-105 and 203-106 cables from CON1 and CON2 at the top of the fanning strip to TB1 of the controller.

Table 4-20—I/O Converter Modules

Part Number	Device	Voltage Range
912-688	Input converter	90 to 140 V AC
919-808	Input converter	180 to 280 V AC
913-108	Output converter	12 to 140 V AC
919-809	Output converter	180 to 280 V AC
913-109	Input converter	2.5 to 28 V DC
913-110	Output converter	5 to 60 V DC
915-282	Normally open relay	0 to 30 V DC, 0 to 250 V AC
921-332	Normally closed relay	0 to 30 V DC, 0 to 250 V AC
922-084	Pass-through jumper	—

Figure 4-14—I/O Fanning Strip



4.9.3 Analog I/O Connections (TB2, CON2)

Analog inputs and outputs are connected at terminal block TB2 on the control module. Refer to Table 4-22 for general connection descriptions and specifications. They may also be connected at terminal block CON2 on the optional Analog Interface Module (321-557). The Analog Interface Module mounts on the control module and provides eight additional inputs and four additional outputs. Analog Interface Module connections are shown in Figure 4-21 and Figure 4-22 and described in Table 4-30. Analog inputs and outputs are defined by the application. Refer to the application documentation for complete functional descriptions.

4.9.4 Serial Connections (TB1, J1, J2, J3, J4, J6, J11, J12)

The drive provides both asynchronous and synchronous serial communication ports. The application software determines the functionality of these ports. Refer to the application documentation for any additional interconnection information specific to the application as well as a description of the communication protocol employed.

For Anybus® and MaxStream™ communication modules, please refer to the module manufacturers' instructions.

Asynchronous serial signals (RS-422/485) are connected either to terminals at block TB1 on the control module (CON12 on the Compact 150 MHz control module) or to modular telephone-type jack J1 (40 MHz control module), J12 (100 MHz control module), J6 (270 MHz control module), and J3 (Compact 100 MHz and Compact 150 MHz control modules). Jacks J3 (40 MHz), J11 (100 MHz), J4 (270 MHz), and J1 (Compact 100 MHz and Compact 150 MHz) provide an RS-232 connection that parallels the signals of J1, J12, and J3. Jacks J4 (40 MHz and Compact 100 MHz), J3 and J6 (100 MHz), and J2 and J3 (270 MHz) provide auxiliary RS-422/485 connections independent from the other ports. Refer to Table 4-21 for TB1 terminal connections. Refer to Figure 4-15 and Table 4-23 for pinouts and descriptions of the modular telephone-type jack connectors.

The Synchronous Serial Interface (SSI), available with all but the 16 MHz and Compact 150 MHz controllers, provides a means of slaving multiple drives together in real time. When supported by the application software, synchronous serial connections are made to jacks J2A and J2B (J2A1 and J2B1 on 270 MHz) using straight-through telephone cables. Refer to Figure 4-15 and
Table 4-23 for pinouts and descriptions of the modular telephone-type jack connectors. Recommended synchronous serial cables are listed in Table 4-24.

When networking two or more drives for either synchronous or asynchronous communications, remove the terminating resistors in all drives *except* the last one. With a synchronous network, this is the slave drive furthest from the master. When using the 20 MHz or 40 MHz control modules, remove both the data *and* clock terminating resistors for a synchronous network.

Pull-up and pull-down resistors are generally required on the receive lines of the host computer to prevent the host from receiving garbage and to establish the ground reference for the serial port of the drive. The 16 MHz control module also provides pull-up and pull-down resistors on the transmit lines. In some networks, it may be necessary to remove the pull-up and pull-down resistors on the receive lines of the drive. Refer to the application documentation for any specific instructions.

Pull-up, pull-down, and terminating resistor locations are shown in Figure 4-16 and described in Table 4-25.

4.9.5 Feedback Interface Connections

The drive can operate with or without a transducer, depending upon the requirements of the application. It can accept feedback from one or more incremental encoders (pulse generators) and/or from a resolver, depending upon the control and interface modules selected. The 20 and 40 MHz control modules can accommodate either a single incremental encoder, dual incremental encoders, or a resolver by adding the appropriate transducer interface. The 100 MHz, 270 MHz, Compact 100 MHz (except 323-656), and Compact 150 MHz control modules have an on-board interface that accepts either an incremental encoder or an absolute/incremental encoder. The non-compact versions can also accommodate one or two additional incremental encoders or a resolver by adding the appropriate interface module.

4.9.5.1 Encoder Connections (CON2, CON3, CON16, CON19, CON23)

The 100 MHz, 270 MHz, Compact 100 MHz (except 323-656), and Compact 150 MHz control modules accommodate one encoder with optional marker pulses and reference inputs. It can also operate with an absolute/incremental encoder. Connections for the on-board interface are shown in Figure 4-17 and described in Table 4-26. The CON19 and CON23 connections should be wired prior to installing the Dual Encoder, Resolver, or Analog interface modules since they will cover the terminal block. The pluggable connector can be removed to simplify wiring.

The Encoder Interface Module (316-887) accommodates one encoder with optional marker pulses. Connections for the single encoder interface are shown in Figure 4-18 and described in Table 4-27.

The Dual Encoder Interface Module (321-952) accommodates two encoders with optional marker pulses and reference inputs. Connections for the dual encoder interface are shown in and described in Table 4-28.

Use of a Unico incremental encoder cable (105-619) is recommended. This cable consists of one twisted pair of 14 AWG wire (for isolated +5 V and isolated Common), three twisted pairs of 18 AWG wire, an overall shield, and a PCV jacket. The cable measures about 9/16" in diameter. At 0.250 A, the cable is good for a maximum of 175' (53 m). When wiring directly, be sure to use wire of sufficient gauge for the isolated +5 V and isolated Common connections to keep the voltage drop at the encoder at 0.25 V or less.

The maximum encoder size that may be used with the interface module is dependent upon motor speed, as follows:

maximum encoder size = 12,000,000 / maximum motor speed (rpm)

For example, the maximum encoder size for an 1,800 rpm motor is 6,666 ppr. The formula allows maximum motor speed to be exceeded safely by 25% without exceeding the rating of the interface module.

4.9.5.2 Resolver Connections (CON2, CON3)

The Resolver Interface Module with Encoder Emulation (322-096) accommodates feedback from a single resolver and echoes that feedback to another drive or device using encoder emulation. Connections for the resolver interface are shown in Figure 4-20 and described in Table 4-29.

Use of a Unico resolver cable (908-368) is recommended. This cable consists of three twisted pairs of 18 AWG wire, individually shielded, and a PCV jacket. If encoder emulation is used, the 105-619 incremental encoder described in the previous section is recommended.

Table 4-21—TB1 Connection Descriptions

Terminal	Control Module / Description			
	16 MHz VFD (322-340) **40 MHz Mixed I/O** (322-100) **100 MHz Mixed I/O** (323-547 and 323-548)	**20 MHz** DCR (321-101) DSV (321-516)	**40 MHz Logic I/O** (322-157) **100 MHz Logic I/O** (323-397 and 323-546) **270 MHz Logic I/O** (324-260) **Compact 100 MHz Logic I/O** (323-060 and 323-656) **Compact 150 MHz Logic I/O** (323-667)	**40 MHz Contact I/O** (322-966)
RS-422/485 Asynchronous Serial Communications				
TB1-1	*Transmit (+)*	*Transmit (+)*	*Transmit (+)*	*Transmit (+)*
TB1-2	*Transmit (–)*	*Transmit (–)*	*Transmit (–)*	*Transmit (–)*
TB1-3	*Receive (–)*	*Receive (–)*	*Receive (–)*	*Receive (–)*
TB1-4	*Receive (+)*	*Receive (+)*	*Receive (+)*	*Receive (+)*
Digital Outputs				
	Mixed I/O:	Mixed I/O:	Logic I/O:	Contact I/O:
TB1-5	*Relay 0 N.O.*	*Relay 0 N.O.*	*Open Collector 0*	*Relay 0 N.O.*
TB1-6	*Relay 0 N.C.*	*Relay 0 N.C.*	*Open Collector 1*	*Relay 0 N.C.*
TB1-7	*Relay 0 Common*	*Relay 0 Common*	*Open Collector 2*	*Relay 1 N.O.*
TB1-8	*Relay 1 N.O.*	*Relay 1 N.O.*	*Open Collector 3*	*Relay 1 N.C.*
TB1-9	*Relay 1 Common*	*Relay 1 Common*	*Open Collector 4*	*Relay 2 N.C.*
TB1-10	*Open Collector*	*Open Collector*	*Open Collector 5*	*Relay 2 N.O.*
	Relays contacts rated 125 V AC @ 5 A Open-collector output rated 24 V DC @ 500 mA	Relays contacts rated 125 V AC @ 5 A Open-collector output rated 24 V DC @ 500 mA	Rated 24 V DC @ 500 mA	Rated 125 V AC @ 5 A
Digital Inputs				
TB1-11	*Logic Common* Inputs need to sink 1 mA to Logic Common	*Logic Common* Inputs need to sink 1 mA to Logic Common	*Logic Common* Inputs need to sink 1 mA to Logic Common	*Logic Common* Inputs need to sink 1 mA to Logic Common
TB1-12	*Input 0*	*Input 0*	*Input 0*	*Input 0*
TB1-13	*Input 1*	*Input 1*	*Input 1*	*Input 1*
TB1-14	*Input 2*	*Input 2*	*Input 2*	*Input 2*
TB1-15	*Input 3*	*Input 3*	*Input 3*	*Input 3*
TB1-16	*Input 4*	*Input 4*	*Input 4*	*Input 4*
TB1-17	*Input 5*	*Input 5*	*Input 5*	*Input 5*
TB1-18	*Input 6*	*Input 6*	*Input 6*	*Input 6*
TB1-19	*Input 7*	*Input 7*	*Input 7*	*Input 7*
TB1-20	*Input 8*	*Input 8*	*Input 8*	*Input 8*
TB1-21	*Input 9*	*Logic Common*	*Input 9*	*Input 9*
TB1-22	*Input 10*	*Input 9*	*Input 10*	*Input 10*
TB1-23	*Input 11*	*Input 10*	*Input 11*	*Input 11*
TB1-24	*Logic Common (16 MHz)* *+5 V DC (40 and 100 MHz)* Maximum output: 10 mA	—	*+5 V DC* Maximum output: 10 mA	*+5 V DC* Maximum output: 10 mA

Table 4-22—TB2 Connection Descriptions

Terminal	Control Module / Description		
	16 MHz VFD (322-340)	**20 MHz** DCR (321-101) DSV (321-516)	**40 MHz Logic I/O** (322-157) **40 MHz Contact I/O** (322-966) **40 MHz Mixed I/O** (322-100) **100 MHz Logic I/O** (323-397 and 323-546) **100 MHz Mixed I/O** (323-547 and 323-548) **270 MHz Logic I/O** (324-260) **Compact 100 MHz Logic I/O** (323-060 and 323-656) **Compact 150 MHz Logic I/O** (323-667)
DC Power Supply Output			
TB2-1	*+24 V DC* Unregulated Maximum output: 250 mA	*+24 V DC* Unregulated Maximum output: 250 mA	*+24 V DC* (†) Unregulated Maximum output: 250 mA
Analog Inputs			
TB2-2	*Analog Input 1* ±10 V DC Input impedance: 100 kΩ	*Analog Input 1* ±10 V DC Input impedance: 100 kΩ	*Analog Input 1* ±10 V DC or 0 to 20 mA Input impedance: 400 kΩ or 500 Ω
TB2-3	*Analog Input 2* 0 to 10 V DC Input impedance: 100 kΩ	*Analog Input 2* 0 to 10 V DC Input impedance: 100 kΩ	*Analog Input 2* ±10 V DC or 0 to 20 mA Input impedance: 400 kΩ or 500 Ω
TB2-4	*Analog Input 3 (+)*	*Analog Input 3 (+)*	*Analog Input 3* ±10 V DC or 0 to 20 mA Input impedance: 400 kΩ or 500 Ω
TB2-5	*Analog Input 3 (–)* 0 to 20 mA Input impedance: 150 Ω	*Analog Input 3 (–)* 0 to 20 mA Input impedance: 150 kΩ	*Analog Input Common* (†) (for TB2-2, -3, and -4) To convert an input to 0 to 20 mA, install a 500 Ω resistor between the input and common (TB2-5)
DC Power Supply Outputs			
TB2-6	*Do not connect*	*Do not connect*	*Do not connect*
TB2-7	*+10 V DC* Maximum output: 10 mA	*+10 V DC* Maximum output: 10 mA	*+10 V DC* (†) Maximum output: 10 mA
TB2-8	*–10 V DC* Maximum output: 10 mA	*–10 V DC* Maximum output: 10 mA	*–10 V DC* (†) Maximum output: 10 mA
Analog Outputs			
TB2-9	*Analog Output 1* ±10 V DC Maximum output: 10 mA	*Analog Output 1* ±10 V DC Maximum output: 10 mA	*Analog Output 1* ±10 V DC Maximum output: 10 mA
TB2-10	*Analog Output 2* ±10 V DC Maximum output: 10 mA	*Analog Output 2* ±10 V DC Maximum output: 10 mA	*Analog Output 2* ±10 V DC Maximum output: 10 mA
TB2-11	*Do not connect*	*Not used*	*Do not connect*
TB2-12	*Not used*	*Not used*	*Analog Output 1* 0 to 20 mA Load impedance: 0 to 1000 Ω
TB2-13	*Not used*	*Not used*	*Analog Output 2* 0 to 20 mA Load impedance: 0 to 1000 Ω

(†) If the power supply outputs of the drive (TB2-1, TB2-7, or TB2-8) are used to power the analog inputs (TB2-2, TB2-3, or TB2-4), Logic Common (TB1-11) must be tied to Analog Input Common (TB2-5) to ensure proper signal reference.

Figure 4-15—Asynchronous Serial Connectors

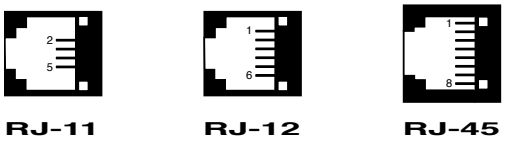


Table 4-23—Serial Connector Pinouts

Pin	Connector / Description					
	J1 (20 and 40 MHz)	**J2A/J2B** (20, 40, 100, and Compact 100 MHz) **J2A1/J2B1** (270 MHz)	**J3** (16 MHz)	**J3** (40 MHz)	**J4** (40 MHz) **J3**, **J6**, and **J12** (100 MHz) **J2**, **J3**, and **J6** (270 MHz) **J1** (Compact 100 and 150 MHz) **J4** (Compact 150 MHz)	**J11** (100 MHz) **J4** (270 MHz) **J3** (Compact 100 and 150 MHz)
Port:	RS-422/485	SSI	RS-422/485	RS-232	RS-422/485	RS-232
Jack:	6-position (RJ-12)	6-position (RJ-12)	6-position (RJ-11 or RJ-12)	6-position (RJ-11 or RJ-12)	8-position (RJ-45)	8-position (RJ-45)
1	+5 V DC	Data (+)	No connection	No connection	+5 V DC	+5 V DC
2	Receive (+)	Data (–)	Receive (+)	Receive	+5 V DC	+5 V DC
3	Receive (–)	Logic Common	Receive (–)	Common(†)	Receive (+)	Receive
4	Transmit (–)	Logic Common	Transmit (–)	Common(†)	Receive (–)	Logic Common
5	Transmit (+)	Clock (–)	Transmit (+)	Transmit	Transmit (–)	Logic Common
6	Common(†)	Clock (+)	No connection	No connection	Transmit (+)	Transmit
7	—	—	—	—	Logic Common	Logic Common
8	—	—	—	—	Logic Common	Logic Common

(†) The commons of J1 and J3 on the 40 MHz controller are tied together but isolated from drive Logic Common.

Table 4-24—Synchronous Serial Cables

Cable Length	Part Number
2 ft.	917-020
4 ft.	917-021
6 ft.	917-022
8 ft.	917-023
10 ft.	917-024
Longer than 10 ft.	Consult factory

Figure 4-16—Serial Communication Resistor Locations

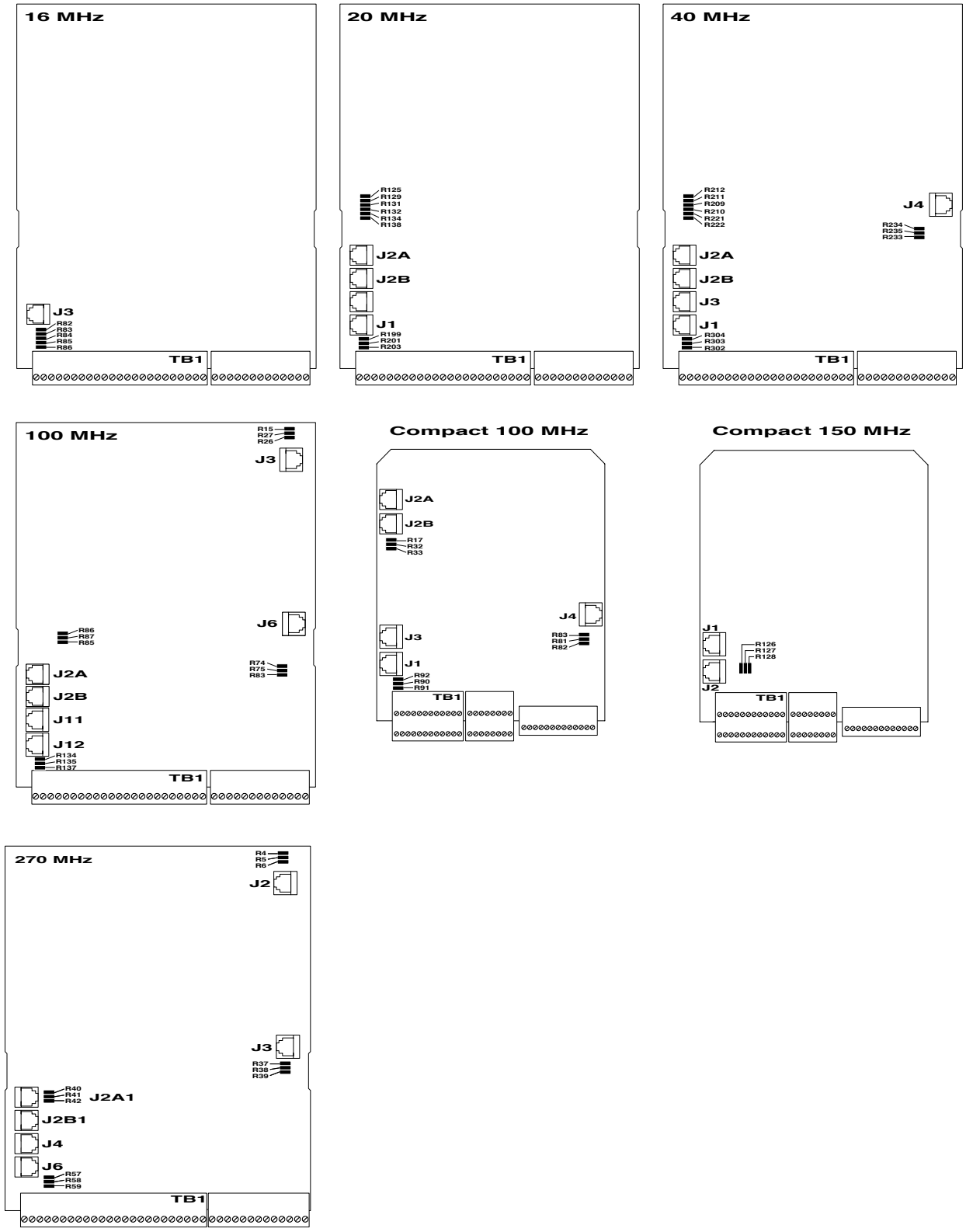


Table 4-25—Serial Communication Resistors

Signal	Controller	Connector	Terminating	Pull-Up	Pull-Down
Asynchronous receive	16 MHz	J3 and TB1	R83 (100 Ω)	Receive: R82 (1.5 kΩ) Transmit: R86 (10.0 kΩ)	Receive: R84 (1.5 kΩ) Transmit: R85 (10.0 kΩ)
	20 MHz	J1 and TB1	R201 (121 Ω)	R199 (1.5 kΩ)	R203 (1.5 kΩ)
	40 MHz	J1 and TB1	R303 (121 Ω)	R304 (1.5 kΩ)	R302 (1.5 kΩ)
		J4	R235 (121 Ω)	R234 (1.5 kΩ)	R233 (1.5 kΩ)
	100 MHz	J12 and TB1	R135 (121 Ω)	R134 (1.5 kΩ)	R137 (1.5 kΩ)
		J3	R27 (121 Ω)	R15 (1.5 kΩ)	R26 (1.5 kΩ)
		J6	R75 (121 Ω)	R74 (1.5 kΩ)	R83 (1.5 kΩ)
	270 MHz	J6 and TB1	R58 (121 Ω)	R57 (1.5 kΩ)	R59 (1.5 kΩ)
		J2	R5 (121 Ω)	R4 (1.5 kΩ)	R6 (1.5 kΩ)
		J3	R38 (121 Ω)	R37 (1.5 kΩ)	R39 (1.5 kΩ)
	Compact 100 MHz	J1 and TB1	R90 (121 Ω)	R92 (1.5 kΩ)	R91 (1.5 kΩ)
		J4	R82 (121 Ω)	R81 (1.5 kΩ)	R83 (1.5 kΩ)
	Compact 150 MHz	J2 and TB1	R126 (121 Ω)	R127 (1.5 kΩ)	R128 (1.5 kΩ)
Synchronous data transmit/receive	20 MHz	J2A and J2B	R129 (121 Ω)	R125 (1.5 kΩ)	R131 (1.5 kΩ)
	40 MHz	J2A and J2B	R211 (121 Ω)	R212 (1.5 kΩ)	R209 (1.5 kΩ)
	100 MHz	J2A and J2B	R87 (121 Ω)	R86 (1.5 kΩ)	R85 (1.5 kΩ)
	270 MHz	J2A1 and J2B1	R41 (121 Ω)	R40 (1.5 kΩ)	R42 (1.5 kΩ)
	Compact 100 MHz	J2A and J2B	R32 (121 Ω)	R17 (1.5 kΩ)	R33 (1.5 kΩ)
Synchronous clock transmit/receive	20 MHz	J2A and J2B	R134 (121 Ω)	R132 (1.5 kΩ)	R138 (1.5 kΩ)
	40 MHz	J2A and J2B	R221 (121 Ω)	R210 (1.5 kΩ)	R222 (1.5 kΩ)
	100 MHz	*(Clock signal embedded in data signal)*			
	270 MHz	*(Clock signal embedded in data signal)*			
	Compact 100 MHz	*(Clock signal embedded in data signal)*			

Figure 4-17—On-Board Encoder Interface Module Connections (100 MHz Controllers 323-397 and 323-547, 270 MHz Controller 324-260, Compact 100 MHz Controller 323-060, and Compact 150 MHz Controller 323-667)

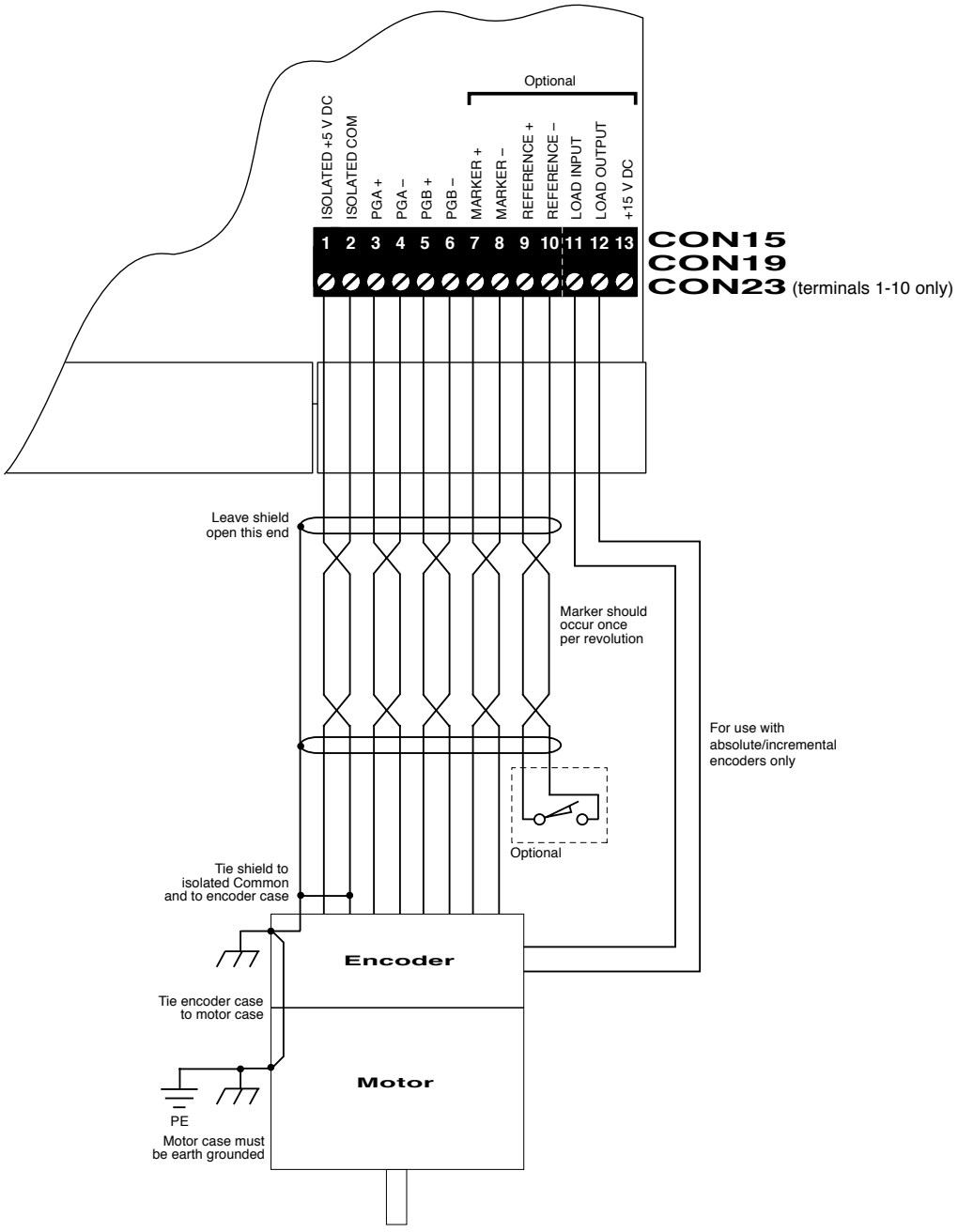


Table 4-26—On-Board Encoder Interface Connections (CON15, CON16, CON19, and CON23)

Terminal	Description
Power Supply Outputs (Isolated)	
CON15-1 *CON16-1* *CON19-1* *CON23-1*	*+5 V DC* *+5 V DC* Maximum output: 250 mA
CON15-2 *CON16-2* *CON19-2* *CON23-2*	*Common* *Common*
Encoder Channel Signals (Isolated)	
CON15-3 *CON15-4* *CON16-3* *CON16-4* *CON19-3* *CON19-4* *CON23-3* *CON23-4*	*PGA (+)* *PGA (–)* *PGA (+)* *PGA (–)* 0 to 5 V nominal
CON15-5 *CON15-6* *CON16-5* *CON16-6* *CON19-5* *CON19-6* *CON23-5* *CON23-6*	*PGB (+)* *PGB (–)* *PGB (+)* *PGB (–)* 0 to 5 V nominal
Marker Pulse Signals (Isolated)	
CON15-7 *CON15-8* *CON16-7* *CON16-8* *CON19-7* *CON19-8* *CON23-7* *CON23-8*	*Marker (+)* *Marker (–)* *Marker (+)* *Marker (–)* 0 to 5 V nominal
CON15-9 *CON15-10* *CON16-9* *CON16-10* *CON19-9* *CON19-10* *CON23-9* *CON23-10*	*Reference (+)* *Reference (–)* *Reference (+)* *Reference (–)* 0 to 5 V nominal
Incremental Serial Interface (Isolated)	
CON16-11 *CON19-11*	*Load Input* *Load Input* +5 V DC
CON16-12 *CON19-12*	*Load Output* *Load Output* 0 to 5 V nominal
Power Supply Output (Isolated)	
CON16-13 *CON19-13*	*+15 V DC* *+15 V DC* Maximum output: 200 mA

Figure 4-18—Encoder Interface Module Connections (316-887)

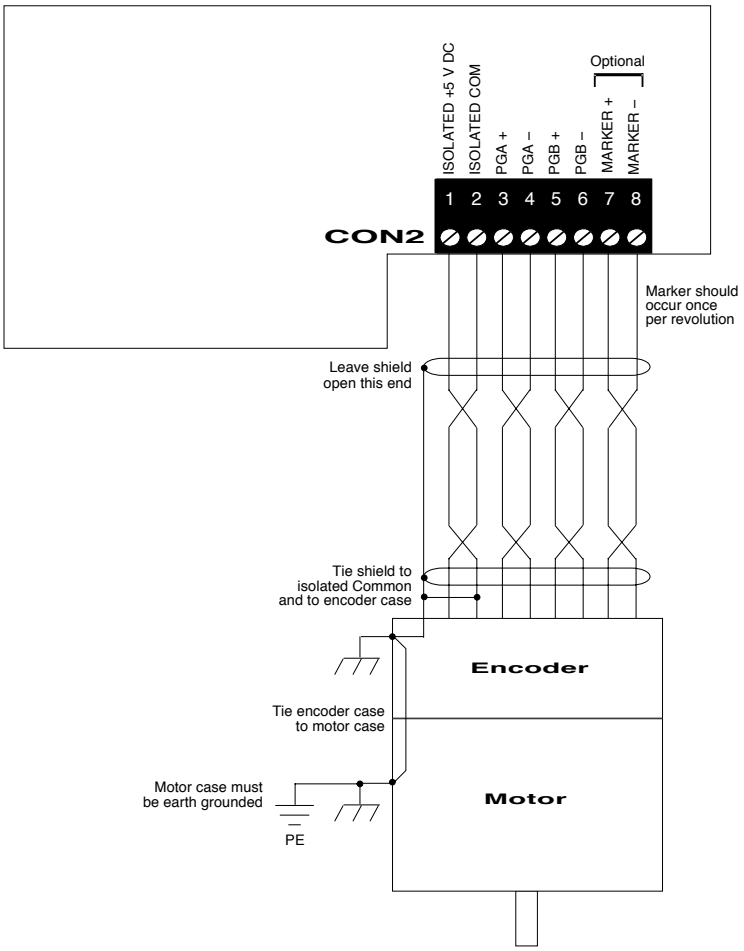


Figure 4-19—Dual Encoder Interface Module Connections (321-952)

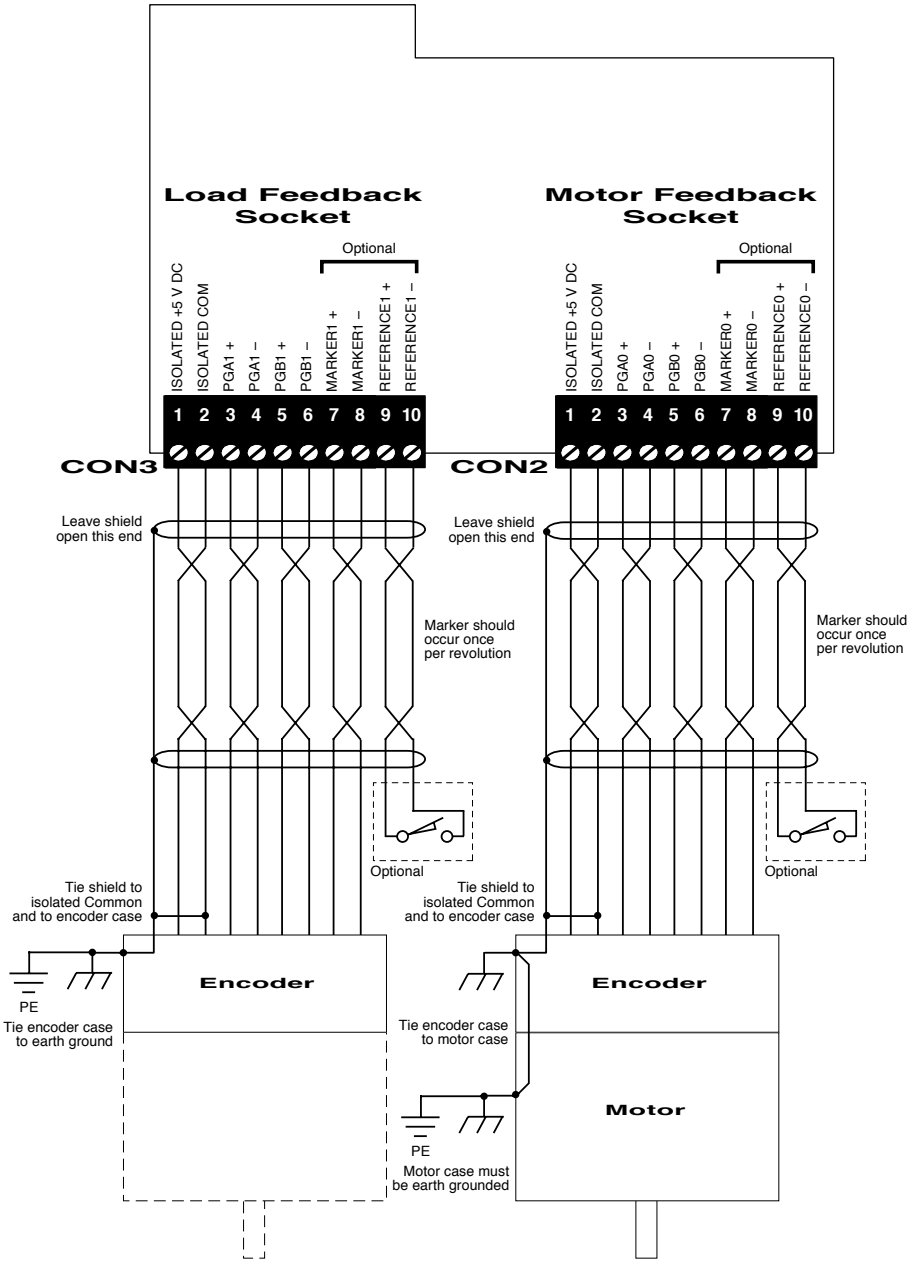


Table 4-27—Encoder Interface Connections (CON2)

Terminal	Description
Power Supply Outputs (Isolated)	
CON2-1	*+5 V DC* Maximum output: 250 mA
CON2-2	*Common*
Encoder Channel Signals (Isolated)	
CON2-3 *CON2-4*	*PGA (+)* *PGA (–)* 0 to 5 V nominal
CON2-5 *CON2-6*	*PGB (+)* *PGB (–)* 0 to 5 V nominal
Marker Pulse Signals (Isolated)	
CON2-7 *CON2-8*	*Marker (+)* *Marker (–)* 0 to 5 V nominal

Table 4-28—Dual Encoder Interface Connections (CON2, CON3)

Terminal	Description
Power Supply Outputs (Isolated)	
CON2-1 *CON3-1*	*+5 V DC* Maximum output: 250 mA
CON2-2 *CON3-2*	*Common*
Encoder Channel Signals (Isolated)	
CON2-3 *CON2-4* *CON3-3* *CON3-4*	*PGA (+)* *PGA (–)* *PGA (+)* *PGA (–)* 0 to 5 V nominal
CON2-5 *CON2-6* *CON3-5* *CON3-6*	*PGB (+)* *PGB (–)* *PGB (+)* *PGB (–)* 0 to 5 V nominal
Marker Pulse Signals (Isolated)	
CON2-7 *CON2-8* *CON3-7* *CON3-8*	*Marker (+)* *Marker (–)* *Marker (+)* *Marker (–)* 0 to 5 V nominal
Reference Signals (Isolated)	
CON2-9 *CON2-10* *CON3-9* *CON3-10*	*Reference (+)* *Reference (–)* *Reference (+)* *Reference (–)* 0 to 5 V nominal

Figure 4-20—Resolver Interface Module with Encoder Emulation Connections (322-096)

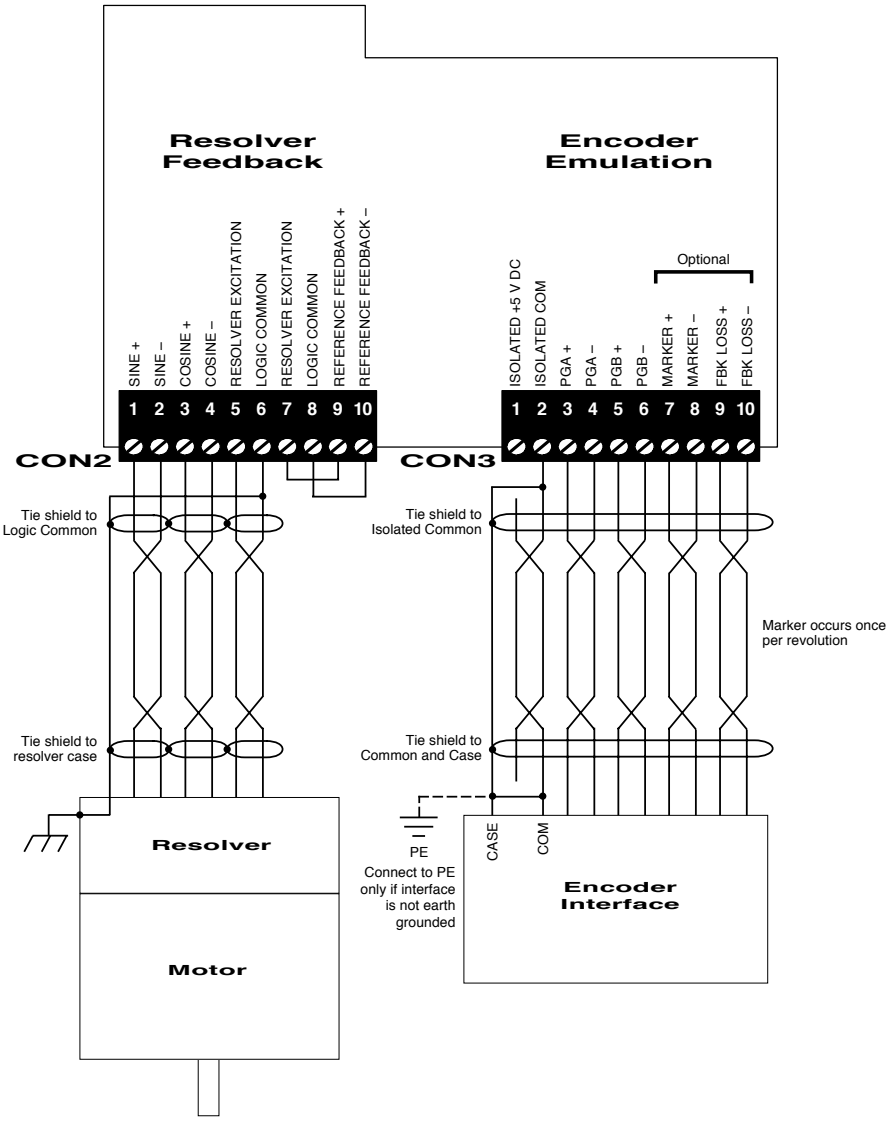


Table 4-29—Resolver Interface Module with Encoder Emulation Connections (CON2, CON3)

Terminal	Description
Resolver	
CON2-1	*Sine (+)*
CON2-2	*Sine (–)* 2 V_{rms} peak-to-peak
CON2-3	*Cosine (+)*
CON2-4	*Cosine (–)* 2 V_{rms} peak-to-peak
CON2-5	*Resolver Excitation*
CON2-6	*Logic Common* 4 V_{rms} at 5 kHz
CON2-7	*Resolver Excitation*
CON2-8	*Logic Common* 4 V_{rms} at 5 kHz
CON2-9	*Reference Feedback (+)*
CON2-10	*Reference Feedback (–)* 4 V_{rms} at 5 kHz
Encoder Emulation	
CON3-1	*Isolated +5 V DC* Maximum output: 250 mA
CON3-2	*Isolated Common*
CON3-3	*PGA (+)*
CON3-4	*PGA (–)* 0 to 5 V nominal
CON3-5	*PGB (+)*
CON3-6	*PGB (–)* 0 to 5 V nominal
CON3-7	*Marker (+)*
CON3-8	*Marker (–)* 0 to 5 V nominal
CON3-9	*Feedback Loss (+)*
CON3-10	*Feedback Loss (–)* 0 to 5 V nominal

Figure 4-21—Analog Interface Module Connections (321-557)

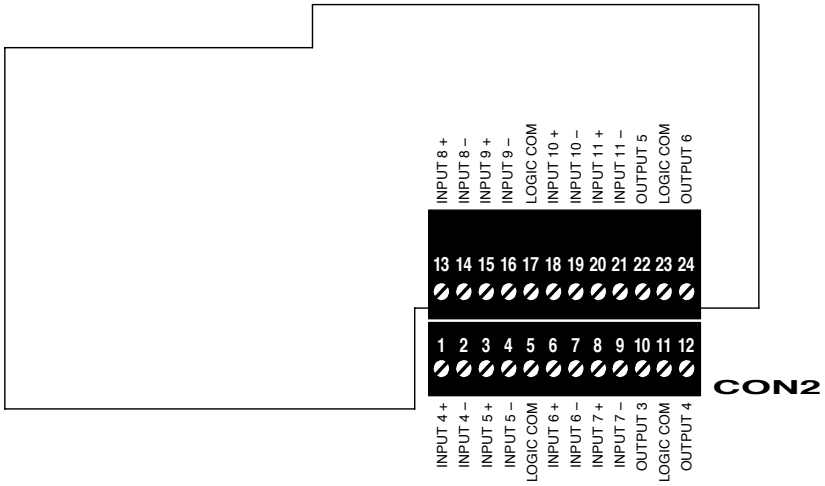


Figure 4-22—Typical Analog Input Wiring

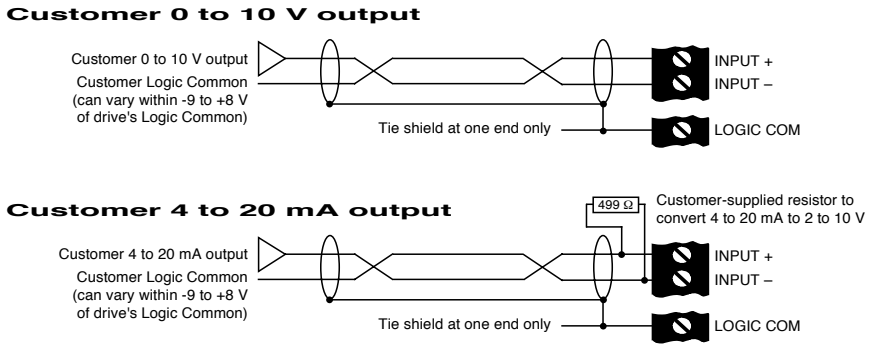


Figure 4-23—Typical Analog Output Wiring

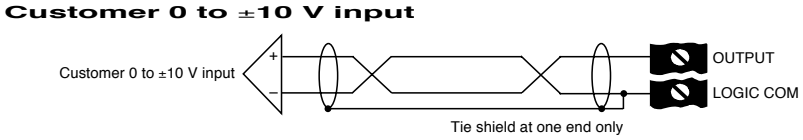


Table 4-30—Analog Interface Module Connections (CON2)

Terminal	Description
Bottom Row	
CON2-1	*Analog Input 4 (+)*
CON2-2	*Analog Input 4 (–)*
CON2-3	*Analog Input 5 (+)*
CON2-4	*Analog Input 5 (–)*
CON2-5	*Logic Common*
CON2-6	*Analog Input 6 (+)*
CON2-7	*Analog Input 6 (–)*
CON2-8	*Analog Input 7 (+)*
CON2-9	*Analog Input 7 (–)*
CON2-10	*Analog Output 3*
CON2-11	*Logic Common*
CON2-12	*Analog Output 4*
Top Row	
CON2-13	*Analog Input 8 (+)*
CON2-14	*Analog Input 8 (–)*
CON2-15	*Analog Input 9 (+)*
CON2-16	*Analog Input 9 (–)*
CON2-17	*Logic Common*
CON2-18	*Analog Input 10 (+)*
CON2-19	*Analog Input 10 (–)*
CON2-20	*Analog Input 11 (+)*
CON2-21	*Analog Input 11 (–)*
CON2-22	*Analog Output 5*
CON2-23	*Logic Common*
CON2-24	*Analog Output 6*
Inputs rated:	0 to 10 V DC or 0 to 20 mA Impedance: 200 kΩ or 500 Ω
Outputs rated:	±10 V DC Maximum output: 6 mA peak Short circuit: 25 mA

5 Troubleshooting/Maintenance

5.1 Overview

This chapter provides information useful in troubleshooting and maintaining the drive hardware. It presents the theory of operation, schematics, power electronics troubleshooting procedures, and general maintenance issues. It also provides a list of field-replaceable components.

5.2 Troubleshooting

This manual is not intended to provide in-depth service instructions. For service beyond that described in this manual, please contact Unico or your representative.

Attention

High voltage may be present even when all electrical power supplies are disconnected. After switching off electrical power, wait at least 15 minutes for bus circuit capacitors to discharge before working on the drive or associated equipment. Use an appropriate voltmeter to further verify that capacitors are discharged before beginning work. Do not rely exclusively on the bus voltage indicator. Dangerous voltage levels may remain even when the indicator is off.

5.2.1 Theory of Operation

The general function of the drive is to convert a fixed voltage and frequency from an electrical power source into a variable voltage and frequency for controlling an AC motor. The block diagrams of the 1100, 1105, 1110, 1120, 1130, 1200, and 1230 drives are shown in Figure 5-1 through Figure 5-13.

A *rectifier section* is used on the 1100, 1105, 1110, and 1200 drives to convert the fixed AC line voltage into a DC bus voltage. The 1120 is a modular design intended for operating a number of units from a common DC bus. Low-power drives use a diode rectifier and resistors to charge the bus capacitors, which is then bypassed by a contact once the bus is up to full voltage. Medium- and high-power drives use silicon-controlled rectifiers (SCRs) to control the charging of the bus capacitors. High-power drives provide for optional twelve-pulse (six-phase) connection of the input to reduce harmonic currents. The 1110 drive is designed for single-phase operation using two, rather than three, AC line voltage terminals. A *rectifier control* coordinates the charging of the bus.

A *link choke* and *bus capacitors* in the 1100, 1105, and 1110 drives form a filter that smoothes the output of the rectifier section into a steady DC voltage. An optional *dynamic brake* device on these units allows regenerative energy from the load to be dissipated in an external resistor when the drive is braking. The dynamic braking device turns on when the bus voltage exceeds a preset value, causing the braking current to flow

in the resistor. The link choke and dynamic brake device is normally part of the converter supplying the DC bus to 1120 units.

A *converter section* is used on the 1130 and 1230 drives to regulate power flow between the AC line and DC bus. The converter uses an insulated gate bipolar transistor (IGBT) bridge to rectify the AC line voltage into a DC bus voltage. This section also regenerates energy from the DC bus to the AC line when the drive is braking. A *regen control* circuit turns on the input IGBTs in synchronism with the AC line to allow bidirectional power flow.

An *inverter section* consisting of six insulated gate bipolar transistors (IGBTs) is used to power an AC motor. This section can produce sine-wave motor voltages and currents of any desired amplitude by rapidly switching the IGBTs using a technique called pulse-width modulation (PWM). A *gate driver* is used to pass switching signals from the drive controller to the IGBTs.

Low-voltage power supplies provide the bias voltages for the control sections. Drives with constant-torque ratings up to 125 hp derive their control voltages from the DC bus using a bus-operated switching supply. Drives with constant-torque ratings greater than 125 hp use a step-down transformer and line-operated switching supply to generate the bias voltages.

Overall operation of the unit is regulated by a *drive control* that incorporates a digital signal processor (DSP) and a digital current regulator (DCR) or digital space vector (DSV) control. This high-speed digital control uses both voltage and current feedback to regulate the output to the motor. Optional *encoder* and *resolver interfaces* are available to provide closed-loop control of motor velocity and/or position. A dual encoder option is available to slave the motor to other sections of a machine or to reduce machine resonance using dual transducer control. Variable-frequency drive (VFD) operation is an option for controlling AC motors in simple applications.

A *keypad* and *display* on the control module provide access to operating and setup parameters. The control module also provides a number of analog and digital inputs that can be used as input to and output from the drive. Serial communication channels are also available for connecting drives to process controllers, communication networks, programmable controllers, or personal computers. Refer to the application manual for a detailed description of the operation of the control as well as the associated keypad and display.

Figure 5-1—1100 Block Diagram (Forms 13 and 17)

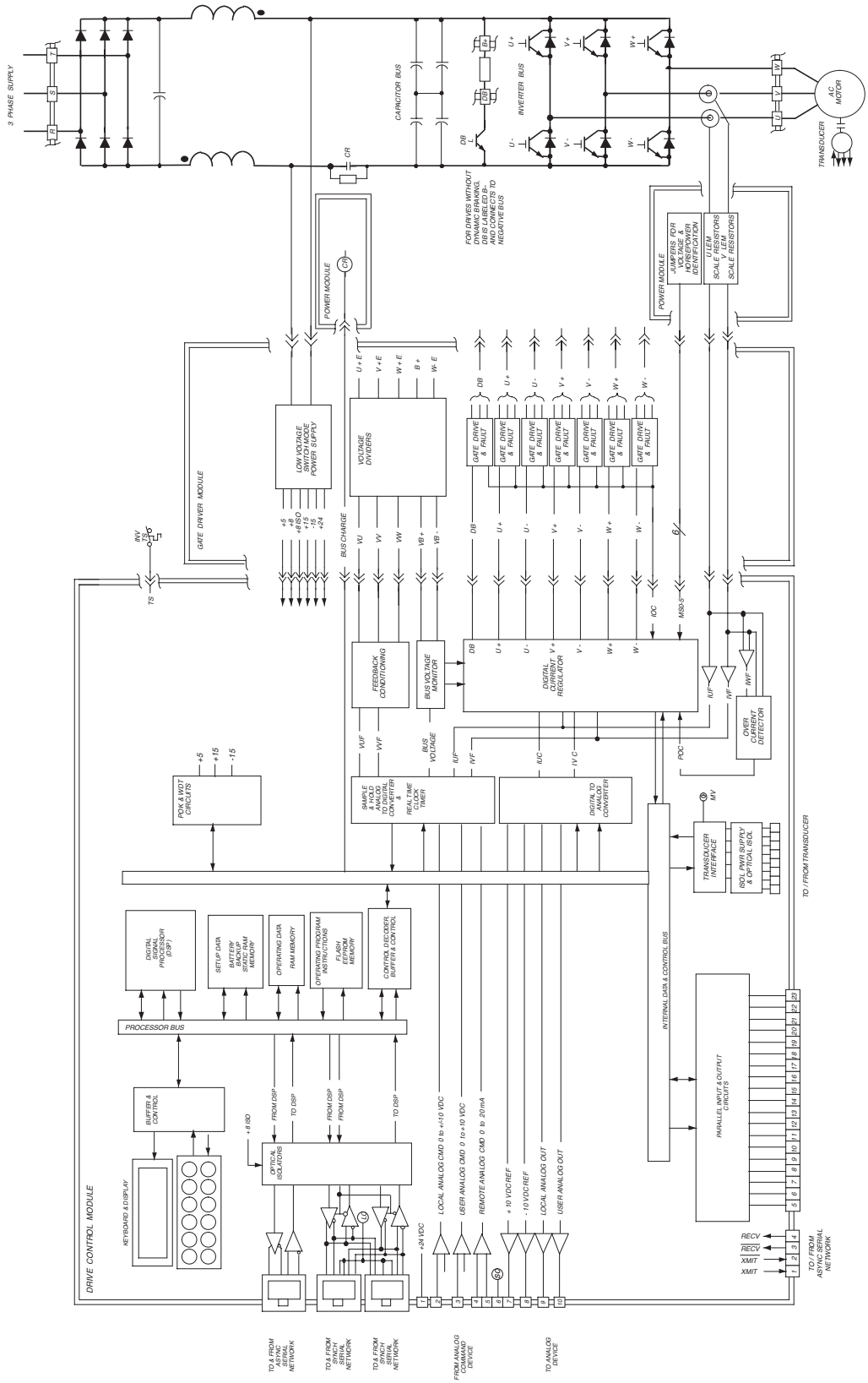


Figure 5-2—1100 Block Diagram (Form 30)

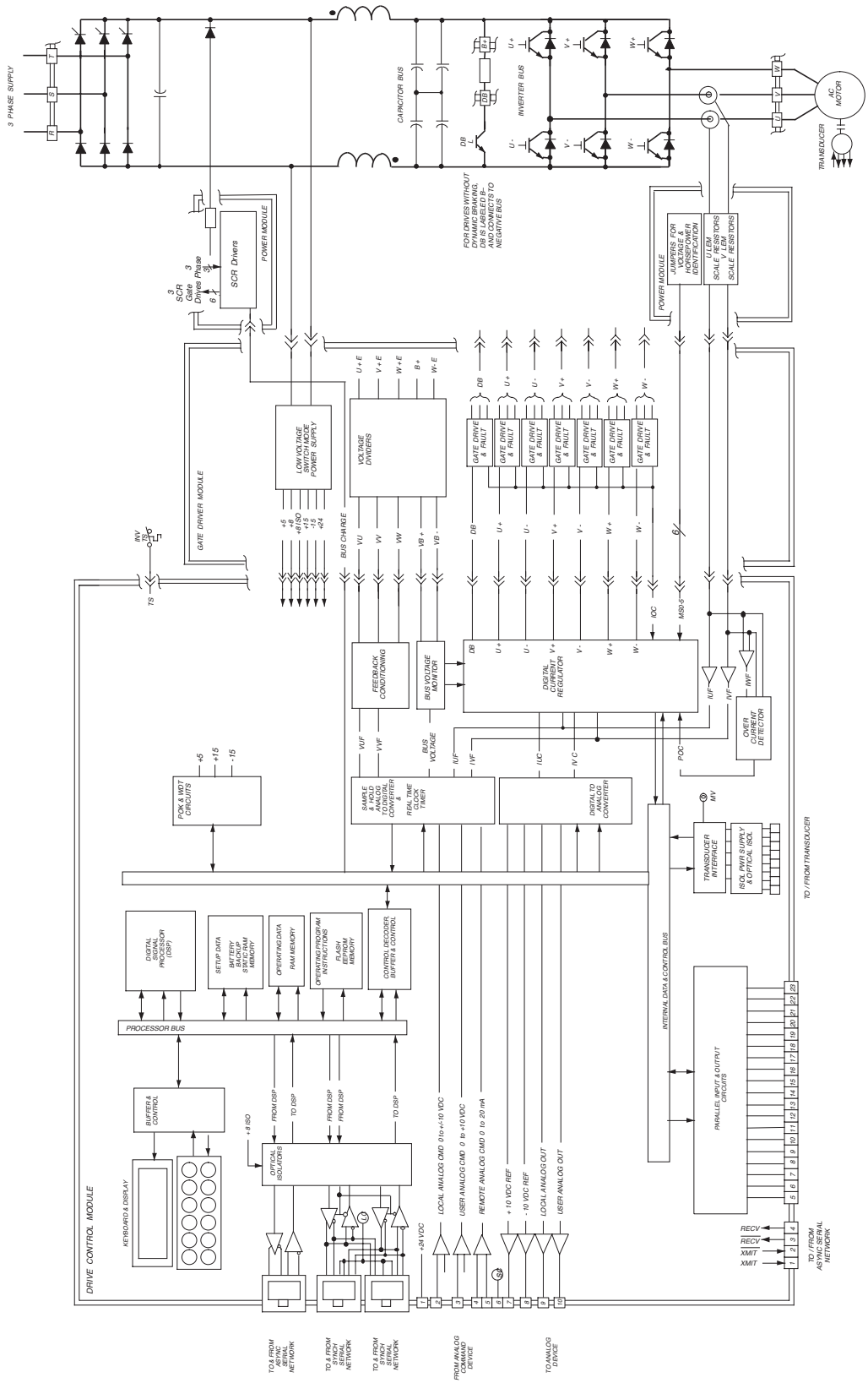


Figure 5-3—1100 Block Diagram (Form 48)

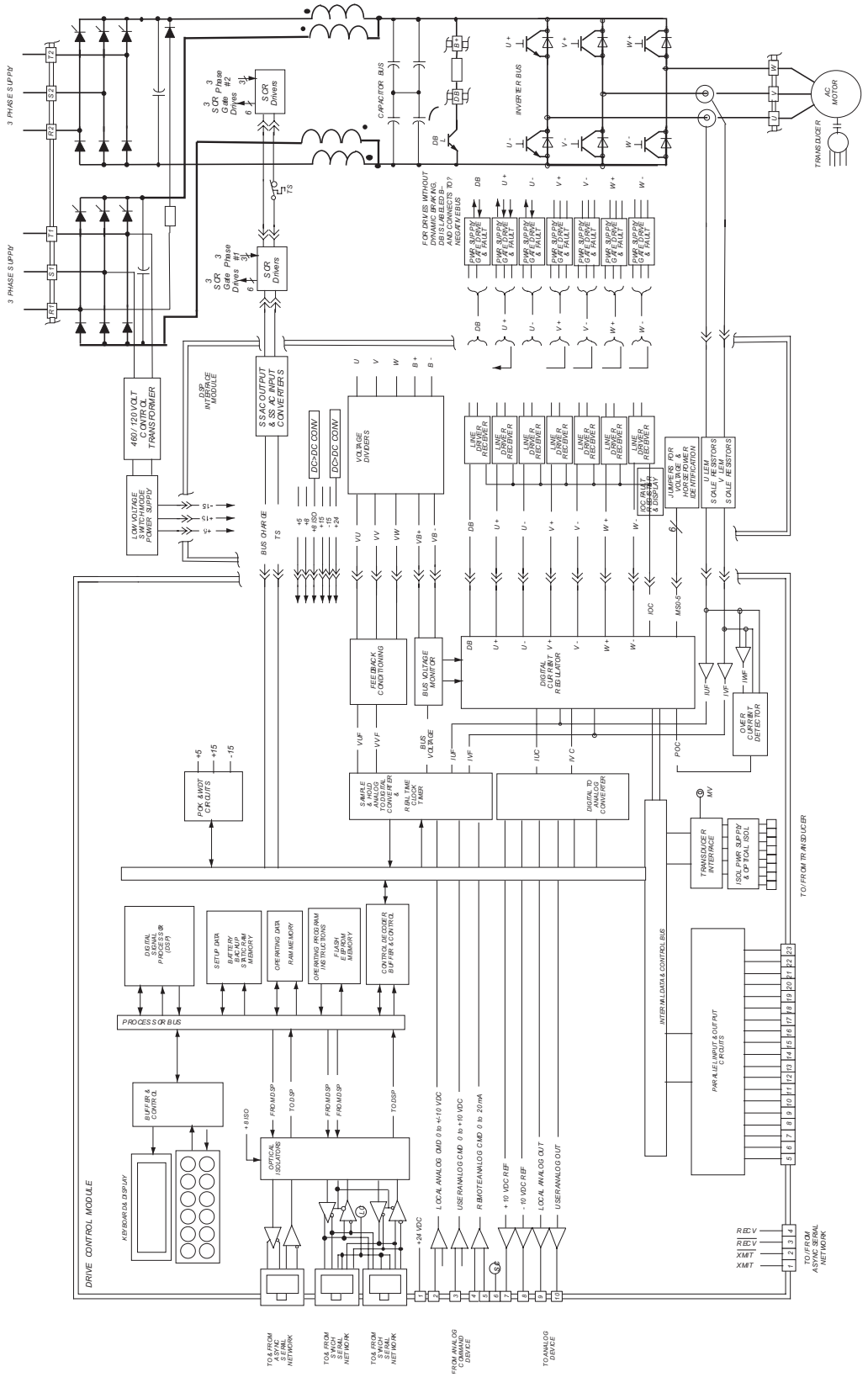


Figure 5-4—1105 Block Diagram (Form 12N and 17N)

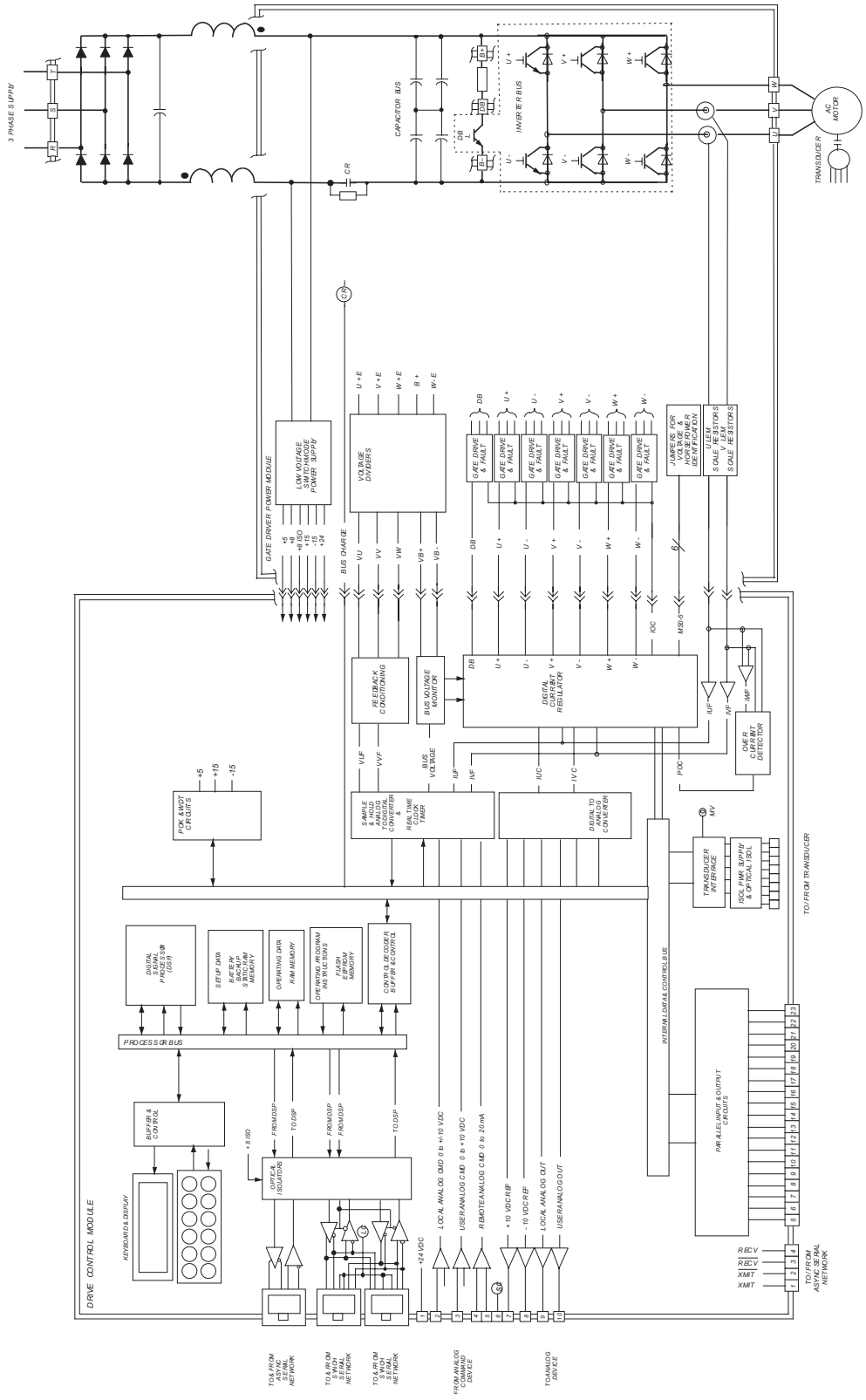


Figure 5-5—1105 Block Diagram (Forms 30 and 34)

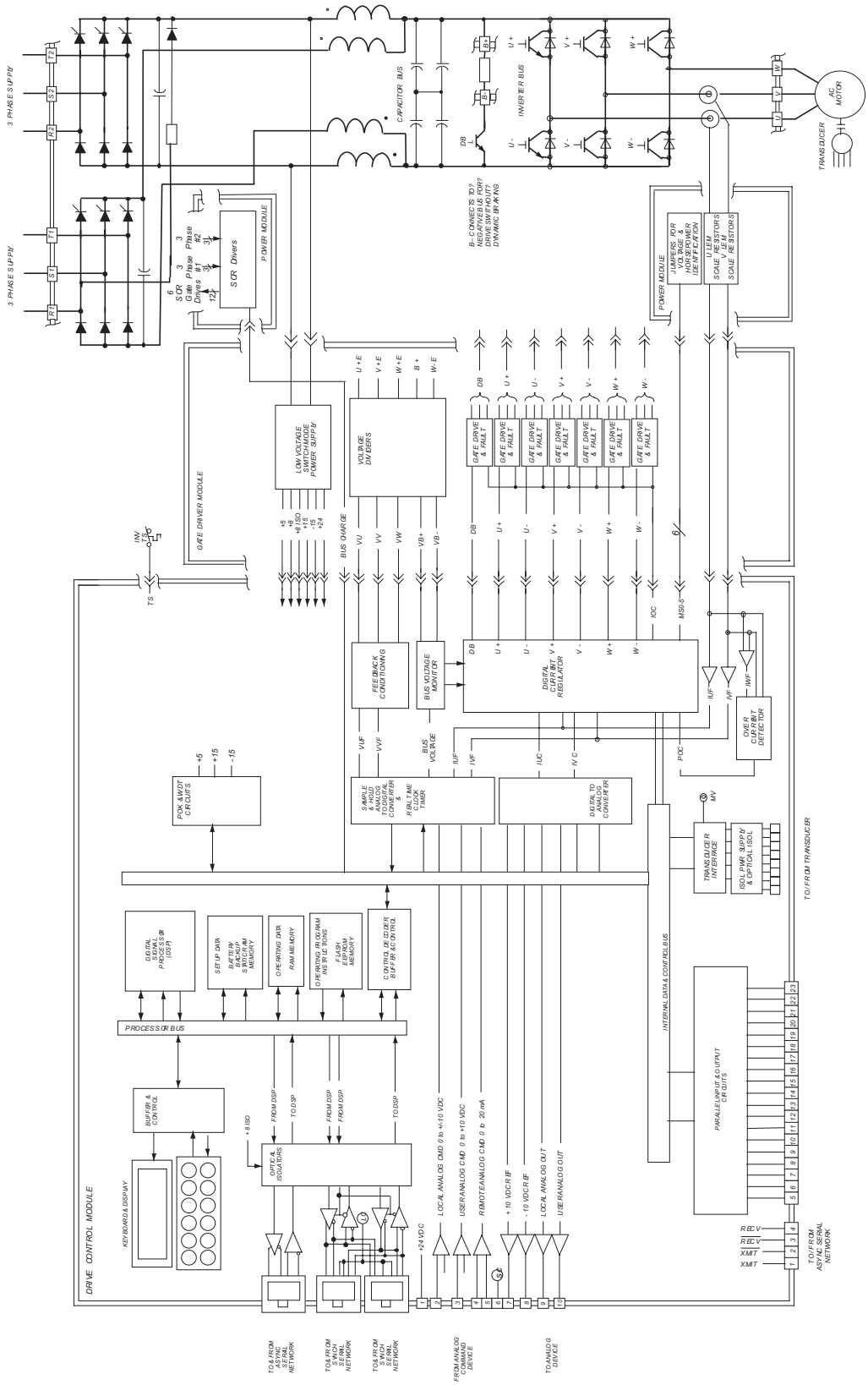


Figure 5-6—1110 Block Diagram (Forms 13 and 17)

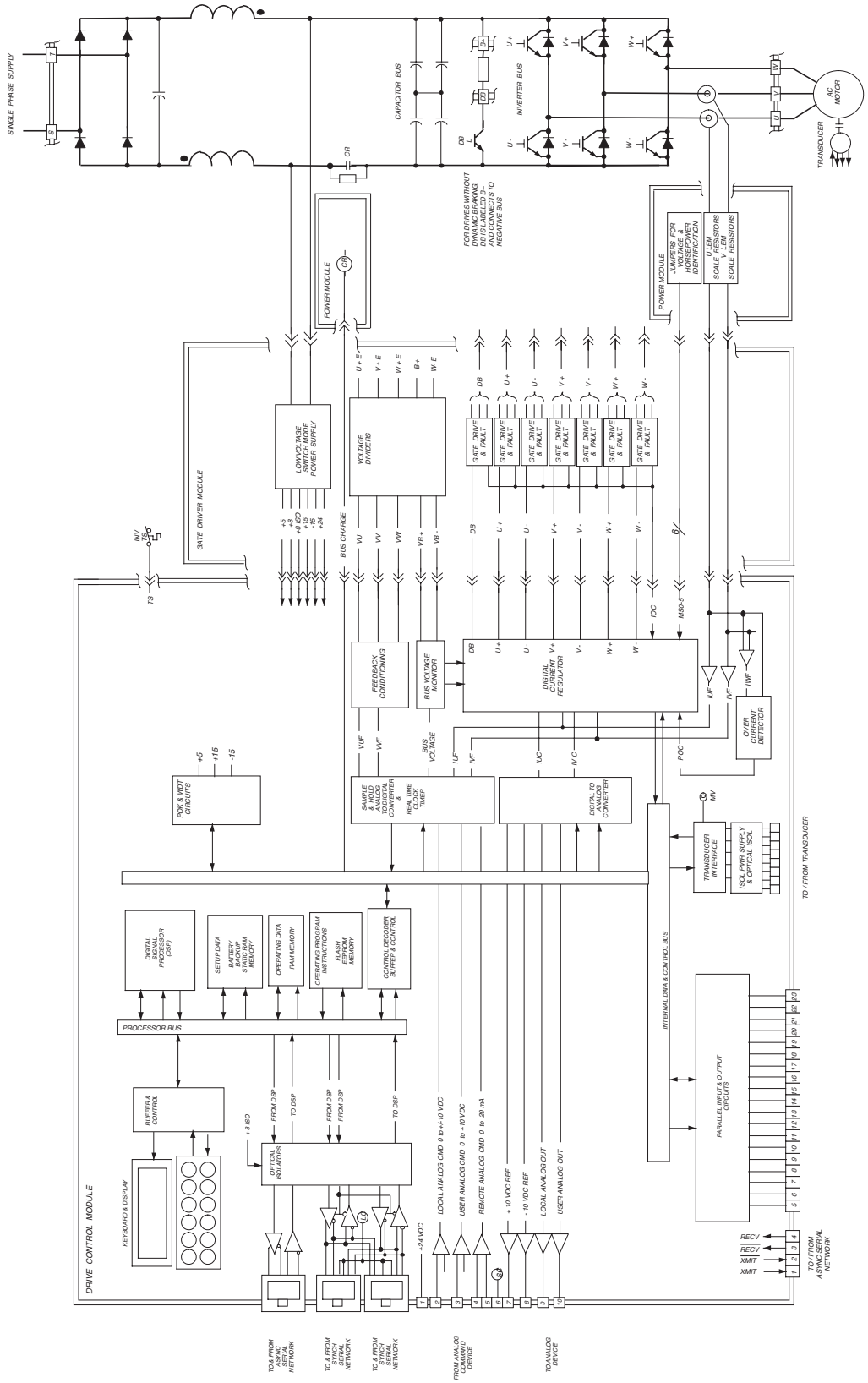


Figure 5-7—1110 Block Diagram (Form 30)

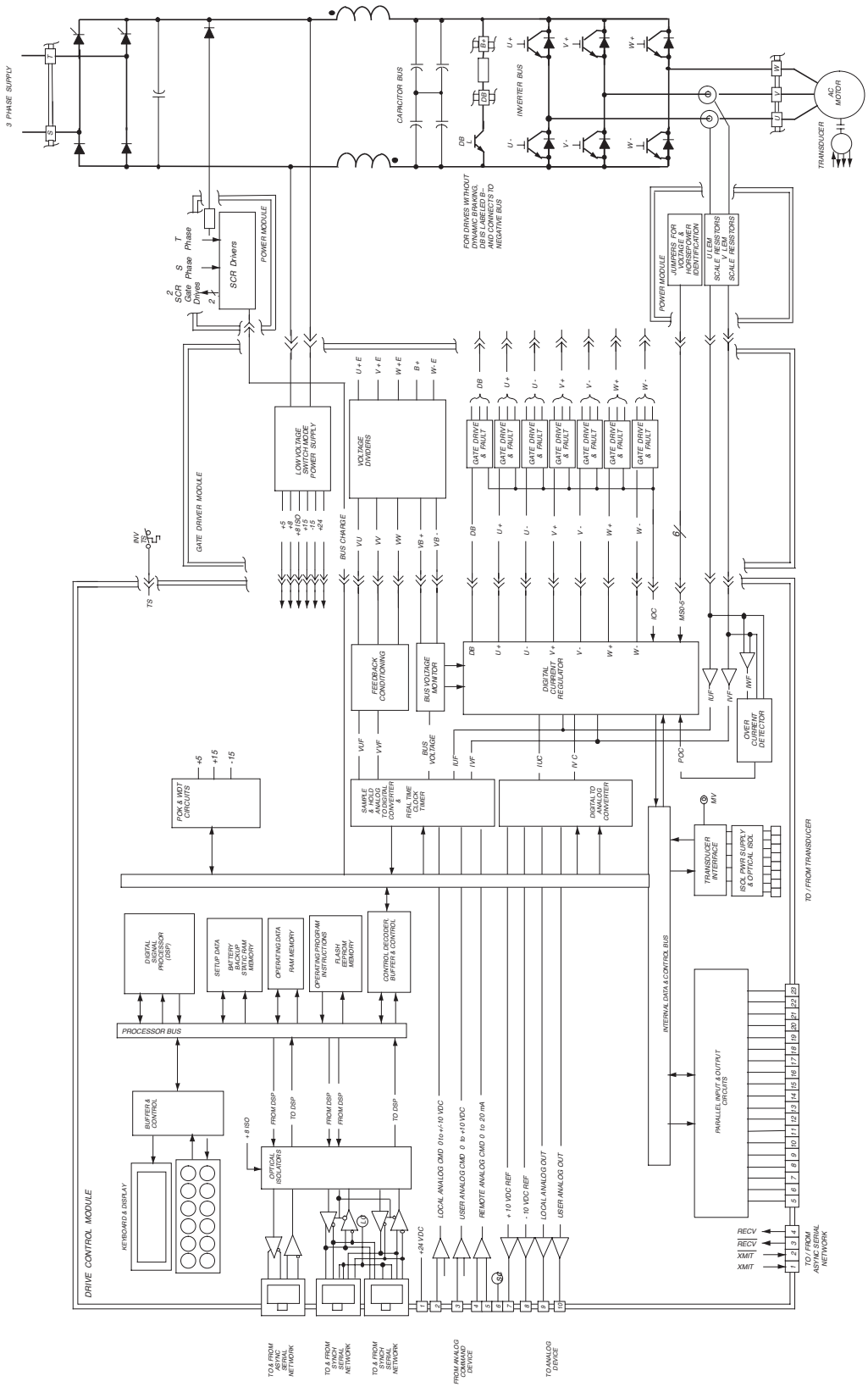


Figure 5-8—1120 Block Diagram

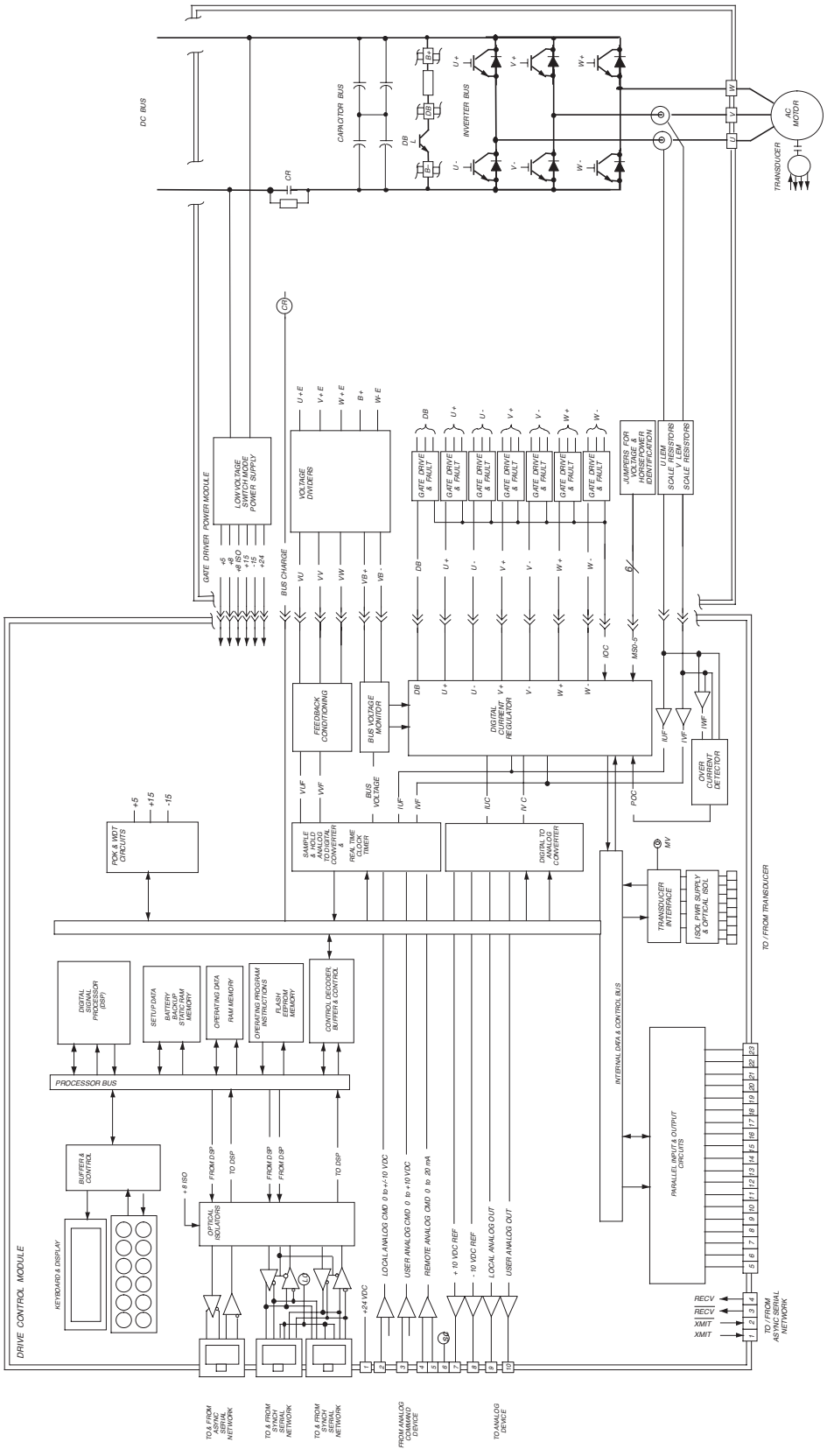


Figure 5-9—1130 Block Diagram

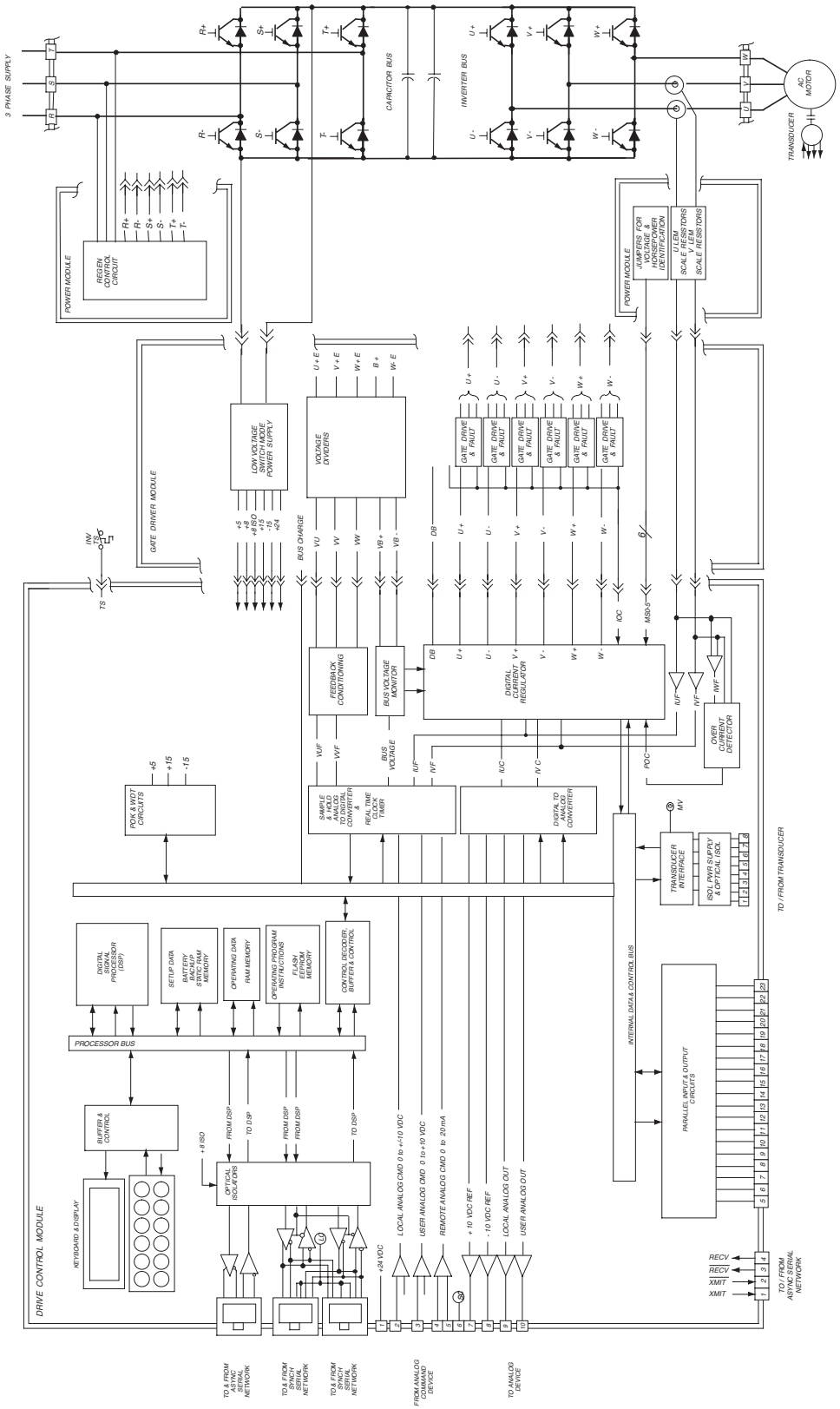


Figure 5-10—1200 Block Diagram (Form 9N and 13N)

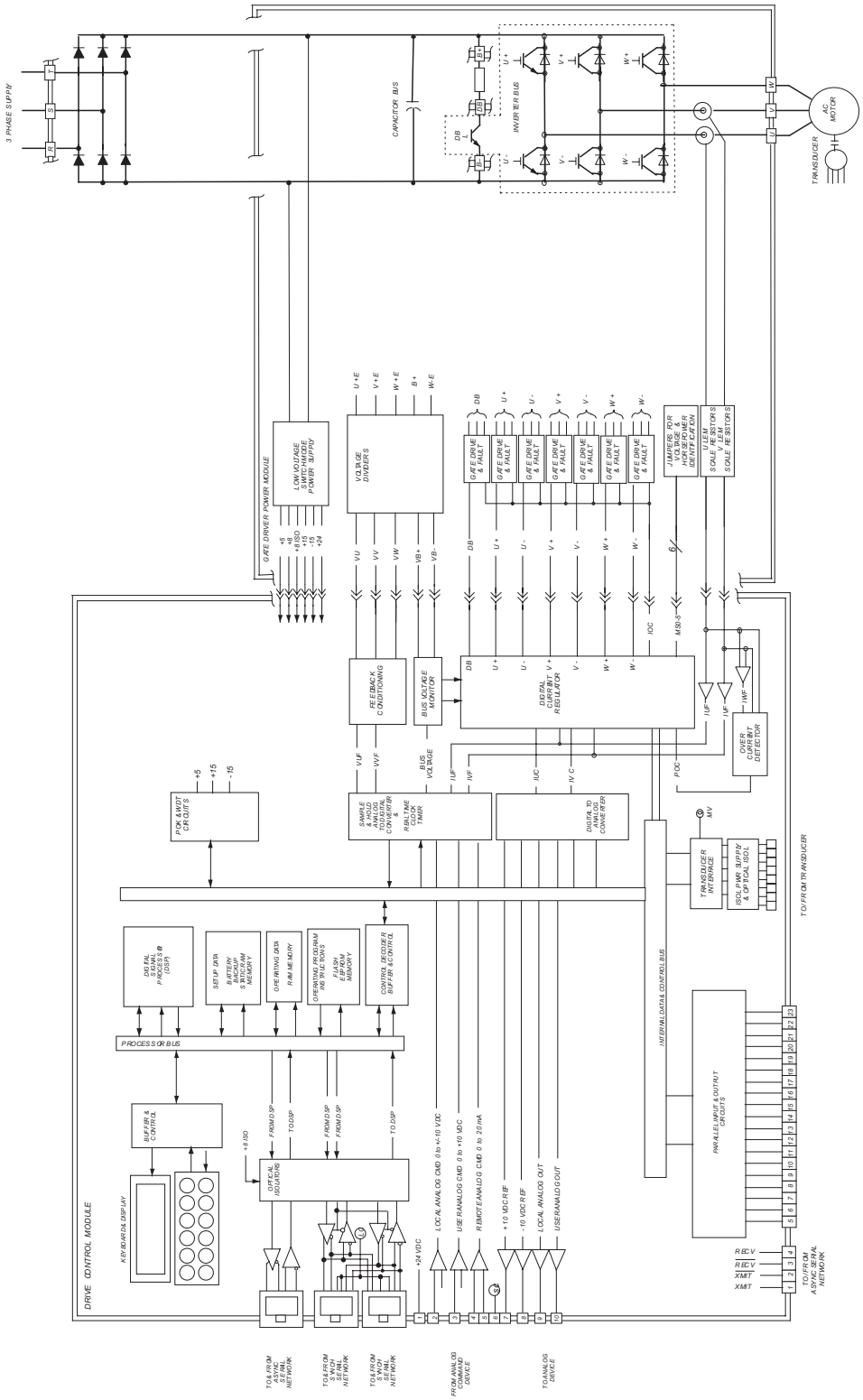


Figure 5-11—1200 Block Diagram (Form 17N)

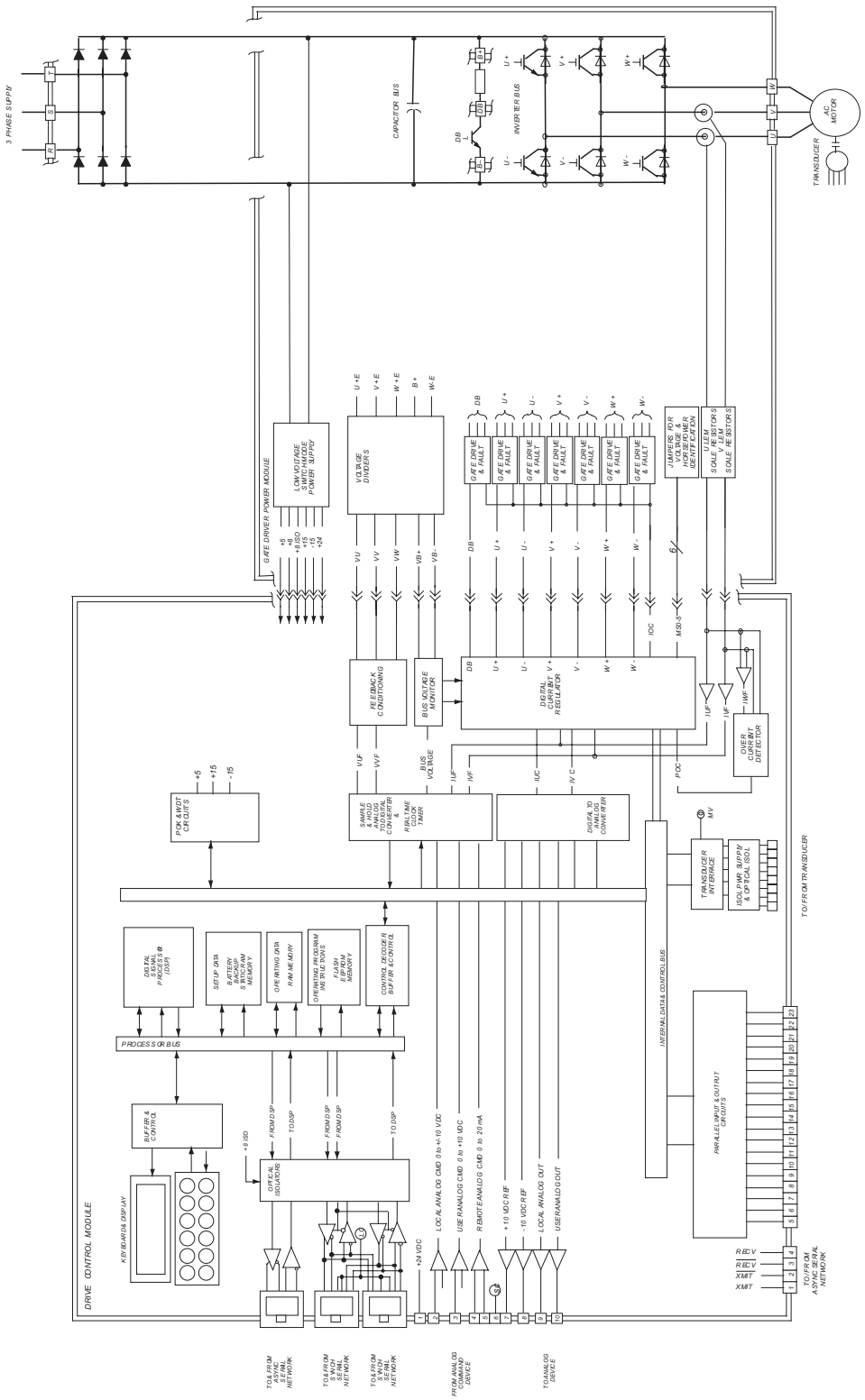


Figure 5-12—1200 Block Diagram (Form 34X)

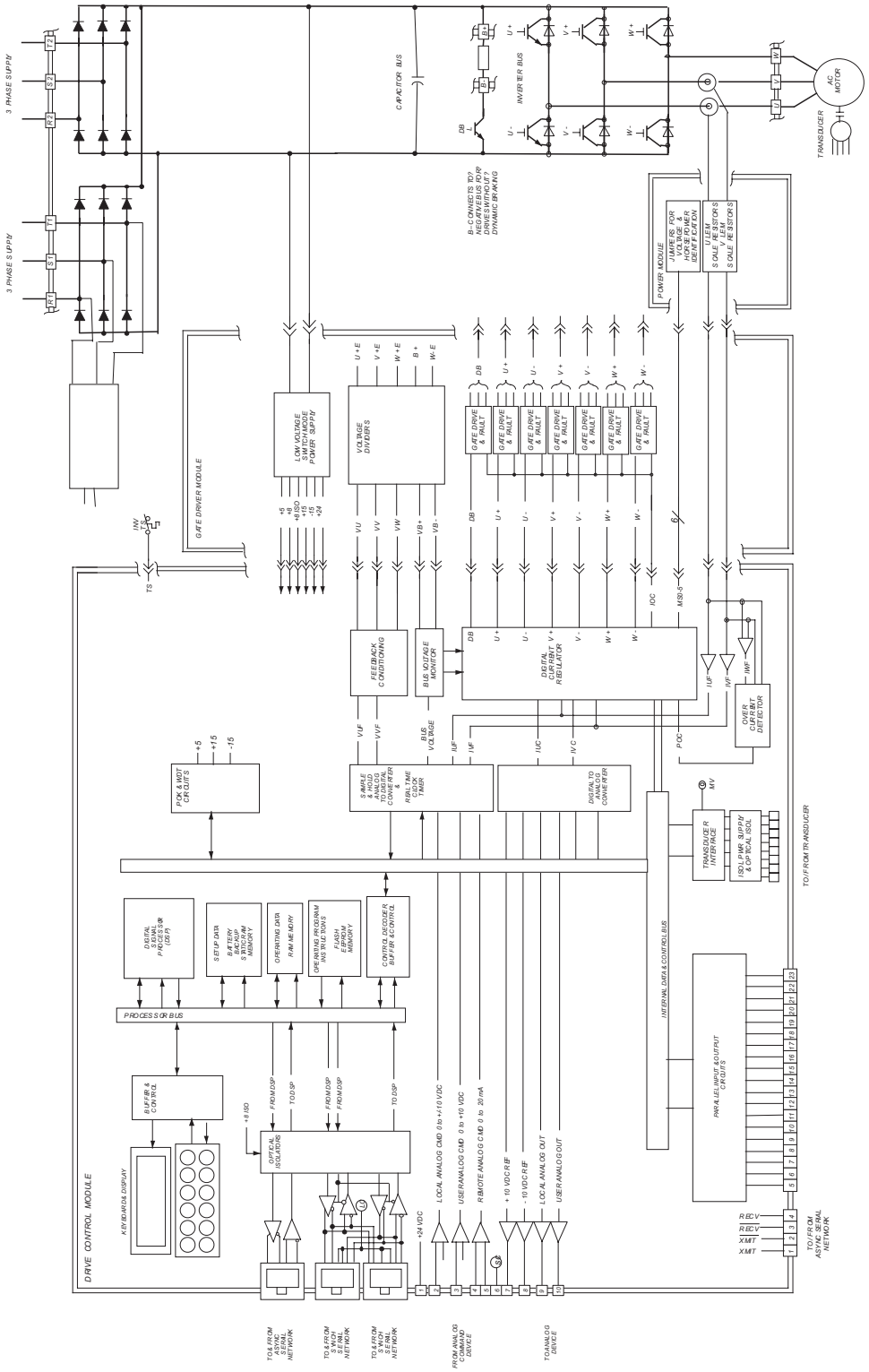


Figure 5-13—1200 Block Diagram (Form 48X)

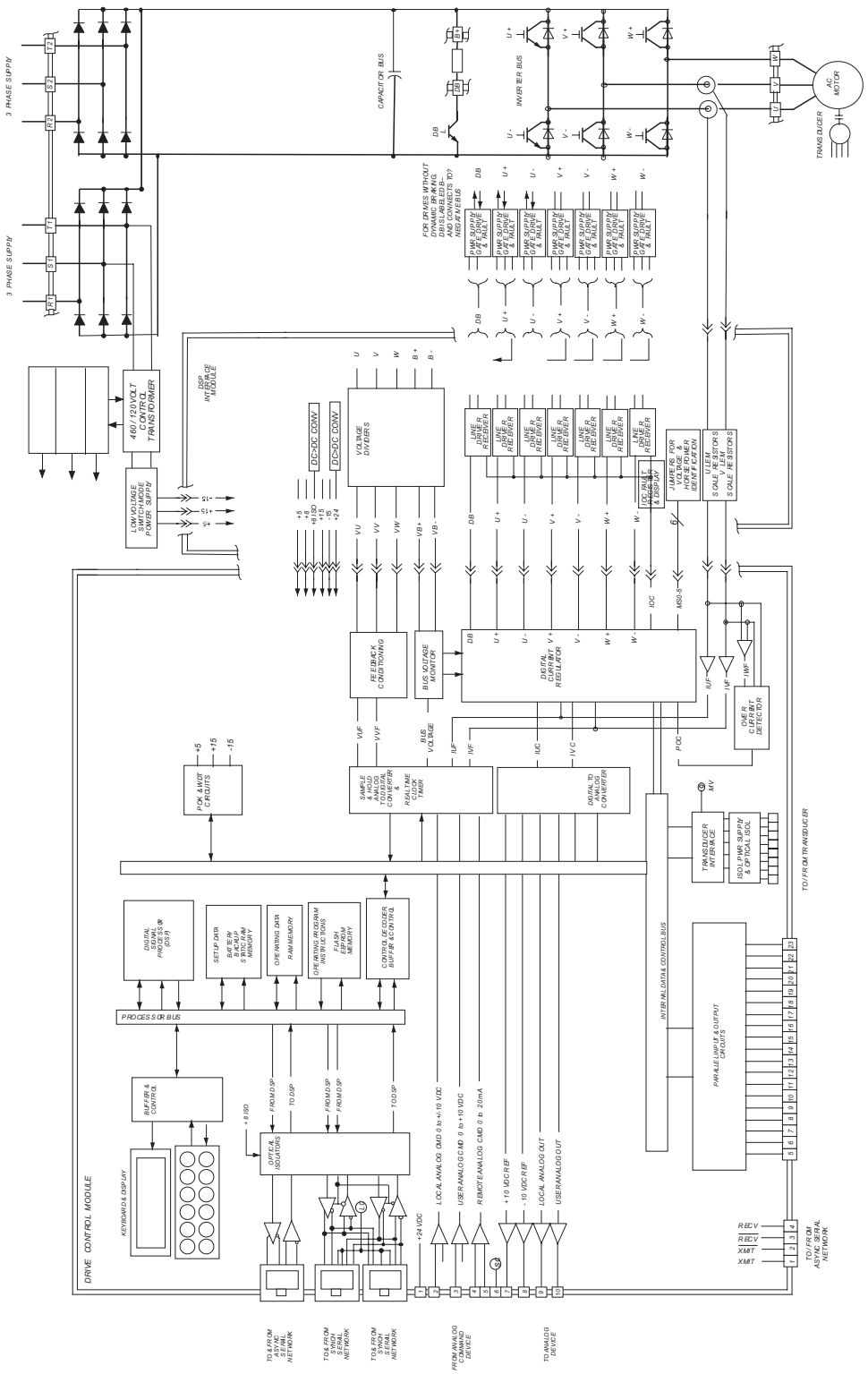
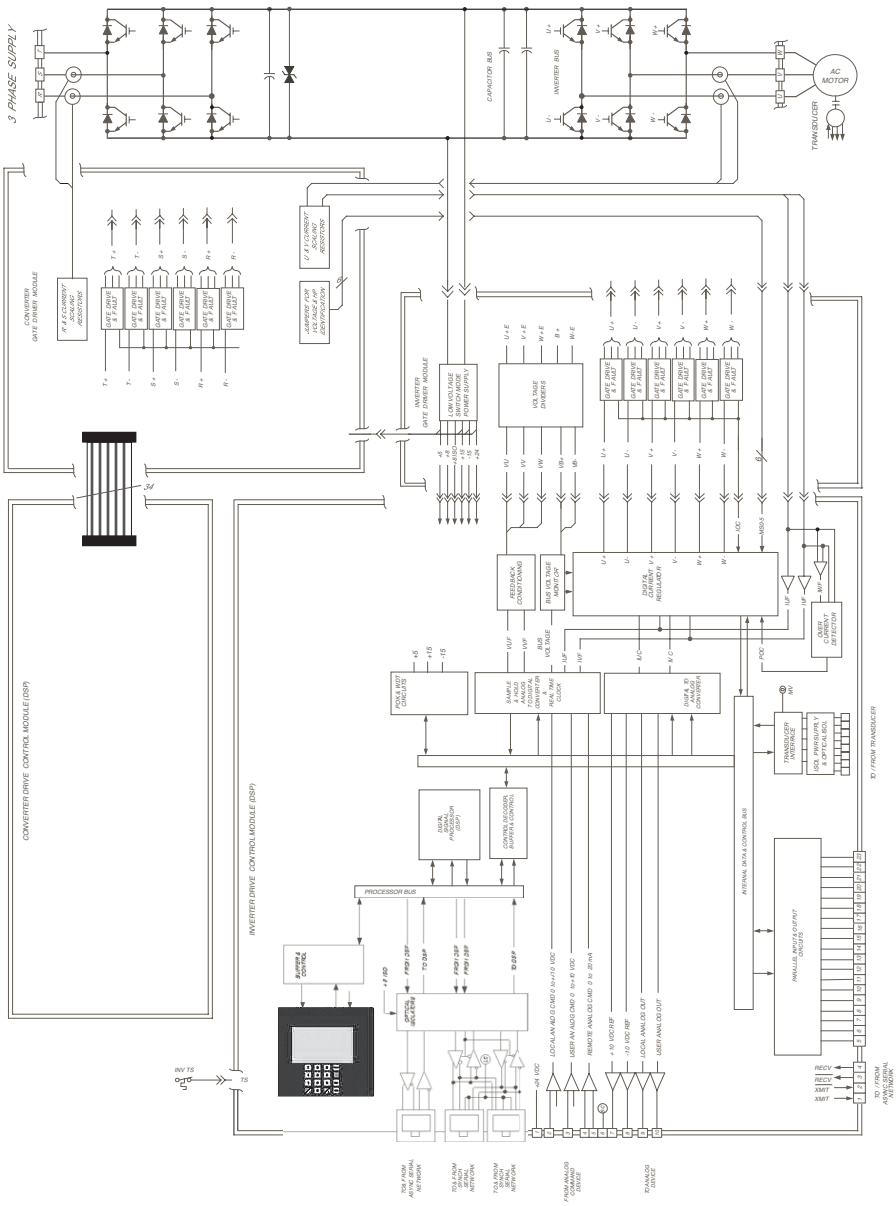


Figure 5-14—1230 Block Diagram (Form 17X)



5.2.2 Rectifier Checking Procedure

The rectifier bridge diodes or SCRs can be checked using a multimeter on the diode range by following the procedure outlined below.

Attention

To avoid an electrical shock hazard and possible damage to the equipment, follow all safety instructions listed in the front of this manual, beginning on page i.

[1] **Remove power**
Lock off the incoming power at the main machine disconnect switch. Use an appropriate meter to verify that all DC bus capacitor banks have been discharged to zero volts before proceeding. Set the meter to DC voltage and read across terminals B+ and B–. The reading should be 0 V before any attempt is made to work on the drive.

[2] **Disconnect power board**
Disconnect all wires from terminals R, S, and T. Remove the three-phase fuses from the transformer or unplug the three-phase connector from the Power Board.

[3] **Take readings**
Using a multimeter on the diode range, take each of the readings indicated in Table 5-1 at the bridge rectifier terminals and check for the appropriate meter reading.

[4] **Reconnect power board**
Insert the three-phase fuses or plug in the three-phase connector on the Power Board.

[5] **Take reading**
With the meter, check B+ to the R1 terminal. It should read 0.25 to 0.40 V with (+) lead to R1 and open with (+) lead to B+.

[6] **Replacement**
Any meter reading other than that specified indicates a defective diode or SCR. Replace defective components or the entire drive.

[7] **Reconnect**
Replace all wires to terminals R, S, and T.

5.2.3 Transistor Checking Procedure

The inverter IGBTs can be checked using a multimeter on the diode range by following the procedure outlined below.

Attention

To avoid an electrical shock hazard and possible damage to the equipment, follow all safety instructions listed in the front of this manual, beginning on page i.

---

[8] **Remove power**

Lock off the incoming power at the main machine disconnect switch. Use an appropriate meter to verify that all DC bus capacitor banks have been discharged to zero volts before proceeding. Set the meter to DC voltage and read across terminals B+ and B–. The reading should be 0 V before any attempt is made to work on the inverter.

[9] **Disconnect wires**

Disconnect all wires from terminals B+, B–, U, V, and W.

[10] **Take readings**

Using a multimeter on the diode range, take each of the readings indicated in Table 5-2 and compare them with the proper values.

[11] **Replacement**

Any meter reading other than that specified indicates a defective transistor or diode. Replace defective components or the entire drive.

[12] **Reconnect**

Replace all wires to terminals B+, B–, U, V, and W.

Table 5-1—Rectifier Checking Terminal Readings

Ohmmeter (+) Lead	Ohmmeter (–) Lead	Proper Meter Reading	Transistor Checked
Bus +	R1, R2	Open	SCR R1+, R2+
Bus +	S1, S2	Open	SCR S1+, S2+
Bus +	T1, T2	Open	SCR T1+, T2+
R1, R2	Bus –	Open	DR1–, DR2–
S1, S2	Bus –	Open	DS1–, DS2–
T1, T2	Bus –	Open	DT1–, DT2–
R1, R2	Bus +	Open	SCR R1+, R2+
S1, S2	Bus +	Open	SCR S1+, S2+
T1, T2	Bus +	Open	SCR T1+, T2+
Bus –	R1, R2	0.25 V to 0.40 V	DR1–, DR2–
Bus –	S1, S2	0.25 V to 0.40 V	DS1–, DS2–
Bus –	T1, T2	0.25 V to 0.40 V	DT1–, DT2–

Table 5-2—Transistor Checking Terminal Readings

Ohmmeter (+) Lead	Ohmmeter (–) Lead	Proper Meter Reading	Transistor Checked
Bus +	B–	Open	Ddb flyback
Bus +	U	Open	QU+
Bus +	V	Open	QV+
Bus +	W	Open	QW+
B–	Bus –	Open	Qdb
U	Bus –	Open	QU–
V	Bus –	Open	QV–
W	Bus –	Open	QW–
B–	Bus +	0.25 V to 0.40 V	Ddb flyback
U	Bus +	0.25 V to 0.40 V	QU+
V	Bus +	0.25 V to 0.40 V	QV+
W	Bus +	0.25 V to 0.40 V	QW+
Bus –	B–	Forms 1, 2, and 3: Open Form 4: 0.25 V to 0.40 V	Qdb
Bus –	U	0.25 V to 0.40 V	QU–
Bus –	V	0.25 V to 0.40 V	QV–
Bus –	W	0.25 V to 0.40 V	QW–

5.3 Maintenance

The drive requires virtually no maintenance. Once the unit has been commissioned, an occasional routine inspection should be sufficient.

5.3.1 Working Life

Unico asserts that the working life of the product will be at least a five-year period from the date of purchase. Service, repair, and component replacement will be available from Unico to support the equipment for a minimum of five years.

5.3.2 Battery Life

Batteries supply nonvolatile memory while power is removed. Battery life is calculated at about ten years, but a typical installation is likely to operate for a longer period.

5.3.3 Disposal

Unico encourages proper recycling of this unit. Metal parts can be recycled. Plastic parts can either be recycled or burned under controlled conditions as regulated locally. If recycling is not feasible, all parts, except for the capacitors used in the DC bus circuit, can be taken to a refuse dump. The capacitors contain an electrolyte that is classified as hazardous waste. Contact local authorities for regulations and proper procedures for their disposal.

5.4 Parts and Repairs

Spare parts, around-the-clock emergency replacement parts, and repair services are available from the factory.

Department	Telephone	Hours
Parts	262.504.7792	Monday–Friday, 7:30 a.m.–5 p.m. Central Time
Emergency parts	262.886.5678	Nights, weekends, and holidays
Repairs	262.504.7365	Monday–Friday, 7:30 a.m.–5 p.m. Central Time
Parts/repairs fax	262.504.7777	

5.4.1 Parts

Replacement parts are stocked at the factory. Emergency parts are sometimes available through regional sales and service offices as well. For advice on which parts to stock, please contact the Parts Department.

Ordering Parts

When calling the Parts Department, please be prepared to provide the Unico part number and quantity requested for each item, an approved purchase order number, and bill-to and ship-to instructions. The Unico system number should also be provided to assist in identifying system-specific parts. Parts with selectable or programmable functions and/or software may require additional information, such as program and revision numbers.

Parts Warranty

New Unico manufactured parts are covered by a 24-month warranty from the date of shipment. Refurbished Unico parts are covered by a 12-month warranty from the date of shipment unless specifically sold with special warranty terms. Non-Unico manufactured parts supplied by Unico will be covered only by the original manufacturers' warranties. All warranties are F.O.B. Franksville, Wisconsin.

Consignment Parts for Warranty Exchange

In cases of a suspected warranty failure of a part within six months of the original sale, Unico will attempt to provide a replacement part for exchange if available. If you are sent a consignment exchange part, you will have 30 days to return the original failed part to Unico. Failure to return the exchanged parts for credit within the specified terms may result in a void of the credit. The consignment order number should be used as the return authorization number and be recorded on the shipment paperwork. Product failure information, such as symptoms or information pertaining to the failure, should also be provided for each part. When Unico receives the exchanged parts, they will be scheduled for repair. When the repair is completed, a credit will be issued to clear the consignment invoice; however, if the part is determined to be damaged in a manner not covered by warranty, you will be contacted and given an explanation of the charges.

5.4.2 Repairs

Return Procedure

All products returned to Unico must have prior authorization. Call the Repair Department to obtain a return material authorization (RMA) number. Be prepared to provide a purchase order number and, for each repair item, the Unico part and serial numbers and an explanation of the priority of the repair. Tag each part with the RMA number and a description of the failure, including any symptoms or other information that may help us determine the cause of the failure. Mark the RMA number clearly on the shipping carton and ship to: Unico, Inc., Repair Department, 3725 Nicholson Road, Franksville, WI 53126-0505. Packages will not be accepted without RMA numbers.

Scheduling

If your equipment is down, Unico can schedule an immediate rush repair of the part when it arrives. A 25% special handling fee will be added to the repair price for rush repair service unless the repair is covered by warranty. Regular repairs are scheduled in the master repair schedule and prioritized by date received. A two- to eight-week turnaround can be expected, depending upon departmental loading. Larger assemblies, motors, inactive or obsolete parts, and non-Unico manufactured items may take longer in order to secure repair components. Repaired parts are returned with a report that provides information on the repair and includes our finding on the suspected cause of the failure. Multiple-part repair orders are shipped complete unless we receive instructions to make multiple shipments.

Repair Warranty

Warranty repairs are performed only at the factory or, if approved, at authorized service centers. Unico-manufactured items repaired under warranty receive the balance of the original Unico warranty. Non-warranty repairs of active Unico-made products receive a 12-month parts-and-labor warranty from the date of the repair. Non-warranty repairs of inactive Unico-made products receive a 90-day parts-and-labor warranty on the module or assembly and a 12-month warranty on the parts and labor for components replaced during the repair. Repairs of obsolete Unico-made products are limited to a 90-day parts-and-labor warranty on components replaced during the repair and may be limited to a credit of the repair charges only.

Table 5-3—Control and Interface Modules

Component	Order Code	Part Number
Control Modules		
16 MHz Control Module with VFD control	V00	322-340
20 MHz Control Module with DCR control	F0x	321-101
20 MHz Control Module with DSV control	F2x	321-516
40 MHz Control Module with logic I/O control	S2x	322-157
100 MHz Control Module with logic I/O control	J2x, J5x, J7x	323-546
100 MHz Control Module with logic I/O control and encoder	J21, J2B, J51, J5B, J71, J7B	323-397
270 MHz Control Module with logic I/O control and encoder	K21, K2B, K51, K5B, K71, K7B	324-260
Compact 100 MHz Control Module with logic I/O control	M2x, M5x, M7x	323-656
Compact 100 MHz Control Module with logic I/O control and encoder	M21, M51, M71	323-060
Compact 150 MHz Control Module with logic I/O control and encoder	N0x, N7x	323-667
I/O Fanning Strip		
12-input/6-output fanning strip	—	708-295
Keypad/Displays		
12-key (2 x 6) keypad with 2 x 24 character display	—	203-045
16-key (4 x 4) keypad with 2 x 24 character display	—	203-046
16-key (4 x 4) keypad with graphic display	—	203-181
Interface Modules		
Encoder Interface Module (5 V)	xx1	316-887
Dual Encoder Interface Module (5 V)	xx2	321-952
Resolver Interface Module with Encoder Emulation	xx3	322-096
Analog Interface Module	xx9	321-557
Anybus® ControlNet™ communication module	—	924-176
Anybus® DeviceNet™ communication module	—	924-027
Anybus® Ethernet communication module	—	924-024
Anybus® Interbus communication module	—	924-175
Anybus® LonWorks® communication module	—	924-177
Anybus® ModBus® Plus communication module	—	924-178
Anybus® Profibus DPV1 communication module	—	924-025
Anybus® Profibus Master communication module	—	925-925
MaxStream™ 900 MHz wireless communication module	—	924-185
MaxStream™ 2.4 GHz wireless communication module	—	924-186
Memory expansion module	—	323-863

Table 5-4—I/O Converter Modules

Device	Voltage Range	Order Code	Part Number
Input converter	90 to 140 V AC	AI1	912-688
Input converter	180 to 280 V AC	AI2	919-808
Output converter	12 to 140 V AC	AO1	913-108
Output converter	180 to 280 V AC	AO2	919-809
Input converter	2.5 to 28 V DC	DCI	913-109
Output converter	5 to 60 V DC	DCO	913-110
Normally open relay	0 to 30 V DC, 0 to 250 V AC	NOR	915-282
Normally closed relay	0 to 30 V DC, 0 to 250 V AC	NCR	921-332
Pass-through jumper	—	—	922-084

Table 5-5—Drive Assemblies (1100 and 1105)

Power CT *hp (kW)*	1100 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB	1105 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB
230 V								
1 1/2 (1.1)	320-879	321-270	321-390	321-404	—	321-157	—	321-170
2 (1.5)	320-880	321-271	321-391	321-405	—	321-158	—	321-171
3 (2.2)	320-881	321-272	321-392	321-406	—	321-159	—	321-172
5 (3.7)	320-882	321-273	321-393	321-407	—	321-160	—	321-173
7 1/2 (5.5)	320-329	321-274	321-394	321-408	—	321-161	—	321-174
10 (7.5)	320-330	321-275	321-395	321-409	—	321-233	—	321-234
15 (11)	320-331	321-276	321-396	321-410	—	321-858	—	321-859
20 (15)	320-332	321-277	321-398	321-411	—	322-033	—	322-034
25 (18)	320-333	321-278	321-399	321-412	—	—	—	—
30 (22)	320-334	321-279	321-400	321-413	—	—	—	—
40 (30)	320-335	321-280	321-401	321-414	—	—	—	—
50 (37)	320-336	321-281	321-402	321-415	—	—	—	—
60 (45)	320-337	321-282	321-403	321-416	—	—	—	—
460 V								
1 1/2 (1.1)	320-883	321-283	321-417	321-438	—	321-162	—	321-175
2 (1.5)	320-884	321-284	321-418	321-439	—	321-163	—	321-176
3 (2.2)	320-885	321-285	321-419	321-440	—	321-164	—	321-177
5 (3.7)	320-886	321-316	321-420	321-441	—	321-165	—	321-178
7 1/2 (5.5)	320-887	321-287	321-421	321-442	—	321-166	—	321-179
10 (7.5)	320-888	321-288	321-422	321-443	—	321-167	—	321-180
15 (11)	320-338	321-289	321-423	321-444	—	321-168	—	321-181
20 (15)	320-339	321-290	321-424	321-445	—	321-169	—	321-182
25 (18)	320-340	321-291	321-425	321-446	—	323-084	—	323-085
30 (22)	320-341	321-292	321-426	321-447	—	322-363	—	322-364
40 (30)	320-342	321-293	321-427	321-448	—	322-365	—	322-366
50 (37)	320-343	321-294	321-428	321-449	323-125	323-119	323-137	323-130

(continued)

Table 5-5—Drive Assemblies (1100 and 1105) *(continued)*

Power CT *hp (kW)*	1100 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB	1105 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB
460 V								
60 (45)	322-450	322-454	322-458	322-462	323-126	323-120	323-138	323-132
75 (55)	322-451	322-455	322-459	322-463	323-127	323-121	323-139	323-133
100 (75)	322-452	322-456	322-460	322-464	320-346	321-297	321-431	321-452
125 (90)	322-453	322-457	322-461	322-465	323-129	323-123	323-141	323-135
150 (110)	321-866	321-871	320-465	320-761	323-588	323-124	323-589	323-136
200 (150)	321-867	321-872	320-466	320-762	—	—	—	—
250 (185)	321-868	321-873	320-467	320-763	—	—	—	—
300 (225)	321-869	321-874	320-468	320-764	—	—	—	—
350 (262)	321-870	321-875	320-758	320-765	—	—	—	—
400 (300)	323-398	323-684	323-399	323-685	—	—	—	—
575 V								
1 1/2 (1.1)	321-138	321-299	321-459	321-480	—	322-919	—	322-904
2 (1.5)	321-139	321-300	321-460	321-481	—	322-920	—	322-905
3 (2.2)	321-140	321-301	321-461	321-482	—	322-921	—	322-906
5 (3.7)	321-141	321-302	321-462	321-483	—	322-922	—	322-907
7 1/2 (5.5)	321-142	321-303	321-463	321-484	—	322-923	—	322-908
10 (7.5)	321-143	321-304	321-464	321-485	—	322-924	—	322-909
15 (11)	321-144	321-305	321-465	321-486	—	322-925	—	322-910
20 (15)	321-145	321-306	321-466	321-487	—	322-926	—	322-911
25 (18)	321-146	321-307	321-467	321-488	—	322-927	—	322-996
30 (22)	321-147	321-308	321-468	321-489	—	322-928	—	322-997
40 (30)	321-148	321-309	321-469	321-490	—	323-142	—	323-154
50 (37)	321-149	321-310	321-470	321-491	323-151	323-143	323-163	323-155
60 (45)	321-150	321-311	321-471	321-492	323-152	323-144	323-164	323-156
75 (55)	321-151	321-312	321-472	321-493	323-153	323-145	323-165	323-157
100 (75)	321-152	321-313	321-473	321-494	323-750	323-146	323-754	323-158
125 (90)	321-153	321-314	321-474	321-495	323-751	323-147	323-755	323-159

(continued)

Table 5-5—Drive Assemblies (1100 and 1105) ***(continued)***

Power CT *hp (kW)*	1100 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB	1105 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB
575 V								
150 (110)	321-876	321-881	320-470	320-768	323-752	323-148	323-756	323-160
200 (150)	321-877	321-882	320-471	320-769	323-753	323-149	323-757	323-161
250 (185)	321-878	321-883	320-472	320-770	—	—	—	—
300 (225)	321-879	321-884	320-473	320-771	—	—	—	—
350 (262)	321-880	321-885	320-759	320-772	—	—	—	—
400 (300)	323-400	323-855	323-401	323-856	—	—	—	—

Table 5-6—Drive Assemblies (1110, 1120, and 1130)

Power CT *hp (kW)*	1110 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB	1120 Chassis	Enclosed	1130 Chassis w/RB	Enclosed w/RB
230 V								
1 1/2 (1.1)	319-261	321-566	321-589	321-612	323-895	321-866	—	—
2 (1.5)	319-262	321-567	321-590	321-613	323-896	321-867	—	—
3 (2.2)	319-263	321-568	321-591	321-614	323-897	321-888	—	—
5 (3.7)	319-264	321-569	321-592	321-615	323-898	321-889	—	—
7 1/2 (5.5)	319-265	321-570	321-593	321-616	323-899	321-890	323-353	320-698
10 (7.5)	319-266	321-571	321-594	321-617	323-900	321-891	323-354	320-289
15 (11)	319-267	321-572	321-595	321-618	323-901	321-892	323-355	320-290
20 (15)	319-268	321-573	321-596	321-619	323-902	321-893	323-356	320-291
25 (18)	319-269	321-574	321-597	321-620	323-903	321-894	323-357	320-292
30 (22)	319-270	321-575	321-598	321-621	323-904	321-895	323-358	320-293
40 (30)	322-102	322-103	322-104	322-105	323-905	321-896	323-359	320-294
50 (37)	—	—	—	—	323-906	321-897	323-360	320-295
60 (45)	—	—	—	—	323-907	321-898	323-361	320-296

(continued)

Table 5-6—Drive Assemblies (1110, 1120, and 1130) *(continued)*

Power CT *hp (kW)*	1110 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB	1120 Chassis	Enclosed	1130 Chassis w/RB	Enclosed w/RB
460 V								
1 1/2 (1.1)	319-271	321-576	321-599	321-622	323-911	321-899	—	—
2 (1.5)	319-273	321-577	321-600	321-623	323-912	321-900	—	—
3 (2.2)	319-274	321-578	321-601	321-624	323-913	321-901	—	—
5 (3.7)	319-275	321-579	321-602	321-625	323-914	321-902	—	—
7 1/2 (5.5)	319-276	321-580	321-603	321-626	322-990	321-903	323-362	320-718
10 (7.5)	319-277	321-581	321-604	321-627	322-991	321-904	323-363	320-719
15 (11)	319-278	321-582	321-605	321-628	322-788	321-905	323-364	320-720
20 (15)	319-279	321-583	321-606	321-629	322-992	321-906	323-365	320-297
25 (18)	319-280	321-584	321-607	321-630	323-910	321-907	323-366	320-298
30 (22)	319-281	321-585	321-608	321-631	319-959	321-908	323-367	320-299
40 (30)	319-282	321-586	321-609	321-632	319-960	321-909	323-368	320-300
50 (37)	319-283	321-587	321-610	321-633	319-961	321-910	323-369	320-301
60 (45)	319-284	321-588	321-611	321-634	319-962	321-911	323-370	320-302
75 (55)	322-106	322-107	322-108	322-109	319-963	321-912	323-371	320-303
100 (75)	—	—	—	—	319-964	321-913	323-372	320-304
125 (90)	—	—	—	—	323-908	321-947	323-373	321-361

(continued)

Table 5-6—Drive Assemblies (1110, 1120, and 1130) ***(continued)***

Power CT *hp (kW)*	1110 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB	1120 Chassis	Enclosed	1130 Chassis w/RB	Enclosed w/RB
575 V								
7 1/2 (5.5)	—	—	—	—	—	—	323-374	320-725
10 (7.5)	—	—	—	—	—	—	323-375	320-726
15 (11)	—	—	—	—	—	—	323-376	320-727
20 (15)	—	—	—	—	—	—	323-377	320-728
25 (18)	—	—	—	—	—	—	323-378	320-729
30 (22)	—	—	—	—	—	—	323-379	320-730
40 (30)	—	—	—	—	—	—	323-380	320-731
50 (37)	—	—	—	—	—	—	323-381	320-732
60 (45)	—	—	—	—	—	—	323-382	320-733
75 (55)	—	—	—	—	—	—	323-383	320-734
100 (75)	—	—	—	—	—	—	323-384	320-735
125 (90)	—	—	—	—	—	—	323-385	321-362

Table 5-7—Drive Assemblies (1200)

Power CT *hp (kW)*	1200 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB
230 V				
1 1/2 (1.1)	—	323-708	—	323-721
2 (1.5)	—	323-709	—	323-722
3 (2.2)	—	323-710	—	323-723
5 (3.7)	—	323-711	—	323-724
7 1/2 (5.5)	—	323-712	—	323-725
10 (7.5)	—	324-512	—	324-513
15 (11)	—	324-514	—	324-515
20 (15)	—	324-620	—	324-621
460 V				
1 1/2 (1.1)	—	323-714	—	323-727
2 (1.5)	—	323-715	—	323-728
3 (2.2)	—	323-716	—	323-729
5 (3.7)	—	323-717	—	323-730
7 1/2 (5.5)	—	323-718	—	323-731
10 (7.5)	—	323-719	—	323-732
15 (11)	—	323-720	—	323-733
20 (15)	—	324-417	—	324-421
25 (18)	—	324-416	—	324-420
30 (22)	—	324-415	—	324-419
40 (30)	324-392	324-414	—	324-541
50 (37)	324-393	324-643	324-672	324-676
60 (45)	324-394	324-644	324-673	324-677
75 (55)	324-395	324-645	324-674	324-678
100 (75)	324-135	324-646	324-675	324-679
125 (90)	324-142	324-431	324-430	324-647
150 (110)	324-143	324-432	324-433	324-648

(continued)

Table 5-7—Drive Assemblies (1200) *(continued)*

Power CT *hp (kW)*	1200 Chassis w/o DB	Chassis w/DB	Enclosed w/o DB	Enclosed w/DB
460 V				
200 (150)	324-434	324-435	324-436	324-437
250 (185)	324-688	324-689	324-762	324-763
300 (225)	324-397	—	324-438	—
400 (300)	324-399	—	324-439	—
500 (375)	324-400	—	324-440	—
600 (450)	324-288	—	324-441	—

Table 5-8—Drive Assemblies (1230)

Power CT *hp (kW)*	1230 Chassis	Enclosed
460 V		
1 1/2 (1.1)	326-975	—
2 (1.5)	326-976	—
3 (2.2)	326-977	—
5 (3.7)	326-978	—
7 1/2 (5.5)	326-979	—
10 (7.5)	325-519	—
15 (11)	325-255	—
20 (15)	325-256	—
25 (18)	325-257	—
30 (22)	325-258	—
40 (30)	324-706	324-711
50 (37)	324-705	324-710
60 (45)	324-704	324-709
75 (55)	324-703	324-708
100 (75)	324-702	324-707

(continued)

Table 5-8—Drive Assemblies (1230) ***(continued)***

Power CT *hp (kW)*	1200 Chassis	Enclosed
460 V		
125 (90)	324-465	—
150 (110)	324-466	—
200 (150)	324-467	—
250 (185)	324-468	—
300 (225)	324-469	—
400 (300)	324-470	—
500 (375)	324-471	—
600 (450)	324-472	—

UNICO–Worldwide

United States

Corporate Headquarters

Unico, Inc.
3725 Nicholson Rd.
P. O. Box 0505
Franksville, WI
53126-0505

262.886.5678
262.504.7396 *fax*

www.unicous.com

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Bucharest, Romania
40.728.664.830

Asia
Beijing, China
86.10.6218.6365

Osaka, Japan
81.66.945.0077

Australia
CMG Pty., Ltd.
Rowville, Victoria
61.3.9237.4000