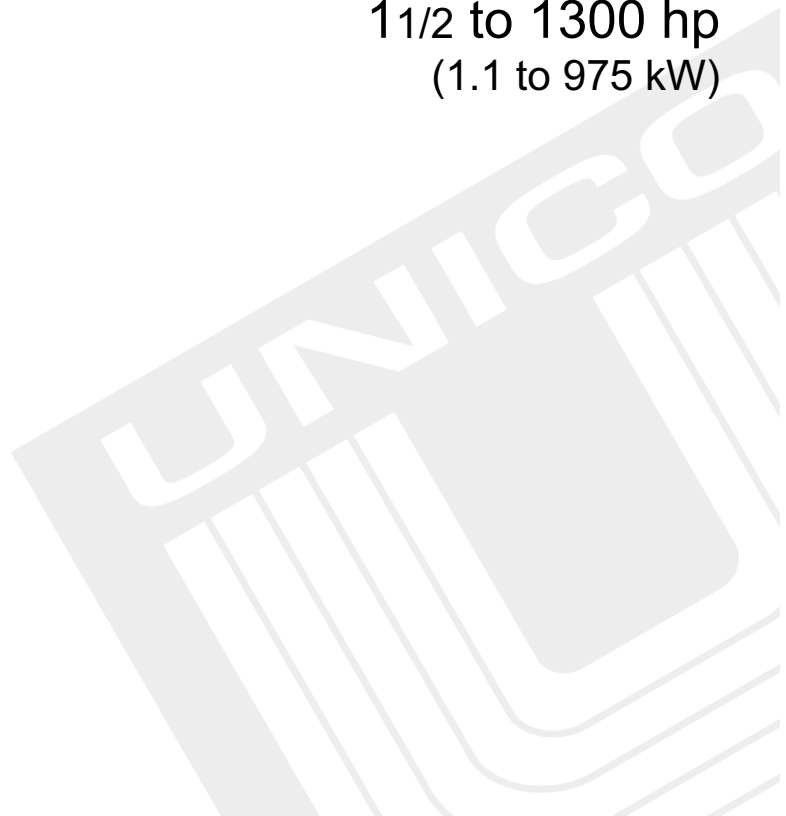


2400 / 2420 / 2450
Performance Drives



Guide to Installation, Troubleshooting, and Maintenance

1 1/2 to 1300 hp
(1.1 to 975 kW)



Notices

Copyright © 2002 by UNICO, Incorporated.

All rights reserved. No part of this publication may be copied, reproduced, or reduced to any electronic media or machine-readable format without the prior written permission of UNICO, Inc.

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.

All trade designations are provided without reference to the rights of their respective owners.

Printed in the United States of America.

Table of Contents

| | |
|--|------------|
| Safety Information | i |
| Overview | i |
| Conventions Used | i |
| General Precautions | ii |
| Installation Precautions | iii |
| Application Precautions | iv |
| Service Precautions | v |
| | |
| 1 About the Manual | 1-1 |
| 1.1 Overview | 1-1 |
| 1.2 Contents | 1-1 |
| 1.2.1 Intended Audience | 1-2 |
| | |
| 2 Product Overview | 2-1 |
| 2.1 Overview | 2-1 |
| 2.2 Unpacking | 2-1 |
| 2.2.1 Verify delivery | 2-2 |
| 2.2.2 Inspect for damage..... | 2-2 |
| 2.2.3 Storage/Transportation | 2-2 |
| 2.2.4 Nameplate Identification | 2-3 |
| 2.3 Family Overview | 2-5 |
| 2.3.1 Features | 2-6 |
| 2.3.2 Drive Architecture | 2-8 |
| 2.4 Specifications..... | 2-12 |
| | |
| 3 Mechanical Installation | 3-1 |
| 3.1 Overview | 3-1 |
| 3.2 Forms..... | 3-1 |
| 3.3 Installation Site Considerations..... | 3-1 |
| 3.3.1 Enclosure | 3-1 |
| 3.3.2 Operating Environment | 3-1 |
| 3.3.3 Cooling | 3-2 |
| 3.4 Layout Considerations..... | 3-4 |
| 3.4.1 Dimensions and Weights | 3-4 |
| 3.4.2 Space Requirements | 3-4 |
| 3.4.3 Arrangement and Orientation..... | 3-4 |
| 3.4.4 Cable Routing | 3-5 |
| 3.5 Installation Procedure | 3-6 |
| 3.5.1 Flush Mounting (all forms) | 3-6 |
| 3.5.2 Foot Mounting (Forms 5, 6, and 7) | 3-6 |
| 3.5.3 Flange Mounting (Forms 5, 6, and 7)..... | 3-7 |
| 3.5.4 Bus and Ground Bars (Forms 5, 6, and 7)..... | 3-7 |

| | | |
|----------|---|------------|
| 4 | Electrical Installation..... | 4-1 |
| 4.1 | Overview | 4-1 |
| 4.2 | Wiring Standards and Codes | 4-1 |
| 4.3 | Insulation Tests | 4-1 |
| 4.4 | Ground Connections | 4-2 |
| 4.4.1 | Ground the Drive Units | 4-2 |
| 4.4.2 | Ground the Power Supply | 4-3 |
| 4.4.3 | Ground the Isolation Transformer..... | 4-3 |
| 4.4.4 | Ground the Motor and Transducer..... | 4-3 |
| 4.4.5 | Ground the 115 V AC Supply | 4-3 |
| 4.4.6 | Connect the Control Grounds..... | 4-3 |
| 4.5 | Input Power Supply Connections (2420 and 2490)..... | 4-4 |
| 4.5.1 | Power Source Conditioning | 4-5 |
| 4.5.2 | Connect the Power Supply | 4-6 |
| 4.5.3 | Input Protection..... | 4-6 |
| 4.6 | Motor Connections (2400, 2420, and 2450)..... | 4-8 |
| 4.6.1 | Motor Field Power Supply (2450 only)..... | 4-8 |
| 4.7 | Dynamic Braking Connections (2420, 2490, and 2491)..... | 4-9 |
| 4.7.1 | Dynamic Braking Resistor | 4-9 |
| 4.7.2 | Fiber-Optic Interface (2491 only)..... | 4-10 |
| 4.8 | DC Bus Connections (all units)..... | 4-10 |
| 4.8.1 | Bus Discharge Circuit..... | 4-11 |
| 4.9 | 115 V AC Power Supply Connections (all units except 2493)..... | 4-16 |
| 4.10 | Converter Interface Connections..... | 4-20 |
| 4.11 | Control Module Connections | 4-36 |
| 4.11.1 | Wiring Precautions | 4-36 |
| 4.11.2 | Asynchronous Serial Connections | 4-41 |
| 4.11.3 | Synchronous Serial Interface (SSI) Connections | 4-43 |
| 4.11.4 | Real-Time Clock Connections | 4-45 |
| 4.11.5 | Analog I/O Connections | 4-46 |
| 4.11.6 | Digital I/O Connections..... | 4-47 |
| 4.11.7 | Incremental Encoder Interface Connections (Expandable Control Module) | 4-50 |
| 4.12 | Feedback Modules | 4-51 |
| 4.12.1 | Incremental Encoder (5 V / 317685 and 15 V / 320106)..... | 4-51 |
| 4.12.2 | Incremental Encoder with Repeater (5 V / 317241)..... | 4-51 |
| 4.12.3 | Serial Sincos Encoder Interface Modules (Asynchronous / 320448 and Synchronous / 322173)..... | 4-55 |
| 4.12.4 | Resolver Interface Modules..... | 4-56 |
| 4.12.5 | Serial Absolute Encoder Interface (321849) | 4-58 |
| 4.12.6 | Analog Interface Module (319354)..... | 4-59 |
| 4.13 | Communication Modules | 4-61 |
| 4.13.1 | Serial Communication Module (318826) | 4-61 |
| 4.13.2 | Fiber-Optic Communication Module (318816)..... | 4-63 |
| 4.13.3 | Remote I/O Communication Module (317848)..... | 4-65 |
| 4.13.4 | Modbus [®] Plus Communication Module (319788) | 4-67 |
| 4.13.5 | ControlNet [™] Communication Module (321812)..... | 4-68 |
| 4.13.6 | Profibus Communication Module (321560)..... | 4-70 |
| 4.13.7 | Ethernet Communication Module (321228)..... | 4-72 |

| | | |
|----------|--|------------|
| 5 | Troubleshooting/Maintenance | 5-1 |
| 5.1 | Overview | 5-1 |
| 5.2 | Troubleshooting | 5-1 |
| 5.2.1 | Theory of Operation | 5-1 |
| 5.2.2 | Rectifier Checking Procedure (2420 and 2490) | 5-14 |
| 5.2.3 | Transistor Checking Procedure (2400 and 2420)..... | 5-16 |
| 5.3 | Maintenance..... | 5-18 |
| 5.3.1 | Working Life..... | 5-18 |
| 5.3.2 | Battery Life | 5-18 |
| 5.3.3 | Disposal..... | 5-18 |
| 5.3.4 | Spare Parts | 5-18 |

Safety Information

Overview

This section states important safety information that must be followed when installing, operating, and servicing drive units from the 2000 family. Study this information carefully before working on or with the units. Failure to follow these instructions may lead to personal injury, death, or damage to the units, motors, 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 convention is 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 units and their applications should install, start up, operate, troubleshoot, and maintain a drive system. 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 drive units and void the manufacturer's warranty.



Attention

Drive units may be sensitive to electrostatic discharge. Static precautions are required when servicing or repairing a unit.



Attention

If an aluminum electrolytic capacitor in a drive unit 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

Equipment is 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.

Installation Precautions



Attention

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



Attention

To provide protection against electrical shock, drive 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.



Attention

The drive units and associated equipment must be properly earth grounded.



Attention

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



Attention

Drive units are not equipped with supply-disconnecting devices. 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, a drive unit's output terminals may be at dangerous voltage levels whenever input power is applied and the bus is charged.



Attention

Drive unit 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 a drive unit or associated equipment. Do this before touching any electrical or mechanical components.



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 unit or associated equipment. Use an appropriate voltmeter to further verify that capacitors are discharged before beginning work. Do not rely exclusively on bus voltage indicators. Dangerous voltage levels may remain even when the indicators are 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 from UNICO's 2000 family of drives. Specifically, the manual pertains to the units listed in Table 1-1.

Table 1-1—2000 Family

| Model | Description |
|-------|----------------------|
| 2400 | Modular AC Inverter |
| 2420 | Integrated AC Drive |
| 2450 | Modular DC Amplifier |
| 2490 | Modular Converter |
| 2491 | Dynamic Brake |
| 2493 | Capacitor Bank |

What's covered

- *Safety Instructions*, discusses safety hazards and procedures important to anyone working with the drive units
- Chapter 2, *Product Overview*, tells how to receive drive units and provides an overview of their architecture, features, and specifications
- Chapter 3, *Mechanical Installation*, provides instructions on physically installing drive units
- Chapter 4, *Electrical Installation*, explains how to make electrical connections
- Chapter 5, *Troubleshooting/Maintenance*, covers basic hardware troubleshooting and maintenance and lists field-replaceable components

What's not covered

This manual does not address aspects of the drive units that depend upon 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 features and modes of operation
- Parameter descriptions
- Detailed 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, operating, or maintaining drive units. 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.

Follow instructions

You can prevent injury and damage to the drive units 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 both this manual *and* the application manual entirely before installing drive units.

2 Product Overview

2.1 Overview

This chapter provides an overview of the 2000 family of drives. The 2000 family consists of both modular drives, which are made up of separate converter and either inverter or amplifier sections, as well as integrated drives that combine those sections. The term *unit* refers to any of these modular or integrated components. The chapter provides instructions on unpacking, identifying, storing, and transporting drive units and familiarizes the user with their basic features, architecture, and specifications.

2.2 Unpacking

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

When unpacking a drive unit, remove any screws that may be securing the unit to its shipping supports. Two or more people are required to safely lift the unit from its packaging.



Attention

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



Attention

Do not lift a unit by its cover, even when it is secured by retaining screws. The cover is not intended to support the weight of the unit. Always rest the unit on its back, never face down or on its side.

2.2.1 Verify delivery

Check that you received the drive unit that was ordered as well as any options or accessories. You should receive two manuals (this installation guide and an application guide) with your order. Contact your supplier regarding any discrepancies.

2.2.2 Inspect for damage

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

2.2.3 Storage/Transportation

If the drive unit must be stored or transported to another location before installation, check that the ambient conditions are acceptable according to Table 2-1. Choose a storage location that is clean, dry, and noncorrosive. Repack and store the unit in its original packaging.

Table 2-1—Storage/Transportation Environment Specifications

| | |
|--------------------|----------------------------------|
| Temperature: | -13° to 158° F (-25° to 70° C) |
| Relative humidity: | 5% to 95%, noncondensing |
| Air pressure: | 20.67" to 31.30" (70 to 106 kPa) |

2.2.4 Nameplate Identification

Each unit is labeled with an identification label that indicates its part number, serial number, and input/output ratings. Sample identification labels are shown in Figure 2-1 through Figure 2-4. Expanded model numbers, similar to those shown in Figure 2-5 through Figure 2-8, are often used in ordering. The expanded model number encodes the type of unit and its configuration, including voltage, power, overload, control type, feedback and packaging options, and application software.

Figure 2-1—Modular AC Inverter Identification Label

| LUNBERG | | ItemNo : 110489 ECL 1 | | 2400 | |
|------------|-------------------|-----------------------|-------|-----------------------|-------|
| SerialNo : | | AC Modular Inverter | | Franklinville, WI USA | |
| INPUT | Horsepower | CT | VT | ET | HP |
| | Kilowatts | 200 | 250 | 300 | 300 |
| | | 150 | 185 | 225 | 185 |
| INPUT | Voltage(DC) | 621 | 621 | 621 | Vdc |
| | Frequency | n/a | n/a | n/a | Hz |
| | Icontinuous | 264 | 330 | 396 | Adc |
| O INPUT | Voltage(3-phase) | 460 | 460 | 460 | Vrms |
| | Frequency | 0-300 | 0-300 | 0-300 | Hertz |
| | Icontinuous | 240 | 300 | 360 | Arms |
| O INPUT | Ioverload(60 sec) | 360 | 360 | 396 | Arms |
| | Imaximum | 480 | 480 | 480 | Arms |
| | Tamb(ctrl/htsnk) | 55/40 | 55/40 | 55/40 | ° C |

| LUNBERG | | ItemNo : 110626 ECL 0 | | 2400 | |
|----------------------------|--|-----------------------|----------|-----------------------|-----|
| SerialNo : | | AC Modular Inverter | | Franklinville, WI USA | |
| <i>Multi-Pole Inverter</i> | | | | | |
| <i>W Pole</i> | | | | | |
| 1 of 3 | | | | | |
| Input : | | Voltage(DC) | 621 Vdc | 513 Vdc | |
| Output : | | Voltage(3-phase) | 460 Vrms | 380 Vrms | |
| Tamb(ctrl/htsnk) | | 55/40 | ° C | 55/40 | ° C |

| LUNBERG | | ItemNo : 110625 ECL 0 | | 2400 | |
|----------------------------|--|-----------------------|----------|-----------------------|-----|
| SerialNo : | | AC Modular Inverter | | Franklinville, WI USA | |
| <i>Multi-Pole Inverter</i> | | | | | |
| <i>U / V Pole</i> | | | | | |
| 2/3 of 3 | | | | | |
| Input : | | Voltage(DC) | 621 Vdc | 513 Vdc | |
| Output : | | Voltage(3-phase) | 460 Vrms | 380 Vrms | |
| Tamb(ctrl/htsnk) | | 55/40 | ° C | 55/40 | ° C |

Figure 2-2—Integrated AC Drive Identification Label

| LUNBERG | | ItemNo : 108924 ECL 7 | | 2420 | |
|------------|-------------------|-----------------------|-------|-----------------------|------|
| SerialNo : | | AC Drive | | Franklinville, WI USA | |
| INPUT | Horsepower | CT | VT | ET | HP |
| | Kilowatts | 50.0 | 60.0 | --- | 50.0 |
| | | 37.0 | 45.0 | --- | 37.0 |
| INPUT | Voltage(3-phase) | 460 | 460 | --- | Vrms |
| | Frequency | 47-63 | 47-63 | --- | Hz |
| | Icontinuous | 58.0 | 69.2 | --- | Arms |
| O INPUT | Voltage(3-phase) | 460 | 460 | --- | Vrms |
| | Frequency | 0-300 | 0-300 | --- | Hz |
| | Icontinuous | 65.0 | 77.0 | --- | Arms |
| O INPUT | Ioverload(60 sec) | 97.5 | 92.4 | --- | Arms |
| | Imaximum | 130.0 | 130.0 | --- | Arms |
| | Tamb(ctrl/htsnk) | 55/55 | 55/55 | --- | ° C |

Figure 2-3—Modular DC Amplifier Identification Label

| LUNBERG | | ItemNo : 110554 ECL 1 | | 2450 | |
|------------|-------------------|-----------------------|-------|-----------------------|-----|
| SerialNo : | | DC Amplifier | | Franklinville, WI USA | |
| INPUT | Horsepower | CT | VT | | HP |
| | Kilowatts | 125 | 150 | | 110 |
| | | 90 | 110 | | 90 |
| INPUT | Voltage(DC) | 621 | 621 | | Vdc |
| | Frequency | n/a | n/a | | Hz |
| | Icontinuous | 166 | 198 | | Adc |
| O INPUT | Voltage(DC) | 500 | 500 | | Vdc |
| | Icontinuous | 205 | 246 | | Adc |
| | Ioverload(60 sec) | 308 | 295 | | Adc |
| O INPUT | Imaximum | 410 | 410 | | Adc |
| | Ifield(Peak/Cont) | 15/15 | 15/15 | | Adc |
| | Tamb(ctrl/htsnk) | 40/40 | 40/40 | | ° C |

Figure 2-4—Modular Converter Identification Label

| LUNBERG | | ItemNo : 109437 ECL 5 | | 2490 | |
|------------------|-------------------|-----------------------|-------|-----------------------|------|
| SerialNo : | | AC Modular Converter | | Franklinville, WI USA | |
| INPUT | Horsepower | 150 | HP | 150 | HP |
| | Kilowatts | 110 | KW | 110 | KW |
| | | | | | |
| INPUT | Voltage(3-phase) | 460 | Vrms | 380 | Vrms |
| | Frequency | 47-63 | Hz | 47-63 | Hz |
| | Icontinuous | 167 | Arms | 202 | Arms |
| O INPUT | Voltage(DC) | 621 | Vdc | 513 | Vdc |
| | Icontinuous | 198 | Adc | 240 | Adc |
| | Ioverload(60 sec) | 297 | Adc | 360 | Adc |
| O INPUT | Imaximum | 396 | Adc | 480 | Adc |
| | Vdb Turn-On | 750 | Vdc | 750 | Vdc |
| | Idb(cont/max) | 38/300 | Adc | 38/300 | Adc |
| Tamb(ctrl/htsnk) | 55/55 | ° C | 55/55 | ° C | |

Figure 2-5—Modular AC Inverter Model Number

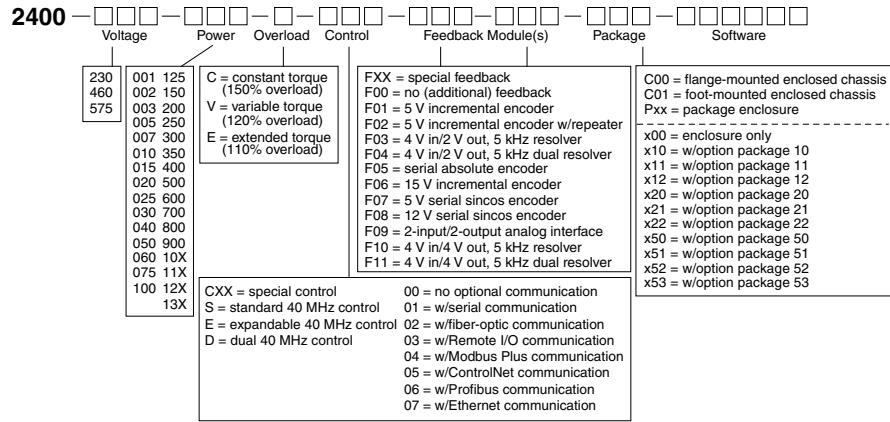


Figure 2-6—Integrated AC Drive Model Number

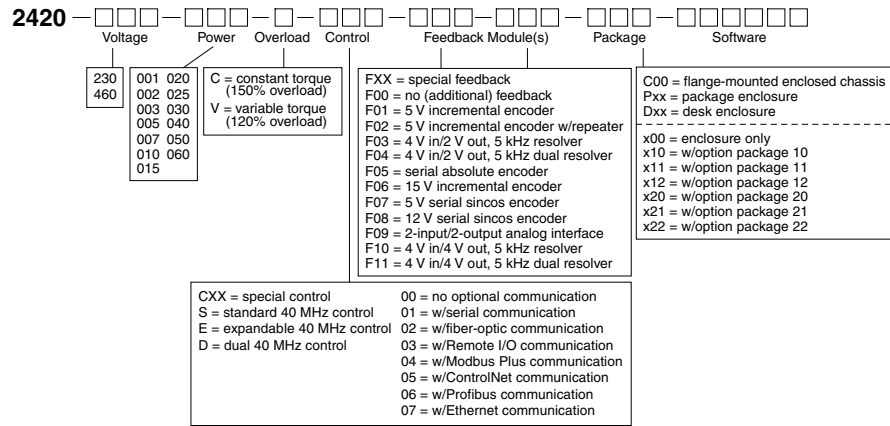


Figure 2-7—Modular DC Amplifier Model Number

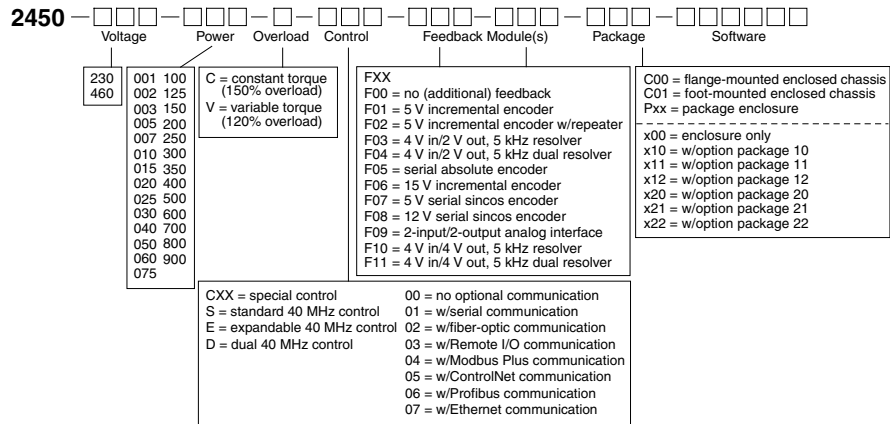
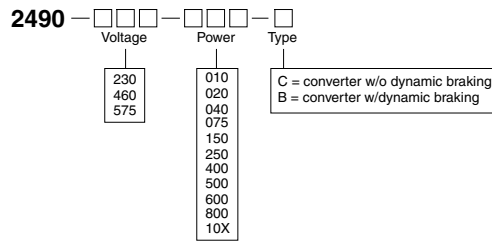


Figure 2-8—Modular Converter Model Number



2.3 Family Overview

The 2000 family of performance drives provides digital control of AC induction, AC synchronous, brushless servo, and DC industrial 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.

The family is comprised of the 2490 modular converters, the 2400 modular AC inverters, the 2420 integrated AC drives, and the 2450 modular DC amplifiers. The drive family shares a common architecture that provides a high degree of internal consistency. By combining this core drive topology in a variety of combinations, the 2000 family furnishes flexible, efficient, and cost-effective solutions to a variety of application needs. Single converters can be used to power multiple AC inverters and/or DC amplifiers using a common bus that allows power to be recirculated between units. Modular inverters can be used in a back-to-back configuration as a regenerative drive. Table 2-2 summarizes the various models within the family.

Table 2-2—2000 Family Summary

| Model | Description | Input Voltages | Power Range |
|-------|----------------------|----------------------|---------------|
| 2400 | Modular AC Inverter | 310/510/620/780 V DC | 1 1/2-1300 hp |
| 2420 | Integrated AC Drive | 230/380/460 V AC | 1 1/2-60 hp |
| 2450 | Modular DC Amplifier | 310/510/620 V DC | 1 1/2-900 hp |
| 2490 | Modular Converter | 230/380/460/575 V AC | 10-1000 hp |

The 2000 family of drives provides several methods of handling regenerative energy produced by overhauling loads or decelerating large inertias. The common-bus architecture allows regenerated energy to recirculate to motoring drives that share the bus connection. Dynamic brake devices are incorporated into the 2490 converters and 2420 drives. Separate 2491 dynamic braking units are available for high-power drives. Optional 2493 capacitor bank units are available for storing and recirculating regenerated energy from cyclic operation of inertial loads.

The 2490 converters and 2420 drives incorporate a link choke to reduce line harmonic currents. Higher-power 2490 units provide optional six-pulse (three-phase) or twelve-pulse (six-phase) connections to meet power quality requirements. The use of 2400 inverters in a regenerative configuration provides near-unity power factor at all loads and speeds.

2.3.1 Features

Motor-Independent Design

A unique design incorporating a proprietary digital current regulator and a state-of-the-art controller allows the 2000 family of drives to operate any AC induction, AC synchronous, brushless servo, or DC industrial motor without the current-loop setup required by conventional drives. Digital space vector control can be selected for reduced motor noise and low current ripple.

Application Flexibility

The 2000 family is extremely flexible and can accommodate a wide range of servo applications. It can be configured to control torque, velocity, or position in applications requiring either constant-, variable-, or extended-torque. Extensive controller options enable the analog and digital I/O, feedback, and serial communication capabilities of the drive to be tailored to the requirements of the application.

Auto Tuning

Once routine electrical connections have been made, simple-to-use auto-tuning features adjust virtually all motor and inertial parameters to the given motor and connected load. Simply enter a few values from the motor nameplate, and the advanced setup routines do the rest. The drive is completely tuned within minutes.

Modular Design

The modular bus design of the 2000 family provides space, cost, and energy savings in many applications. A drive system incorporates a separate 2490 converter unit that rectifies incoming AC power to provide a common DC bus. The converter is comprised of a full-wave diode or SCR bridge, a link choke, a bus-charging circuit, a dynamic braking circuit, and a capacitor bank. The 2400 AC inverters and 2450 DC amplifiers consist of IGBT-based, four-quadrant PWM amplifiers that operate from the DC bus of the converter unit. High-power 2400 AC inverters are comprised of three separate poles, while 2450 DC amplifiers consist of two separate poles.

Energy Savings

Multiple 2400 AC inverters and 2450 DC amplifiers can be operated from a single 2490 converter unit. This allows applications that naturally share regenerative energy, such as an uncoiler and recoiler, to reuse the energy, rather than dissipate it as heat through resistors. A much smaller converter is therefore needed than would be required using two integrated drives. Alternately, an inverter can be used in place of the converter to regenerate power to the line. In cyclic applications, an optional capacitor bank can be used to store regenerated energy and to return stored energy to the load.

Power Quality

The 2000 family drives incorporate built-in link chokes that provide near-unity overall power factor and low harmonic line currents at all motor speeds. High-power units also offer a six-phase (twelve-pulse) configuration for further minimizing line harmonics in critical applications. When a regenerative inverter is used in place of the converter, a unity power factor is achieved and virtually all harmonic currents are eliminated.

Application-Specific Software

Application software determines the specific features and operation of a drive. A wide variety of general-purpose and application-engineered software options enables each drive to be tailored to specific customer requirements. Software is available for such applications as test stands, elevators, press feeders, winders, rotary cutoffs, spindles, flying cutoffs, and wire drawing, to name a few. Further customization is possible with many programs using *UEdit™*, a Windows-based programming tool that allows users to extend an application using ladder diagrams and function blocks.

Optically Isolated Digital I/O

All digital inputs and outputs are optically isolated. Depending upon the controller, as many as 32 individually isolated digital I/O are provided, each of which can be programmed by the application to be an input or output. The voltage of each can be chosen from a wide range of AC and DC values.

Transducer/Transducerless Design

The 2000 family drives can operate with or without a feedback transducer. An incremental encoder is typically used for feedback, although absolute encoders, resolvers, and serial sincos encoders are also supported. Transducerless operation is offered for less demanding velocity-loop applications.

Serial Communications

Each drive includes a synchronous serial port for drive coordination and an asynchronous serial port for general-purpose communication with process controllers, communication networks, programmable controllers, and personal computers. Optional modules provide connection to Remote I/O, ControlNet, Profibus, Modbus Plus, and Ethernet communication networks.

Multiaxis Operation

Built-in synchronous communication channels allow drives to provide precisely coordinated torque, velocity, and/or position control. A master clock line is used to synchronize the sampling of data across the entire multidrive system.

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 through the keypad for precision and repeatability. Readouts and fault messages are displayed in plain language.

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 a three-phase AC motor or into variable field and armature voltages for controlling a DC motor.

Drives generally use an input section that handles power flow between an AC line and a DC bus in addition to an output section that controls power flow between the DC bus and an AC or DC motor. The input section of a drive can be either a rectifier or an inverter. The rectifier provides a one-way flow of power from the AC line to the DC bus, while an inverter allows power to flow in both directions.

The 2400 and 2450 drives are constructed as modular units with separate input (rectifier or inverter) and output (inverter or amplifier) sections. The 2420 AC drives are constructed as stand-alone integrated units that combine input (rectifier) and output (inverter) sections. Nonregenerative drives use a 2490 converter to provide a rectified DC bus to power one or more 2400 AC inverters or 2450 DC amplifiers. Line-regenerative drives use a 2400 AC inverter to provide the power flow between the line and the DC bus for one or more 2400 AC inverters. The basic architecture of nonregenerative and line-regenerative AC and DC drives is shown in Figure 2-9 through Figure 2-13.

The modular construction of the 2000 family allows a single rectifier or inverter to feed a common DC bus. This common-bus architecture minimizes input power requirements by allowing motoring and braking power to circulate between drives. Large inverter and amplifier units are themselves modular for ease of handling. The 2420 combines a rectifier and inverter into a stand-alone drive intended for motoring-type loads. The 2420 can also furnish the bus for a limited drive system of 2400 inverter units.

An input *rectifier section* is used on the nonregenerative 2400, 2420, and 2450 drives to convert the fixed AC line voltage into a DC bus voltage. The rectifier section for the 2400 and 2450 drives is provided by a separate 2490 converter. 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. 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. A *rectifier control* coordinates the charging of the bus and operation of a dynamic brake device.

A *link choke* and *bus capacitors* used in nonregenerative configurations form a filter that smoothes the output of the rectifier section into a steady DC voltage. An optional *dynamic brake* device allows regenerative energy from the load to be dissipated in an external resistor when the drive is braking.

An *input inverter section* used in line-regenerative applications regulates power flow between the AC line and DC bus. The input inverter 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.

In 2400 inverters and 2420 drives, an *output 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). In 2450 amplifiers, an *output amplifier section* consisting of six IGBTs uses PWM operation to produce the

variable field and armature voltage needed for control of DC motors. 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. A variety of optional feedback interface modules are available to provide closed-loop control of motor velocity and/or position. Various serial communication interfaces are also available that provide interfaces for popular serial communication protocols.

A *standard controller* provides a cost-effective solution for simple applications with limited I/O requirements. An *expandable controller* is used in applications that require multiple transducers and/or expanded digital I/O capacity. A *dual controller* uses tandem digital signal processors (DSPs) to provide high frequency and bandwidth operation.

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 2-9—Architecture of Nonregenerative 2400 AC Drives

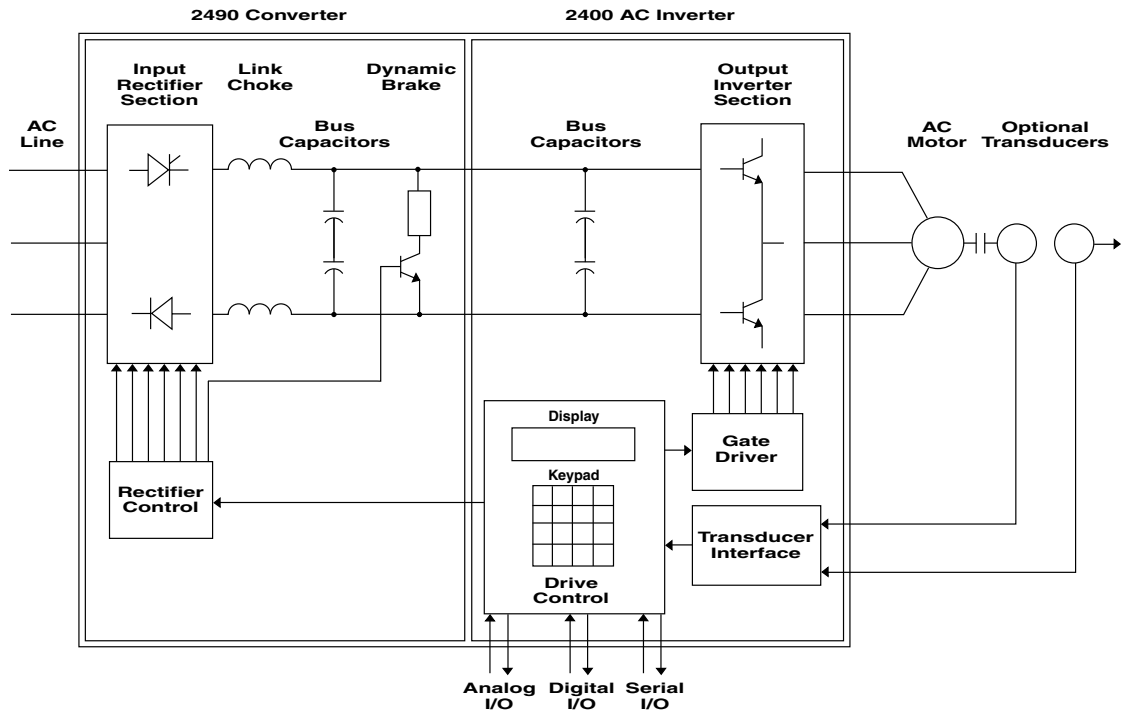


Figure 2-10—Architecture of Line-Regenerative 2400 AC Drives

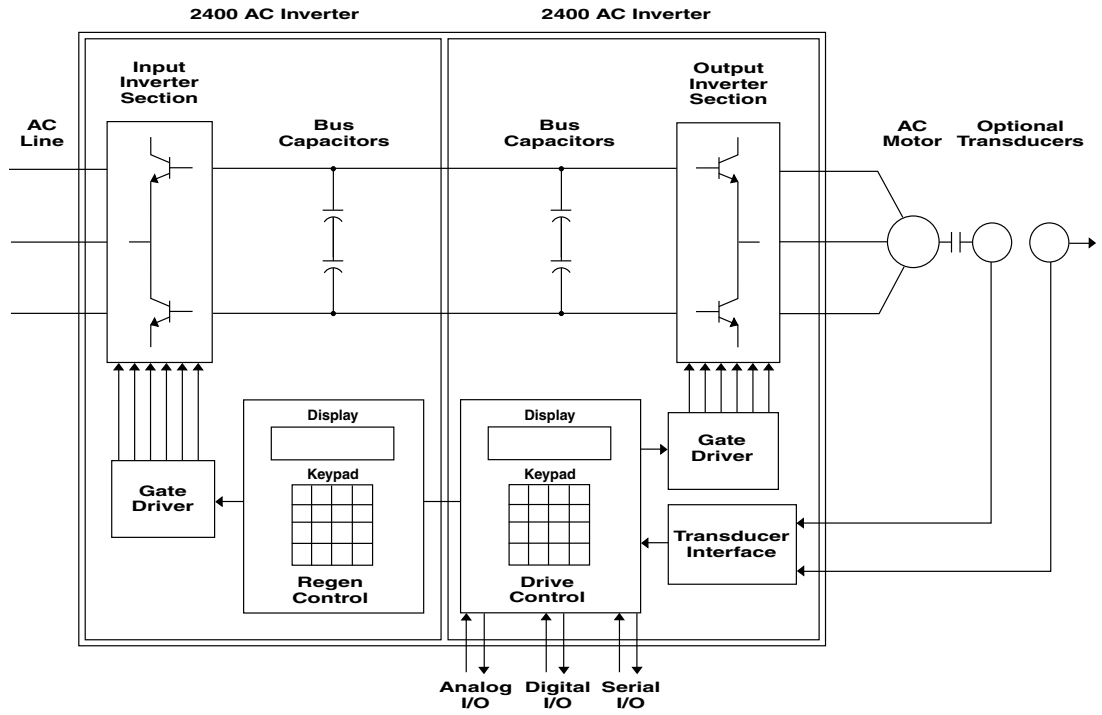


Figure 2-11—Architecture of 2420 AC Drives

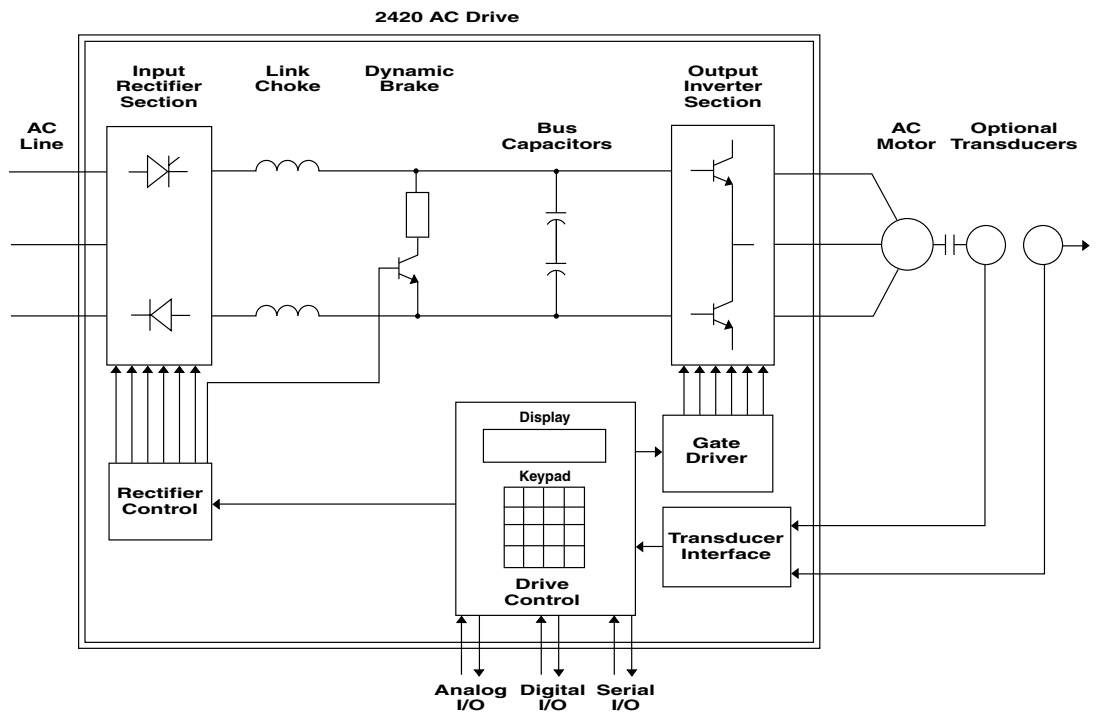


Figure 2-12—Architecture of Nonregenerative 2450 DC Drives

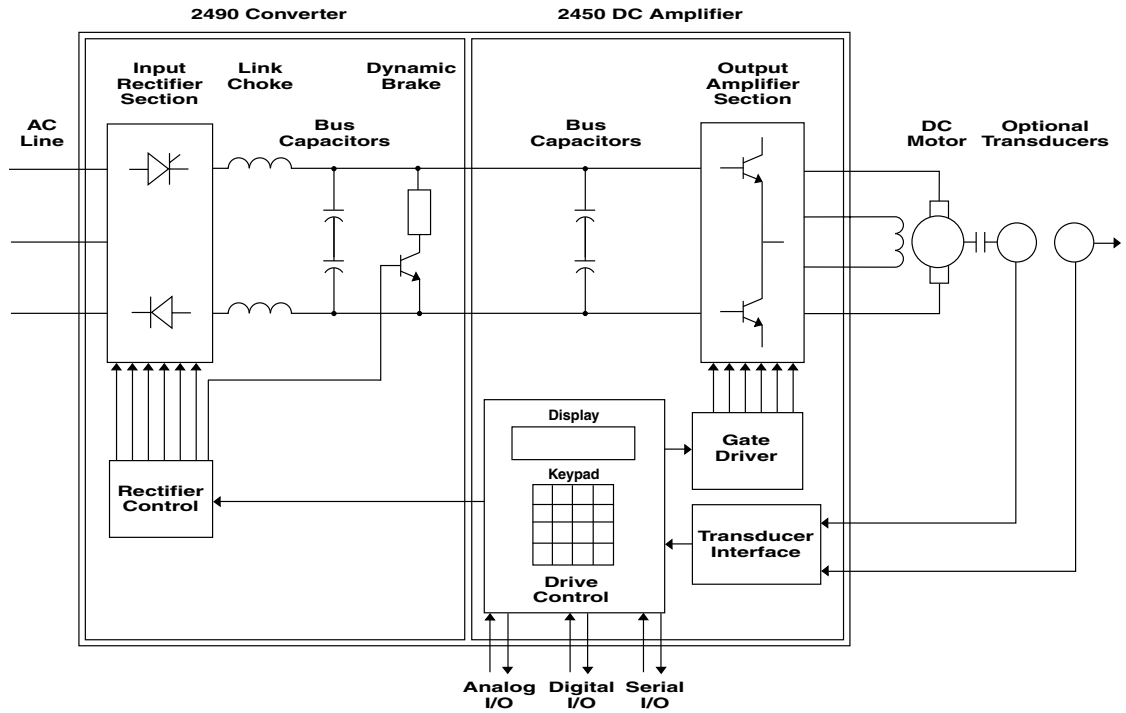
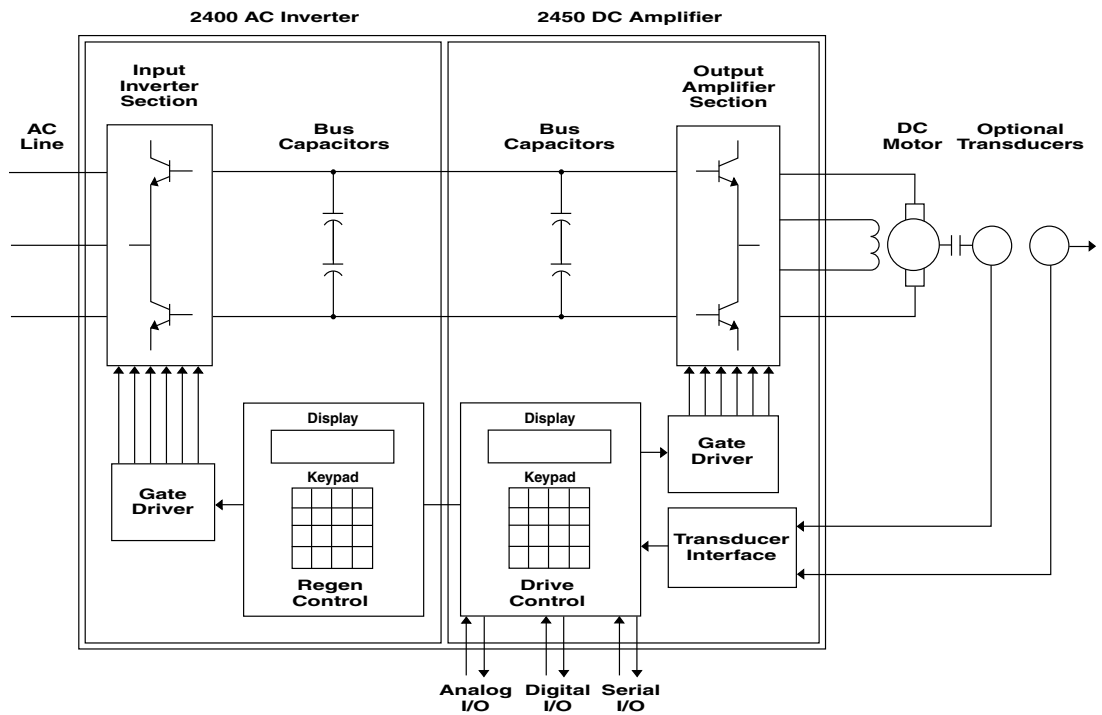


Figure 2-13—Architecture of Line-Regenerative 2450 DC Drives



2.4 Specifications

Detailed drive unit specifications are provided in Table 2-3 through Table 2-24 below.

Table 2-3—Electrical Specifications

| | | | |
|----------------------------|---|--|-----------------------|
| Input Supply | | | |
| Line voltage: | 200 to 240 V AC, three- or six-phase 380 to 480 V AC, three- or six-phase 500 to 600 V AC, three- or six-phase (2400) | | |
| | (Six-phase input available only with 2490 230 V AC 75 hp and 460/575 V AC 150 hp and above) | | |
| | 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 63 Hz | | |
| Power factor: | Displacement: 1.00 at all loads and speeds | | |
| | Overall: 0.94 at rated load (2420 and 2490) 0.98 at rated load (line-regenerative 2400) | | |
| Output Rating | | | |
| Voltage: | Zero to input supply voltage, three-phase (2400 and 2420) Zero to ±135% of input supply voltage, DC (2450) | | |
| Frequency (2400 and 2420): | Zero to 120 Hz without transducer Zero to 480 Hz with transducer | | |
| Switching frequency: | Programmable from 2.0 to 12.0 kHz | | |
| Service Conditions | | | |
| Efficiency: | 97% nominal at rated switching frequency | | |
| Overload current: | <i>Torque</i> | <i>Overload (1 min)</i> | <i>Maximum</i> |
| | Constant | 150% of rated | 200% of rated |
| | Variable | 120% to 150% of rated, depending upon selected mode of operation (2400 and 2420) | 140% to 160% of rated |
| | | 120% of rated (2450) | |
| | Extended (2400) | 110% of rated | 120% to 140% of rated |

Table 2-4—Environmental Specifications

Operating Environment

| | |
|-----------------------|--|
| Temperature: | Control section: 32° to 131° F (0° to 55° C) Heat sink (2400 and 2420): Less than 125 hp (CT): 32° to 131° F (0° to 55° C) 125 hp (CT) or more: 32° to 104° F (0° to 40° C) Heat sink (2450): 32° to 104° F (0° to 40° C) Heat sink (2490): Less than 250 hp (CT): 32° to 131° F (0° to 55° C) 250 hp (CT) or more: 32° to 104° F (0° to 40° C) |
| Relative humidity: | 5% to 95%, noncondensing |
| Altitude: | 0 to 3,300 ft (0 to 1,000 m) above sea level <i>Derate output power 1% per 330 ft (100 m) above 3,300 ft (1,000 m). Contact supplier for additional limitations for operation above 6,600 ft (2000 m).</i> |
| 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 <i>If the drive unit 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.</i> |
| Contamination levels: | Class 3C2 for chemicals (IEC 721-3-3) Class 3S2 for dust (IEC 721-3-3) |

Storage Environment

| | |
|--------------------|----------------------------------|
| Temperature: | −13° to 158° F (−25° to 70° C) |
| Relative humidity: | 5% to 95%, noncondensing |
| Air pressure: | 20.67" to 31.30" (70 to 106 kPa) |

Transportation Environment

| | |
|--------------------|----------------------------------|
| Temperature: | −13° to 158° F (−25° to 70° C) |
| Relative humidity: | 5% to 95%, noncondensing |
| Air pressure: | 20.67" to 31.30" (70 to 106 kPa) |

Table 2-5—Performance Specifications

Position Control

| | |
|--------------|-------|
| Bandwidth: | 50 Hz |
| Settle time: | 10 ms |

Velocity Control

| | |
|-------------|--|
| Bandwidth: | 100 Hz with transducer 10 Hz without transducer |
| Range: | Zero to base speed at full torque Base speed to 480 Hz at constant power with transducer Base speed to 120 Hz at constant power without transducer |
| Regulation: | $\pm 0.001\%$ of base speed, down to zero, with transducer $\pm 0.5\%$ of base speed, 2 Hz and above, without transducer |

Torque Control

| | |
|-------------|---|
| Bandwidth: | 300 Hz with DCR control 100 Hz with DSV control |
| Range: | Constant torque: zero to 200% of rated Variable torque: zero to 150% of rated Extended torque: zero to 120% of rated (2400) |
| Regulation: | $\pm 2.0\%$ of maximum with transducer $\pm 5.0\%$ of maximum without transducer |

Table 2-6—Processor/Memory Specifications

| | |
|--------------------------|---|
| Central processing unit: | Standard and Expandable control: 56002 digital signal processor (DSP) Dual control: Two (2) 56002 digital signal processors (DSPs) |
| Clock frequency: | 40 MHz |
| Data memory: | 32 kilobyte battery-backed static RAM |
| Scratch pad memory: | 96 kilobyte high-speed RAM |
| Program memory: | 1.5 megabyte flash EPROM |

Table 2-7—Input/Output Specifications

| | |
|-------------------|---|
| Analog | |
| Inputs: | Three (3) 12-bit analog inputs (± 10 V DC or 0 to 20 mA) Optional Analog Interface Module: Two (2) 16-bit analog inputs (± 10 V DC) |
| Outputs: | Two (2) 12-bit analog outputs (± 10 V DC) Optional Analog Interface Module: Two (2) 16-bit analog outputs (± 10 V DC) |
| Digital | |
| Inputs: | Expandable control: Two (2) programmable isolated inputs |
| Outputs: | Two (2) programmable contact outputs (Form A contacts rated 250 V AC @ 5 A) |
| Configurable I/O: | Standard control: Eight (8) optional isolated I/O points Expandable or Dual control: 16 or 32 optional isolated I/O points |

Table 2-8—Serial Communication Specifications

| | |
|------------------------------|---|
| Asynchronous | |
| Port: | RS-232/422/485, isolated |
| Baud rate: | Application dependent (up to 57.6 kbaud) |
| Protocol: | Application dependent |
| Synchronous | |
| Port: | RS-422/485 for high-speed drive command |
| Channels: | Clock synchronization and data channels |
| Baud rate: | Application dependent (up to 1 Mbaud) |
| Communication Modules | |
| Provision: | One (1) optional communication module provision |
| Modules: | Serial Communication Module: Two (2) RS-232/422/485 synchronous/asynchronous ports Fiber-Optic Communication Module: One (1) fiber-optic synchronous/asynchronous port One (1) RS-232/422/485 synchronous/asynchronous port Remote I/O Communication Module: Two (2) Remote I/O interfaces Modbus [®] Plus Communication Module: One (1) Modbus [®] Plus interface ControlNet [™] Communication Module: One (1) ControlNet [™] interface Profibus Communication Module: One (1) Profibus DP interface Ethernet Communication Module: One (1) Ethernet interface |

Table 2-9—Serial Communication Module (318826) Specifications

Serial Communications (Ports A and B)

| | |
|---------------------|------------------------------------|
| Compatibility: | RS-232/422/485, optically isolated |
| Duplex: | Half or full |
| Communication rate: | Up to 1 Mbaud |

Table 2-10—Fiber-Optic Communication Module (318816) Specifications

Serial Communications (Port B)

| | |
|---------------------|------------------------------------|
| Compatibility: | RS-232/422/485, optically isolated |
| Duplex: | Half or full |
| Communication rate: | Up to 1 Mbaud |

Serial Communications (Fiber-Optic Port A)

| | |
|---------------------|---------------|
| Communication rate: | Up to 1 Mbaud |
|---------------------|---------------|

Table 2-11—Remote I/O Communication Module (317848) Specifications

Remote I/O Communications (Ports A and B)

| | |
|-----------------------|--|
| Protocol: | 1771 Remote I/O |
| Communication rate: | 57.5 to 230.4 kbaud |
| Distance: | 10,000 ft. (3,000 m) at 57.5 kbaud 5,000 ft. (1,500 m) at 115.2 kbaud 2,500 ft. (750 m) at 230.4 kbaud |
| Maximum discrete I/O: | 128 inputs and 128 outputs per channel |

Table 2-12—Modbus Plus Communication Module (319788) Specifications

Processor

| | |
|--------------------------|-----------------------------|
| Central processing unit: | Intel 80C152 microprocessor |
| Clock frequency: | 16 MHz |

Modbus Plus Communications

| | |
|-----------------------|---|
| Protocol: | Modbus Plus |
| Communication rate: | 1 Mbaud up to 1,500 ft. (450 m) without repeaters |
| Maximum discrete I/O: | 32 words of inputs and 32 words of outputs per node |

**Table 2-13—ControlNet™ Communication Module (321812)
Specifications**

Processor

Central processing unit: Motorola 68360 microprocessor
Clock frequency: 33 MHz

Memory

Data memory: 1 megabyte battery-backed static RAM
Scratch pad memory: 512 kilobyte high-speed RAM
Program memory: 2 megabyte flash EPROM

ControlNet Communications (Ports CNA and CNB)

Communication rate: 5 Mbaud
Distance: To 3,300 ft. (1,000 m) with two nodes (without repeaters)
Number of nodes: 99 maximum addressable, 48 without a repeater

Serial Communications (Port A)

Compatibility: RS-232/422/485, optically isolated
Duplex: Half or full
Communication rate: Console port: 300 to 115.2 kbaud

Serial Communications (Fiber-Optic Ports B, C and D)

Communication rate: 300 to 1 Mbaud

**Table 2-14—Profibus Communication Module (321560)
Specifications**

Processor

Central processing unit: Motorola 68360 microprocessor
Clock frequency: 33 MHz

Memory

Data memory: 1 megabyte battery-backed static RAM
Scratch pad memory: 2 megabyte high-speed RAM
Program memory: 2 megabyte flash EPROM

Profibus Communications (Port E)

Communication rate: Up to 12 Mbaud
Distance: 3,300 ft. (1,000 m) at 187.5 kbaud
660 ft. (200 m) at 1.5 Mbaud
330 ft. (100 m) at 3 to 12 Mbaud
Number of nodes: 126 maximum addressable

Serial Communications / Console Port (A)

Compatibility: RS-232/422/485, optically isolated
Duplex: Half or full
Communication rate: Console port: 300 to 115.2 kbaud

Serial Communications / Fiber-Optic Ports (B, C and D)

Communication rate: 300 to 1 Mbaud

**Table 2-15—Ethernet Communication Module (321228)
Specifications**

| | |
|---|---|
| Processor | |
| Central processing unit: | Motorola 68360 microprocessor |
| Clock frequency: | 33 MHz |
| Memory | |
| Data memory: | 1 megabyte battery-backed static RAM |
| Scratch pad memory: | 2 megabyte high-speed RAM |
| Program memory: | 2 megabyte flash EPROM |
| Ethernet Communications (Port E) | |
| Communication rate: | 10 Mbaud |
| Distance: | To 330 ft. (100 m) with two nodes (without repeaters) |
| Node addressing: | 1.0.0.1 to 126.255.255.254 |
| Serial Communications / Console Port (A) | |
| Compatibility: | RS-232/422/485, optically isolated |
| Duplex: | Half or full |
| Communication rate: | Console port: 300 to 115.2 kbaud |
| Serial Communications / Fiber-Optic Ports (B, C and D) | |
| Communication rate: | 300 to 1 Mbaud |

Table 2-16—Feedback Interface Specifications

| | |
|---------------------|---|
| Built-in interface: | Expandable or Dual control: One (1) incremental encoder interface |
| Provision(s): | Standard control: One (1) optional feedback module provision Expandable or Dual control: Two (2) optional feedback module provisions |
| Modules: | 5 V incremental encoder interface 5 V incremental encoder interface with repeater 4 V resolver interface 4 V dual resolver interface 2 V resolver interface 2 V dual resolver interface Serial absolute encoder interface 15 V incremental encoder interface Asynchronous serial sincos encoder interface Synchronous serial sincos encoder interface 2-input/2-output analog interface |

Table 2-17—Incremental Encoder Interface Module Specifications

| | 5 V interface (317685 and built-in expandable controller) | 5 V interface with repeater (317241) | 15 V interface (320106) |
|--------------------------------|--|--|--|
| Power Supply | | | |
| Voltage: | 5 V DC ($\pm 5\%$), isolated | 5 V DC ($\pm 5\%$), isolated | 15 V DC ($\pm 5\%$), isolated |
| External load: | 480 mA maximum | 480 mA maximum | 120 mA maximum |
| Input Signals | | | |
| Channels: | Differential, A and B quadrature and marker | Differential, A and B quadrature and marker | Differential, A and B quadrature and marker |
| Required encoder output: | RS-422/RS-485 compatible | RS-422/RS-485 compatible | — |
| Allowable voltage: | ± 2.7 V maximum | ± 2.7 V maximum | 15 V maximum |
| Switching threshold voltage: | ± 2.4 V | ± 2.4 V | 8 V |
| Input impedance: | — | — | 1000 Ω |
| Input current: | ± 5 to ± 60 mA | ± 5 to ± 60 mA | 5 mA minimum |
| Common mode voltage: | 300 V maximum | 300 V maximum | 300 V maximum |
| Allowable quadrature error: | $\pm 36^\circ$ | $\pm 36^\circ$ | $\pm 36^\circ$ |
| Input frequency: | 750 kHz maximum (3 MHz after x4 multiplication) | 750 kHz maximum (3 MHz after x4 multiplication) | 750 kHz maximum (3 MHz after x4 multiplication) |
| Reference Input | | | |
| Signal: | Differential (RS-422/RS-485 compatible) or single-ended | Differential (RS-422/RS-485 compatible) or single-ended | Differential (RS-422/RS-485 compatible) or single-ended |
| Allowable voltage: | 5 V maximum | 5 V maximum | 5 V maximum |
| Switching threshold voltage: | 3 V | 3 V | 3 V |
| Input impedance: | 100 Ω | 100 Ω | 100 Ω |
| Input current: | 5 mA minimum | 5 mA minimum | 5 mA minimum |
| Common mode voltage: | 300 V maximum | 300 V maximum | 300 V maximum |
| Repeater Output Signals | | | |
| Channels: | — | Isolated differential, A, B, marker, and reference | — |
| Driver output: | — | RS-422 compatible | — |
| Differential voltage: | — | 1.5 V minimum @ 40 mA | — |
| Differential current: | — | 50 mA maximum | — |
| Common mode voltage: | — | 3 V maximum | — |
| Test Point | | | |
| Analog velocity: | ± 10 V @ ± 250 kHz (1 MHz after x4 multiplication) | ± 10 V @ ± 250 kHz (1 MHz after x4 multiplication) | ± 10 V @ ± 250 kHz (1 MHz after x4 multiplication) |

Table 2-18—Serial Sincos Encoder Interface Module Specifications

| | Asynchronous (320448) | Synchronous (322173) |
|----------------------------------|-----------------------------------|---|
| Power Supply | | |
| Voltage: | 12 V DC ($\pm 5\%$), isolated | 12 V DC ($\pm 5\%$), isolated |
| External load: | 100 mA maximum | 100 mA maximum |
| Sine/Cosine Input Signals | | |
| Channels: | Differential analog input | Differential analog input |
| Amplitude: | 1 V ($\pm 10\%$) peak-to-peak | 1 V ($\pm 10\%$) peak-to-peak |
| Offset voltage: | 3.0 V DC maximum | 3.0 V DC maximum |
| Frequency: | 256 kHz maximum | 256 kHz maximum |
| Input impedance: | 124 Ω | 124 Ω |
| Serial Communications | | |
| Type: | Asynchronous | Synchronous |
| Signal: | RS-485, optically isolated (data) | RS-485, optically isolated (clock and data) |
| Baud rate: | 9600 | 2 Mbaud maximum |
| Terminating impedance: | 134 Ω | 134 Ω |
| Driver source impedance: | 20 Ω | 20 Ω |
| Protocol: | HIPERFACE [®] | EnDat [®] |

Table 2-19—Resolver Interface Module Specifications

| | 4 V Single (320176) | 2 V Single (322195) | 4 V Dual (320315) | 2 V Dual (322197) |
|----------------------------------|-------------------------------|-------------------------------|--|--|
| Reference Output | | | | |
| Frequency: | 5 kHz | 5 kHz | 5 kHz | 5 kHz |
| Amplitude: | 4 V _{rms} | 2 V _{rms} | 4 V _{rms} | 2 V _{rms} |
| Feedback Input | | | | |
| Sine/cosine amplitude: | 2 V _{rms} | 2 V _{rms} | 2 V _{rms} | 2 V _{rms} |
| Transformation ratio: | 0.5 | 1.0 | 0.5 | 1.0 |
| Resolution | 10- to 16-bit, programmable | 10- to 16-bit, programmable | Low-speed: 14-bit High-speed: 10- to 16-bit, programmable | Low-speed: 14-bit High-speed: 10- to 16-bit, programmable |
| Maximum Recommended Speed | <i>Resolution</i> | <i>Speed</i> | | |
| | 10-bit | 50,000 rpm | | |
| | 12-bit | 12,000 rpm | | |
| | 14-bit | 3,000 rpm | | |
| | 16-bit | 800 rpm | | |

**Table 2-20—Serial Absolute Encoder Module (321849)
Specifications**

Power Supply

| | |
|----------------|---------------------------------|
| Voltage: | 15 V DC ($\pm 5\%$), isolated |
| External load: | 120 mA maximum |

Synchronous Serial Communications

| | |
|------------------------|--|
| Clock and data: | RS-485, optically isolated |
| Baud rate: | 125, 250, 500, or 1000 kbaud, programmable |
| Terminating impedance: | 120 Ω |
| Packet: | 24- or 25-bit, selectable |

Table 2-21—Analog Interface Module Specifications (319354)

Analog Inputs

| | |
|----------------------|--|
| Channels: | Two differential channels |
| Resolution: | 16-bit |
| Input range: | 0 to ± 10 V 0 to 20 mA with external 500 Ω differential resistor |
| Input impedance: | 400 k Ω (0 to ± 10 V) 500 Ω (0 to 20 mA) |
| Common mode voltage: | 12 V maximum |

Analog Outputs

| | |
|-------------------|--------------|
| Channels: | Two channels |
| Resolution: | 16-bit |
| Output range: | ± 10 V |
| Maximum output: | 10 mA |
| Output impedance: | 100 Ω |

Table 2-22—Protection Specifications

-
- | | |
|--------------------------------------|-------------------------------|
| • Ground fault | • Heat sink overtemperature |
| • Motor phase-to-phase short circuit | • Power transistor fault |
| • DC bus overvoltage | • Control undervoltage |
| • DC bus undervoltage | • Memory malfunction |
| • Instantaneous overcurrent | • Processor not running fault |
| • Motor overload | |
-

Refer to the application documentation for additional protective features.

Table 2-23—Product Range

| Input Voltage | A p p l i c a t i o n | | |
|------------------|-------------------------------|-----------------------------|-----------------------------|
| | Constant-Torque | Variable-Torque | Extended-Torque |
| 2400 | | | |
| 230 V AC | 1 1/2-75 hp (1.1-55 kW) | 2-100 hp (1.5-75 kW) | — |
| 380 V AC | 1 1/2-1000 hp (1.1-750 kW) | 2-1100 hp (1.5-825 kW) | — |
| 460 V AC | 1 1/2-1000 hp (1.1-750 kW) | 2-1100 hp (1.5-825 kW) | 25-1200 hp (18-900 kW) |
| 575 V AC | 125-1100 hp (90-825 kW) | 150-1200 hp (110-900 kW) | 200-1300 hp (150-975 kW) |
| 2420 | | | |
| 230 V AC | 1 1/2-25 hp (1.1-18 kW) | 2-30 hp (1.5-22 kW) | — |
| 380 V AC | 1 1/2-50 hp (1.1-37 kW) | 2-60 hp (1.5-45 kW) | — |
| 460 V AC | 1 1/2-50 hp (1.1-37 kW) | 2-60 hp (1.5-45 kW) | — |
| 2450 | | | |
| 230 V AC | 1 1/2-150 hp (1.1-110 kW) | 2-200 hp (1.5-150 kW) | — |
| 380 V AC | 1 1/2-800 hp (1.1-600 kW) | 2-900 hp (1.5-675 kW) | — |
| 460 V AC | 1 1/2-800 hp (1.1-600 kW) | 2-900 hp (1.5-675 kW) | — |

Table 2-24—2400 and 2420 Output Current Ratings

| Power <i>hp (kW)</i> | Current | | Constant Torque | | Variable Torque ^(†) | |
|-------------------------|--------------------------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|--|
| | Continuous <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> | |
| 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 | |
| 15 (11) | 42.0 | 63.0 | 84.0 | 50.4 | 56.0 | |
| 20 (15) | 54.0 | 81.0 | 108.0 | 64.8 | 84.0 | |
| 25 (18) | 68.0 | 102.0 | 136.0 | 81.6 | 108.0 | |
| 30 (22) | 80.0 | 120.0 | 160.0 | 96.0 | 136.0 | |
| 40 (30) | 104.0 | 156.0 | 208.0 | 124.8 | 160.0 | |
| 50 (37) | 130.0 | 195.0 | 260.0 | 156.0 | 208.0 | |
| 60 (45) | 154.0 | 231.0 | 308.0 | 184.8 | 260.0 | |
| 75 (55) | 192.0 | 288.0 | 384.0 | 230.4 | 308.0 | |
| 100 (75) | 248.0 | — | — | 297.6 | 384.0 | |
| 380 V | | | | | | |
| 1 1/2 (1.1) | 3.4 | 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 | |

(continued)

(†) The variable-torque ratings provided in this table reflect a standard 120% overload. Variable-torque units may be operated at up to 150% overload by selecting the appropriate mode in software. To determine the maximum overload current for this alternate mode, use the constant-torque overload figure for the same power but limit it to the variable-torque maximum current.

Table 2-24—2400 and 2420 Output Current Ratings (continued)

| Power <i>hp (kW)</i> | Current | Constant Torque | | Variable Torque ^(†) | |
|-------------------------|--------------------------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|
| | Continuous <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> |
| 380 V | | | | | |
| 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 |
| 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 | 828.0 | 960.0 | 662.4 | 840.0 |
| 500 (375) | 690.0 | 1035.0 | 1200.0 | 828.0 | 960.0 |
| 600 (450) | 828.0 | 1242.0 | 1440.0 | 993.6 | 1080.0 |
| 700 (525) | 966.0 | 1449.0 | 1680.0 | 1159.2 | 1440.0 |
| 800 (600) | 1104.0 | 1656.0 | 1920.0 | 1324.8 | 1680.0 |
| 900 (675) | 1242.0 | 1863.0 | 2160.0 | 1490.4 | 1920.0 |
| 1000 (750) | 1380.0 | 2070.0 | 2400.0 | 1656.0 | 2160.0 |
| 1100 (825) | 1518.0 | — | — | 1821.6 | 2400.0 |

(continued)

Table 2-24—2400 and 2420 Output Current Ratings (continued)

| Power <i>hp (kW)</i> | Current | Constant Torque | | Variable Torque ^(†) | | Extended Torque | |
|-------------------------|--------------------------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|
| | Continuous <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> |
| 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 | 13.1 | 15.2 | — | — |
| 10 (7.5) | 14.0 | 21.0 | 28.0 | 16.8 | 22.0 | — | — |
| 15 (11) | 21.0 | 31.5 | 42.0 | 25.2 | 28.0 | — | — |
| 20 (15) | 27.0 | 40.5 | 54.0 | 32.4 | 42.0 | — | — |
| 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 |
| 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 | 720.0 | 960.0 | 576.0 | 840.0 | 528.0 | 720.0 |
| 500 (375) | 600.0 | 900.0 | 1200.0 | 720.0 | 960.0 | 660.0 | 840.0 |
| 600 (450) | 720.0 | 1080.0 | 1440.0 | 864.0 | 1200.0 | 792.0 | 960.0 |
| 700 (525) | 840.0 | 1260.0 | 1680.0 | 1008.0 | 1440.0 | 924.0 | 1200.0 |
| 800 (600) | 960.0 | 1440.0 | 1920.0 | 1152.0 | 1680.0 | 1056.0 | 1440.0 |

(continued)

Table 2-24—2400 and 2420 Output Current Ratings (continued)

| Power <i>hp (kW)</i> | Current | Constant Torque | | Variable Torque ^(†) | | Extended Torque | |
|-------------------------|--------------------------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|
| | Continuous <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> |
| 460 V | | | | | | | |
| 900 (675) | 1080.0 | 1620.0 | 2160.0 | 1296.0 | 1920.0 | 1188.0 | 1680.0 |
| 1000 (750) | 1200.0 | 1800.0 | 2400.0 | 1440.0 | 2160.0 | 1320.0 | 1920.0 |
| 1100 (825) | 1320.0 | — | — | 1584.0 | 2400.0 | 1452.0 | 2160.0 |
| 1200 (900) | 1440.0 | — | — | — | — | 1584.0 | 2400.0 |
| 575 V | | | | | | | |
| 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 | 720.0 | 960.0 | 576.0 | 768.0 | 528.0 | 672.0 |
| 600 (450) | 576.0 | 864.0 | 1152.0 | 691.2 | 960.0 | 633.6 | 768.0 |
| 700 (525) | 672.0 | 1008.0 | 1344.0 | 806.4 | 1152.0 | 739.2 | 960.0 |
| 800 (600) | 768.0 | 1152.0 | 1536.0 | 921.6 | 1344.0 | 844.8 | 1152.0 |
| 900 (675) | 864.0 | 1296.0 | 1728.0 | 1036.8 | 1536.0 | 950.4 | 1344.0 |
| 1000 (750) | 960.0 | 1440.0 | 1920.0 | 1152.0 | 1728.0 | 1056.0 | 1536.0 |
| 1100 (825) | 1056.0 | 1584.0 | 2112.0 | 1267.2 | 1920.0 | 1161.6 | 1728.0 |
| 1200 (900) | 1152.0 | — | — | 1382.4 | 2112.0 | 1267.2 | 1920.0 |
| 1300 (975) | 1248.0 | — | — | — | — | 1372.8 | 2112.0 |

Table 2-25—2450 Output Current Ratings

| Power <i>hp (kW)</i> | Current | | Constant Torque | | Variable Torque | |
|-------------------------|-------------------------------------|-----------------------------------|----------------------------------|-----------------------------------|----------------------------------|--|
| | Continuous <i>A_{dc}</i> | Overload <i>A_{dc}</i> | Maximum <i>A_{dc}</i> | Overload <i>A_{dc}</i> | Maximum <i>A_{dc}</i> | |
| 230 V | | | | | | |
| 1 1/2 (1.1) | 6.6 | 9.9 | 13.2 | — | — | |
| 2 (1.5) | 8.5 | 12.8 | 17.0 | 10.2 | 13.2 | |
| 3 (2.2) | 12.2 | 18.3 | 24.4 | 14.6 | 17.0 | |
| 5 (3.7) | 20.0 | 30.0 | 40.0 | 24.0 | 24.4 | |
| 7 1/2 (5.5) | 29.0 | 43.5 | 58.0 | 34.8 | 40.0 | |
| 10 (7.5) | 38.0 | 57.0 | 76.0 | 45.6 | 58.0 | |
| 15 (11) | 55.0 | 82.5 | 110.0 | 66.0 | 76.0 | |
| 20 (15) | 72.0 | 108.0 | 144.0 | 86.4 | 110.0 | |
| 25 (18) | 89.0 | 133.5 | 178.0 | 106.8 | 144.0 | |
| 30 (22) | 106.0 | 159.0 | 212.0 | 127.2 | 178.0 | |
| 40 (30) | 140.0 | 210.0 | 280.0 | 168.0 | 212.0 | |
| 50 (37) | 173.0 | 259.5 | 346.0 | 207.6 | 280.0 | |
| 60 (45) | 206.0 | 309.0 | 412.0 | 247.2 | 346.0 | |
| 75 (55) | 255.0 | 382.5 | 510.0 | 306.0 | 412.0 | |
| 100 (75) | 341.0 | 511.5 | 682.0 | 409.2 | 510.0 | |
| 125 (90) | 425.0 | 637.5 | 850.0 | 510.0 | 682.0 | |
| 150 (110) | 506.0 | 759.0 | 1012.0 | 607.2 | 850.0 | |
| 200 (150) | 675.0 | — | — | 810.0 | 1012.0 | |

(continued)

Table 2-25—2450 Output Current Ratings (continued)

| Power <i>hp (kW)</i> | Current | Constant Torque | | Variable Torque | |
|-------------------------|--------------------------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|
| | Continuous <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> | Overload <i>A_{rms}</i> | Maximum <i>A_{rms}</i> |
| 460 V | | | | | |
| 1 1/2 (1.1) | 2.7 | 4.1 | 5.4 | — | — |
| 2 (1.5) | 3.6 | 5.4 | 7.2 | 4.3 | 5.4 |
| 3 (2.2) | 5.4 | 8.1 | 10.8 | 6.5 | 7.2 |
| 5 (3.7) | 9.0 | 13.5 | 18.0 | 10.8 | 10.8 |
| 7 1/2 (5.5) | 13.6 | 20.4 | 27.2 | 16.3 | 18.0 |
| 10 (7.5) | 18.0 | 27.0 | 36.0 | 21.6 | 27.2 |
| 15 (11) | 27.0 | 40.5 | 54.0 | 32.4 | 36.0 |
| 20 (15) | 34.0 | 51.0 | 68.0 | 40.8 | 54.0 |
| 25 (18) | 43.0 | 64.5 | 86.0 | 51.6 | 68.0 |
| 30 (22) | 51.0 | 76.5 | 102.0 | 61.2 | 86.0 |
| 40 (30) | 67.0 | 100.5 | 134.0 | 80.4 | 102.0 |
| 50 (37) | 83.0 | 124.5 | 166.0 | 99.6 | 134.0 |
| 60 (45) | 99.0 | 148.5 | 198.0 | 118.8 | 166.0 |
| 75 (55) | 123.0 | 184.5 | 246.0 | 147.6 | 198.0 |
| 100 (75) | 164.0 | 246.0 | 328.0 | 196.8 | 246.0 |
| 125 (90) | 205.0 | 307.5 | 410.0 | 246.0 | 328.0 |
| 150 (110) | 246.0 | 369.0 | 492.0 | 295.2 | 410.0 |
| 200 (150) | 328.0 | 492.0 | 656.0 | 393.6 | 492.0 |
| 250 (185) | 410.0 | 615.0 | 820.0 | 492.0 | 656.0 |
| 300 (225) | 492.0 | 738.0 | 984.0 | 590.4 | 820.0 |
| 350 (262) | 574.0 | 861.0 | 1148.0 | 688.8 | 984.0 |
| 400 (300) | 656.0 | 984.0 | 1312.0 | 787.2 | 1148.0 |
| 500 (375) | 820.0 | 1230.0 | 1640.0 | 984.0 | 1312.0 |
| 600 (450) | 984.0 | 1476.0 | 1968.0 | 1180.8 | 1640.0 |
| 700 (525) | 1148.0 | 1722.0 | 2296.0 | 1377.6 | 1968.0 |
| 800 (600) | 1312.0 | 1968.0 | 2624.0 | 1574.4 | 2296.0 |
| 900 (675) | 1476.0 | — | — | 1771.2 | 2624.0 |

3 Mechanical Installation

3.1 Overview

Proper mechanical installation of drive units 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 units.

3.2 Forms

Drive units are classified into seven different *forms* according to their physical size and configuration. Form 1 through Form 5 units are individual components, while Form 6 and 7 units are comprised of multiple pole sections that function together as a single unit. Refer to Table 3-4 through Table 3-9, beginning on page 3-8, to determine the form of a unit based upon its voltage, torque, and power ratings.

3.3 Installation Site Considerations

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

3.3.1 Enclosure

Drive units may be ordered either as stand-alone components or as part of a packaged drive system incorporating additional elements within an enclosure. When ordered as stand-alone components, the units are supplied as enclosed chassis (IP00) that must be mounted inside an enclosure for safety.



Attention

To provide protection against electrical shock, drive 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

Drive units 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. Table 3-1 specifies the required ambient operating conditions.

Table 3-1—Operating Environment Specifications

| | |
|-----------------------|--|
| Temperature: | Control section: 32° to 131° F (0° to 55° C) Heat sink: Less than 125 hp (CT): 32° to 131° F (0° to 55° C) 125 hp (CT) or more: 32° to 104° F (0° to 40° C) |
| Relative humidity: | 5% to 95%, noncondensing |
| Altitude: | 0 to 3,300 ft (0 to 1,000 m) above sea level <i>Derate output power 1% per 330 ft (100 m) above 3,300 ft (1,000 m). Contact supplier for additional limitations for operation above 6,600 ft (2000 m).</i> |
| 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 <i>If the drive unit 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.</i> |
| Contamination levels: | Class 3C2 for chemicals (IEC 721-3-3) Class 3S2 for dust (IEC 721-3-3) |

3.3.3 Cooling

Thermal management techniques may be necessary to keep drive units operating within required temperature specifications, particularly when units are installed within confined spaces. Units cool themselves using fans that circulate air across a heat sink. Form 5, 6, and 7 inverter or amplifier units also have separate fans for cooling the control section above the heat sink. On larger units, a choice of mounting configurations provides flexibility in selecting a cooling method. Additional ventilating or cooling equipment may be required.

3.3.3.1 Thermal Load

The total power dissipated by each drive unit is given in Table 3-10 through Table 3-14 at the end of this chapter. For Form 5 through Form 7 units, where the heat sink can be mounted externally to the enclosure, dissipation figures are also provided for the control section and heat sink independently. 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

The path that circulating air takes through a drive unit depends upon the form of the unit (see Section 3.2) and the mounting configuration selected, as described below and illustrated in Figure 3-1. Mounting instructions for each of these configurations are provided in Section 3.5.

Internal Circulation (all forms)

Enclosure air is circulated through the unit and vented within the enclosure. Form 1 through Form 4 units draw air in through the bottom and exhaust it out the top. These units can be flush-mounted either to an enclosure subpanel or directly to the enclosure wall. Form 5 through Form 7 units draw air in through the sides of the heat sink and exhaust it out the back. These units may be either foot-mounted to a subpanel or enclosure wall using optional mounting brackets or flush-mounted to a subpanel with a cutout behind the heat sink to permit circulation.

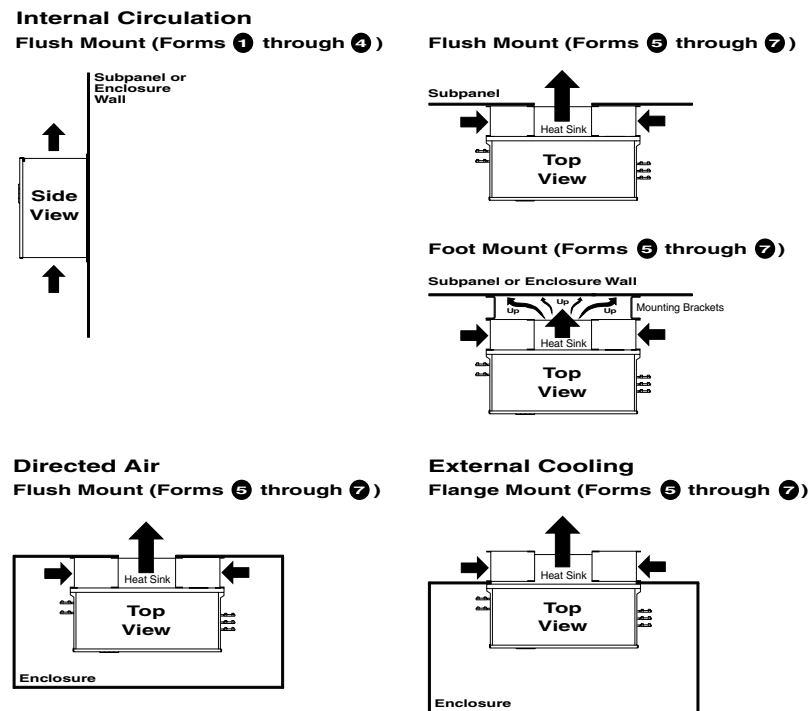
Directed-Air Circulation (Forms 5, 6, and 7)

Enclosure air is directed through the sides of the heat sink and vented out the back to the outside through a cutout in the enclosure wall. Units must be flush-mounted directly to the enclosure wall over the cutout. An adequate volume of air must be made available within the enclosure to replace the 800 cfm exhausted by each drive unit mounted in this fashion. This inflow should be properly filtered to ensure that it meets the environmental specifications in Table 3-1.

External Cooling (Forms 5, 6, and 7)

Heat is dissipated externally by flange-mounting the unit with its heat sink protruding through a cutout in the enclosure wall. Outside air is drawn through the sides of the heat sink and vented out the back.

Figure 3-1—Airflow/Mounting Options



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 unit are provided beginning on page 3-12 in Figure 3-3 through Figure 3-6. Approximate unit weights are given in Table 3-4 through Table 3-9 beginning on page 3-8.



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 unit for heat dissipation, access to electrical connections, and maintenance. Recommended clearances above and below, between, and behind units are indicated in Table 3-2. Depending upon the application, additional horizontal clearance may be required between Form 5 units to accommodate the bending radius of wires connected to the external terminal bars. Be sure to also leave enough clearance for removing and replacing the cover during installation and servicing.

Metal bus and ground bars used to interconnect Form 5, 6, and 7 units dictate the vertical spacing between units. If these bars are used, care must be taken when flush- or flange-mounting such units to stay within the specified vertical tolerance. When units are foot-mounted, mounting brackets automatically ensure correct vertical spacing.

Table 3-2—Mounting Clearances

| Form | Vertical | Horizontal | Behind |
|----------------|-------------------------|-------------------------|------------------------|
| | <i>in (mm)</i> | <i>in (mm)</i> | <i>in (mm)</i> |
| 1, 2, 3, and 4 | 12.00" or more (305) | 0.30" or more (8) | — |
| 5, 6, and 7 | 0.75" ± 0.13" (19) | 12.00" or more (305) | 4.00" or more (102) |

3.4.3 Arrangement and Orientation

Drive units 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 2400, 2420, and 2450 units so that their keypad/displays can be accessed comfortably by the operator. The average adult is 5' 6" (168 cm) tall, so mount accordingly if possible.

Drive units should be arranged to economize space and simplify wiring. Figure 3-2 shows typical arrangements for multiple units sharing a common bus and for multisection units. Any practical configuration that satisfies clearance requirements may be used, however.

Forms 1, 2, 3, and 4

When multiple Form 1 through 4 units share a common bus, they are normally arranged horizontally with the inverters or amplifiers to the left of the converter and the capacitor bank unit to the right. If units are mounted in more than one row, be certain to maintain proper vertical clearance between rows for cooling airflow.

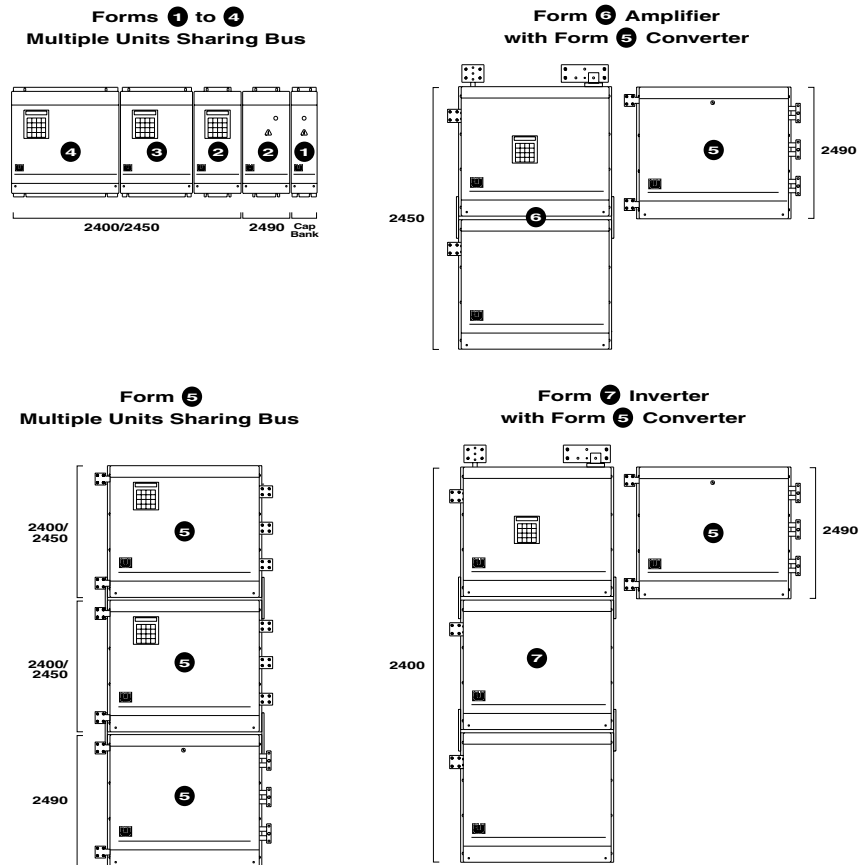
Form 5

When multiple Form 5 units share a common bus, they are normally mounted in a column with the converter unit below the inverter or amplifier units.

Forms 6 and 7

Form 6 and 7 units are multisection units comprised of two and three pole sections, respectively, stacked in a column. Bus and ground bars join the pole sections and dictate the vertical arrangement. The converter unit is usually located to the right of the column.

Figure 3-2—Typical Mounting Schemes



3.4.4 Cable Routing

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

3.5 Installation Procedure

Drive units are provided as flush-mountable enclosed chassis (IP00) for mounting inside an enclosure. Form 5, 6, and 7 units may also be foot- or flange-mounted. Figure 3-3 through Figure 3-9, beginning on page 3-12, 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 unit(s). 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

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



Attention

Do not lift a unit by its cover, even when it is secured by retaining screws. The cover is not intended to support the weight of the unit. Always rest the unit on its back, never face down or on its side.

3.5.1 Flush Mounting (all forms)

All units may be flush mounted to a subpanel inside an enclosure or directly to an enclosure wall. Form 5, 6, and 7 units require a cutout in the panel or enclosure wall to allow air to vent out the back. Refer to Figure 3-7. Allow clearance behind the cutout for airflow as recommended in Table 3-2.

Mount Form 1 through Form 4 units according to Figure 3-3 using four 1/4" (6 mm) bolts or studs. Mount Form 5, 6, and 7 units according to Figure 3-7 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.

3.5.2 Foot Mounting (Forms 5, 6, and 7)

Form 5, 6, and 7 units may be foot-mounted to a subpanel inside an enclosure or directly to an enclosure wall using optional foot-mounting brackets. These brackets position the heat sink the required distance from the mounting surface while forming a vertical channel for conveying exhausted air. They also greatly simplify mounting since they provide the proper interunit spacing.

Select the appropriate single-, double-, or triple-unit brackets from Table 3-3 according to the number of units to be mounted in a column. Mounting kits contain a pair of brackets. Refer to Figure 3-8 for mounting bracket hole and stud locations. 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.

Table 3-3—Foot-Mounting Brackets

| Mounting Kit Part Number | Single-Bracket Part Number | Description |
|--------------------------|----------------------------|------------------------------|
| 709628 | 110156 | Single-unit mounting bracket |
| 709629 | 110145 | Double-unit mounting bracket |
| 709630 | 110188 | Triple-unit mounting bracket |

3.5.3 Flange Mounting (Forms 5, 6, and 7)

Form 5, 6, and 7 units can be flange-mounted with their heat sinks extending through a cutout in the enclosure wall. Units are designed to provide NEMA 4 (IP66) integrity when flange-mounted inside a suitable NEMA 4 enclosure using a 322607 gasket. Refer to Figure 3-9 for hole locations and cutout dimensions. Allow the recommended clearance behind the heat sink for airflow (see Table 3-2).

To flange-mount a unit, first remove the fan shrouds by removing the six hex-head screws attaching each shroud to the underside of the heat sink. Pull the shrouds out far enough to disconnect the electrical connectors, then remove the shrouds completely. Mount the gasket to the inside of the enclosure. Push the heat sink through the cutout in the enclosure wall, then attach the unit to the enclosure wall using 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. From outside the enclosure, reconnect the electrical connectors in any order. Route the wires away from the fan blades, making certain that they will not be pinched by the fan shrouds, then reattach both fan shrouds.

3.5.4 Bus and Ground Bars (Forms 5, 6, and 7)

Metal bus bars and ground bars are provided with Form 6 and 7 units for interconnecting separate poles. They are optionally available for interconnecting multiple Form 5 units and are recommended for wiring simplicity and integrity. Bus and ground bars must be installed after the drive units have been mounted.

Form 5 units have external bus connections on the left side. For each pair of neighboring units, install a 110019 bus bar between the B+ terminals (located near the top of each unit and close to the heat sink) and another between the B- terminals (located near the bottom of each unit and away from the heat sink). Refer to Figure 3-10.

Form 6 and 7 units have internal bus connections. For each pair of neighboring units, install a 109503 bus bar with attached insulator between the B+ bus plates (located along the left side of the units) and another between the B- bus plates (located along the right side of the units). Refer to Figure 3-11. Access is tight, so use a 3/8" speed wrench and be careful not to drop hardware into the unit. Mount the outer bars before the inner bars. To install the B- bus bar in the top pole unit, first remove the bar jumpering the B- terminals to the bus.

For each pair of units, install two ground bars (108123), one on each side, connecting the bottom ground holes of one unit (located on the sides of the heat sink flange) with the top ground holes of the next unit. Use two 1/4"-20 screws with washers and locking washers for each bar. Refer to Figure 3-10 or Figure 3-11.

Table 3-4—2400 Inverter Forms / Weights

| Power | | | Form | Weights |
|-----------------------|-----------------------|-----------------------|------|----------------|
| CT | VT | ET | | |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>hp (kW)</i> | | <i>lb (kg)</i> |
| 230 V | | | | |
| 1 1/2–15 (1.1-11) | 2–20 (1.5-15) | — | ② | 29 (13) |
| 20–40 (15-30) | 25–50 (18-37) | — | ③ | 54 (25) |
| 50–75 (37-55) | 60–100 (45-75) | — | ④ | 87 (40) |
| 460 V | | | | |
| 1 1/2–25 (1.1-18) | 2–30 (1.5-22) | 25–40 (18-30) | ② | 29 (13) |
| 30–60 (22-45) | 40–75 (30-55) | 50–100 (37-75) | ③ | 54 (25) |
| 75–100 (55-75) | 100–125 (75-90) | 125–150 (90-110) | ④ | 87 (40) |
| 125–250 (90-185) | 150–300 (110-225) | 200–350 (150-262) | ⑤ | 200 (91) |
| 300–400 (225-300) | 350–500 (262-375) | 400–600 (300-450) | ⑤ | 220 (100) |
| 500–600 (375-450) | 600–700 (450-525) | 700–800 (525-600) | ⑦ | 490 (223) |
| 700–1000 (525-750) | 800–1100 (600-825) | 900–1200 (675-900) | ⑦ | 550 (250) |
| 575 V | | | | |
| 125–250 (90-185) | 150–300 (110-225) | 200–350 (150-262) | ⑤ | 200 (91) |
| 300–400 (225-300) | 350–500 (262-375) | 400–600 (300-450) | ⑤ | 220 (100) |
| 500–600 (375-450) | 600–700 (450-525) | 700–800 (525-600) | ⑦ | 490 (223) |
| 700–1100 (525-825) | 800–1200 (600-900) | 900–1300 (675-975) | ⑦ | 550 (250) |

Table 3-5—2420 Drive Forms / Weights

| Power | | Form | Weights |
|-----------------------|-------------------|------|----------------|
| CT | VT | | |
| <i>hp (kW)</i> | <i>hp (kW)</i> | | <i>lb (kg)</i> |
| 230 V | | | |
| 1 1/2–15 (1.1-2.2) | 2–20 (1.5-3.7) | 3 | 54 (25) |
| 20–25 (15-18) | 25–30 (18-22) | 4 | 87 (40) |
| 460 V | | | |
| 1 1/2–25 (1.1-18) | 2–30 (1.5-22) | 3 | 54 (25) |
| 30–50 (22-37) | 40–60 (30-45) | 4 | 87 (40) |

Table 3-6—2450 Amplifier Forms / Weights

| Power | | Form | Weights |
|----------------------|----------------------|------|----------------|
| CT | VT | | |
| <i>hp (kW)</i> | <i>hp (kW)</i> | | <i>lb (kg)</i> |
| 230 V | | | |
| 1 1/2–15 (1.1-11) | 2–20 (1.5-15) | 2 | 29 (13) |
| 20–30 (15-22) | 25–40 (18-30) | 3 | 54 (25) |
| 40–60 (30-45) | 50–75 (37-55) | 4 | 87 (40) |
| 75–150 (55-110) | 100–200 (75-150) | 5 | 220 (100) |
| 460 V | | | |
| 1 1/2–25 (1.1-18) | 2–30 (1.5-22) | 2 | 29 (13) |
| 30–50 (22-37) | 40–60 (30-45) | 3 | 54 (25) |
| 60–75 (45-55) | 75–100 (55-75) | 4 | 87 (40) |
| 100–250 (75-185) | 125–300 (90-225) | 5 | 200 (91) |
| 300–500 (225-375) | 350–600 (262-450) | 6 | 350 (159) |
| 600–800 (450-600) | 700–900 (525-675) | 6 | 400 (182) |

Table 3-7—2490 Converter Forms / Weights

| Power | Form | Weights |
|-----------------------|-------------|----------------|
| <i>hp (kW)</i> | | <i>lb (kg)</i> |
| 230 V | | |
| 10–20 (7.5-15) | ② | 36 (16) |
| 40 (30) | ③ | 65 (30) |
| 75 (55) | ④ | 87 (40) |
| 460 V | | |
| 20 (15) | ② | 36 (16) |
| 40 (30) | ② | 39 (18) |
| 75 (55) | ③ | 70 (32) |
| 150 (110) | ④ | 87 (40) |
| 250 (185) | ⑤ | 157 (71) |
| 400–800 (300-600) | ⑤ | 180 (82) |
| 575 V | | |
| 150 (110) | ④ | 87 (40) |
| 250 (185) | ⑤ | 157 (71) |
| 400–1000 (300-750) | ⑤ | 180 (82) |

Table 3-8—2491 Dynamic Brake Forms / Weights

| Power | Rating | Form | Weights |
|----------------|----------------|------|----------------|
| <i>hp (kW)</i> | <i>hp (kW)</i> | | <i>lb (kg)</i> |
| 460 V | | | |
| 400 (300) | 100 (75) | ③ | 54 (25) |
| 600 (450) | 150 (112) | ③ | 54 (25) |
| 800 (600) | 200 (150) | ③ | 54 (25) |
| 575 V | | | |
| 600 (450) | 150 (112) | ③ | 54 (25) |
| 800 (600) | 200 (150) | ③ | 54 (25) |
| 1000 (750) | 250 (187) | ③ | 54 (25) |

Table 3-9—2493 Capacitor Bank Forms / Weights

| Size | Form | Weights |
|--------------|------|----------------|
| <i>μfd</i> | | <i>lb (kg)</i> |
| 230 V | | |
| 26,400 | ① | 25 (11) |
| 44,000 | ① | 25 (11) |
| 132,000 | ③ | 55 (25) |
| 220,000 | ④ | 88 (40) |
| 460 V | | |
| 6,600 | ① | 25 (11) |
| 11,000 | ① | 25 (11) |
| 33,000 | ③ | 55 (25) |
| 55,000 | ④ | 88 (40) |
| 575 V | | |
| 6,900 | ① | 25 (11) |
| 20,700 | ③ | 55 (25) |
| 34,500 | ④ | 88 (40) |

Figure 3-3—Physical and Mounting Dimensions (Forms 1, 2, 3, and 4)

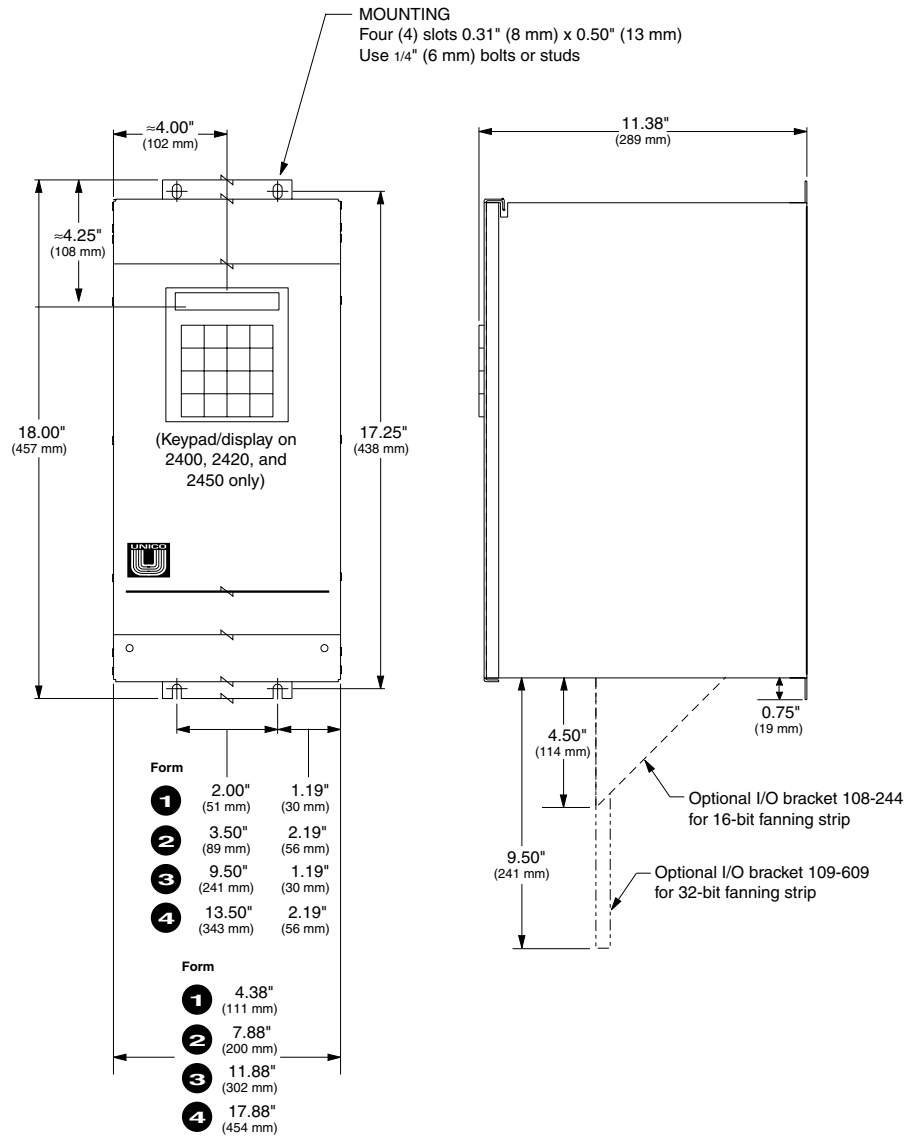
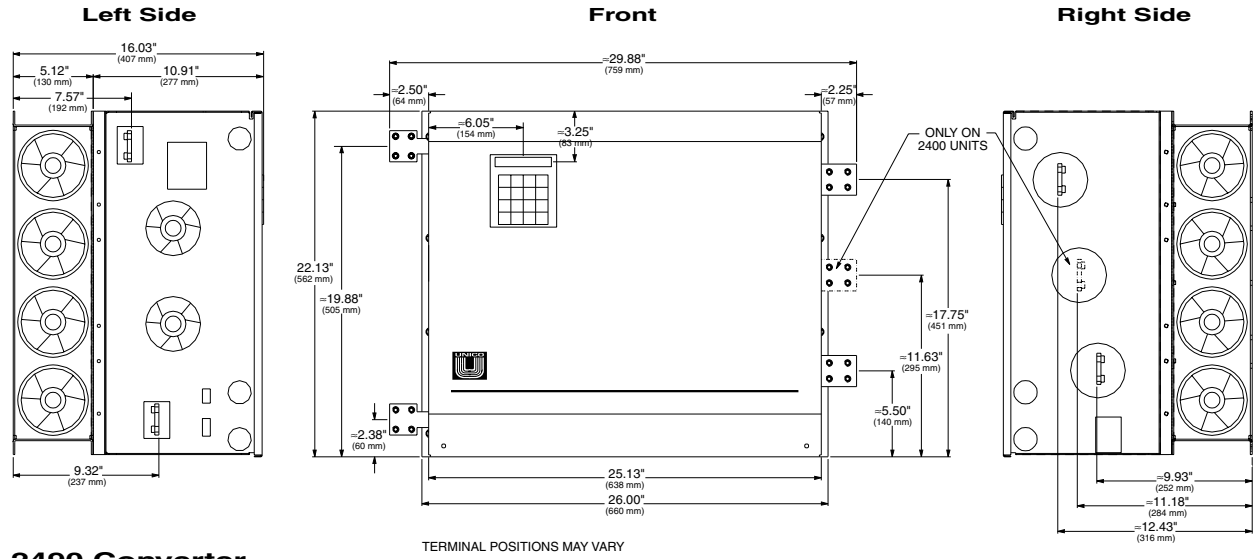


Figure 3-4—Physical Dimensions (Forms 5)

2400 Inverter / 2450 Amplifier



2490 Converter

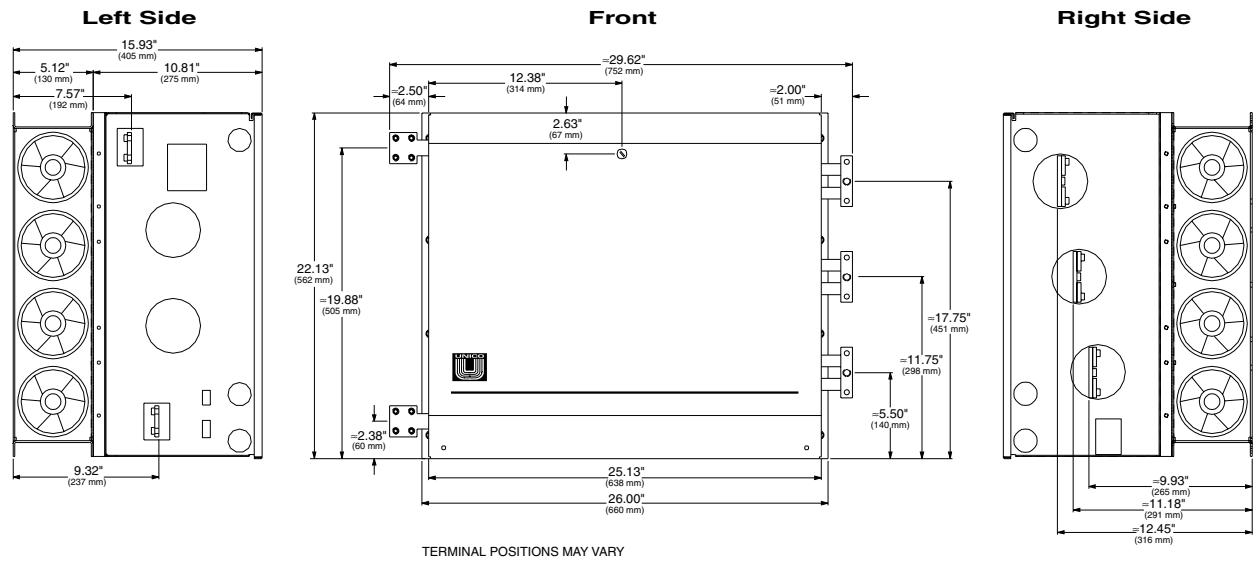
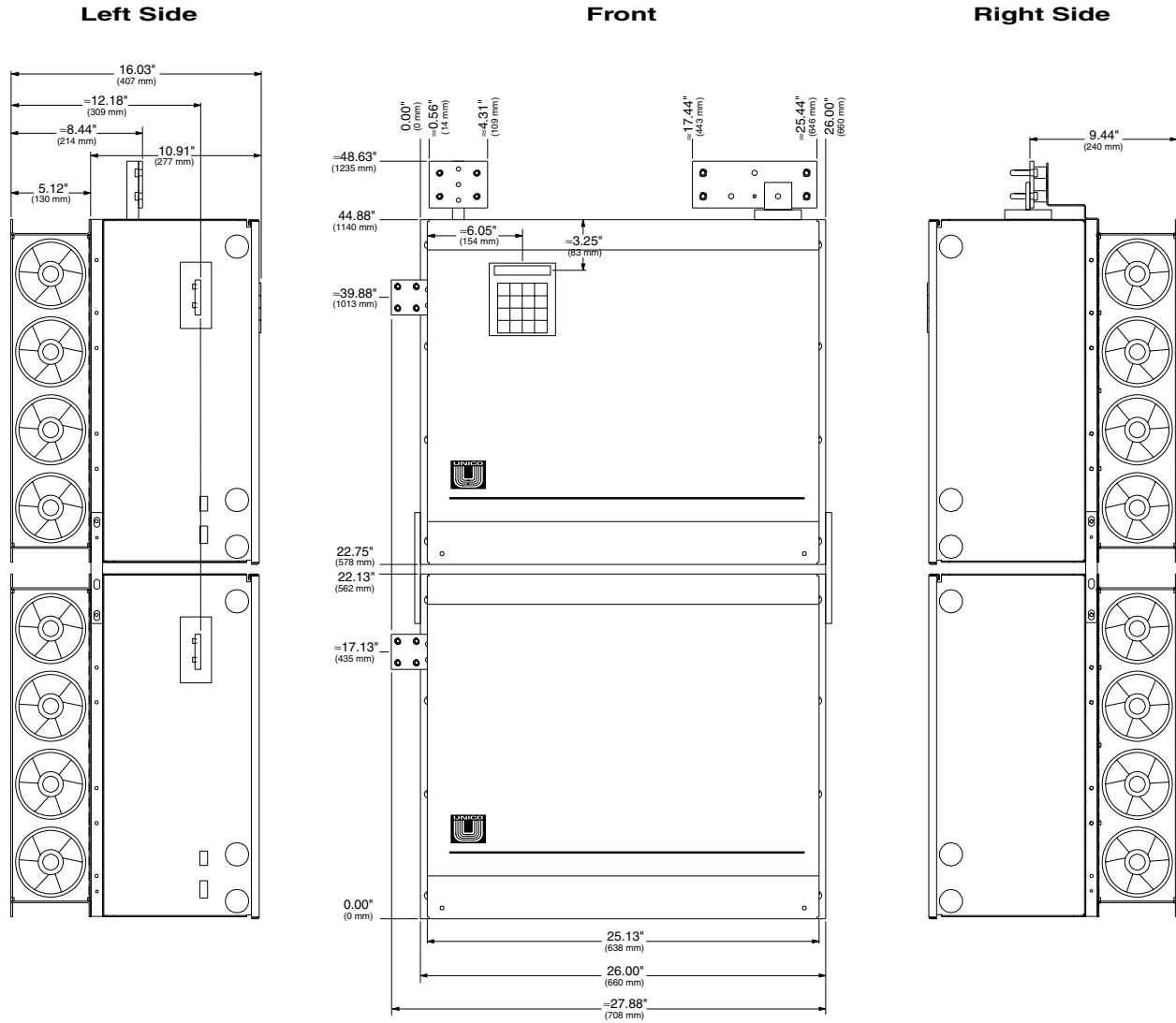
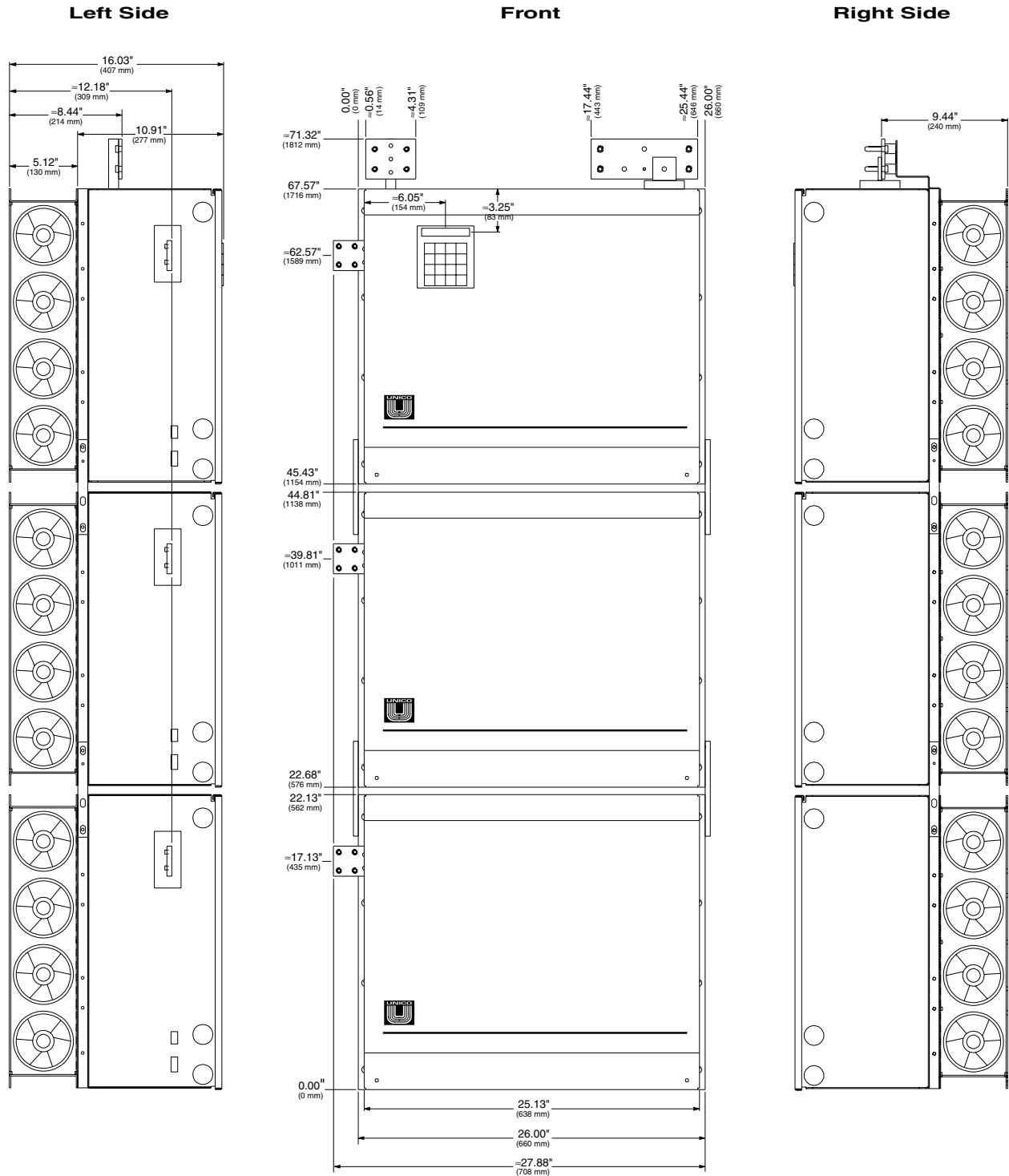


Figure 3-5—Physical Dimensions (Forms 5)



TERMINAL POSITIONS MAY VARY

Figure 3-6—Physical Dimensions (Forms 7)



TERMINAL POSITIONS MAY VARY

Figure 3-7—Flush-Mounting Dimensions (Forms 5, 6, and 7)

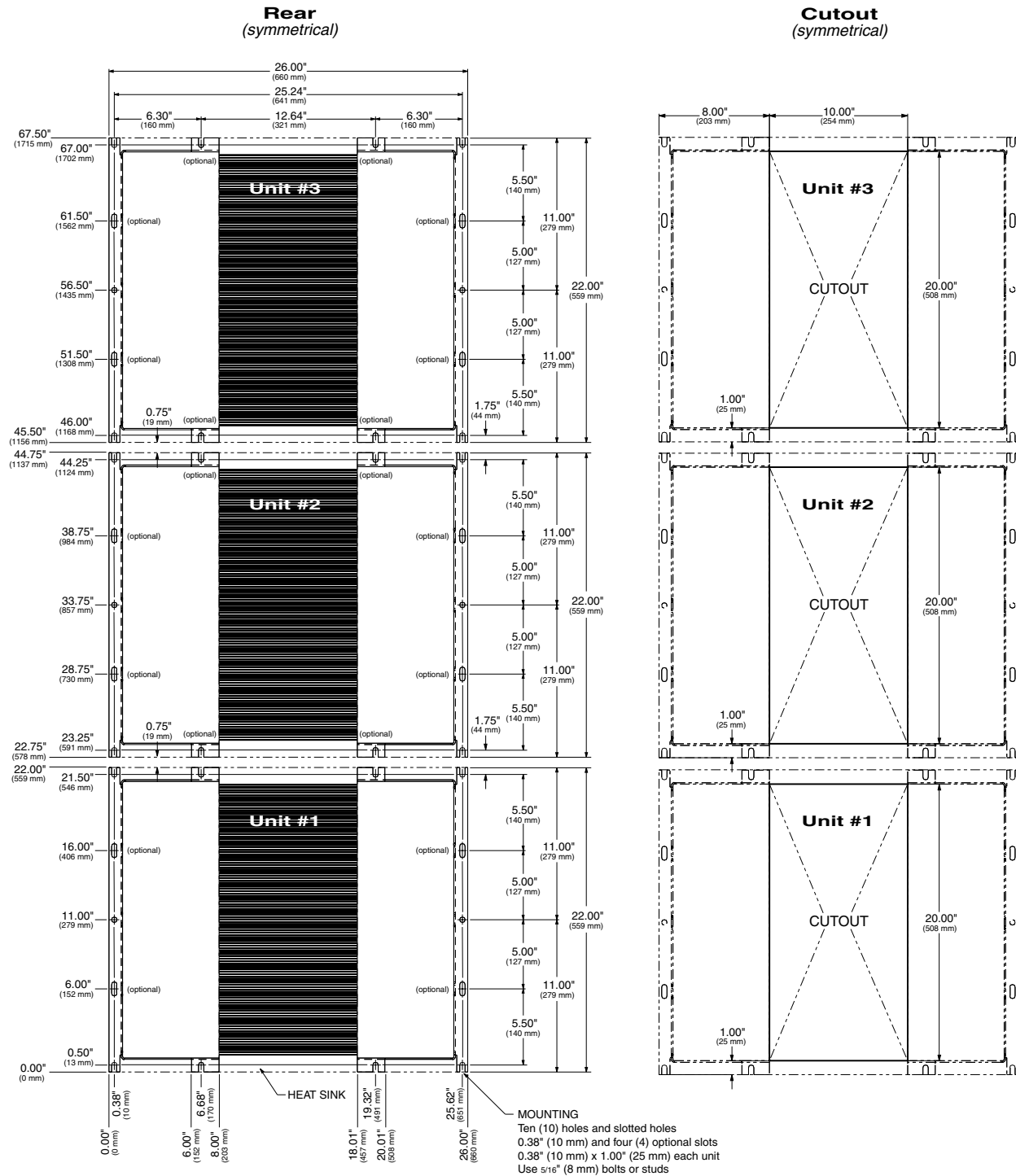
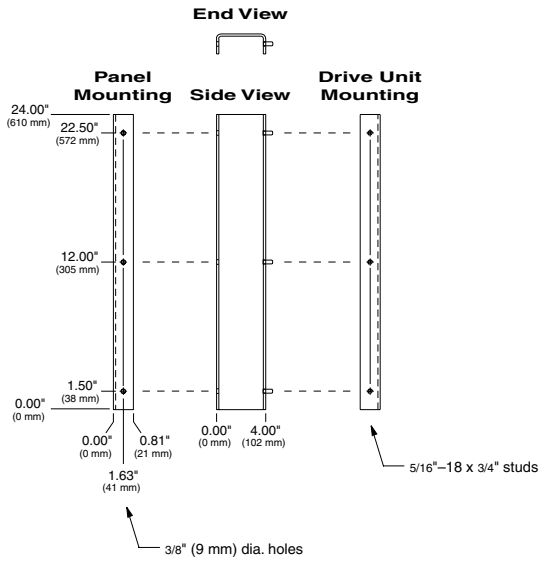
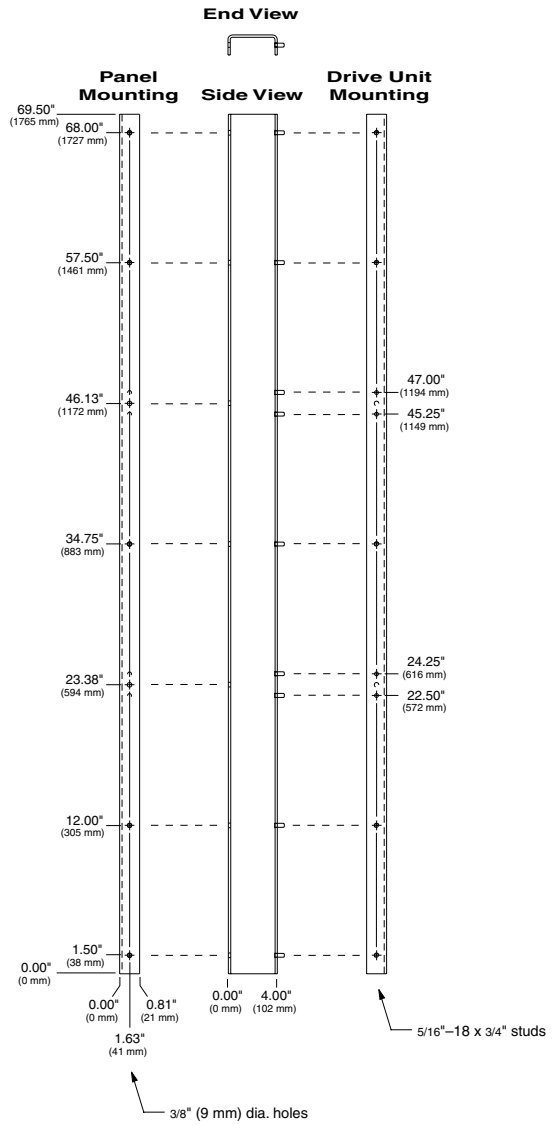


Figure 3-8—Foot-Mounting Bracket Dimensions

Single-Unit Bracket (110-156)



Triple-Unit Bracket (110-188)



Double-Unit Bracket (110-145)

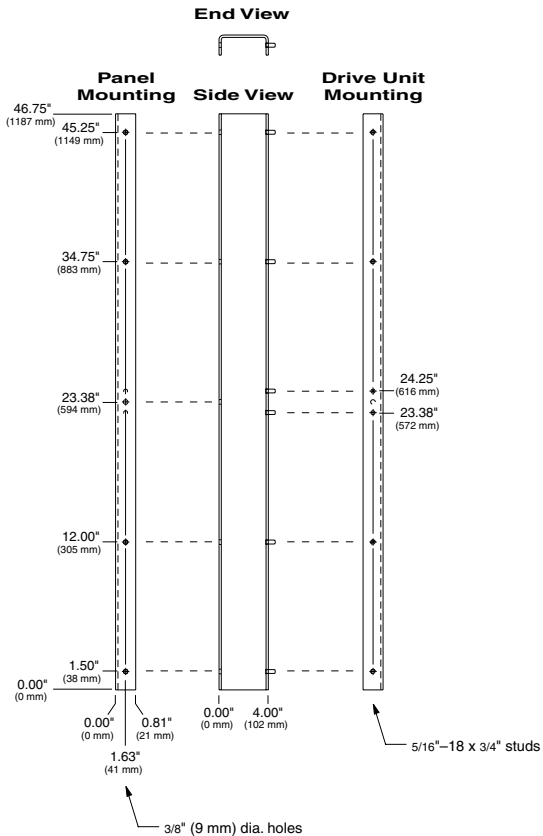


Figure 3-9—Flange-Mounting and Cutout Dimensions

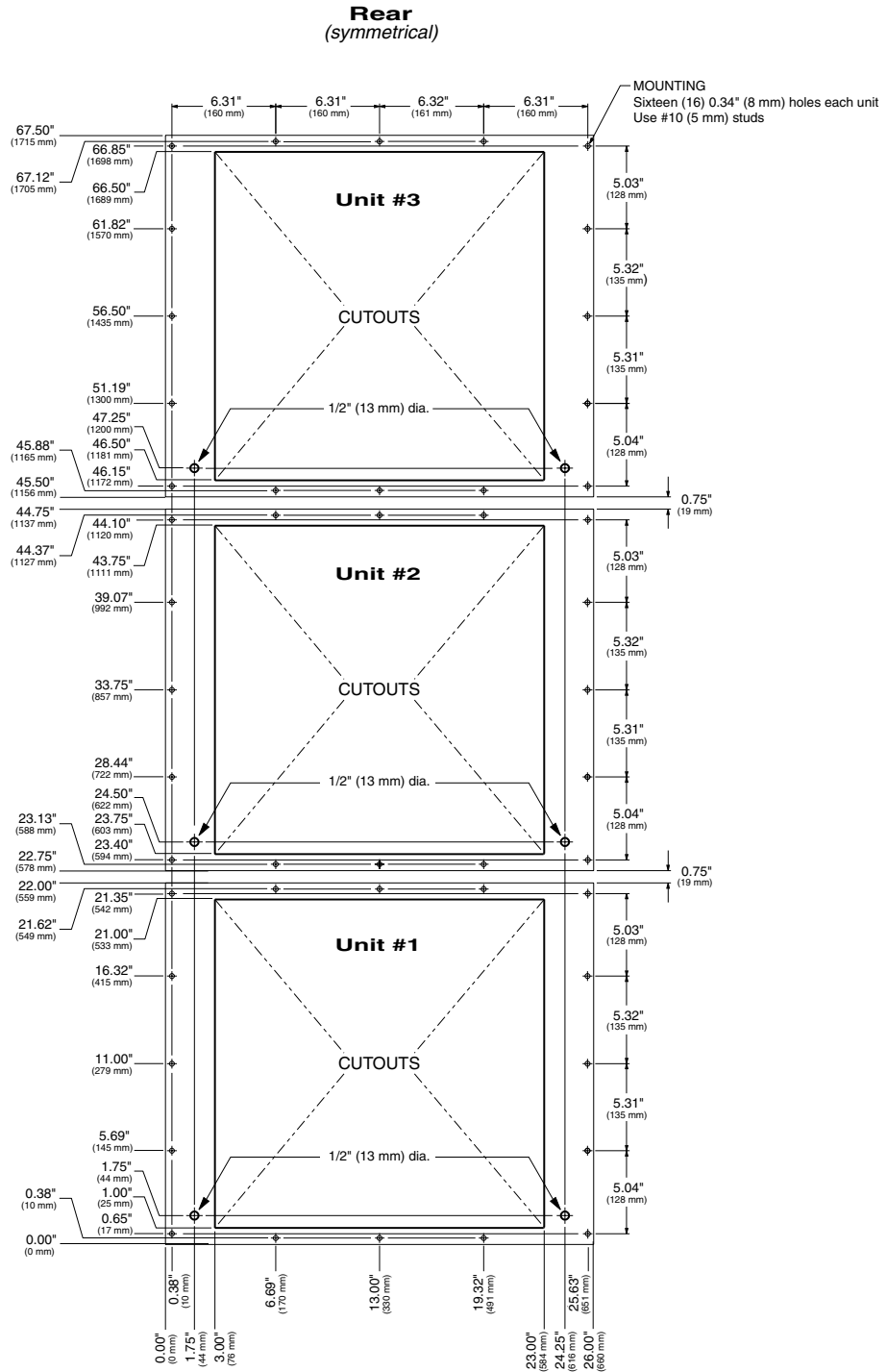


Figure 3-10—Bus and Ground Bars (Form 5)

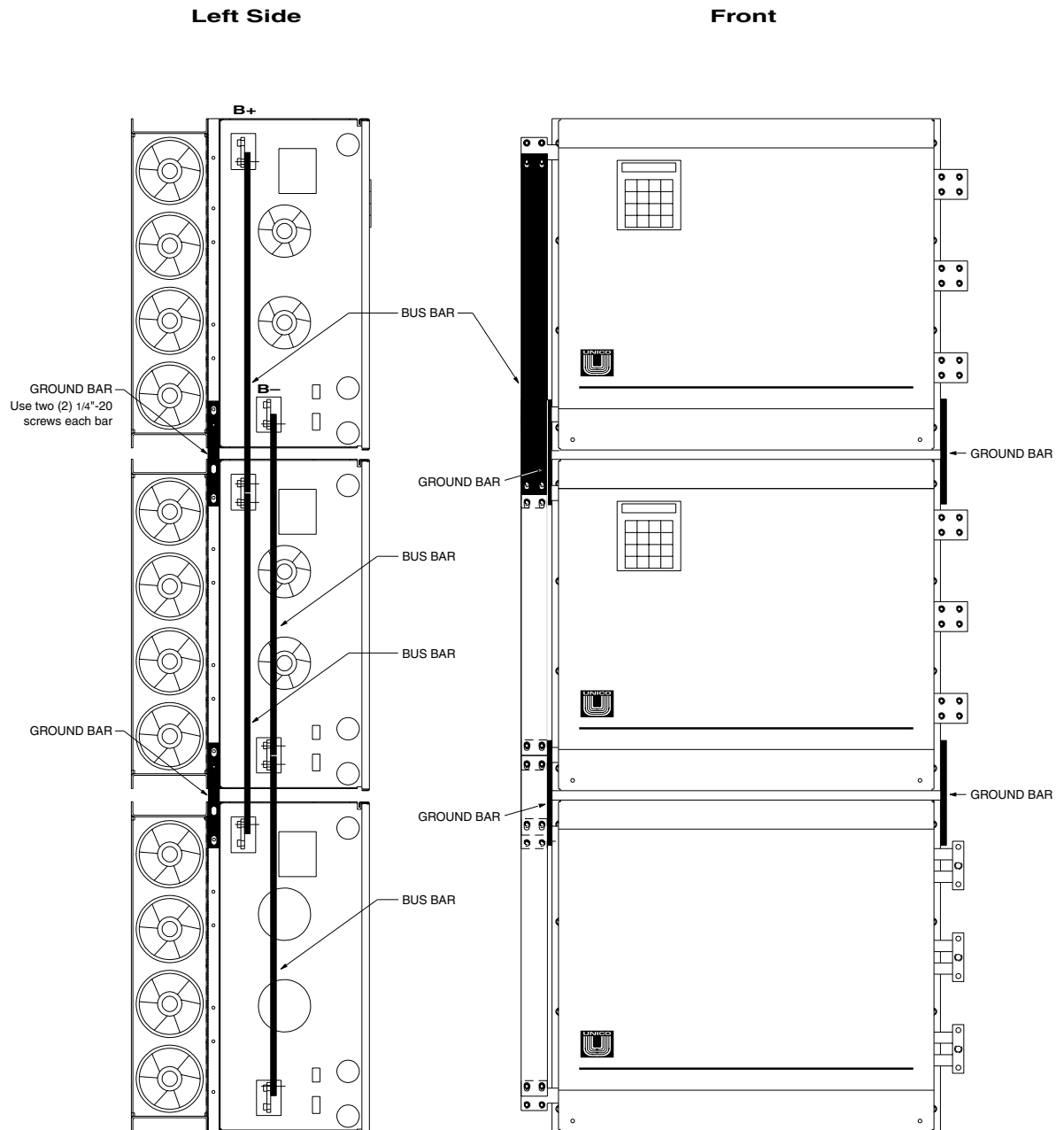


Figure 3-11—Bus and Ground Bars (Forms 6 and 7)

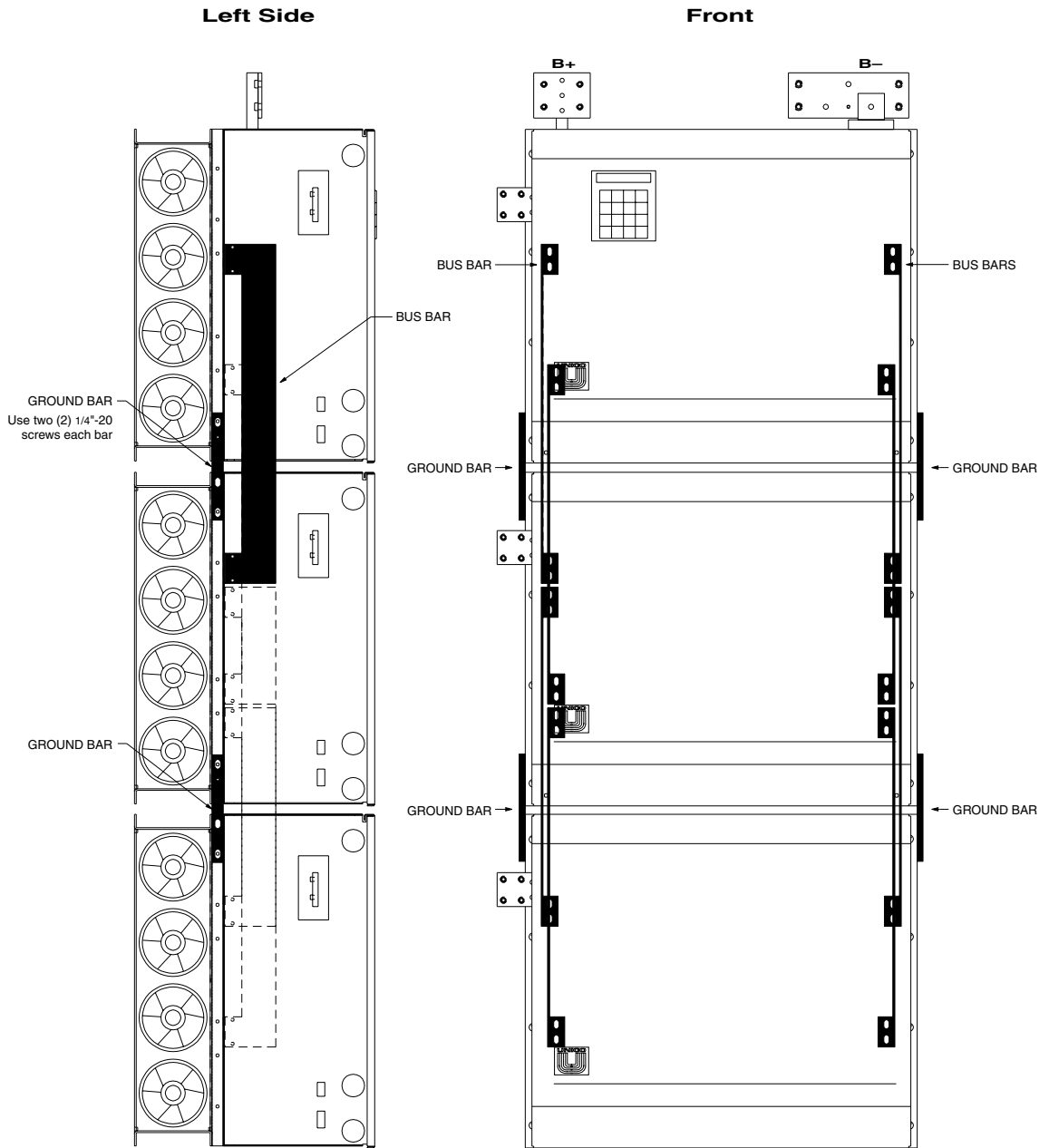


Table 3-10—2400 Inverter Power Dissipation

| 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) | — | — | — | 0.137 |
| 2 (1.5) | 3 (2.2) | — | — | — | 0.144 |
| 3 (2.2) | 5 (3.7) | — | — | — | 0.166 |
| 5 (3.7) | 7 1/2 (5.5) | — | — | — | 0.212 |
| 7 1/2 (5.5) | 10 (7.5) | — | — | — | 0.267 |
| 10 (7.5) | 15 (11) | — | — | — | 0.315 |
| 15 (11) | 20 (15) | — | — | — | 0.429 |
| 20 (15) | 25 (18) | — | — | — | 0.540 |
| 25 (18) | 30 (22) | — | — | — | 0.653 |
| 30 (22) | 40 (30) | — | — | — | 0.751 |
| 40 (30) | 50 (37) | — | — | — | 0.946 |
| 50 (37) | 60 (45) | — | — | — | 1.171 |
| 60 (45) | 75 (55) | — | — | — | 1.366 |
| 75 (55) | 100 (75) | — | — | — | 1.675 |
| 460 V | | | | | |
| 1 1/2 (1.1) | 2 (1.5) | — | — | — | 0.132 |
| 2 (1.5) | 3 (2.2) | — | — | — | 0.138 |
| 3 (2.2) | 5 (3.7) | — | — | — | 0.158 |
| 5 (3.7) | 7 1/2 (5.5) | — | — | — | 0.198 |
| 7 1/2 (5.5) | 10 (7.5) | — | — | — | 0.247 |
| 10 (7.5) | 15 (11) | — | — | — | 0.290 |
| 15 (11) | 20 (15) | 25 (18) | — | — | 0.391 |
| 20 (15) | 25 (18) | 30 (22) | — | — | 0.478 |
| 25 (18) | 30 (22) | 40 (30) | — | — | 0.578 |
| 30 (22) | 40 (30) | 50 (37) | — | — | 0.679 |
| 40 (30) | 50 (37) | 60 (45) | — | — | 0.853 |
| 50 (37) | 60 (45) | 75 (55) | — | — | 1.040 |

(continued)

Table 3-10—2400 Inverter 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) | — | — | 1.214 |
| 75 (55) | 100 (75) | 125 (90) | — | — | 1.502 |
| 100 (75) | 125 (90) | 150 (110) | — | — | 1.908 |
| 125 (90) | 150 (110) | 200 (150) | 0.231 | 2.153 | 2.384 |
| 150 (110) | 200 (150) | 250 (185) | 0.251 | 2.484 | 2.735 |
| 200 (150) | 250 (185) | 300 (225) | 0.291 | 3.312 | 3.603 |
| 250 (185) | 300 (225) | 350 (262) | 0.465 | 4.140 | 4.605 |
| 300 (225) | 350 (262) | 400 (300) | 0.505 | 4.968 | 5.473 |
| 350 (262) | 400 (300) | 500 (375) | 0.545 | 5.796 | 6.341 |
| 400 (300) | 500 (375) | 600 (450) | 0.585 | 6.624 | 7.209 |
| 500 (375) | 600 (450) | 700 (525) | 0.843 | 8.280 | 9.123 |
| 600 (450) | 700 (525) | 800 (600) | 0.923 | 9.936 | 10.859 |
| 700 (525) | 800 (600) | 900 (675) | 1.255 | 11.592 | 12.847 |
| 800 (600) | 900 (675) | 1000 (750) | 1.335 | 13.248 | 14.583 |
| 900 (675) | 1000 (750) | 1100 (825) | 1.465 | 14.904 | 16.369 |
| 1000 (750) | 1100 (825) | 1200 (900) | 1.545 | 16.560 | 18.105 |
| 575 V | | | | | |
| 125 (90) | 150 (110) | 200 (150) | 0.231 | 2.400 | 2.631 |
| 150 (110) | 200 (150) | 250 (185) | 0.251 | 2.765 | 3.016 |
| 200 (150) | 250 (185) | 300 (225) | 0.291 | 3.686 | 3.977 |
| 250 (185) | 300 (225) | 350 (262) | 0.465 | 4.608 | 5.073 |
| 300 (225) | 350 (262) | 400 (300) | 0.505 | 5.530 | 6.035 |
| 350 (262) | 400 (300) | 500 (375) | 0.545 | 6.451 | 6.996 |
| 400 (300) | 500 (375) | 600 (450) | 0.585 | 7.373 | 7.958 |
| 500 (375) | 600 (450) | 700 (525) | 0.843 | 9.216 | 10.059 |
| 600 (450) | 700 (525) | 800 (600) | 0.923 | 11.059 | 11.982 |

(continued)

Table 3-10—2400 Inverter Power Dissipation *(continued)*

| Power | | | Dissipation | | |
|----------------|----------------|----------------|-------------|-----------|-----------|
| CT | VT | ET | Control | Heat Sink | Total |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>hp (kW)</i> | <i>kW</i> | <i>kW</i> | <i>kW</i> |
| 575 V | | | | | |
| 700 (525) | 800 (600) | 900 (675) | 1.255 | 12.902 | 14.157 |
| 800 (600) | 900 (675) | 1000 (750) | 1.335 | 14.746 | 16.081 |
| 900 (675) | 1000 (750) | 1100 (825) | 1.465 | 16.589 | 18.054 |
| 1000 (750) | 1100 (825) | 1200 (900) | 1.545 | 18.432 | 19.977 |
| 1100 (825) | 1200 (900) | 1300 (975) | 1.625 | 20.275 | 21.900 |

Table 3-11—2420 Power Dissipation

| P o w e r | | Dissipation |
|------------------|----------------|--------------------|
| CT | VT | Total |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>kW</i> |
| 230 V | | |
| 1 1/2 (1.1) | 2 (1.5) | 0.167 |
| 2 (1.5) | 3 (2.2) | 0.177 |
| 3 (2.2) | 5 (3.7) | 0.209 |
| 5 (3.7) | 7 1/2 (5.5) | 0.272 |
| 7 1/2 (5.5) | 10 (7.5) | 0.350 |
| 10 (7.5) | 15 (11) | 0.420 |
| 15 (11) | 20 (15) | 0.578 |
| 20 (15) | 25 (18) | 0.733 |
| 25 (18) | 30 (22) | 0.891 |
| 460 V | | |
| 1 1/2 (1.1) | 2 (1.5) | 0.155 |
| 2 (1.5) | 3 (2.2) | 0.163 |
| 3 (2.2) | 5 (3.7) | 0.189 |
| 5 (3.7) | 7 1/2 (5.5) | 0.241 |
| 7 1/2 (5.5) | 10 (7.5) | 0.304 |
| 10 (7.5) | 15 (11) | 0.360 |
| 15 (11) | 20 (15) | 0.489 |
| 20 (15) | 25 (18) | 0.603 |
| 25 (18) | 30 (22) | 0.732 |
| 30 (22) | 40 (30) | 0.859 |
| 40 (30) | 50 (37) | 1.087 |
| 50 (37) | 60 (45) | 1.329 |

Table 3-12—2450 Amplifier Power Dissipation

| Power | | Dissipation | | |
|----------------|----------------|-------------|-----------|-----------|
| CT | VT | Control | Heat Sink | Total |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>kW</i> | <i>kW</i> | <i>kW</i> |
| 230 V | | | | |
| 1 1/2 (1.1) | 2 (1.5) | — | — | 0.118 |
| 2 (1.5) | 3 (2.2) | — | — | 0.127 |
| 3 (2.2) | 5 (3.7) | — | — | 0.143 |
| 5 (3.7) | 7 1/2 (5.5) | — | — | 0.175 |
| 7 1/2 (5.5) | 10 (7.5) | — | — | 0.214 |
| 10 (7.5) | 15 (11) | — | — | 0.248 |
| 15 (11) | 20 (15) | — | — | 0.328 |
| 20 (15) | 25 (18) | — | — | 0.411 |
| 25 (18) | 30 (22) | — | — | 0.490 |
| 30 (22) | 40 (30) | — | — | 0.559 |
| 40 (30) | 50 (37) | — | — | 0.697 |
| 50 (37) | 60 (45) | — | — | 0.859 |
| 60 (45) | 75 (55) | — | — | 0.997 |
| 75 (55) | 100 (75) | 0.177 | 1.037 | 1.214 |
| 100 (75) | 125 (90) | 0.211 | 1.934 | 2.145 |
| 125 (90) | 150 (110) | 0.231 | 2.434 | 2.665 |
| 150 (110) | 200 (150) | 0.251 | 2.808 | 3.059 |
| 460 V | | | | |
| 1 1/2 (1.1) | 2 (1.5) | — | — | 0.132 |
| 2 (1.5) | 3 (2.2) | — | — | 0.138 |
| 3 (2.2) | 5 (3.7) | — | — | 0.158 |
| 5 (3.7) | 7 1/2 (5.5) | — | — | 0.198 |
| 7 1/2 (5.5) | 10 (7.5) | — | — | 0.247 |
| 10 (7.5) | 15 (11) | — | — | 0.290 |
| 15 (11) | 20 (15) | — | — | 0.391 |
| 20 (15) | 25 (18) | — | — | 0.478 |

(continued)

Table 3-12—2450 Amplifier Power Dissipation (continued)

| Power | | Dissipation | | |
|----------------|----------------|-------------|-----------|-----------|
| CT | VT | Control | Heat Sink | Total |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>kW</i> | <i>kW</i> | <i>kW</i> |
| 460 V | | | | |
| 25 (18) | 30 (22) | — | — | 0.578 |
| 30 (22) | 40 (30) | — | — | 0.679 |
| 40 (30) | 50 (37) | — | — | 0.853 |
| 50 (37) | 60 (45) | — | — | 1.040 |
| 60 (45) | 75 (55) | — | — | 1.214 |
| 75 (55) | 100 (75) | — | — | 1.502 |
| 100 (75) | 125 (90) | 0.197 | 1.711 | 1.908 |
| 125 (90) | 150 (110) | 0.231 | 2.153 | 2.384 |
| 150 (110) | 200 (150) | 0.251 | 2.484 | 2.735 |
| 200 (150) | 250 (185) | 0.291 | 3.312 | 3.603 |
| 250 (185) | 300 (225) | 0.465 | 4.140 | 4.605 |
| 300 (225) | 350 (262) | 0.505 | 4.968 | 5.473 |
| 350 (262) | 400 (300) | 0.545 | 5.796 | 6.341 |
| 400 (300) | 500 (375) | 0.585 | 6.624 | 7.209 |
| 500 (375) | 600 (450) | 0.843 | 8.280 | 9.123 |
| 600 (450) | 700 (525) | 0.923 | 9.936 | 10.859 |
| 700 (525) | 800 (600) | 1.255 | 11.592 | 12.847 |
| 800 (600) | 900 (675) | 1.335 | 13.248 | 14.583 |

Table 3-13—2490 Converter Power Dissipation

| Power <i>hp (kW)</i> | Dissipation | | |
|-------------------------|----------------------|------------------------|--------------------|
| | Control <i>kW</i> | Heat Sink <i>kW</i> | Total <i>kW</i> |
| 230 V | | | |
| 10 (7.5) | — | — | 0.179 |
| 20 (15) | — | — | 0.267 |
| 40 (30) | — | — | 0.455 |
| 75 (55) | — | — | 0.773 |
| 460 V | | | |
| 20 (15) | — | — | 0.200 |
| 40 (30) | — | — | 0.309 |
| 75 (55) | — | — | 0.513 |
| 150 (110) | — | — | 0.922 |
| 250 (185) | 0.681 | 0.792 | 1.473 |
| 400 (300) | 1.067 | 1.267 | 2.334 |
| 500 (375) | 1.287 | 1.584 | 2.871 |
| 600 (450) | 1.507 | 1.901 | 3.408 |
| 800 (600) | 1.947 | 2.535 | 4.482 |
| 575 V | | | |
| 150 (110) | — | — | 0.827 |
| 250 (185) | 0.681 | 0.634 | 1.315 |
| 400 (300) | 1.067 | 1.014 | 2.081 |
| 500 (375) | 1.287 | 1.267 | 2.554 |
| 600 (450) | 1.507 | 1.521 | 3.028 |
| 800 (600) | 1.947 | 2.028 | 3.975 |
| 1000 (750) | 2.387 | 2.535 | 4.922 |

Table 3-14—2491 Dynamic Brake Power Dissipation

| Power | Rating | Dissipation |
|----------------|----------------|---------------------------|
| <i>hp (kW)</i> | <i>hp (kW)</i> | Total <i>kW</i> |
| 460 V | | |
| 400 (300) | 100 (75) | 200 |
| 600 (450) | 150 (112) | 300 |
| 800 (600) | 200 (150) | 400 |
| 575 V | | |
| 400 (300) | 100 (75) | 200 |
| 600 (450) | 150 (112) | 300 |
| 800 (600) | 200 (150) | 400 |
| 1000 (750) | 250 (187) | 500 |

4 Electrical Installation

4.1 Overview

This chapter explains the electrical installation of drive units. It covers grounding, input and control power, motor output, dynamic braking, and basic control connections. Since control signals vary from application to application, refer to the appropriate software documentation for specific wiring instructions.

4.2 Wiring Standards and Codes

The installation crew is responsible for following the wiring plan produced by the design engineer for the specific application. 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.

4.3 Insulation Tests

Any site insulation tests must be performed before making electrical connections to the drive units. 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 drive units are disconnected from the input power (R, S, T or R1, R2, S1, S2, T1, T2). Also verify that the motor cable is disconnected from the 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 M Ω .
- 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 M Ω .

4.4 Ground Connections

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

The drive system, power supply, motor, and control circuits should all share a common earth ground, as shown in Figure 4-1. Ground connection terminal specifications are provided in Table 4-8 through Table 4-13 beginning on page 4-23. All wires should be copper with a rating of 167° F (75° C) or higher.

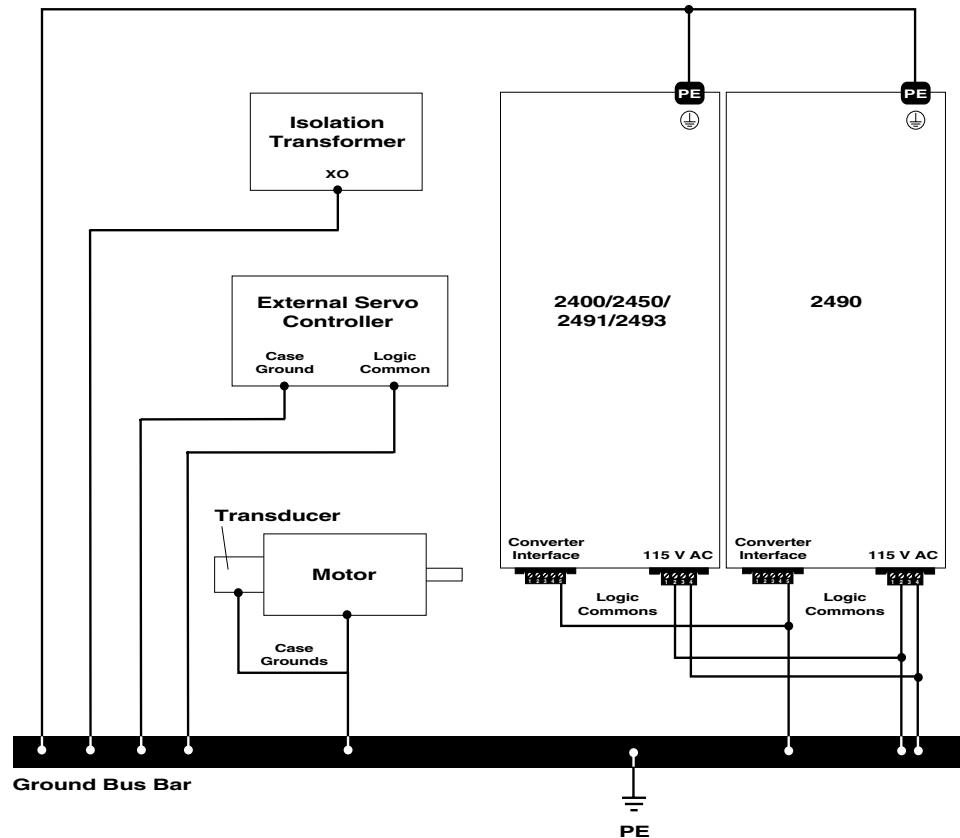


Ground terminal designation

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. They are intended for connecting both the protective earth ground electrode as well as any external protective grounding conductors.

PE

Figure 4-1—Typical Ground Connections



4.4.1 Ground the Drive Units

Connect the case grounds (PE) of the various system components to the star grounding bus of the cabinet. A grounding electrode conductor or bonding jumper must be connected from the star grounding bus to either a grounding electrode buried in the earth or a suitable plant ground with solid connections to earth ground. Refer to Publication NFPA No. 70, Article 250, and to the IEEE “greenbook” for details on grounding and grounding electrodes.

Forms ①, ②, ③, and ④

The PE connection on Form 1 through 4 units is made to studs at the top of the unit.

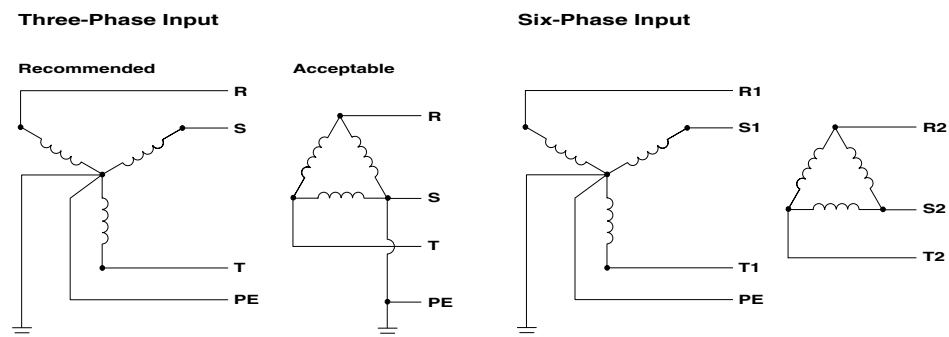
Form ⑤, ⑥, and ⑦

The external PE connection on Form 5 through 7 units is made to the top or bottom ground hole on the side of the heat sink flange using a 1/4"-20 screw. Metal ground bars for interconnecting multiple poles are provided with Form 6 and 7 units and are optional with multiple Form 5 units. These bars are installed when the drive is mounted (see Section 3.5.4).

4.4.2 Ground the Power Supply

For maximum ground fault protection, the incoming line power supply must be earth grounded according to Figure 4-2. It is recommended that a three-phase supply be configured as a wye with a grounded neutral. A grounded delta configuration is also acceptable. Drive units will operate from an open delta, but with reduced ground fault protection. With a six-phase supply, phases R1, S1, and T1 should be configured as a wye with a grounded neutral while phases R2, S2, and T2 should be configured as an open delta.

Figure 4-2—Input Power Supply Grounding



4.4.3 Ground the Isolation Transformer

If an isolation transformer is used, connect the neutral of the transformer to the star grounding bus of the cabinet.

4.4.4 Ground the Motor and Transducer

The motor case and transducer case, if present, must also be connected to the star grounding bus of the cabinet. To minimize electrical noise emissions, it is recommended that a ground lead from the motor case either return with the motor leads to the PE connection of 2400, 2420, and 2450 units.

4.4.5 Ground the 115 V AC Supply

Connect the neutral line of the 115 V AC power supply to the star grounding bus of the cabinet.

4.4.6 Connect the Control Grounds

Connect the logic commons of the various low-voltage control circuits and any external control circuits to the star grounding bus of the cabinet. The Logic Common connections of the drive units are made at the Converter Interface and 115 V AC terminal blocks. Refer to Sections 4.9 and 4.10 for further information.

4.5 Input Power Supply Connections (2420 and 2490)

The 2420 and 2490 drive units must be connected to an AC input power supply. These units are suitable for use on a circuit capable of delivering a maximum of 200,000 A_{rms} symmetrical, 300 V or 600 V maximum, when used with the AC input line fuses specified in Table 4-14 and Table 4-15.



Attention

- Do not supply input voltages higher than that specified. Higher input voltages may damage the drive unit.
 - Input power (R, S, T or R1, R2, S1, S2, T1, T2) should be able to supply at least 1.5 times the capacity of the drive unit.
 - Do not connect supply input voltage (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 drive by applying and removing power. Use only the keypad, digital inputs, or serial commands to operate.
 - Do not perform the Megger test.
-



Attention

Drive units are not equipped with supply-disconnecting devices. 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.



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 unit or associated equipment. Use an appropriate voltmeter to further verify that capacitors are discharged before beginning work. Do not rely exclusively on bus voltage indicators. Dangerous voltage levels may remain even when the indicators are off.

4.5.1 Power Source Conditioning

The use of an AC line reactor and/or isolation transformer is recommended under certain circumstances. The 2420 and 2490 drive units are designed for direct connection to AC lines of the correct voltage and impedance. Use the rules that follow to determine whether an isolation transformer or line reactor is required. Refer to Table 4-16 on page 4-31 for isolation transformer sizing specifications and Table 4-17 on page 4-32 for line reactor sizing specifications. You may purchase these options directly from UNICO or from your value-added reseller. Contact your representative or the factory directly for more information.

Impedance mismatch

Input lines must have a minimum impedance of 1% relative to the rated input kVA of the 2420 or 2490 drive unit (assume the horsepower rating of the unit 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 unit 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 unit. 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. Drive units can be damaged by extreme voltage and current spikes.

Power factor correction capacitors

If the AC line supplying the drive system has power factor correction capacitors that are switched in and out, an isolation transformer or AC line reactor must be installed between the drive unit and the capacitors. Drive units 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.

4.5.2 Connect the Power Supply

Depending upon the model and power rating, a drive unit may accept either a three-phase input for six-pulse operation or a six-phase input for 12-pulse operation. Units are phase-sequence insensitive, so the input leads may be connected in any order. Input connection terminal specifications are provided in Table 4-8 through Table 4-13 beginning on page 4-23. All wires should be copper with a rating of 167° F (75° C) or higher. Make certain AC power inputs are routed separately from control signals.

2420 and 2490 (Forms ② and ③)

These units accept a three-phase input. Connect the power supply leads to R, S, and T as shown in Figure 4-3.

2490 (Forms ④ and ⑤)

These units accept either a three- or six-phase input. For a three-phase input, connect the power supply leads to the jumper bars between R1 and R2, S1 and S2, and T1 and T2 according to Figure 4-3. For a six-phase input, remove the jumper bars and connect the power supply leads directly to R1, R2, S1, S2, T1, and T2 as shown in Figure 4-4.

4.5.3 Input Protection

The drive system must be protected from short circuits using either a circuit breaker or fusing.

Fuses are not supplied and must be provided externally to the 2420 and 2490 units. Fuse recommendations and specifications are provided beginning on page 4-28 in Table 4-14 (2420 drive) and Table 4-15 (2490 converter). 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 for the 2490 differ for 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 4-15.

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 drive units 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 4-14 and Table 4-15 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 or from your value-added reseller. Contact your representative or the factory directly for more information.

Figure 4-3—Three-Phase (Six-Pulse) Input Connections

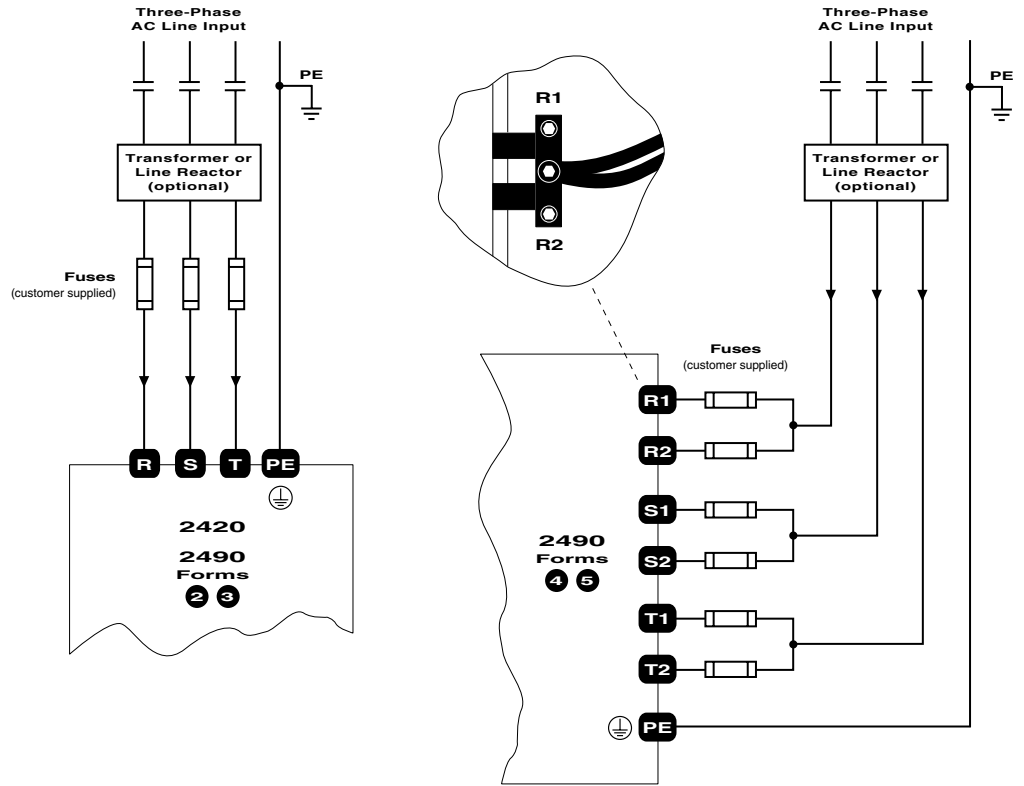
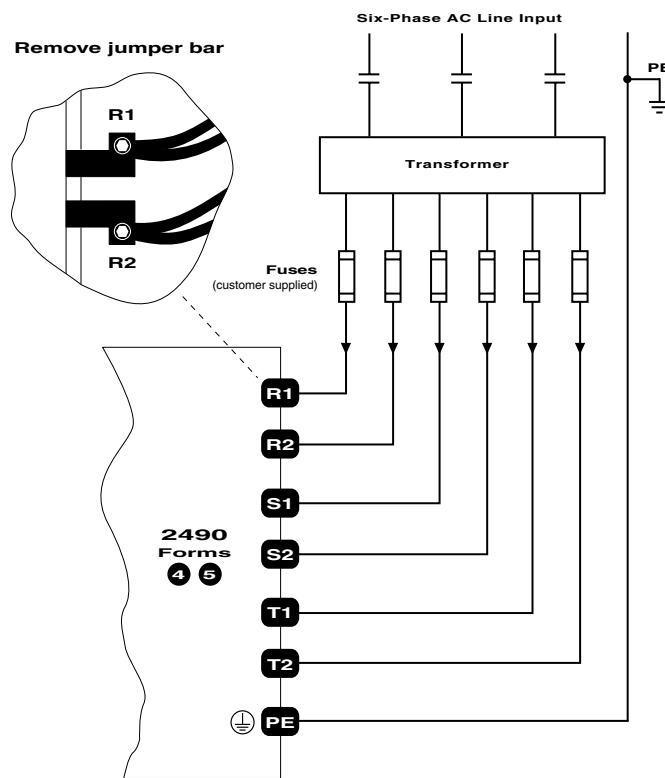


Figure 4-4—Six-Phase (12-Pulse) Input Connections



4.6 Motor Connections (2400, 2420, and 2450)

Each 2400, 2420, and 2450 drive unit can operate a single motor. Connect AC motor leads to terminals U, V, and W on 2400 and 2420 units. Connect DC motor leads to terminals A1 and A2 on 2450 units. These terminals are located at the top of Form 2 through 4 units, along the right side of Form 5 units, and on the left side of Form 6 and 7 units. Refer to Figure 4-5. Motor output terminal specifications are provided in Table 4-8 through Table 4-13 beginning on page 4-23. All wires should be copper with a rating of 167° F (75° C) or higher. Use of a metal-jacketed motor cable is recommended to minimize noise emissions. Refer to Table 2-24 or Table 2-25 to determine the output current rating of a drive unit.

If the motor has a transducer, the motor leads may be connected in any order and the controller 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.

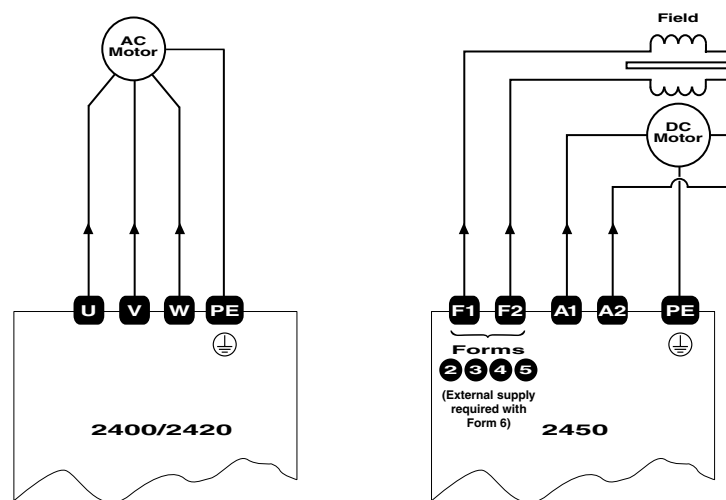
Care must be exercised to minimize the electrical noise interference caused by high-frequency voltage switching on these connections. Make certain that motor outputs are routed separately from both control signals and AC input power and that control signals are appropriately shielded.

4.6.1 Motor Field Power Supply (2450 only)

Form 2 through 5 2450 amplifier units have an internal power supply for energizing the DC motor field. Form 6 units require an external field supply. Stand-alone supplies are available directly from UNICO or from your value-added reseller. Contact your representative or the factory directly for more information.

Connect the field windings to the F1 and F2 terminals located at the top of Form 2 through 5 units as shown in Figure 4-5. Field power supply terminal specifications are provided in Table 4-10 on page 4-25. All wires should be copper with a rating of 167° F (75° C) or higher.

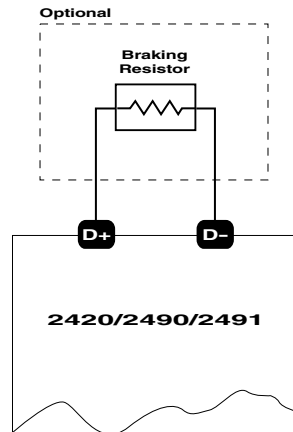
Figure 4-5—Motor Connections



4.7 Dynamic Braking Connections (2420, 2490, and 2491)

Dynamic braking control is included with 2420 drives and is optional with 2490 converters. Converters rated 400 hp or more require a 2491 dynamic braking unit that mounts separately from the converter. Braking units have maximum continuous ratings of 25% of the rating of the associated converters. Refer to Table 4-18 on page 4-35 for dynamic braking module specifications.

Figure 4-6—Dynamic Brake Connections



4.7.1 Dynamic Braking Resistor

Dynamic braking resistors are available from the factory or you may supply your own. Resistors are sized to give a braking torque of either 150% or 200% of rated torque with a capacity of 5%, 10%, or 20% of the associated converter power rating. Consult the factory for other combinations. Refer to Table 4-18 on page 4-35 for dynamic braking resistor sizing.

Connect the power resistor to the D+ and D– terminals at the top of either the 2420, 2490, or 2491 unit as shown in Figure 4-6. Dynamic braking terminal specifications are provided in Table 4-8 through Table 4-13 beginning on page 4-23. All wires should be copper with a rating of 167° F (75° C) or higher.

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.

4.7.2 Fiber-Optic Interface (2491 only)

The 2491 dynamic brake unit is provided with a fiber-optic cable for interfacing with the converter unit. The cable is preconnected to the dynamic brake Gate Drive Module and hangs out of the bottom of the unit. Plug the free end of the cable into the Charging Control Module as shown in Figure 4-7.

Figure 4-7—Dynamic Brake Unit Fiber-Optic Interface Connection

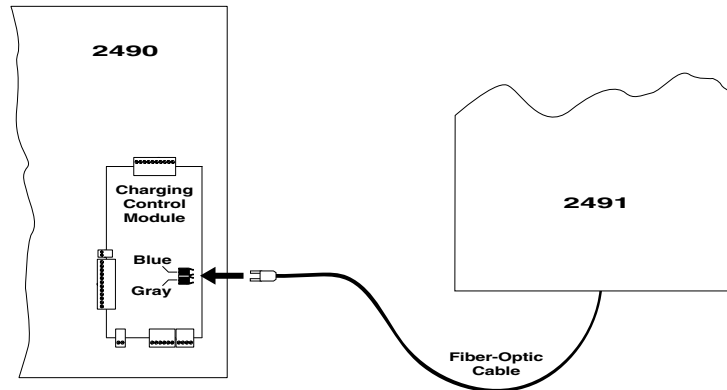


Table 4-1—Dynamic Brake Unit Fiber-Optic Interface Connection

| Connection | Signal | Description |
|----------------------------|------------------|---|
| Blue fiber-optic connector | IGBT Not Faulted | Fiber-optic signal from the Gate Drive module of the braking unit. Lit during normal operation, dark when the dynamic braking IGBT has faulted. |
| Gray fiber-optic connector | IGBT Enable | Fiber-optic signal from the Charging Control Module of the converter. Lit when the dynamic braking IGBT is enabled, dark when it is disabled. |

4.8 DC Bus Connections (all units)

A 2490 converter unit supplies the DC bus that powers a modular drive system. In some cases, a 2420 drive may also furnish the bus for a limited 2400 drive system. Connect each 2400, 2450, 2491, and 2493 drive unit within the system in parallel with this bus using the B+ and B– terminals, as shown in Figure 4-8. Bus terminals are located inside the top of Form 1 through Form 4 units, on the left-hand side of Form 5 units, and externally at the top of Form 6 and 7 units. Bus terminal specifications are provided in Table 4-8 through Table 4-13 beginning on page 4-23. Use the bus current information listed in Table 4-3 to determine proper wire sizing. Nominal bus voltages are provided in Table 4-2. All wires should be copper with a rating of 167° F (75° C) or higher.

External bus bars may be used in lieu of wires to mechanically interconnect multiple Form 5 units, and internal bus bars are used to interconnect the poles of Form 6 and 7 units. These bars should already have been installed during mechanical installation, as described in Section 3.5.4.

Table 4-2—Nominal Bus Voltages

| Input Power | Bus Voltage |
|-------------|-------------|
| 230 V AC | 311 V DC |
| 460 V AC | 621 V DC |
| 575 V AC | 776 V DC |

4.8.1 Bus Discharge Circuit

A resistor can be added to more quickly discharge the DC bus after power has been removed. A normally closed contact is placed in series with the resistor, and the complete circuit is connected in parallel with the bus. This circuit must be interlocked such that the coil is energized and the contact opened whenever line power is applied. Connect the discharge circuit to the B+ and B- terminals of the 2490 converter or 2420 drive as shown in Figure 4-8.



Attention

If power to the drive system is going to be cycled on and off frequently, the resistor may overheat. Be sure to size the resistor carefully. Consult the factory for sizing assistance.



Attention

The discharge 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.

Figure 4-8—DC Bus Connections

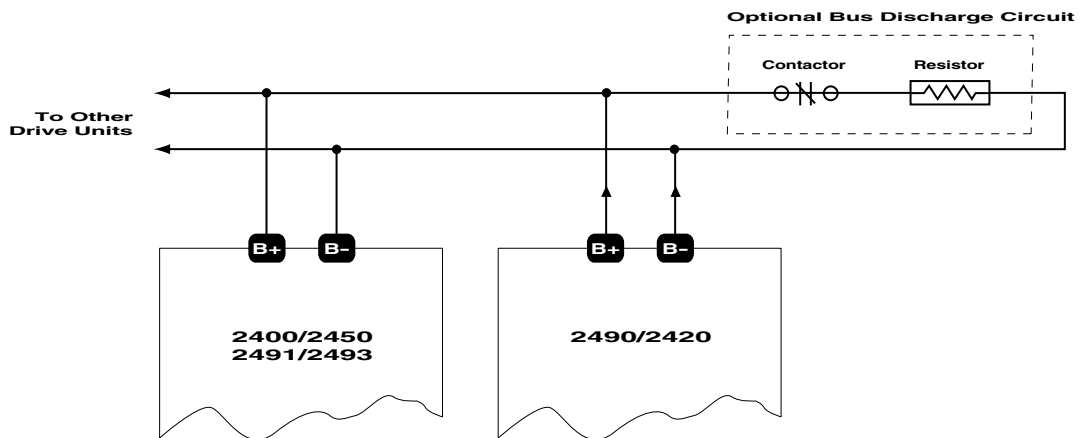


Table 4-3—DC Bus Currents

| Power | 2400 | 2420 |
|----------------|-----------------------|-----------------------|
| | 2450 | |
| | 2490 | |
| <i>hp (kW)</i> | <i>A_{dc}</i> | <i>A_{dc}</i> |
| 230 V | | |
| 1 1/2 (1.1) | 5.1 | 4.3 |
| 2 (1.5) | 6.3 | 5.3 |
| 3 (2.2) | 9.1 | 7.7 |
| 5 (3.7) | 14.9 | 12.5 |
| 7 1/2 (5.5) | 21.9 | 18.5 |
| 10 (7.5) | 28.5 | 24.1 |
| 15 (11) | 42.8 | 36.1 |
| 20 (15) | 56.0 | 47.3 |
| 25 (18) | 70.3 | 59.3 |
| 30 (22) | 83.5 | 70.5 |
| 40 (30) | 109.9 | — |
| 50 (37) | 137.4 | — |
| 60 (45) | 163.8 | — |
| 75 (55) | 204.5 | — |
| 100 (75) | 268.4 | — |
| 125 (90) | 336.6 | — |
| 150 (110) | 396.0 | — |
| 200 (150) | 528.0 | — |

(continued)

Table 4-3—DC Bus Currents *(continued)*

| Power | 2400 2450 | 2420 | Power | 2400 2450 | 2420 |
|----------------|-----------------------|-----------------------|----------------|-----------------------|-----------------------|
| <i>hp (kW)</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>hp (kW)</i> | <i>A_{dc}</i> | <i>A_{dc}</i> |
| 380 V | | | | | |
| 1 1/2 (1.1) | 3.1 | 2.5 | 125 (90) | 203.7 | — |
| 2 (1.5) | 3.8 | 3.1 | 150 (110) | 239.7 | — |
| 3 (2.2) | 5.6 | 4.4 | 200 (150) | 319.6 | — |
| 5 (3.7) | 9.0 | 7.2 | 250 (185) | 399.5 | — |
| 7 1/2 (5.5) | 13.2 | 10.6 | 300 (225) | 479.3 | — |
| 10 (7.5) | 17.3 | 13.8 | 350 (262) | 559.3 | — |
| 15 (11) | 25.9 | 20.8 | 400 (300) | 639.2 | — |
| 20 (15) | 33.9 | 27.2 | 500 (375) | 798.9 | — |
| 25 (18) | 42.5 | 34.1 | 600 (450) | 958.9 | — |
| 30 (22) | 50.5 | 40.5 | 700 (525) | 1118.6 | — |
| 40 (30) | 66.6 | 53.4 | 800 (600) | 1278.4 | — |
| 50 (37) | 83.2 | 66.7 | 900 (675) | 1438.2 | — |
| 60 (45) | 99.1 | 79.5 | 1000 (750) | 1598.0 | — |
| 75 (55) | 123.8 | — | 1100 (825) | 1757.8 | — |
| 100 (75) | 162.5 | — | | | |

(continued)

Bus currents for 2490 units operating at 380 V are the same as 460 V, but the available power is derated to 0.826 times rated.

Table 4-3—DC Bus Currents *(continued)*

| Power | 2400 | 2420 | Power | 2400 | 2420 |
|----------------|-----------------------|-----------------------|----------------|-----------------------|-----------------------|
| | 2450 | | | 2450 | |
| | 2490 | | | 2490 | |
| <i>hp (kW)</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>hp (kW)</i> | <i>A_{dc}</i> | <i>A_{dc}</i> |
| 460 V | | | | | |
| 1 1/2 (1.1) | 2.6 | 2.2 | 125 (90) | 168.3 | — |
| 2 (1.5) | 3.1 | 2.7 | 150 (110) | 198.0 | — |
| 3 (2.2) | 4.6 | 3.9 | 200 (150) | 264.0 | — |
| 5 (3.7) | 7.4 | 6.3 | 250 (185) | 330.0 | — |
| 7 1/2 (5.5) | 10.9 | 9.2 | 300 (225) | 396.0 | — |
| 10 (7.5) | 14.3 | 12.0 | 350 (262) | 462.0 | — |
| 15 (11) | 21.4 | 18.1 | 400 (300) | 528.0 | — |
| 20 (15) | 28.0 | 23.6 | 500 (375) | 660.0 | — |
| 25 (18) | 35.1 | 29.7 | 600 (450) | 792.1 | — |
| 30 (22) | 41.7 | 35.2 | 700 (525) | 924.1 | — |
| 40 (30) | 55.0 | 46.4 | 800 (600) | 1056.1 | — |
| 50 (37) | 68.7 | 58.0 | 900 (675) | 1188.1 | — |
| 60 (45) | 81.9 | 69.2 | 1000 (750) | 1320.1 | — |
| 75 (55) | 102.3 | — | 1100 (825) | 1452.1 | — |
| 100 (75) | 134.2 | — | 1200 (900) | 1584.1 | — |

(continued)

Table 4-3—DC Bus Currents *(continued)*

| Power | 2400 |
|----------------|-----------------------|
| | 2490 |
| <i>hp (kW)</i> | <i>A_{dc}</i> |
| 575 V | |
| 125 (90) | 134.7 |
| 150 (110) | 158.4 |
| 200 (150) | 211.2 |
| 250 (185) | 264.0 |
| 300 (225) | 316.8 |
| 350 (262) | 369.6 |
| 400 (300) | 422.4 |
| 500 (375) | 528.0 |
| 600 (450) | 633.6 |
| 700 (525) | 739.3 |
| 800 (600) | 844.9 |
| 900 (675) | 950.9 |
| 1000 (750) | 1056.1 |
| 1100 (825) | 1161.7 |
| 1200 (900) | 1267.3 |
| 1300 (975) | 1372.9 |

4.9 115 V AC Power Supply Connections (all units except 2493)

External 115 V AC power is required to operate the fans and/or control modules of all drive units except the 2493 capacitor bank. Separate connections are provided for each. It is recommended that a filtered power supply be used for control power, while an unfiltered source is sufficient for the fans.

Connect each unit as shown in Figure 4-9. The terminal block is located beneath Form 2 through 4 units on the front right-hand side and on the left sidewall of Form 5, 6, and 7 pole units. With pole units, control power terminals are only provided for the unit with a controller (the W pole of an AC inverter or the A2 pole of a DC amplifier). Terminal specifications are given in Table 4-5. Current requirements are listed in Table 4-6.

Figure 4-9—115 V AC Power Supply Connections

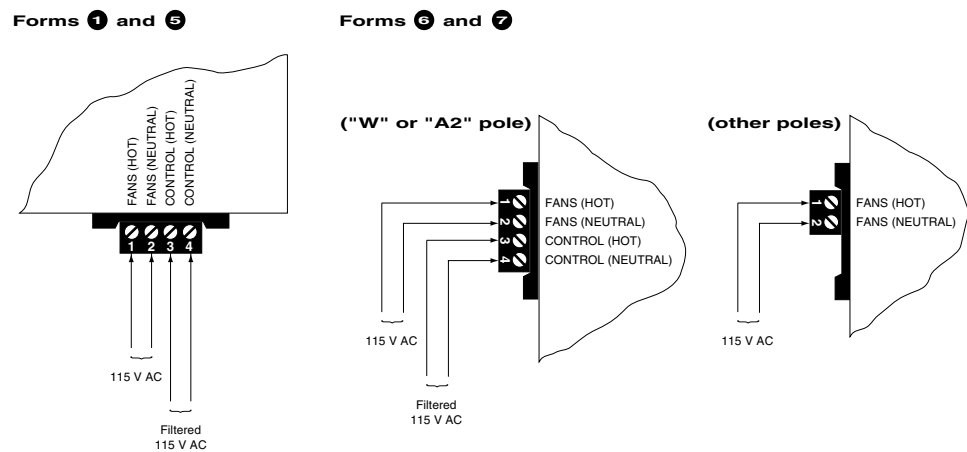


Table 4-4—115 V AC Power Supply Connections

| Terminal | Signal | Description |
|----------|-------------------|-------------------------------------|
| 1 | Fans (hot) | 115 V AC power for fans. |
| 2 | Fans (neutral) | |
| 3 | Control (hot) | 115 V AC power for control modules. |
| 4 | Control (neutral) | |

Table 4-5—115 V AC and Converter Interface Terminal Specifications

| Connector | Acceptable Wire Sizes | Tightening Torque |
|---------------------|------------------------|---------------------------|
| | AWG (mm ²) | in•lb (Nm) |
| Converter Interface | 12 to 24 (3.3-0.21) | 4.4 to 5.3 (0.50-0.60) |
| 115 V AC | 12 to 24 (3.3-0.21) | 4.4 to 5.3 (0.50-0.60) |

Table 4-6—115 V AC Power Supply Currents

| Power | | 2400 / 2450 | | 2420 | | 2490 | |
|----------------|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| CT | VT | Control | Fans | Control | Fans | Control | Fans |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> |
| 230 V | | | | | | | |
| 1 1/2 (1.1) | 2 (1.5) | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 2 (1.5) | 3 (2.2) | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 3 (2.2) | 5 (3.7) | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 5 (3.7) | 7 1/2 (5.5) | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 7 1/2 (5.5) | 10 (7.5) | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 10 (7.5) | 15 (11) | 0.65 | 0.12 | 0.65 | 0.24 | 0.65 | 0.12 |
| 15 (11) | 20 (15) | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 20 (15) | 25 (18) | 0.65 | 0.24 | 0.65 | 0.37 | 0.65 | 0.12 |
| 25 (18) | 30 (22) | 0.65 | 0.24 | 0.65 | 0.37 | — | — |
| 30 (22) | 40 (30) | 0.65 | 0.24 | — | — | — | — |
| 40 (30) | 50 (37) | 0.65 | 0.24 | — | — | 0.65 | 0.24 |
| 50 (37) | 60 (45) | 0.65 | 0.37 | — | — | — | — |
| 60 (45) | 75 (55) | 0.65 | 0.37 | — | — | — | — |
| 75 (55) | 100 (75) | 0.65 | 0.37 | — | — | 0.65 | 0.37 |
| 100 (75) | 125 (90) | 0.65 | 0.49 | — | — | — | — |
| 125 (90) | 150 (110) | 0.65 | 0.49 | — | — | — | — |
| 150 (110) | 200 (150) | 0.65 | 0.49 | — | — | — | — |

(continued)

Table 4-6—115 V AC Power Supply Currents (continued)

| Power | | | 2400 / 2450 | | 2420 | | 2490 | |
|----------------|----------------|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| CT | VT | ET | Control | Fans | Control | Fans | Control | Fans |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>hp (kW)</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> |
| 460 V | | | | | | | | |
| 1 1/2 (1.1) | 2 (1.5) | — | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 2 (1.5) | 3 (2.2) | — | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 3 (2.2) | 5 (3.7) | — | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 5 (3.7) | 7 1/2 (5.5) | — | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 7 1/2 (5.5) | 10 (7.5) | — | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 10 (7.5) | 15 (11) | — | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 15 (11) | 20 (15) | 25 (18) | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 20 (15) | 25 (18) | 30 (22) | 0.65 | 0.12 | 0.65 | 0.24 | 0.65 | 0.12 |
| 25 (18) | 30 (22) | 40 (30) | 0.65 | 0.12 | 0.65 | 0.24 | — | — |
| 30 (22) | 40 (30) | 50 (37) | 0.65 | 0.24 | 0.65 | 0.37 | — | — |
| 40 (30) | 50 (37) | 60 (45) | 0.65 | 0.24 | 0.65 | 0.37 | 0.65 | 0.12 |
| 50 (37) | 60 (45) | 75 (55) | 0.65 | 0.24 | 0.65 | 0.37 | — | — |
| 60 (45) | 75 (55) | 100 (75) | 0.65 | 0.24 | — | — | — | — |
| 75 (55) | 100 (75) | 125 (90) | 0.65 | 0.37 | — | — | 0.65 | 0.24 |
| 100 (75) | 125 (90) | 150 (110) | 0.65 | 0.37 | — | — | — | — |
| 125 (90) | 150 (110) | 200 (150) | 0.65 | 0.49 | — | — | — | — |
| 150 (110) | 200 (150) | 250 (185) | 0.65 | 0.49 | — | — | 0.65 | 0.37 |
| 200 (150) | 250 (185) | 300 (225) | 0.65 | 0.49 | — | — | — | — |
| 250 (185) | 300 (225) | 350 (262) | 1.09 | 1.22 | — | — | 0.65 | 0.49 |
| 300 (225) | 350 (262) | 400 (300) | 1.09 | 1.22 | — | — | — | — |
| 350 (262) | 400 (300) | 500 (375) | 1.09 | 1.22 | — | — | — | — |
| 400 (300) | 500 (375) | 600 (450) | 1.09 | 1.22 | — | — | 0.65 | 0.97 |
| 500 (375) | 600 (450) | 700 (525) | 2.39 | 1.46 | — | — | 0.65 | 0.97 |
| 600 (450) | 700 (525) | 800 (600) | 2.39 | 1.46 | — | — | 0.65 | 0.97 |
| 700 (525) | 800 (600) | 900 (675) | 2.39 | 3.65 | — | — | — | — |
| 800 (600) | 900 (675) | 1000 (750) | 2.39 | 3.65 | — | — | 0.65 | 0.97 |
| 900 (675) | 1000 (750) | 1100 (825) | 2.83 | 3.65 | — | — | — | — |
| 1000 (750) | 1100 (825) | 1200 (900) | 2.83 | 3.65 | — | — | — | — |

(continued)

Table 4-6—115 V AC Power Supply Currents (continued)

| Power | | | 2400 | | 2490 | |
|----------------|----------------|----------------|-----------------------|-----------------------|-----------------------|-----------------------|
| CT | VT | ET | Control | Fans | Control | Fans |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>hp (kW)</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> | <i>A_{dc}</i> |
| 575 V | | | | | | |
| 125 (90) | 150 (110) | 200 (150) | 0.65 | 0.49 | — | — |
| 150 (110) | 200 (150) | 250 (185) | 0.65 | 0.49 | 0.65 | 0.37 |
| 200 (150) | 250 (185) | 300 (225) | 0.65 | 0.49 | — | — |
| 250 (185) | 300 (225) | 350 (262) | 1.09 | 1.22 | 0.65 | 0.49 |
| 300 (225) | 350 (262) | 400 (300) | 1.09 | 1.22 | — | — |
| 350 (262) | 400 (300) | 500 (375) | 1.09 | 1.22 | — | — |
| 400 (300) | 500 (375) | 600 (450) | 1.09 | 1.22 | 0.65 | 0.97 |
| 500 (375) | 600 (450) | 700 (525) | 2.39 | 1.46 | 0.65 | 0.97 |
| 600 (450) | 700 (525) | 800 (600) | 2.39 | 1.46 | 0.65 | 0.97 |
| 700 (525) | 800 (600) | 900 (675) | 2.39 | 3.65 | — | — |
| 800 (600) | 900 (675) | 1000 (750) | 2.39 | 3.65 | 0.65 | 0.97 |
| 900 (675) | 1000 (750) | 1100 (825) | 2.83 | 3.65 | — | — |
| 1000 (750) | 1100 (825) | 1200 (900) | 2.83 | 3.65 | 0.65 | 0.97 |
| 1100 (825) | 1200 (900) | 1300 (975) | 2.83 | 3.65 | — | — |

4.10 Converter Interface Connections

The 2490 converter unit communicates its fault conditions with the inverters or amplifiers it powers using the converter interface connection. The interface also coordinates the resetting of those faults from the individual controllers. A converter interface is also provided on the 2420 drive for systems in which the drive is used to power additional 2400 units.

Connect the converter interface signals from the 2490 or 2420 unit to each 2400 inverter or 2450 amplifier operating from the same bus, as shown in Figure 4-10. The terminal block is located beneath Form 1 through 4 units on the left-hand side and on the left sidewall of Form 5, 6, and 7 units. With Form 6 and 7 pole units, only the pole with a controller has the connection. Terminal specifications are given in Table 4-5.

Figure 4-10—Converter Interface Connections

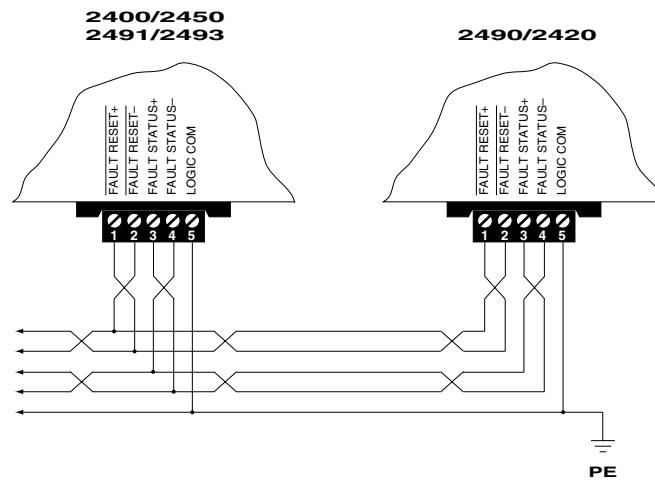


Table 4-7—Converter Interface Connections

| Terminal | Signal | Description |
|----------|---------------------|--|
| 1 | Not Fault Reset (+) | Differential fault reset signal from the inverter or amplifier controller(s). The signal goes low to reset the converter and is low while the motor is on. |
| 2 | Not Fault Reset (-) | |
| 3 | Fault Status (+) | Differential fault status signal from converter that informs the inverter or amplifier controller(s) that the converter has faulted. |
| 4 | Fault Status (-) | |
| 5 | Logic Common | Logic Common |

Figure 4-11—2400 Connections (Form 5)

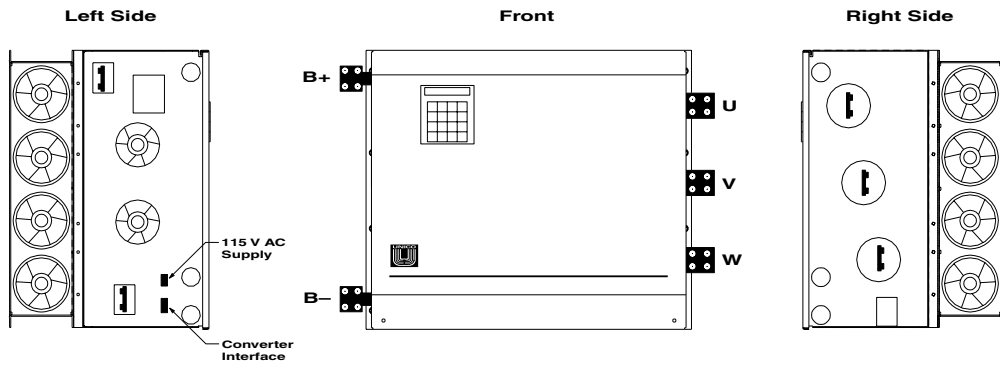


Figure 4-12—2400 Connections (Form 7)

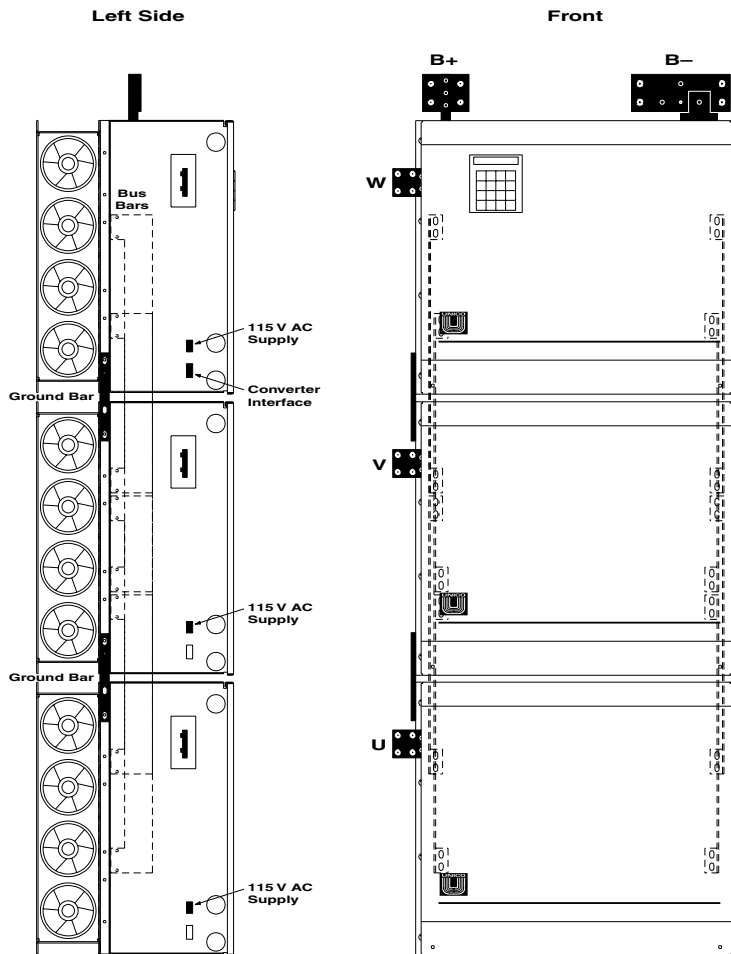


Figure 4-13—2450 Connection Locations (Form 5)

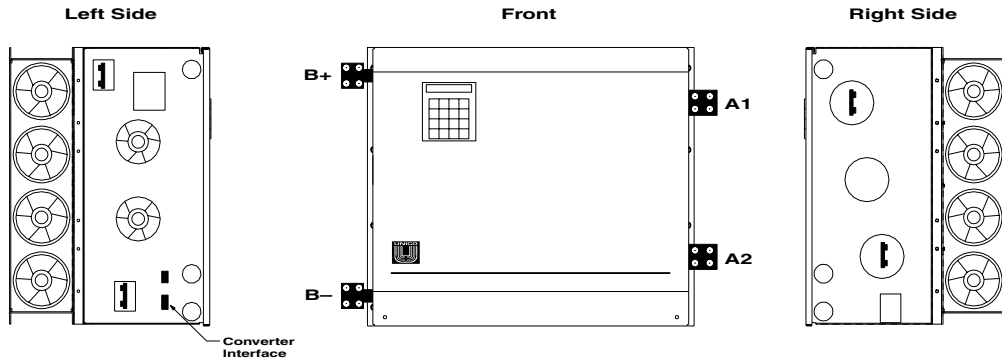


Figure 4-14—2450 Connection Locations (Form 6)

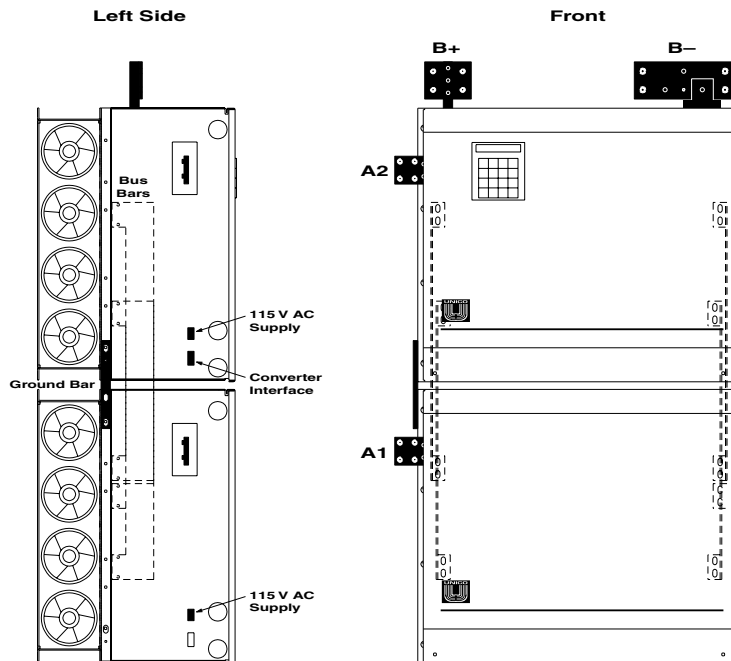


Figure 4-15—2490 Connection Locations (Form 5)

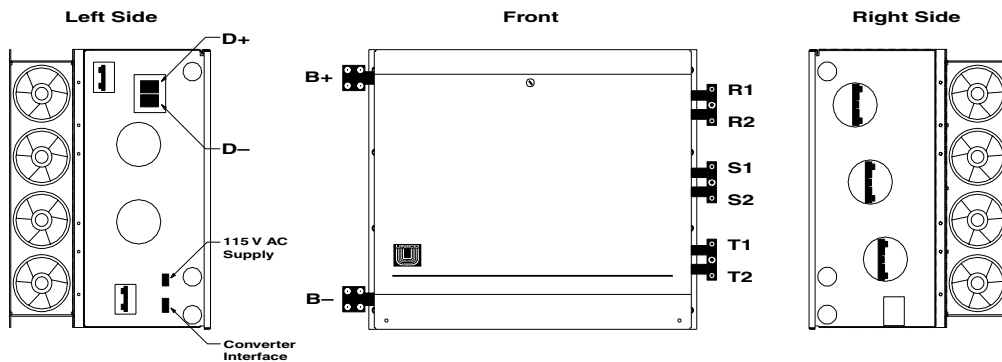


Table 4-8—2400 Ground and Power Terminal Specifications

| Power | | | Terminal | | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------------|---------------------------|-----------------------------|-----------------------|-----------------------------|----------------------|
| | | | Ground (PE) | Motor Output (U, V, W) | | DC Bus (B+, B-) | | |
| CT | VT | ET | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>hp (kW)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> |
| 230 V | | | | | | | | |
| 1 1/2–15 (1.1-11) | 2–20 (1.5-15) | — | #10-32 x 3/4" stud | 27 (3.1) | 6 to 18 (13-0.82) | 45 to 35 (5.1-4.0) | 5/16"-18 x 1" stud | 120 (14) |
| 20-40 (15-30) | 25–50 (18-37) | — | 1/4"-20 x 1" stud | 58 (6.6) | 6 to 18 (13-0.82) | 45 to 35 (5.1-4.0) | 5/16"-18 x 1" stud | 120 (14) |
| 50–75 (37-55) | 60–100 (45-75) | — | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1 3/4" stud | 120 (14) |
| 460 V | | | | | | | | |
| 1 1/2–25 (1.1-18) | 2–30 (1.5-22) | 25–40 (18-30) | #10-32 x 3/4" stud | 27 (3.1) | 6 to 18 (13-0.82) | 45 to 35 (5.1-4.0) | 5/16"-18 x 1" stud | 120 (14) |
| 30–50 (22-37) | 40–60 (30-45) | 50–75 (37-55) | 1/4"-20 x 1" stud | 58 (6.6) | 6 to 18 (13-0.82) | 45 to 35 (5.1-4.0) | 5/16"-18 x 1" stud | 120 (14) |
| 60 (45) | 75 (55) | 100 (75) | 1/4"-20 x 1" stud | 58 (6.6) | 8 to 22 (8.3-0.33) | 13 to 16 (1.5-1.8) | 5/16"-18 x 1" stud | 120 (14) |
| 75–100 (55-75) | 100–125 (75-90) | 125–150 (90-110) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1 3/4" stud | 120 (14) |
| 125–400 (90-300) | 150–500 (110-375) | 200–600 (150-450) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts (†) | 216 (24) |
| 500–1000 (375-750) | 600–1100 (450-825) | 700–1200 (525-900) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts | 216 (24) |
| 575 V | | | | | | | | |
| 125–400 (90-300) | 150–500 (110-375) | 200–600 (150-450) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts (†) | 216 (24) |
| 500–1100 (375-825) | 600–1200 (450-900) | 700–1300 (525-975) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts | 216 (24) |

(†) Ground and/or bus bars may be used instead of wires to interconnect multiple units or poles.

Table 4-9—2420 Ground and Power Terminal Specifications

| Power | | Terminal | | | | | | | | | |
|----------------------|------------------|--|-------------|--|-----------------------|--|-----------------------|--|-------------|--|-------------|
| | | Ground (PE) | | AC Line Input (R, S, T) | | Motor Output (U, V, W) | | DC Bus (B+, B-) | | Dynamic Braking (D+, D-) | |
| CT | VT | Acceptable Tightening | | Acceptable Tightening | | Acceptable Tightening | | Acceptable Tightening | | Acceptable Tightening | |
| | | Wire Sizes | Torque | Wire Sizes | Torque | Wire Sizes | Torque | Wire Sizes | Torque | Wire Sizes | Torque |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>AWG (mm²) in•lb (Nm)</i> | | <i>AWG (mm²) in•lb (Nm)</i> | | <i>AWG (mm²) in•lb (Nm)</i> | | <i>AWG (mm²) in•lb (Nm)</i> | | <i>AWG (mm²) in•lb (Nm)</i> | |
| 230 V | | | | | | | | | | | |
| 1 1/2–15 (1.1-11) | 2–20 (1.5-15) | 1/4"-20 x 1" stud | 58 (6.6) | 6 to 18 (13-0.82) | 45 to 35 (5.1-4.0) | 6 to 18 (13-0.82) | 45 to 35 (5.1-4.0) | 8 to 18 (8.3-0.82) | 30 (3.4) | 8 to 18 (8.3-0.82) | 30 (3.4) |
| 20–25 (15-18) | 25–30 (18-22) | 1/4"-20 x 1" stud | 58 (6.6) | 6 to 18 (13-0.82) | 20 (2.3) | 6 to 18 (13-0.82) | 20 (2.3) | 6 to 18 (13-0.82) | 20 (2.3) | 6 to 18 (13-0.82) | 20 (2.3) |
| 460 V | | | | | | | | | | | |
| 1 1/2–25 (1.1-18) | 2–30 (1.5-22) | 1/4"-20 x 1" stud | 58 (6.6) | 6 to 18 (13-0.82) | 45 to 35 (5.1-4.0) | 6 to 18 (13-0.82) | 45 to 35 (5.1-4.0) | 8 to 18 (8.3-0.82) | 30 (3.4) | 8 to 18 (8.3-0.82) | 30 (3.4) |
| 30–50 (22-37) | 40–60 (30-45) | 1/4"-20 x 1" stud | 58 (6.6) | 6 to 18 (13-0.82) | 20 (2.3) | 6 to 18 (13-0.82) | 20 (2.3) | 6 to 18 (13-0.82) | 20 (2.3) | 6 to 18 (13-0.82) | 20 (2.3) |

Table 4-10—2450 Ground and Power Terminal Specifications

| Power | | Terminal | | | | | | | |
|----------------------|----------------------|-----------------------------|-------------------|-----------------------------|-----------------------|-----------------------------|-----------------------|-----------------------------|-----------------------|
| | | Ground (PE) | | Motor Output (A1, A2) | | Field Supply (F1, F2) | | DC Bus (B+, B-) | |
| CT | VT | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> |
| 230 V | | | | | | | | | |
| 1 1/2–15 (1.1-11) | 2–20 (1.5-15) | #10-32 x 3/4" stud | 27 (3.1) | 8 to 22 (8.3-0.33) | 13 to 16 (1.5-1.8) | 8 to 22 (8.3-0.33) | 13 to 16 (1.5-1.8) | 5/16"-18 x 1" stud | 120 (14) |
| 20–30 (15-22) | 25–40 (18-30) | 1/4"-20 x 1" stud | 58 (6.6) | 6 to 18 (13-0.82) | 20 (2.3) | 6 to 18 (13-0.82) | 20 (2.3) | 5/16"-18 x 1" stud | 120 (14) |
| 40–60 (30-45) | 50–75 (37-55) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1 3/4" stud | 120 (14) |
| 75–150 (55-110) | 100–200 (75-150) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts | 216 (24) | 8 to 22 (†) (8.3-0.33) | 13 to 16 (1.5-1.8) |
| 460 V | | | | | | | | | |
| 1 1/2–20 (1.1-15) | 2–25 (1.5-18) | #10-32 x 3/4" stud | 27 (3.1) | 8 to 22 (8.3-0.33) | 13 to 16 (1.5-1.8) | 8 to 22 (8.3-0.33) | 13 to 16 (1.5-1.8) | 5/16"-18 x 1" stud | 120 (14) |
| 30–50 (22-37) | 40–60 (30-45) | 1/4"-20 x 1" stud | 58 (6.6) | 6 to 18 (13-0.82) | 20 (2.3) | 6 to 18 (13-0.82) | 20 (2.3) | 5/16"-18 x 1" stud | 120 (14) |
| 60–75 (45-55) | 75–100 (55-75) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1 3/4" stud | 120 (14) |
| 100–250 (75-185) | 125–300 (90-225) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts | 216 (24) | 8 to 22 (†) (8.3-0.33) | 13 to 16 (1.5-1.8) |
| 300–800 (225-600) | 350–900 (262-675) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts | 216 (24) | — | — |

(†) Ground and/or bus bars may be used instead of wires to interconnect multiple units or poles.

Table 4-11—2490 Ground and Power Terminal Specifications

| Power | Terminal | | | | | | | |
|-----------------------|-----------------------------|-------------------|---|-------------------|-----------------------------|-------------------|-----------------------------|-------------------|
| | Ground (PE) | | AC Line Input (R, S, T or R1, R2, S1, S2, T1, T2) | | DC Bus (B+, B-) | | Dynamic Braking (D+, D-) | |
| | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque |
| <i>hp (kW)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> |
| 230 V | | | | | | | | |
| 10–20 (7.5-15) | #10-32 x 3/4" stud | 27 (3.1) | 5/16"-18 x 1" stud | 120 (14) | 8 to 18 (8.3-0.82) | 30 (3.4) | 8 to 18 (8.3-0.82) | 30 (3.4) |
| 40 (30) | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1 3/4" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) |
| 75 (55) | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) |
| 460 V | | | | | | | | |
| 20–40 (15-30) | #10-32 x 3/4" stud | 27 (3.1) | 5/16"-18 x 1" stud | 120 (14) | 8 to 18 (8.3-0.82) | 30 (3.4) | 8 to 18 (8.3-0.82) | 30 (3.4) |
| 75–150 (55-110) | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) |
| 250–800 (185-600) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts (†) | 216 (24) | 5/16"-18 x 1" stud | 120 (14) |
| 575 V | | | | | | | | |
| 150 (110) | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) |
| 250–1000 (185-750) | 1/4"-20 screws (†) | 108 (12) | 5/16"-18 x 1" bolts | 216 (24) | 5/16"-18 x 1" bolts (†) | 216 (24) | 5/16"-18 x 1" stud | 120 (14) |

(†) Ground and/or bus bars may be used instead of wires to interconnect multiple units or poles.

Table 4-12—2491 Ground and Power Terminal Specifications

| Power Rating | | Terminal | | | | | |
|-----------------------|----------------------|-----------------------------|-------------------|-----------------------------|-------------------|-----------------------------|-------------------|
| | | Ground (PE) | | DC Bus (B+, B-) | | Dynamic Braking (D+, D-) | |
| | | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque |
| <i>hp (kW)</i> | <i>hp (kW)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> |
| 460 V | | | | | | | |
| 400–800 (300-600) | 100–200 (75-150) | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) |
| 575 V | | | | | | | |
| 600–1000 (450-750) | 150–250 (112-187) | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 1" stud | 120 (14) | 5/16"-18 x 1" stud | 120 (14) |

Table 4-13—2493 Ground and Power Terminal Specifications

| Size | Terminal | | | |
|--------------------|-----------------------------|-------------------|-----------------------------|-------------------|
| | Ground (PE) | | DC Bus (B+, B-) | |
| | Acceptable Wire Sizes | Tightening Torque | Acceptable Wire Sizes | Tightening Torque |
| <i>μfd</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> | <i>AWG (mm²)</i> | <i>in•lb (Nm)</i> |
| 230 V | | | | |
| 26,400 44,000 | #10-32 x 3/4" stud | 27 (3.1) | 5/16"-18 x 13/4" stud | 120 (14) |
| 132,000 220,000 | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 13/4" stud | 120 (14) |
| 460 V | | | | |
| 6,600 11,000 | #10-32 x 3/4" stud | 27 (3.1) | 5/16"-18 x 13/4" stud | 120 (14) |
| 33,000 55,000 | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 13/4" stud | 120 (14) |
| 575 V | | | | |
| 6,900 | #10-32 x 3/4" stud | 27 (3.1) | 5/16"-18 x 13/4" stud | 120 (14) |
| 20,700 34,500 | 1/4"-20 x 1" stud | 58 (6.6) | 5/16"-18 x 13/4" stud | 120 (14) |

Table 4-14—2420 Fuse Specifications

| Rated Power | Input Current | Fuse Current | Fuse Voltage | Recommended Fuse | |
|--------------------|------------------------|------------------------|------------------------|-------------------------|--------------------|
| <i>hp (kW)</i> | <i>A_{rms}</i> | <i>A_{rms}</i> | <i>V_{rms}</i> | <i>Manufacturer</i> | <i>Part Number</i> |
| 230 V | | | | | |
| 1 1/2 (1.1) | 4.3 | 10 | 250 | Bussman | FWX 10A14F |
| 2 (1.5) | 5.3 | 10 | 250 | Bussman | FWX 10A14F |
| 3 (2.2) | 7.7 | 10 | 250 | Bussman | FWX 10A14F |
| 5 (3.7) | 12.5 | 15 | 250 | Bussman | FWX 15A14F |
| 7 1/2 (5.5) | 18.5 | 25 | 250 | Bussman | FWX 25A14F |
| 10 (7.5) | 24.1 | 30 | 250 | Bussman | FWX 30A14F |
| 15 (11) | 36.1 | 50 | 250 | Bussman | FWX 50A |
| 20 (15) | 47.3 | 60 | 250 | Bussman | FWX 60A |
| 25 (18) | 59.3 | 80 | 250 | Bussman | FWX 80A |
| 30 (22) | 70.5 | 90 | 250 | Bussman | FWX 90A |
| 380 V | | | | | |
| 1 1/2 (1.1) | 2.5 | 3 | 500 | Bussman | FWH 3A14F |
| 2 (1.5) | 3.1 | 4 | 500 | Bussman | FWH 4A14F |
| 3 (2.2) | 4.4 | 6 | 500 | Bussman | FWH 6A14F |
| 5 (3.7) | 7.2 | 10 | 500 | Bussman | FWH 10A14F |
| 7 1/2 (5.5) | 10.6 | 15 | 500 | Bussman | FWH 15A14F |
| 10 (7.5) | 13.8 | 20 | 500 | Bussman | FWH 20A14F |
| 15 (11) | 20.8 | 25 | 500 | Bussman | FWH 25A14F |
| 20 (15) | 27.2 | 35 | 500 | Bussman | FWH 35B |
| 25 (18) | 34.1 | 45 | 500 | Bussman | FWH 45B |
| 30 (22) | 40.5 | 50 | 500 | Bussman | FWH 50B |
| 40 (30) | 53.4 | 70 | 500 | Bussman | FWH 70B |
| 50 (37) | 66.7 | 90 | 500 | Bussman | FWH 90B |
| 60 (45) | 79.5 | 100 | 500 | Bussman | FWH 100B |

(continued)

Table 4-14—2420 Fuse Specifications (continued)

| Rated Power | Input Current | Fuse Current | Fuse Voltage | Recommended Fuse | |
|--------------------|------------------------|------------------------|------------------------|-------------------------|--------------------|
| <i>hp (kW)</i> | <i>A_{rms}</i> | <i>A_{rms}</i> | <i>V_{rms}</i> | <i>Manufacturer</i> | <i>Part Number</i> |
| 460 V | | | | | |
| <i>hp (kW)</i> | | | | | |
| 1 1/2 (1.1) | 2.2 | 3 | 500 | Bussman | FWH 3A14F |
| 2 (1.5) | 2.7 | 4 | 500 | Bussman | FWH 4A14F |
| 3 (2.2) | 3.9 | 5 | 500 | Bussman | FWH 5A14F |
| 5 (3.7) | 6.3 | 10 | 500 | Bussman | FWH 10A14F |
| 7 1/2 (5.5) | 9.2 | 12 | 500 | Bussman | FWH 12A14F |
| 10 (7.5) | 12.0 | 15 | 500 | Bussman | FWH 15A14F |
| 15 (11) | 18.1 | 25 | 500 | Bussman | FWH 25A14F |
| 20 (15) | 23.6 | 30 | 500 | Bussman | FWH 30A14F |
| 25 (18) | 29.7 | 40 | 500 | Bussman | FWH 40B |
| 30 (22) | 35.2 | 45 | 500 | Bussman | FWH 45B |
| 40 (30) | 46.4 | 60 | 500 | Bussman | FWH 60B |
| 50 (37) | 58.0 | 70 | 500 | Bussman | FWH 70B |
| 60 (45) | 69.2 | 90 | 500 | Bussman | FWH 90B |

Table 4-15—2490 Fuse Specifications

| Rated Power | Input Current | Fuse Current | Fuse Voltage | Recommended Fuse | |
|----------------|------------------------|------------------------|------------------------|---------------------|-----------------------|
| <i>hp (kW)</i> | <i>A_{rms}</i> | <i>A_{rms}</i> | <i>V_{rms}</i> | <i>Manufacturer</i> | <i>Part Number</i> |
| 230 V | | | | | |
| 10 (7.5) | 24.1 | 30 | 250 | Bussman | FWX 30A14F |
| 20 (15) | 47.3 | 60 | 250 | Bussman | FWX 60A |
| 40 (30) | 92.8 | 125 | 250 | Bussman | FWX 125A |
| 75 (55) | 172.7 | 225 | 250 | Bussman | FWX 225A |
| 460 V | 380 V | | | | |
| <i>hp (kW)</i> | <i>kW</i> | | | | |
| 20 (15) | 12 | 23.6 | 30 | 500 | Bussman FWH 30A14F |
| 40 (30) | 25 | 46.4 | 60 | 500 | Bussman FWH 60B |
| 75 (55) | 46 | 86.3 | 125 | 500 | Bussman FWH 125B |
| 150 (110) | 92 | 167.2 | 225 | 500 | Bussman FWH 225A |
| 250 (185) | 155 | 278.7 | 350 | 500 | Bussman FWH 350A |
| 400 (300) | 250 | 445.9 | 600 | 500 | Bussman FWH 600A |
| 500 (375) | 310 | 557.3 | 700 | 500 | Bussman FWH 700A |
| 600 (450) | 375 | 668.8 | 800 | 500 | Bussman FWH 800A |
| 800 (600) | 500 | 891.7 | 1200 | 500 | Bussman FWH 1200A |
| 575 V | | | | | |
| 150 (110) | | 133.8 | 175 | 700 | Bussman FWP 175B |
| 250 (185) | | 222.9 | 300 | 700 | Bussman FWP 300A |
| 400 (300) | | 356.7 | 450 | 700 | Bussman FWP 450A |
| 500 (375) | | 445.9 | 600 | 700 | Bussman FWP 600A |
| 600 (450) | | 535.0 | 700 | 700 | Bussman FWP 700A |
| 800 (600) | | 713.4 | 900 | 700 | Bussman FWP 900A |
| 1000 (750) | | 891.7 | 1200 | 700 | Bussman FWP 1200A |

Table 4-16—Isolation Transformer Ratings

| Power | Rating | Power | Rating |
|----------------|---------------|----------------|---------------|
| <i>hp (kW)</i> | <i>kVA</i> | <i>hp (kW)</i> | <i>kVA</i> |
| 1½ (1.1) | 3 | 600 (450) | 660 |
| 2 (1.5) | 3 | 700 (525) | 770 |
| 2 (1.5) | 3 | 800 (600) | 880 |
| 3 (2.2) | 5 | 900 (675) | 990 |
| 5 (3.7) | 7.5 | 1000 (750) | 1100 |
| 7½ (5.5) | 11 | 1100 (825) | 1210 |
| 10 (7.5) | 15 | 1200 (900) | 1320 |
| 15 (11) | 20 | 1300 (975) | 1430 |
| 20 (15) | 27 | | |
| 25 (18) | 34 | | |
| 30 (22) | 40 | | |
| 40 (30) | 51 | | |
| 50 (37) | 63 | | |
| 60 (45) | 75 | | |
| 75 (55) | 93 | | |
| 100 (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 | | |

Table 4-17—Three-Phase Line Reactor Ratings

| Power | Current | I n d u c t a n c e | |
|----------------|------------------------|---------------------|----------------|
| | | 3.0% Impedance | 6.0% Impedance |
| <i>hp (kW)</i> | <i>A_{rms}</i> | <i>mH</i> | <i>mH</i> |
| 230 V | | | |
| 1 1/2 (1.1) | 6 | 1.836 | 3.675 |
| 2 (1.5) | 8 | 1.378 | 2.757 |
| 3 (2.2) | 12 | 0.919 | 1.838 |
| 5 (3.7) | 16 | 0.689 | 1.376 |
| 7 1/2 (5.5) | 21 | 0.525 | 1.050 |
| 10 (7.5) | 27 | 0.408 | 0.817 |
| 15 (11) | 45 | 0.245 | 0.490 |
| 20 (15) | 55 | 0.200 | 0.401 |
| 25 (18) | 80 | 0.138 | 0.276 |
| 30 (22) | 80 | 0.138 | 0.276 |
| 40 (30) | 110 | 0.100 | 0.200 |
| 75 (55) | 200 | 0.055 | 0.110 |

(continued)

Table 4-17—Three-Phase Line Reactor Ratings *(continued)*

| Power | Current | I n d u c t a n c e | | |
|----------------|------------------------|---------------------|-------------------|-------------------|
| | | 1.5% Impedance | 3.0% Impedance | 5.0% Impedance |
| <i>hp (kW)</i> | <i>A_{rms}</i> | <i>mH</i> | <i>mH</i> | <i>mH</i> |
| 460 V | | | | |
| 1 1/2 (1.1) | 3 | 3.667 | 7.351 | 12.251 |
| 2 (1.5) | 4 | 2.757 | 5.513 | 9.189 |
| 3 (2.2) | 6 | 1.836 | 3.675 | 6.126 |
| 5 (3.7) | 8 | 1.378 | 2.757 | 4.594 |
| 7 1/2 (5.5) | 12 | 0.919 | 1.838 | 3.063 |
| 10 (7.5) | 16 | 0.689 | 1.376 | 2.297 |
| 15 (11) | 21 | 0.525 | 1.050 | 1.470 |
| 20 (15) | 27 | 0.408 | 0.817 | 1.361 |
| 25 (18) | 35 | 0.315 | 0.630 | 1.050 |
| 30 (22) | 45 | 0.245 | 0.490 | 0.817 |
| 40 (30) | 55 | 0.200 | 0.401 | 0.668 |
| 50 (37) | 80 | 0.138 | 0.276 | 0.459 |
| 60 (45) | 80 | 0.138 | 0.276 | 0.459 |
| 75 (55) | 110 | 0.100 | 0.200 | 0.334 |
| 150 (110) | 200 | 0.055 | 0.110 | 0.184 |
| 250 (185) | 300 | 0.037 | 0.074 | 0.123 |
| 400 (300) | 480 | 0.023 | 0.046 | 0.077 |
| 500 (375) | 600 | 0.018 | 0.037 | 0.061 |
| 600 (450) | 750 | 0.015 | 0.029 | 0.049 |
| 800 (600) | 950 | 0.012 | 0.023 | 0.039 |

(continued)

Table 4-17—Three-Phase Line Reactor Ratings *(continued)*

| Power | Current | I n d u c t a n c e | | |
|----------------|------------------------|---------------------|----------------|----------------|
| | | 2.4% Impedance | 3.0% Impedance | 5.0% Impedance |
| <i>hp (kW)</i> | <i>A_{rms}</i> | <i>mH</i> | <i>mH</i> | <i>mH</i> |
| 575 V | | | | |
| 150 (110) | 160 | 0.130 | 0.172 | 0.287 |
| 250 (185) | 250 | 0.088 | 0.110 | 0.184 |
| 400 (300) | 420 | 0.053 | 0.066 | 0.109 |
| 500 (375) | 480 | 0.046 | 0.057 | 0.096 |
| 600 (450) | 600 | 0.037 | 0.046 | 0.077 |
| 800 (600) | 750 | 0.029 | 0.037 | 0.061 |
| 1000 (750) | 950 | 0.023 | 0.029 | 0.048 |

Table 4-18—Dynamic Braking Resistors

| Power | 150% Braking | | | 200% Braking | | | Duty Cycle / Power | | |
|----------------|--------------|----------|----------|--------------|----------|----------|--------------------|----------|----------|
| | 230 V | 460 V | 575 V | 230 V | 460 V | 575 V | 5% | 10% | 20% |
| <i>hp (kW)</i> | Ω | Ω | Ω | Ω | Ω | Ω | <i>W</i> | <i>W</i> | <i>W</i> |
| 1 1/2 (1.1) | 64.1 | 256.4 | — | 48.1 | 192.3 | — | 51 | 101 | 203 |
| 2 (1.5) | 49.0 | 196.1 | — | 36.8 | 147.1 | — | 68 | 135 | 270 |
| 3 (2.2) | 34.7 | 138.9 | — | 26.0 | 104.2 | — | 101 | 203 | 405 |
| 5 (3.7) | 21.9 | 87.7 | — | 16.4 | 65.8 | — | 169 | 338 | 675 |
| 7 1/2 (5.5) | 15.2 | 60.6 | — | 11.4 | 45.5 | — | 253 | 506 | 1013 |
| 10 (7.5) | 11.9 | 47.6 | — | 8.93 | 35.7 | — | 338 | 675 | 1350 |
| 15 (11) | 7.94 | 31.7 | — | 5.95 | 23.8 | — | 506 | 1013 | 2025 |
| 20 (15) | 6.17 | 24.7 | — | 4.63 | 18.5 | — | 675 | 1350 | 2700 |
| 25 (18) | 4.90 | 19.6 | — | 3.68 | 14.7 | — | 844 | 1688 | 3375 |
| 30 (22) | 4.17 | 16.7 | — | 3.13 | 12.5 | — | 1013 | 2025 | 4050 |
| 40 (30) | 3.21 | 12.6 | — | 2.40 | 9.62 | — | 1350 | 2700 | 5400 |
| 50 (37) | — | 10.3 | — | — | 7.69 | — | 1688 | 3375 | 6750 |
| 60 (45) | — | 8.66 | — | — | 6.49 | — | 2025 | 4050 | 8100 |
| 75 (55) | 1.74 | 6.94 | — | 1.30 | 5.21 | — | 2531 | 5063 | 10125 |
| 150 (110) | — | 3.70 | 5.79 | — | 2.78 | 4.34 | 5063 | 10125 | 20250 |
| 250 (185) | — | 2.22 | 3.47 | — | 1.67 | 2.60 | 8438 | 16875 | 33750 |
| 400 (300) | — | 1.39 | 2.17 | — | 1.04 | 1.63 | 13500 | 27000 | 54000 |
| 500 (375) | — | 1.11 | 1.74 | — | 0.83 | 1.30 | 16875 | 33750 | 67500 |
| 600 (450) | — | 0.93 | 1.45 | — | 0.69 | 1.09 | 20250 | 40500 | 81000 |
| 800 (600) | — | 0.69 | 1.09 | — | 0.52 | 0.81 | 27000 | 54000 | 108000 |
| 1000 (750) | — | 0.56 | 0.87 | — | 0.42 | 0.65 | 33750 | 67500 | 135000 |

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

4.11 Control Module Connections

The drive accepts a variety of analog and digital inputs and outputs, synchronous and asynchronous serial communications, and feedback signals. These control connections are made to either a Standard or Expandable Control Module and to optional feedback and communication modules that mount on those controllers.

The general layout of the external connections to the control modules is shown in Figure 4-16 and Figure 4-17 and discussed in the sections that follow. Certain connections are common to both modules. Table 4-20 identifies the connectors that plug into the modules. Control module terminal specifications are given in Table 4-19. All wires should be copper with a rating of 167° F (75° C) or higher.

4.11.1 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 (\pm) current input signals together

Figure 4-16—Standard Control Modules (319729/AC and 320801/DC)

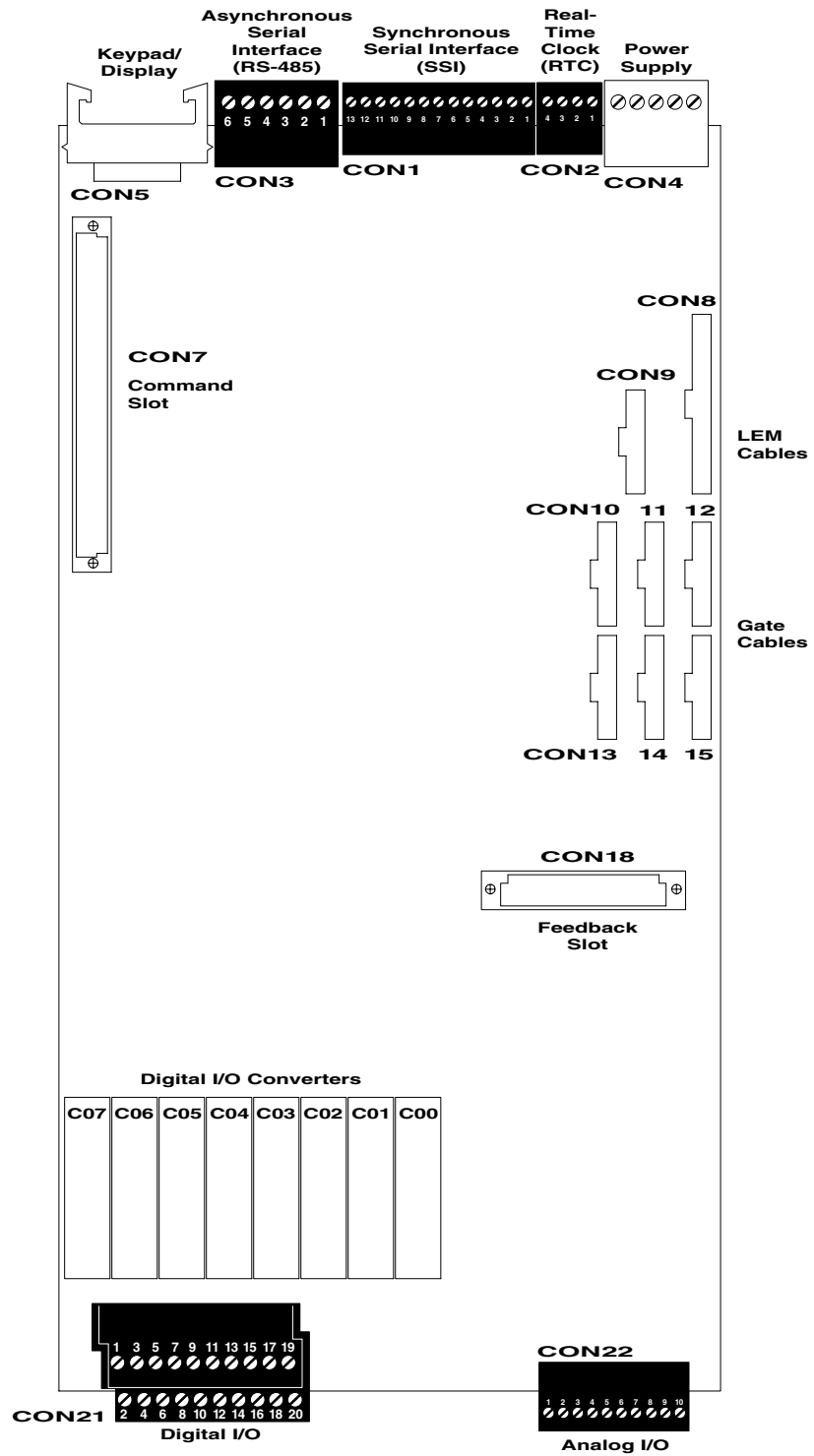


Figure 4-17—Expandable Control Module (318725)

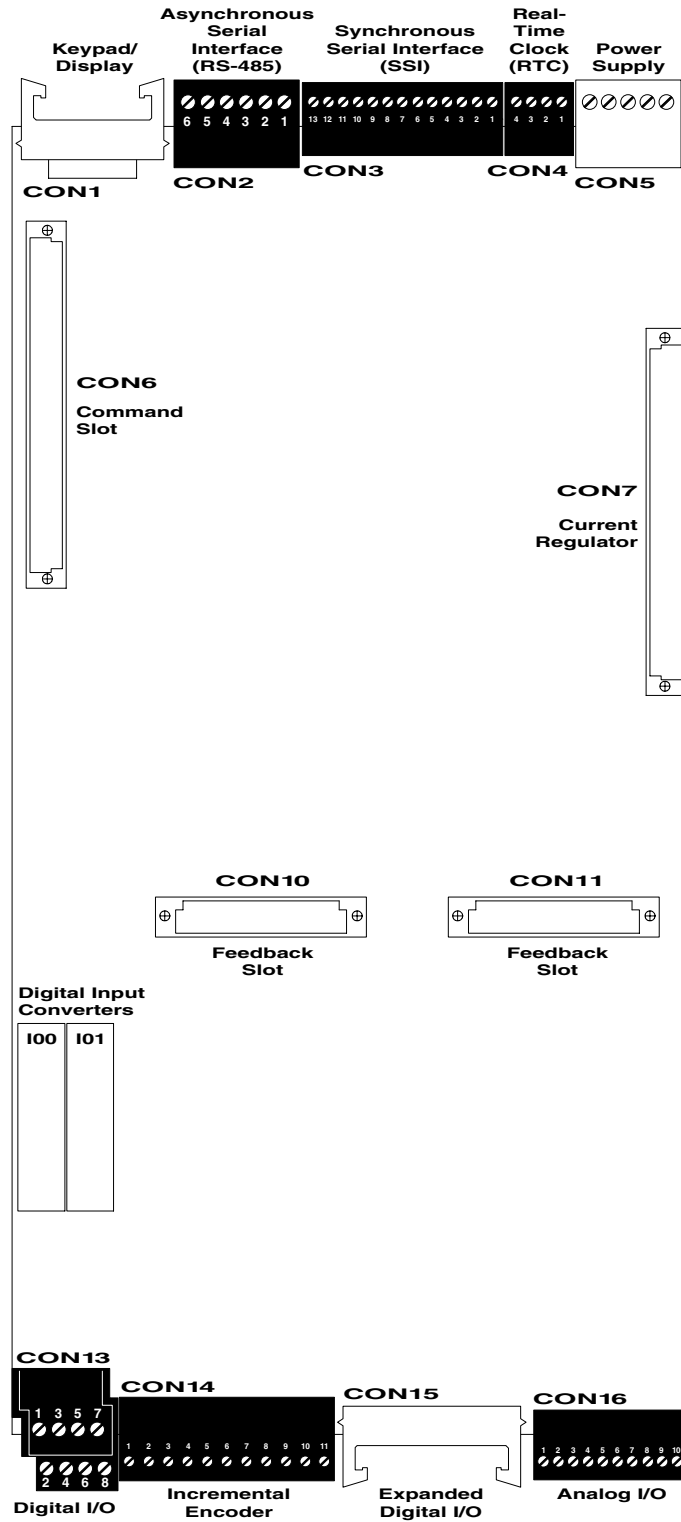


Table 4-19—Control Signal Terminal Specifications

| Module | Connector(s) | Acceptable | Tightening |
|---|------------------------|------------------------|---------------|
| | | Wire Sizes | Torque |
| | | AWG (mm ²) | in•lb (Nm) |
| Control Modules | | | |
| Standard Control Module (319729 and 320801) | CON1, CON2, CON22 | 16 to 28 (1.3-0.09) | 2.2 (0.25) |
| | CON3, CON21 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Expandable Control Module (318725) | CON3, CON4, CON16 | 16 to 28 (1.3-0.09) | 2.2 (0.25) |
| | CON2, CON13, CON14 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| I/O Fanning Strips | | | |
| 16-Bit Fanning Strip (320102) | CON2, CON3 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| 32-Bit Fanning Strip (320146 and 319437) | CON2, CON3, CON4, CON5 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Feedback Modules | | | |
| Incremental Encoder Interface Modules (317685, 320106, and 317241) | CON2 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Serial Sincos Encoder Interface Modules (320448 and 322173) | CON2 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Resolver Interface Modules (320176, 322195, 320315, and 322197) | CON2 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Serial Absolute Encoder Interface Module (321849) | CON2, CON3 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Analog Interface Module (319354) | CON2 | 16 to 28 (1.3-0.09) | 2.2 (0.25) |
| Communication Modules | | | |
| Serial Communication Module (318826) | CON3, CON4 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Fiber-Optic Communication Module (318816) | CON3 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Remote I/O Communication Module (317848) | CON2, CON3 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Modbus Plus Communication Module (319788) | CON3 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| ControlNet Communication Module (321812) | CON3 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Profibus Communication Module (321560) | CON6 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |
| Ethernet Communication Module (321228) | CON5 | 12 to 24 (3.3-0.21) | 7.1 (0.80) |

Table 4-20—Plug-In Connectors

| Controller / Connector | Function |
|-------------------------------|---|
| Both Controllers | |
| Keypad/Display Module | Connects the control module with the Keypad/Display Module that serves as the built-in operator interface. |
| Communication module slot | Accommodates a variety of communication modules that transfer data serially. For a list of communication modules, refer to Table 2-8. |
| Feedback module slot(s) | Accommodate(s) the various optional feedback interface modules that provide position, speed, or analog feedback. The Standard controller has one feedback slot, while the Expandable controller has two. For a list of feedback modules, refer to Table 2-16. |
| Digital I/O converter sockets | Accept the digital I/O converter modules that determine the voltage of the configurable input and output points. The Standard controller accepts eight converters, while the Expandable accepts two. |
| Standard Controller | |
| LEM cables | Interface the control module to the LEM module, which provides drive size and current feedback information to the control module from the power section. |
| Gate cables | Interface the control module to the IGBT gate drivers to pass power and IGBT enable signals to the gate drivers and return IGBT status signals. |
| Expandable Controller | |
| Current Regulator Module | Connects the control module to the Current Regulator Module, a separate module used only with the Expandable Control Module. |
| Expanded digital I/O | Allows a 16- or 32-bit digital I/O fanning strip to be added to expand the available I/O. Fanning strips use the same I/O converters as the control module. |

4.11.2 Asynchronous Serial Connections

Each control module provides a built-in optically isolated RS-232/422/485 serial port for general asynchronous communications with other devices at up to 57,600 baud. Specific connections as well as the syntax of communication, known as the protocol, are discussed in the application manual.

The recommended serial interface connection is the four-wire RS-485. It allows a maximum number of 32 devices on one multidrop serial link. RS-485 uses differential inputs and is, therefore, more immune to noise than single-ended systems such as RS-232. RS-485 can also tolerate higher common-mode voltage levels, thereby allowing it to operate over long distances. The maximum wire length is about 3,900 ft. (1,200 m).

The interface supports a hybrid electrical specification that allows it to work with both RS-232 and RS-485 devices. The RS-232 specification requires the transmitter to provide +5 V to +15 V for a logic 0 and -5 V to -15 V for a logic 1. The control module provides +5 V and -5 V signal levels that meet the specification. The RS-485 specification is a differential signal and requires a ± 200 mV minimum differential signal for the logic states. Typically, this is implemented with signals that swing between 0 V and 5 V. The control module uses -5 V and +5 V instead.

Figure 4-18—Asynchronous Serial Connections

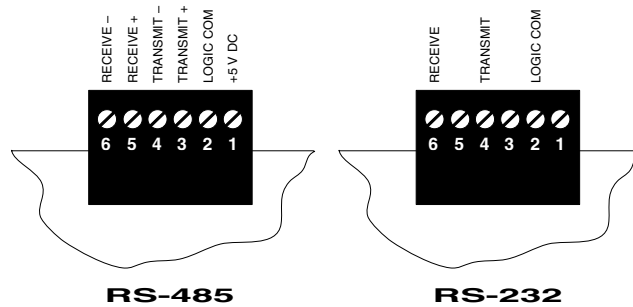


Table 4-21—Asynchronous Serial Connections

| Terminal | Signal | Description |
|----------|-------------------|--|
| 1 | +5 V DC | Logic power supply for the interface. The interface is not isolated, so this is also the same +5 V DC that powers the drive unit. This terminal can also be used to connect a pull-up resistor in a multidrop network. |
| 2 | Logic Common | <p>Logic Common for the interface. It is optically isolated and floats relative to earth ground.</p> <p>With an RS-232 device, connect to the signal common of the external device since this is a single-ended interface and both signals are referenced to it.</p> <p>With an RS-485 device, connect to the logic common of the external device. When drive units are bussed together as a network, connect the Logic Commons of all drive units to keep the common-mode voltage between them within the -7 V to +12 V specification of RS-485. This terminal can also be used to connect a pull-down resistor in a multidrop network.</p> |
| 3 | Transmit Data (+) | Differential signal that transmits data to the receiving device. With an RS-232 device, use terminal 4 as transmit. |
| 4 | Transmit Data (-) | |
| 5 | Receive Data (+) | Differential signal that passes data into the receiver of the interface. With an RS-232 device, use terminal 6 as receive. |
| 6 | Receive Data (-) | |

4.11.3 Synchronous Serial Interface (SSI) Connections

Each control module provides a synchronous serial interface (SSI) for slaving together multiple axes. The SSI protocol is a proprietary protocol that provides accurate communication at high speeds. A master amplifier generates commands that can be received by multiple slave amplifiers. The sample clock can also be passed between master and slave(s) for precise time and position synchronization.

Connect the Transmit Clock terminals of the master to the Receive Clock terminals of all slaves. Similarly, connect the Transmit Data terminals of the master to the Receive Data terminals of all slaves. The last slave device should terminate the Receive Clock– and Receive Data– signals by jumpering terminals 9 and 10 and terminals 12 and 13. If a device is both a master and a slave, the termination is made at the last *receiving* device. See Figure 4-19. Refer to the application manual for required software settings.

Data that is to be synchronized to the same clock must use the real-time clock interface (see Section 4.11.4).

Figure 4-19—Synchronous Serial Connections

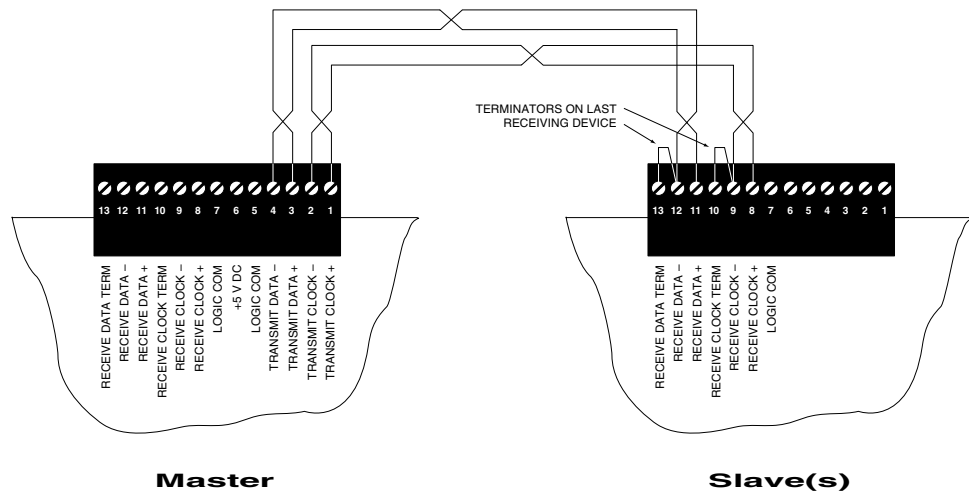


Table 4-22—Synchronous Serial Connections

| Terminal | Signal | Description |
|----------|---------------------------|--|
| 1 | Transmit Clock (+) | Differential signal passed to the slave receiving information. Used to clock data bits into the receiver. |
| 2 | Transmit Clock (-) | |
| 3 | Transmit Data (+) | Differential signal that transmits data to the slave receiving information. |
| 4 | Transmit Data (-) | |
| 5 | Logic Common | Logic Common for the interface. The interface is not isolated, so this is also Logic Common for the drive unit. When drive units are bussed together as a network, connect the Logic Commons of all drive units to keep the common-mode voltage between them within the -7 V to +12 V specification of RS-485. This terminal can also be used to connect a pull-down resistor. |
| 6 | +5 V DC | Logic power supply for the interface. The interface is not isolated, so this is also the same +5 V DC that powers the drive unit. This terminal can also be used to connect a pull-up resistor. |
| 7 | Logic Common | Logic Common |
| 8 | Receive Clock (+) | Differential signal used to clock the data line into the receiver of this drive unit. |
| 9 | Receive Clock (-) | |
| 10 | Receive Clock Termination | Provides a 121 Ω termination resistor for the Receive Clock lines. Jumper with terminal 9 to put the resistor across the Receive Clock lines. |
| 11 | Receive Data (+) | Differential signal that passes data into the receiver of this drive unit. The Receive Clock lines provide the clocking information to the receiver. |
| 12 | Receive Data (-) | |
| 13 | Receive Data Termination | Provides a 121 Ω termination resistor for the Receive Data lines. Jumper with terminal 12 to put the resistor across Receive Data lines. |

4.11.4 Real-Time Clock Connections

Each control module provides a real-time clock interface for synchronizing drives in a multi-axis system. This interface is used in conjunction with the synchronous serial interface (SSI). The sample clock that is used to control the various control loops can be passed from a master drive to the slave drive(s) so that they all sample at the same time. This is especially important if position synchronization is needed, although many applications that coordinate speed/torque can also benefit. If the real-time clock connections are not used, data transmissions will not be synchronized.

Interconnect the Real-Time Clock terminals and the Logic Commons of all drives, as shown in Figure 4-20. Terminate the last device by jumpering terminals 3 and 4. Refer to the application manual for required software settings.

Figure 4-20—Real-Time Clock Connections

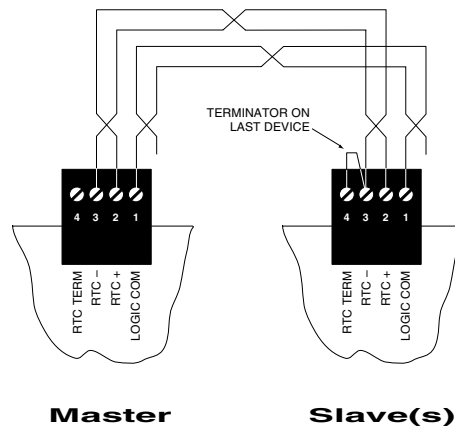


Table 4-23—Real-Time Clock Connections

| Terminal | Signal | Description |
|----------|-----------------------------|---|
| 1 | Logic Common | Logic Common for the interface. The interface is not isolated, so this is also Logic Common for the drive unit. It is wired between all drive units that are bussed together so that the common-mode voltage between them is kept within the -7 V to $+12\text{ V}$ specification of RS-485. |
| 2 | Real-Time Clock (+) | Differential signal that is passed to the slave that is receiving the information. Used to synchronize the sampling of the drive units. |
| 3 | Real-Time Clock (-) | |
| 4 | Real-Time Clock Termination | Provides a $121\ \Omega$ termination resistor for the Real-Time Clock lines. Jumper with terminal 3 to put the resistor across the Real-Time Clock lines. |

4.11.5 Analog I/O Connections

Each control module provides three ± 10 V DC or 0 to 20 mA inputs and two ± 10 V DC outputs. These analog channels have 12 bits of resolution. Inputs are differential, providing for some common-mode voltage rejection to eliminate ground loops. Outputs are referenced to the signal common of the control module. The functionality of each of these signals is determined by the application software.

Figure 4-21—Analog I/O Connections

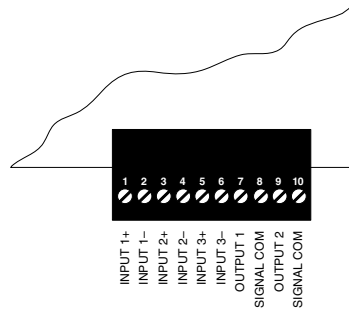


Table 4-24—Analog I/O Connections

| Terminal | Signal | Description |
|----------|--------------------|---|
| 1 | Analog Input 1 (+) | Differential analog input 1. 0 to ± 10 V DC or 0 to 20 mA Input impedance: 400 k Ω or 500 Ω To convert to 0 to 20 mA, install a 500 Ω resistor between the terminals. |
| 2 | Analog Input 1 (-) | |
| 3 | Analog Input 2 (+) | Differential analog input 2. 0 to ± 10 V DC or 0 to 20 mA Input impedance: 400 k Ω or 500 Ω To convert to 0 to 20 mA, install a 500 Ω resistor between the terminals. |
| 4 | Analog Input 2 (-) | |
| 5 | Analog Input 3 (+) | Differential analog input 3. 0 to ± 10 V DC or 0 to 20 mA Input impedance: 400 k Ω or 500 Ω To convert to 0 to 20 mA, install a 500 Ω resistor between the terminals. |
| 6 | Analog Input 3 (-) | |
| 7 | Analog Output 1 | Analog output 1. 0 to ± 10 V DC Maximum output: 10 mA |
| 8 | Signal Common | Not isolated (is also Signal Common for the drive unit). Provided as a reference voltage for Analog Output 1. |
| 9 | Analog Output 2 | Analog output 2. 0 to ± 10 V DC Maximum output: 10 mA |
| 10 | Signal Common | Not isolated (is also Signal Common for the drive unit). Provided as a reference voltage for Analog Output 2. |

4.11.6 Digital I/O Connections

Each control module provides a number of digital I/O points that can be tailored to an application by installing appropriately rated AC or DC input or output converter modules. The quantity and kind of I/O available depend upon the controller.

The Standard Control Module provides two relay outputs and eight configurable I/O points, each of which can be an input or output depending upon the converter selected. The Expandable Control Module provide two inputs and two relay outputs on the module itself and accepts up to 16 or 32 configurable I/O points using an optional fanning strip that mounts beneath 2400, 2420, or 2450 units.

I/O capabilities are summarized in Table 4-25. The application software determines the functionality of each input and output. Refer to the application documentation for specific information on programming these signals. Table 4-26 lists available I/O converters and their voltage ranges. The layout of the on-board digital I/O is shown in Figure 4-22 and Figure 4-23. The layout of fanning strip I/O is shown in Figure 4-24 through Figure 4-26.

Table 4-25—Digital I/O Summary

| Bit | Standard Controller | Expandable Controller |
|--------------------------------|---|---|
| Inputs | | |
| I00 | — | Input converters (mount on module; see Figure 4-23) |
| I01 | — | |
| Outputs | | |
| O00 | Dry-contact relays (on-board module; see Figure 4-22) <i>Form A contacts rated 250 V AC @ 5 A</i> | Dry-contact relays (on-board module; see Figure 4-23) <i>Form A contacts rated 250 V AC @ 5 A</i> |
| O01 | | |
| Configurable I/O Points | | |
| C00-C07 | Input, output, or relay converters (mount on module; see Figure 4-22) | Input, output, or relay converters (mount on separate 16-bit or 32-bit I/O fanning strip; see Figure 4-24 through Figure 4-26) |
| C08-C15 | — | |
| C16-C31 | — | Input, output, or relay converters (mount on separate 32-bit I/O fanning strip; see Figure 4-25 and Figure 4-26) |

Table 4-26—I/O Converter Modules

| Part Number | Device | Voltage Range |
|-------------|-----------------------|-----------------------------|
| 912688 | Input converter | 90 to 140 V AC |
| 919808 | Input converter | 180 to 280 V AC |
| 913108 | Output converter | 12 to 140 V AC |
| 919809 | Output converter | 180 to 280 V AC |
| 913109 | Input converter | 2.5 to 28 V DC |
| 913110 | Output converter | 5 to 60 V DC |
| 915282 | Normally open relay | 0 to 30 V DC, 0 to 250 V AC |
| 921332 | Normally closed relay | 0 to 30 V DC, 0 to 250 V AC |

Figure 4-22—On-Board Digital I/O (Standard Control Module)

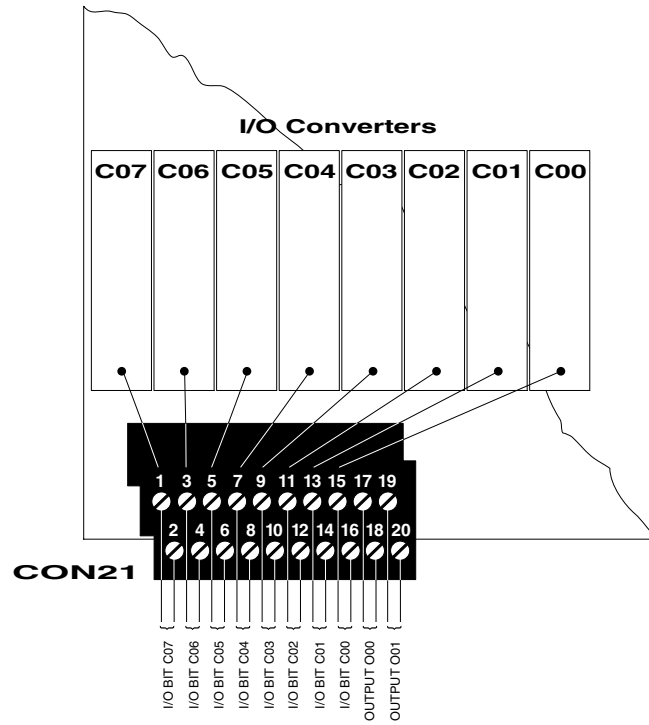


Figure 4-23—On-Board Digital I/O (Expandable Control Module)

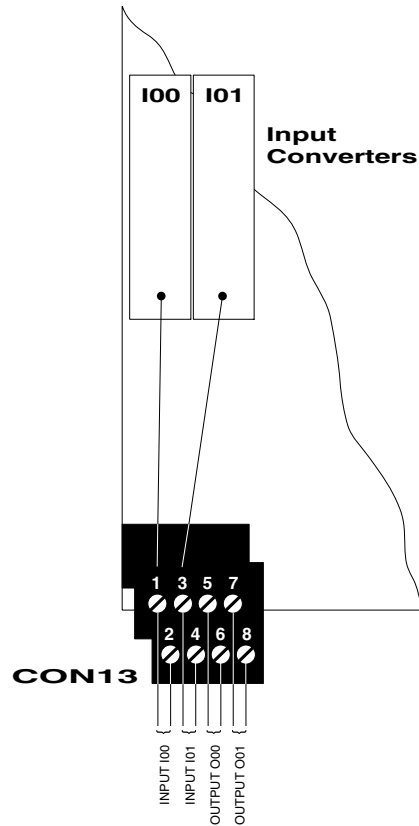


Figure 4-24—16-Bit Fanning Strip Expanded Digital I/O (320102)

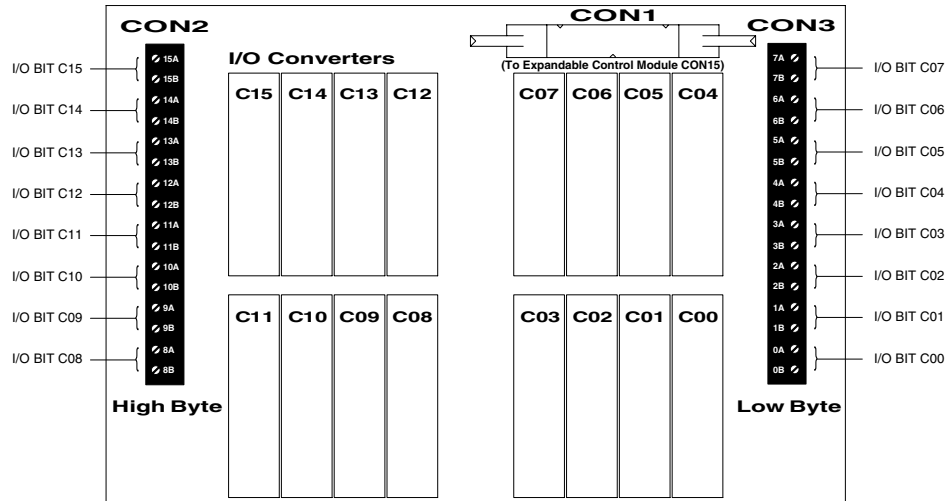


Figure 4-25—32-Bit Fanning Strip Expanded Digital I/O (320146)

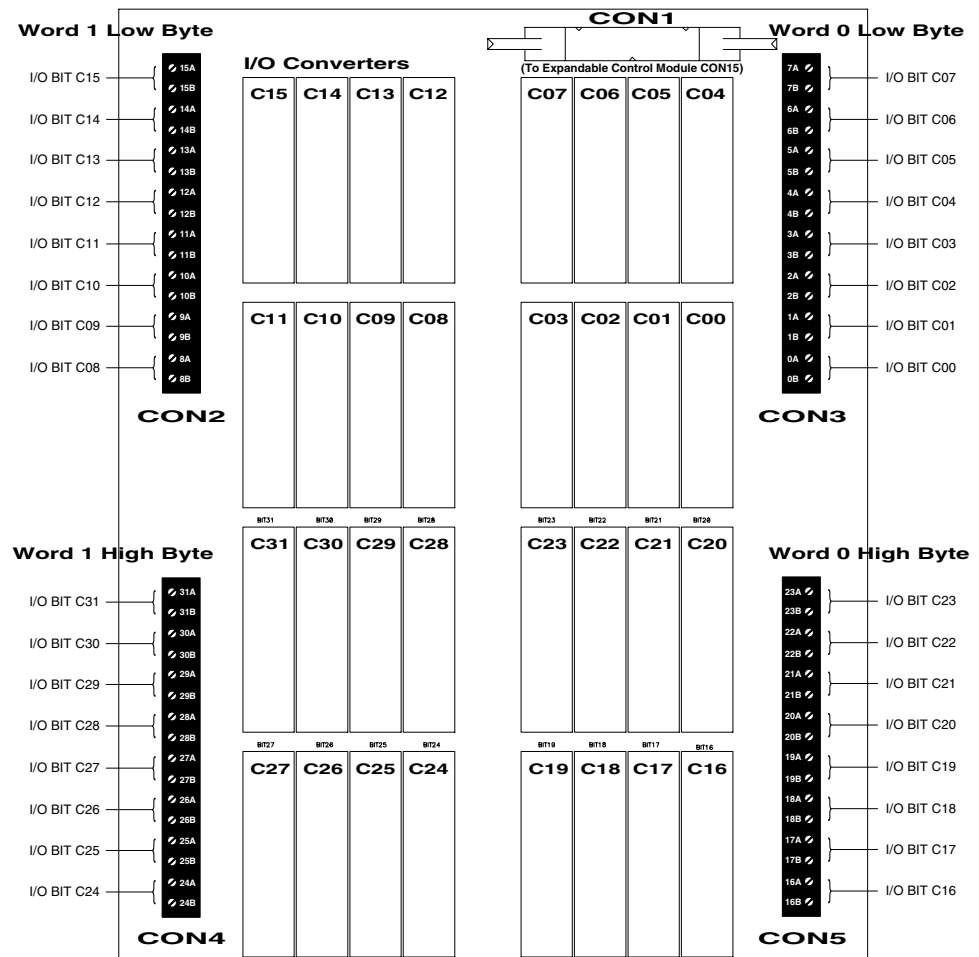
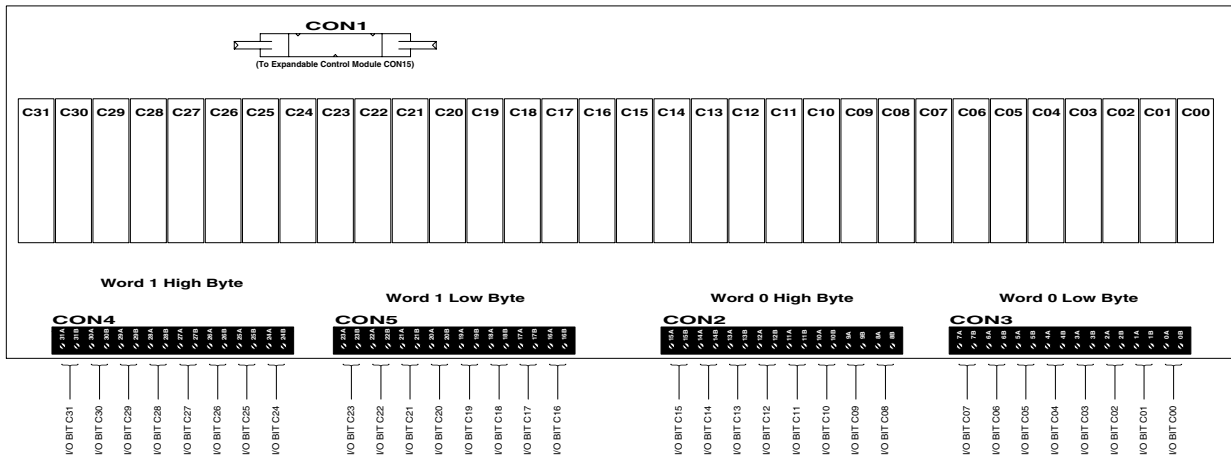


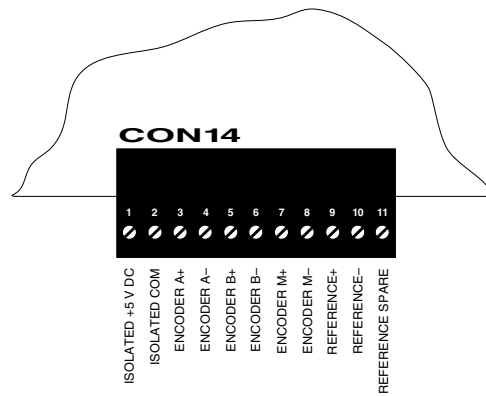
Figure 4-26—32-Bit Fanning Strip Expanded Digital I/O (319437)



4.11.7 Incremental Encoder Interface Connections (Expandable Control Module)

The Expandable controller has a built-in incremental encoder interface. Refer to Section 4.12.1 for connection descriptions and wiring diagrams.

Figure 4-27—On-Board Incremental Encoder Connections



4.12 Feedback Modules

A variety of optional feedback interface modules are available for providing closed-loop control of motor velocity and/or position or for obtaining machine or material feedback. These modules mount on the control module. The Standard Control Module accommodates one feedback interface, while the Expandable Control Module accepts two interfaces in addition to a built-in incremental encoder interface.

4.12.1 Incremental Encoder (5 V / 317685 and 15 V / 320106)

The incremental encoder interface modules (as well as the interface on-board the Expandable controller) are fully isolated from the encoder and can therefore be used with or without an encoder that is isolated from the motor.

Each interface supports differential inputs for quadrature channels A and B, an optional “zero” marker pulse, and a high-speed reference input. It also provides an isolated power supply for the encoder.

The differential inputs are not line receivers and can only sink 60 mA. If your encoder is not using a current-limited driver (that is, line driver), you must introduce current-limiting resistors into the circuit.

Nonisolated Encoder

The encoder cable should be made of individually shielded twisted-pair wire. The power supply wire should be of sufficient gauge to limit the voltage drop and keep the encoder supply within its specified range. Figure 4-28 shows the recommended connections with an encoder that is not isolated from the motor. Tie the shields together and earth ground them at the motor along with the ground for the encoder power supply. Leave the shields open at the drive-unit end.

Isolated Encoder

Figure 4-29 shows the recommended connection with an encoder that is isolated from the motor. Tie the shields together and earth ground them at the drive unit along with the ground for the encoder power supply. Tie the shields together and connect them to the case ground of the isolated encoder.

4.12.2 Incremental Encoder with Repeater (5 V / 317241)

The Incremental Encoder with Repeater Interface Module is identical to the standard Incremental Encoder Interface with the addition of additional line drivers and a separate terminal block that duplicates the isolated encoder signals to another device or controller.

Figure 4-28— Nonisolated Encoder Connections

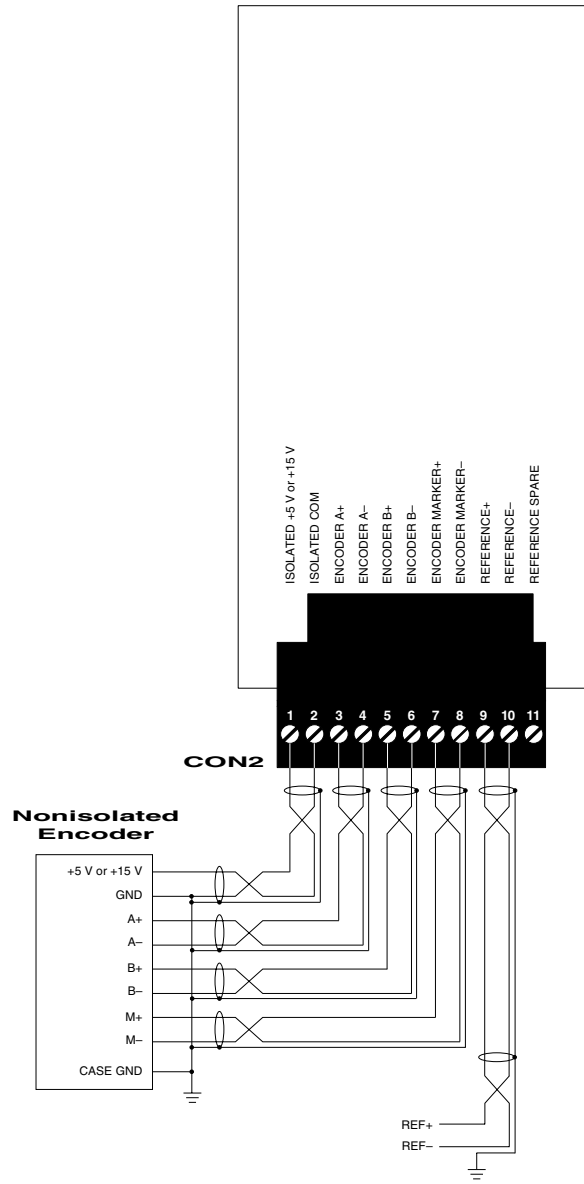


Figure 4-29—Isolated Encoder Connections

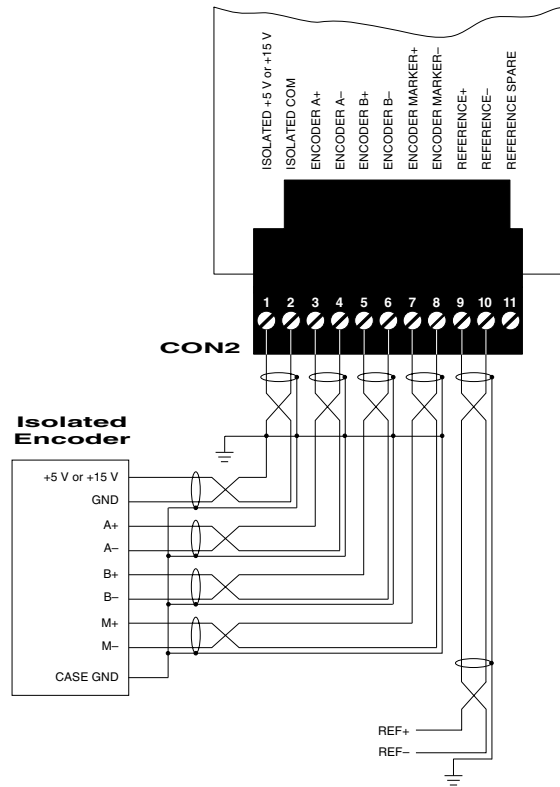


Figure 4-30—Incremental Encoder Interface with Repeater Module (317241) Connections

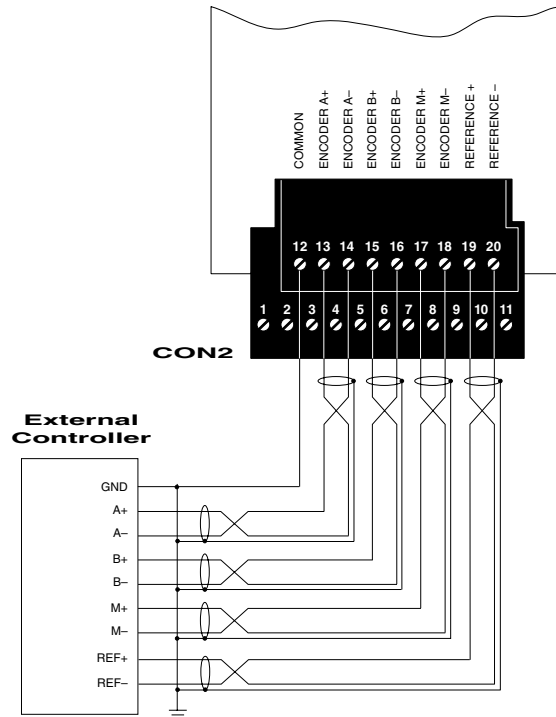


Table 4-27—Incremental Encoder Interface Connections

| Connection | Signal | Description |
|---|-------------------------|--|
| <i>Incremental Encoder Interface Modules (317865 and 320106) and Incremental Encoder Interface Module with Repeater (317241)</i> | | |
| CON2-1 | Isolated +5 or +15 V DC | Powers the encoder. Supply is isolated from the control module. See Table 2-17 for voltage and maximum load specifications. |
| CON2-2 | Isolated Common | Common for the isolated supply. |
| CON2-3 | Encoder A (+) | Differential input for channel A. |
| CON2-4 | Encoder A (-) | |
| CON2-5 | Encoder B (+) | Differential input for channel B. |
| CON2-6 | Encoder B (-) | |
| CON2-7 | Encoder M (+) | Differential input for marker channel. The marker input is a pulse that occurs once per revolution and is used for referencing the motor as well as to monitor the encoder for lost pulses. |
| CON2-8 | Encoder M (-) | |
| CON2-9 | Reference (+) | Differential reference input. Used by some applications to reference the motor to the machine over multiple revolutions or to reference another object for tracking. |
| CON2-10 | Reference (-) | |
| CON2-11 | Reference spare | The reference input is designed for a 5 V signal. This terminal is a spare provided as a placeholder so that a series resistor can be installed in series with the reference signal to permit voltage inputs greater than 5 V. |
| <i>Incremental Encoder Interface Module with Repeater (317241)</i> | | |
| CON2-12 | Common | Repeater isolated supply common. |
| CON2-13 | Encoder A (+) | Repeated from terminals 3 and 4. |
| CON2-14 | Encoder A (-) | |
| CON2-15 | Encoder B (+) | Repeated from terminals 5 and 6. |
| CON2-16 | Encoder B (-) | |
| CON2-17 | Encoder M (+) | Repeated from terminals 7 and 8. |
| CON2-18 | Encoder M (-) | |
| CON2-19 | Reference (+) | Repeated from terminals 9 and 10. |
| CON2-20 | Reference (-) | |

4.12.3 Serial Sincos Encoder Interface Modules (Asynchronous / 320448 and Synchronous / 322173)

Figure 4-31—Serial Sincos Encoder Interface Module Connections

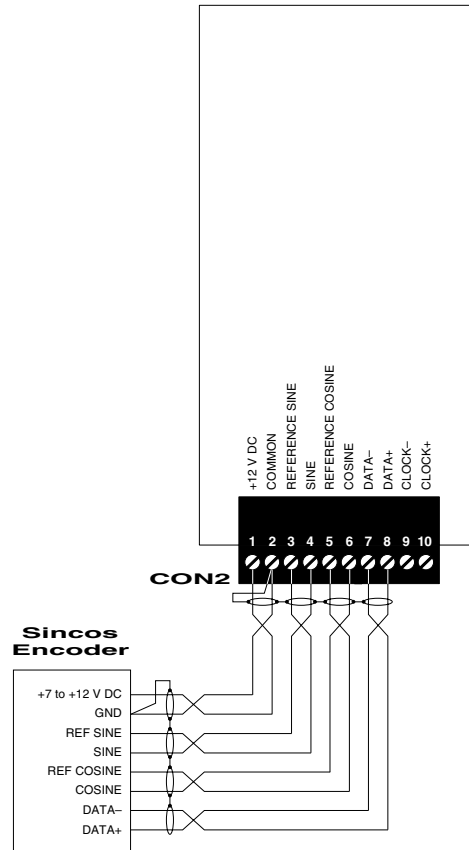


Table 4-28—Serial Sincos Encoder Interface Connections

| Connection | Signal | Description |
|-------------------|----------------------------|---|
| CON2-1 | Isolated +12 V DC | Powers the encoder. Supply is isolated from the control module. See Table 2-18 for voltage and maximum load specifications. |
| CON2-2 | Isolated Common | Common for the isolated supply. |
| CON2-3 CON2-4 | Reference Sine Sine | Differential sine input. 1 V peak-to-peak is expected. |
| CON2-5 CON2-6 | Reference Cosine Cosine | Differential cosine input. 1 V peak-to-peak is expected. |
| CON2-7 CON2-8 | Data (-) Data (+) | Differential RS-485 asynchronous/synchronous serial data signal. |
| CON2-9 CON2-10 | Clock (-) Clock (+) | Differential RS-485 synchronous serial clock signal. Only used with synchronous module (322173). |

4.12.4 Resolver Interface Modules

Figure 4-32—Resolver Interface Module (4 V / 320176 and 2 V / 322195) Connections

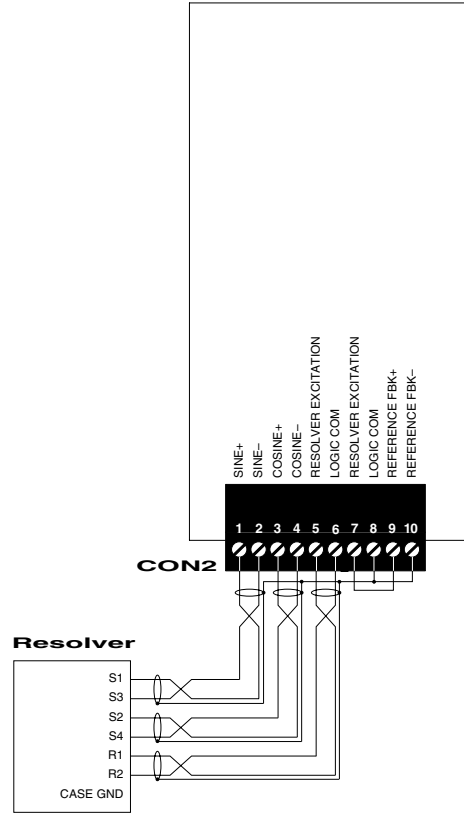


Figure 4-33—Dual Resolver Interface Module (4 V / 320315 and 2 V / 322197) Connections

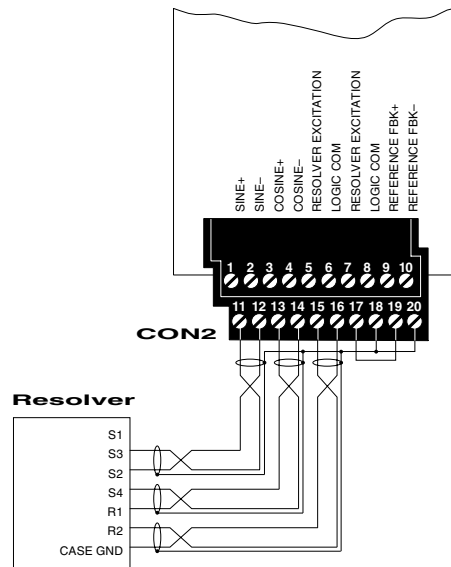


Table 4-29—Resolver Interface Module Connections

| Connection | Signal | Description |
|--|------------------------|--|
| Top Row / Channel 1 | | |
| CON2-1 | Sine (+) | Differential sine feedback signal from channel 1 of the resolver. Either 2 V _{rms} or 4 V _{rms} is expected, depending upon the module. See Table 2-19 for voltage specifications. |
| CON2-2 | Sine (-) | |
| CON2-3 | Cosine (+) | Differential cosine feedback signal from channel 1 of the resolver. Either 2 V _{rms} or 4 V _{rms} is expected, depending upon the module. See Table 2-19 for voltage specifications. |
| CON2-4 | Cosine (-) | |
| CON2-5 | Resolver Excitation | Excitation voltage (4 V _{rms}), relative to Logic Common, provided to channel 1 of the resolver. See Table 2-19 for voltage specifications. |
| CON2-6 | Logic Common | |
| CON2-7 | Resolver Excitation | Same as CON2-5 and 6. |
| CON2-8 | Logic Common | |
| CON2-9 | Reference Feedback (+) | Differential reference feedback voltage. |
| CON2-10 | Reference Feedback (-) | |
| Bottom Row / Channel 2 (Dual Resolvers) | | |
| CON2-11 | Sine (+) | Differential sine feedback signal from channel 2 of the resolver. Either 2 V _{rms} or 4 V _{rms} is expected, depending upon the module. See Table 2-19 for voltage specifications. |
| CON2-12 | Sine (-) | |
| CON2-13 | Cosine (+) | Differential cosine feedback signal from channel 2 of the resolver. Either 2 V _{rms} or 4 V _{rms} is expected, depending upon the module. See Table 2-19 for voltage specifications. |
| CON2-14 | Cosine (-) | |
| CON2-15 | Resolver Excitation | Excitation voltage (4 V _{rms}), relative to Logic Common, provided to channel 2 of the resolver. See Table 2-19 for voltage specifications. |
| CON2-16 | Logic Common | |
| CON2-17 | Resolver Excitation | Same as CON2-15 and 16. |
| CON2-18 | Logic Common | |
| CON2-19 | Reference Feedback (+) | Differential reference feedback voltage. |
| CON2-20 | Reference Feedback (-) | |

4.12.5 Serial Absolute Encoder Interface (321849)

Figure 4-34—Serial Absolute Encoder Interface Connections

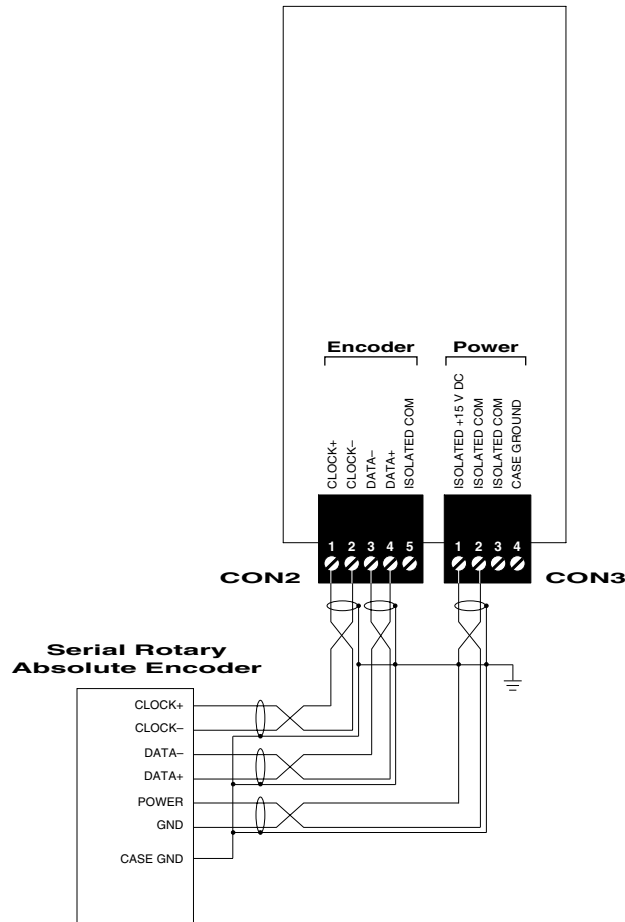


Table 4-30—Serial Absolute Encoder Interface Connections

| Connection | Signal | Description |
|------------------------|-------------------|---|
| Encoder Signals | | |
| CON2-1 | Clock (+) | Differential RS-485 synchronous serial clock signal. |
| CON2-2 | Clock (-) | |
| CON2-3 | Data (-) | Differential RS-485 synchronous serial data signal. |
| CON2-4 | Data (+) | |
| CON2-5 | Isolated Common | Common. |
| Power | | |
| CON3-1 | Isolated +15 V DC | Powers the encoder. Supply is isolated from the control module. See Table 2-20 for voltage and maximum load specifications. |
| CON3-2 | Isolated Common | Common for the isolated supply. |
| CON3-3 | Isolated Common | |
| CON3-4 | Case Ground | Case ground for the module. |

4.12.6 Analog Interface Module (319354)

The Analog Interface Module increases the analog I/O capabilities of the Standard and Expandable control modules. Dual 16-bit analog-to-digital converters (ADC) and digital-to-analog converters (DAC) provide two additional inputs and two additional outputs.

Figure 4-35—Analog Interface Connections

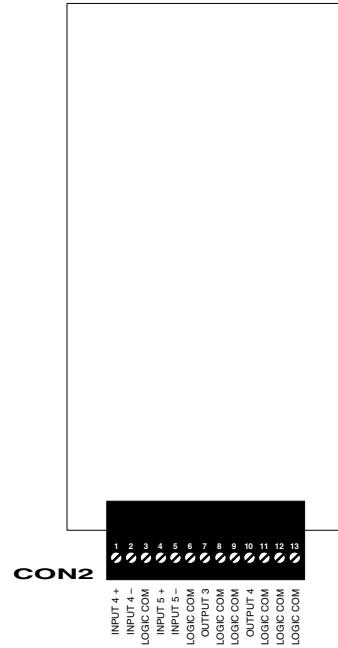


Table 4-31—Analog Interface Module Connections

| Connection | Signal | Description |
|-------------------------------|--|---|
| CON2-1 CON2-2 | Analog Input 4 (+) Analog Input 4 (-) | Differential analog input 4. <i>0 to ±10 V DC or 0 to 20 mA</i> <i>Input impedance: 400 kΩ or 500 Ω</i> <i>To convert to 0 to 20 mA, install a 500 Ω resistor between the terminals.</i> |
| CON2-3 | Logic Common | Shield for CON2-1 and 2 twisted pair. |
| CON2-4 CON2-5 | Analog Input 5 (+) Analog Input 5 (-) | Differential analog input 5. <i>0 to ±10 V DC or 0 to 20 mA</i> <i>Input impedance: 400 kΩ or 500 Ω</i> <i>To convert to 0 to 20 mA, install a 500 Ω resistor between the terminals.</i> |
| CON2-6 | Logic Common | Shield for CON2-4 and 5 twisted pair. |
| CON2-7 | Analog Output 3 | Analog output 3. <i>0 to ±10 V DC</i> <i>Maximum output: 10 mA</i> |
| CON2-8 CON2-9 | Logic Common Logic Common | Logic Common. Provided as a reference voltage for Analog Output 3 and for shielding the twisted pair. |
| CON2-10 | Analog Output 4 | Analog output 4. <i>0 to ±10 V DC</i> <i>Maximum output: 10 mA</i> |
| CON2-11 CON2-12 CON2-13 | Logic Common Logic Common Logic Common | Logic Common. Provided as a reference voltage for Analog Output 4 and for shielding the twisted pair. |

4.13 Communication Modules

A variety of optional communication modules is available for interfacing the drive with external devices using popular communication protocols. Each control module accepts a single communication module.

4.13.1 Serial Communication Module (318826)

The Serial Communication Module provides two optically isolated RS-232/422/485 ports for general synchronous/asynchronous communications at up to 1 Mbaud.

Figure 4-36—Serial Communication Module Connections

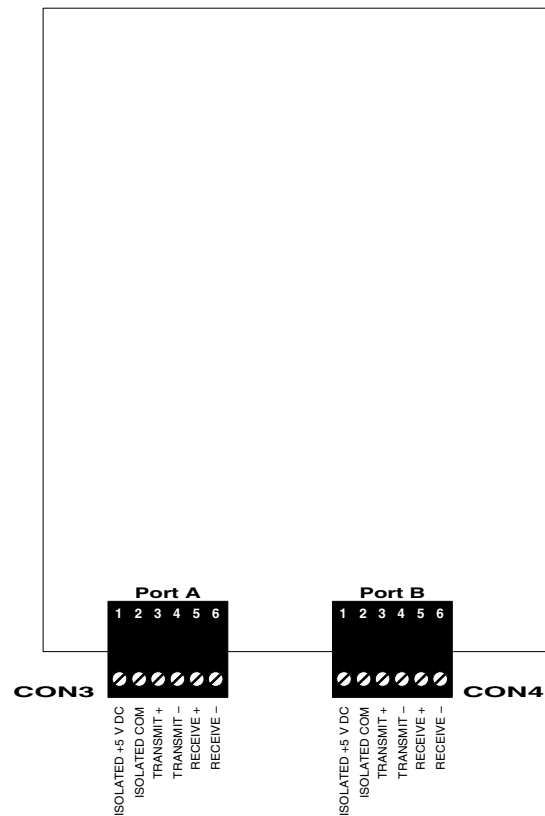


Table 4-32—Serial Communication Module Connections

| Connection | Signal | Description |
|--|--|---|
| Port A—Synchronous/Asynchronous Serial Communications | | |
| CON3-1 | Isolated +5 V DC | Logic power supply for the interface. The interface is isolated, so this is not the same +5 V DC that powers the drive unit. This terminal can also be used to connect a pull-up resistor in a multidrop network. |
| CON3-2 | Isolated Common | Logic Common for the interface. It is optically isolated and floats relative to earth ground. With an RS-232 device, connect to the signal common of the external device since this is a single-ended interface and both signals are referenced to it. With an RS-485 device, connect to the logic common of the external device. When drive units are bussed together as a network, connect the Logic Commons of all drive units to keep the common-mode voltage between them within the –7 V to +12 V specification of RS-485. This terminal can also be used to connect a pull-down resistor in a multidrop network. |
| CON3-3 CON3-4 | Transmit Data (+) Transmit Data (–) | Differential signal that transmits data to the receiving device. With an RS-232 device, use terminal 4 as transmit. |
| CON3-5 CON3-6 | Receive Data (+) Receive Data (–) | Differential signal that passes data into the receiver of the interface. With an RS-232 device, use terminal 6 as receive. |
| Port B—Synchronous/Asynchronous Serial Communications | | |
| CON4-1 | Isolated +5 V DC | Same as CON3-1. |
| CON4-2 | Isolated Common | Same as CON3-2. |
| CON4-3 CON4-4 | Transmit Data (+) Transmit Data (–) | Same as CON3-3 and 4. |
| CON4-5 CON4-6 | Receive Data (+) Receive Data (–) | Same as CON3-5 and 6. |

4.13.2 Fiber-Optic Communication Module (318816)

The Fiber-Optic Communication Module provides one fiber-optic port and one optically isolated RS-232/422/485 port for general synchronous/asynchronous communications at up to 1 Mbaud.

Figure 4-37—Fiber-Optic Communication Module Connections

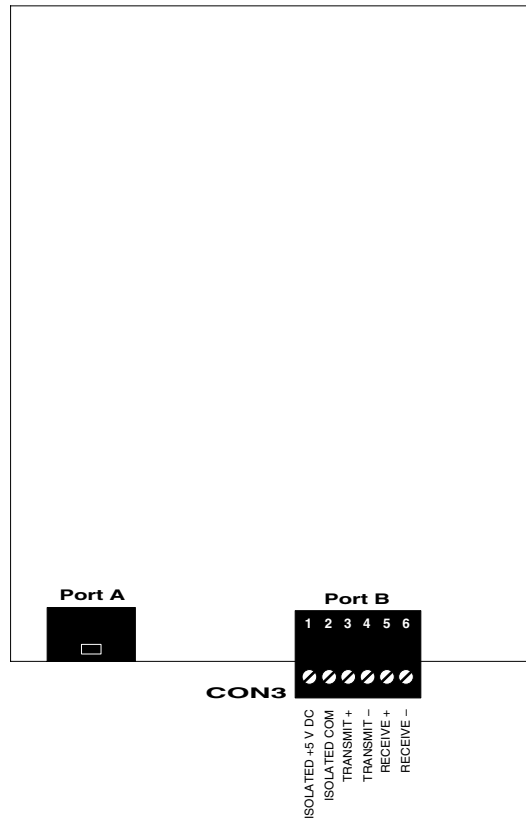


Table 4-33—Fiber-Optic Communication Module Connections

| Connection | Signal | Description |
|--|--|--|
| Port A—Synchronous/Asynchronous Serial Communications | | |
| Fiber-Optic Connector | Transmit Data/ Receive Data | Fiber-optic synchronous/asynchronous serial communication signals. |
| Port B—Synchronous/Asynchronous Serial Communications | | |
| CON3-1 | Isolated +5 V DC | Logic power supply for the interface. The interface is isolated, so this is not the same +5 V DC that powers the drive unit. This terminal can also be used to connect a pull-up resistor in a multidrop network. |
| CON3-2 | Isolated Common | Logic Common for this interface. It is optically isolated and floats relative to earth ground. With an RS-232 device, connect to the signal common of the external device since this is a single-ended interface and both signals are referenced to it. With an RS-485 device, connect to the logic common of the external device. When drive units are bussed together as a network, connect the Logic Commons of all drive units to keep the common-mode voltage between them within the –7 V to +12 V specification of RS-485. This terminal can also be used to connect a pull-down resistor in a multidrop network. |
| CON3-3 CON3-4 | Transmit Data (+) Transmit Data (–) | Differential signal that transmits data to the receiving device. With an RS-232 device, use terminal 4 as transmit. |
| CON3-5 CON3-6 | Receive Data (+) Receive Data (–) | Differential signal that passes data into the receiver of the interface. With an RS-232 device, use terminal 6 as receive. |

4.13.3 Remote I/O Communication Module (317848)

The Remote I/O Communication Module provides dual interfaces for communicating input and output status and other data with a programmable controller or other Remote I/O network device. Both discrete message and block transfers are supported.

Figure 4-38—Remote I/O Communication Module Connections

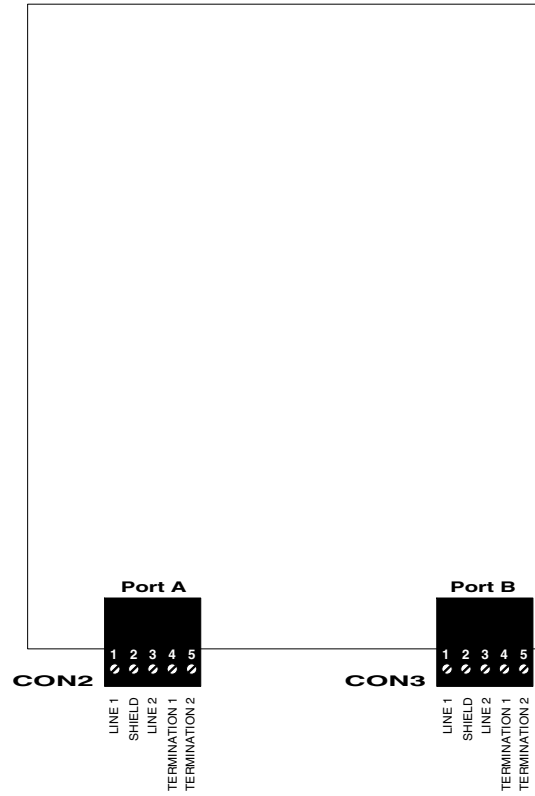


Table 4-34—Remote I/O Communication Module Connections

| Connection | Signal | Description |
|---|---------------|--|
| Port A—Remote I/O Communications | | |
| CON2-1 | Line 1 | Line 1 of the communication signal. Twisted pair with Line 2. |
| CON2-2 | Shield | Shield for the Line 1 and Line 2 twisted pair. Connected at the module end only. |
| CON2-3 | Line 2 | Line 2 of the communication signal. Twisted pair with Line 1. |
| CON2-4 | Termination 1 | Provides an 82.5 Ω terminating resistor. |
| CON2-5 | Termination 2 | Jumper 4 and 5 together for the last node on a network. |
| Port B—Remote I/O Communications | | |
| CON3-1 | Line 1 | Same as CON2-1. |
| CON3-2 | Shield | Same as CON2-2. |
| CON3-3 | Line 2 | Same as CON2-3. |
| CON3-4 | Termination 1 | Same as CON2-4 and 5. |
| CON3-5 | Termination 2 | |

4.13.4 Modbus® Plus Communication Module (319788)

The Modbus Plus Communication Module provides an interface for communicating register and status data between devices on a Modbus Plus network at up to 1 Mbaud.

Figure 4-39—Modbus® Plus Communication Module Connections

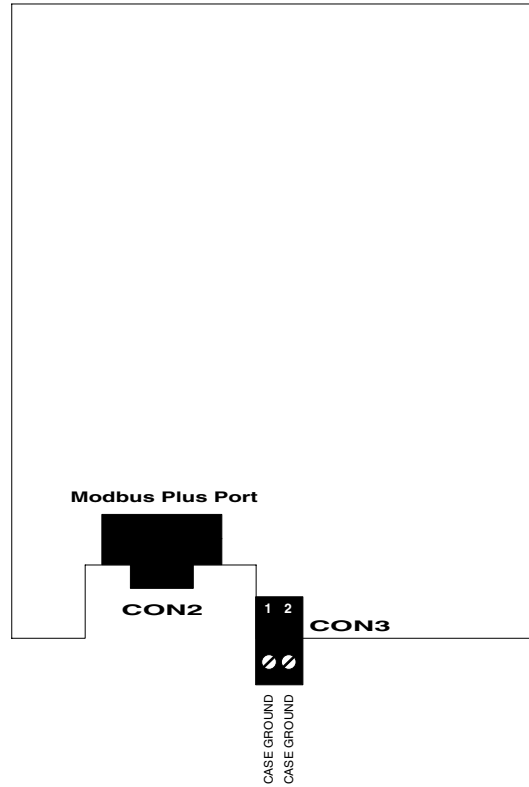


Table 4-35—Modbus® Plus Communication Module Connections

| Connection | Signal | Description |
|--|---------------------|--|
| Modbus Plus Communications Port | | |
| CON2 | Modbus Plus Network | 9-pin female D-sub connector for linking to Modbus Plus network. |
| Case Ground | | |
| CON3-1 | Case Ground | Case ground for the module. |
| CON3-2 | Case Ground | |

4.13.5 ControlNet™ Communication Module (321812)

The ControlNet™ Communication Module allows the drive to communicate with other controllers, operator devices, and other devices using the ControlNet protocol. It provides high-speed transfer of real-time control and I/O data as well as non-time-critical message data. Redundant ControlNet connections are provided to protect against data loss in crucial applications. The module also provides an optically isolated RS-232/422/485 asynchronous console port and three high-speed synchronous/asynchronous fiber-optic ports for use in certain applications.

Figure 4-40—ControlNet™ Communication Module Connections

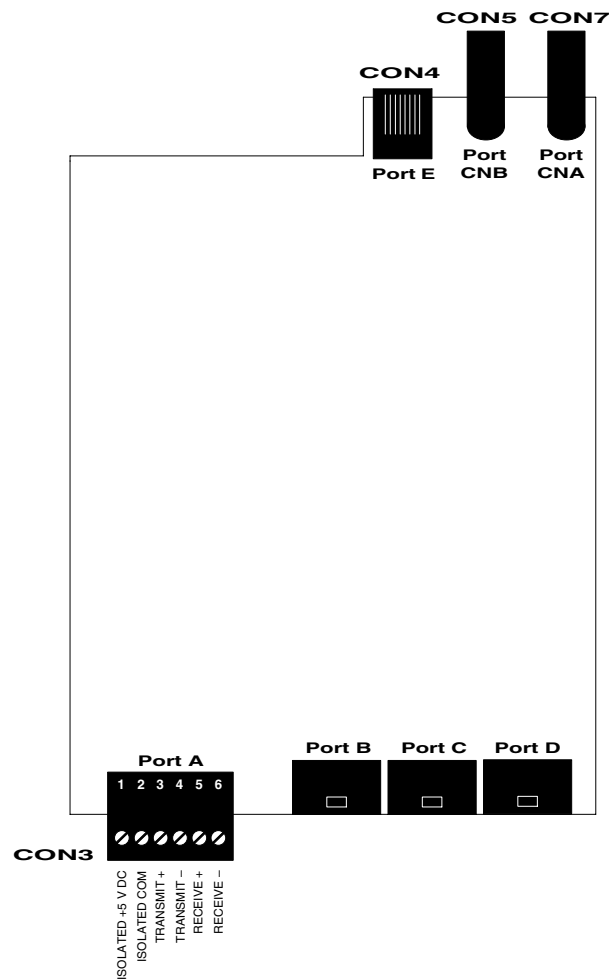


Table 4-36—ControlNet™ Communication Module Connections

| Connection | Signal | Description |
|---|--|---|
| Ports CNA, CNB—ControlNet Communications | | |
| CON5 (CNB) CON7 (CNA) | ControlNet Network | Redundant ControlNet communications ports (coaxial cable with BNC connectors). |
| Port E—ControlNet Diagnostics | | |
| CON4 | NAP Interface | ControlNet diagnostic port. |
| Port A (Console Port)—Asynchronous Serial Communications | | |
| CON3-1 | Isolated +5 V DC | Logic power supply for the interface. The interface is isolated, so this is not the same +5 V DC that powers the drive unit. This terminal can also be used to connect a pull-up resistor in a multidrop network. |
| CON3-2 | Isolated Common | Logic Common for the interface. It is optically isolated and floats relative to earth ground. With an RS-232 device, connect to the signal common of the external device since this is a single-ended interface and both signals are referenced to it. With an RS-485 device, connect to the logic common of the external device. When drive units are bussed together as a network, connect the Logic Commons of all drive units to keep the common-mode voltage between them within the –7 V to +12 V specification of RS-485. This terminal can also be used to connect a pull-down resistor in a multidrop network. |
| CON3-3 CON3-4 | Transmit Data (+) Transmit Data (–) | Differential signal that transmits data to the receiving device. With an RS-232 device, use terminal 4 as transmit. |
| CON3-5 CON3-6 | Receive Data (+) Receive Data (–) | Differential signal that passes data into the receiver of the interface. With an RS-232 device, use terminal 6 as the receive. |
| Ports B, C, and D—Synchronous/Asynchronous Serial Communications | | |
| Fiber-Optic Connectors | Transmit Data/ Receive Data | Fiber-optic synchronous/asynchronous serial communication ports. |

4.13.6 Profibus Communication Module (321560)

The Profibus Communication Module provides a Profibus DP-Slave interface for communicating input/output and parameter data with a master device at rates up to 12 Mbaud. Both cyclic and diagnostic data types are supported by the implementation. The module also provides an optically isolated RS-232/422/485 asynchronous console port and three high-speed synchronous/asynchronous fiber-optic ports for use in certain applications.

Figure 4-41—Profibus Communication Module Connections

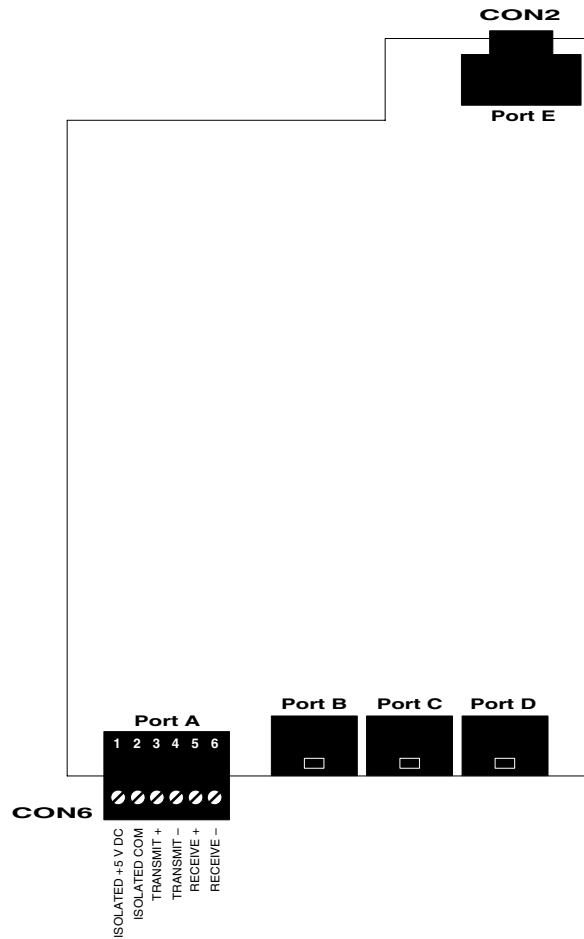


Table 4-37—Profibus Communication Module Connections

| Connection | Signal | Description |
|---|--------------------------------|---|
| Port E—Profibus Communications | | |
| CON2 | Profibus Network | 9-pin female D-sub connector for linking to Profibus network. |
| Port A (Console Port)—Asynchronous Serial Communications | | |
| CON6-1 | Isolated +5 V DC | Logic power supply for the interface. The interface is isolated, so this is not the same +5 V DC that powers the drive unit. This terminal can also be used to connect a pull-up resistor in a multidrop network. |
| CON6-2 | Isolated Common | Logic Common for the interface. It is optically isolated and floats relative to earth ground. With an RS-232 device, connect to the signal common of the external device since this is a single-ended interface and both signals are referenced to it. With an RS-485 device, connect to the logic common of the external device. When drive units are bussed together as a network, connect the Logic Commons of all drive units to keep the common-mode voltage between them within the -7 V to $+12\text{ V}$ specification of RS-485. This terminal can also be used to connect a pull-down resistor in a multidrop network. |
| CON6-3 | Transmit Data (+) | Differential signal that transmits data to the receiving device. With an RS-232 device, use terminal 4 as transmit. |
| CON6-4 | Transmit Data (–) | |
| CON6-5 | Receive Data (+) | Differential signal that passes data into the receiver of the interface. With an RS-232 device, use terminal 6 as receive. |
| CON6-6 | Receive Data (–) | |
| Ports B, C, and D—Synchronous/Asynchronous Serial Communications | | |
| Fiber-Optic Connectors | Transmit Data/ Receive Data | Fiber-optic synchronous/asynchronous serial communication ports. |

4.13.7 Ethernet Communication Module (321228)

The Ethernet Communication Module interfaces the drive to an Ethernet network for general communications up to 10 Mbaud. The module also provides an optically isolated RS-232/422/485 asynchronous console port and three high-speed synchronous/asynchronous fiber-optic ports for use in certain applications.

Figure 4-42— Ethernet Communication Module Connections

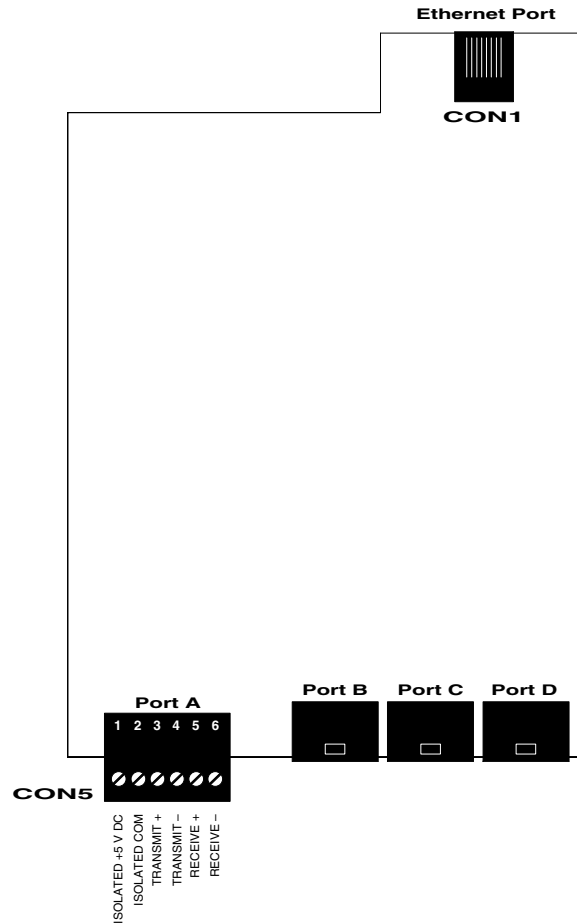


Table 4-38—Ethernet Communication Module Connections

| Connection | Signal | Description |
|---|--------------------------------|---|
| Port E—Ethernet Communications | | |
| CON1 | Ethernet Network | RJ-45 telephone connector for linking to Ethernet network. |
| Port A (Console Port)—Asynchronous Serial Communications | | |
| CON5-1 | Isolated +5 V DC | Logic power supply for the interface. The interface is isolated, so this is not the same +5 V DC that powers the drive unit. This terminal can also be used to connect a pull-up resistor in a multidrop network. |
| CON5-2 | Isolated Common | Logic Common for the interface. It is optically isolated and floats relative to earth ground. With an RS-232 device, connect to the signal common of the external device since this is a single-ended interface and both signals are referenced to it. With an RS-485 device, connect to the logic common of the external device. When drive units are bussed together as a network, connect the Logic Commons of all drive units to keep the common-mode voltage between them within the -7 V to $+12\text{ V}$ specification of RS-485. This terminal can also be used to connect a pull-down resistor in a multidrop network. |
| CON5-3 | Transmit Data (+) | Differential signal that transmits data to the receiving device. With an RS-232 device, use terminal 4 as transmit. |
| CON5-4 | Transmit Data (–) | |
| CON5-5 | Receive Data (+) | Differential signal that passes data into the receiver of the interface. With an RS-232 device, use terminal 6 as receive. |
| CON5-6 | Receive Data (–) | |
| Ports B, C, and D—Synchronous/Asynchronous Serial Communications | | |
| Fiber-Optic Connectors | Transmit Data/ Receive Data | Fiber-optic synchronous/asynchronous serial communication ports. |

5 Troubleshooting/Maintenance

5.1 Overview

This chapter provides information useful in troubleshooting and maintaining drive-unit 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 document, 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 unit or associated equipment. Use an appropriate voltmeter to further verify that capacitors are discharged before beginning work. Do not rely exclusively on bus voltage indicators. Dangerous voltage levels may remain even when the indicators are 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 a three-phase AC motor or into variable field and armature voltages for controlling a DC motor.

Drives generally use an input section that handles power flow between an AC line and a DC bus in addition to an output section that controls power flow between the DC bus and an AC or DC motor. The input section of a drive can be either a rectifier or an inverter. The rectifier provides a one-way flow of power from the AC line to the DC bus, while an inverter allows power to flow in both directions.

The 2400 and 2450 drives are constructed as modular units with separate input (rectifier or inverter) and output (inverter or amplifier) sections. The 2420 AC drives are constructed as stand-alone integrated units that combine input (rectifier) and output (inverter) sections. Nonregenerative drives use a 2490 converter to provide a rectified DC bus to power one or more 2400 AC inverters or 2450 DC amplifiers. Line-regenerative drives use a 2400 AC inverter to provide the power flow between the line and the DC bus for one or more 2400 AC inverters.

The modular construction of the 2000 family allows a single rectifier or inverter to feed a common DC bus. This common-bus architecture minimizes input power requirements by allowing motoring and braking power to circulate between drives. Large inverter and

amplifier units are themselves modular for ease of handling. The 2420 combines a rectifier and inverter into a stand-alone drive intended for motoring-type loads. The 2420 can also furnish the bus for a limited drive system of 2400 inverter units.

An input *rectifier section* is used on the nonregenerative 2400, 2420, and 2450 drives to convert the fixed AC line voltage into a DC bus voltage. The rectifier section for the 2400 and 2450 drives is provided by a separate 2490 converter. 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. 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. A *rectifier control* coordinates the charging of the bus and operation of a dynamic brake device.

A *link choke* and *bus capacitors* used in nonregenerative configurations form a filter that smoothes the output of the rectifier section into a steady DC voltage. An optional *dynamic brake* device allows regenerative energy from the load to be dissipated in an external resistor when the drive is braking.

An *input inverter section* is used in line-regenerative applications regulates power flow between the AC line and DC bus. The input inverter 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.

In 2400 inverters and 2420 drives, an *output 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). In 2450 amplifiers, an *output amplifier section* consisting of six IGBTs uses PWM operation to produce the variable field and armature voltage needed for control of DC motors. 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. A variety of optional feedback interface modules are available to provide closed-loop control of motor velocity and/or position. Various serial communication interfaces are also available that provide interfaces for popular serial communication protocols.

A *standard controller* provides a cost-effective solution for simple applications with limited I/O requirements. An *expandable controller* is used in applications that require multiple transducers and/or expanded digital I/O capacity. A *dual controller* uses tandem digital signal processors (DSPs) to provide high frequency and bandwidth operation.

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 5-1—2400 Block Diagram (Form 2)

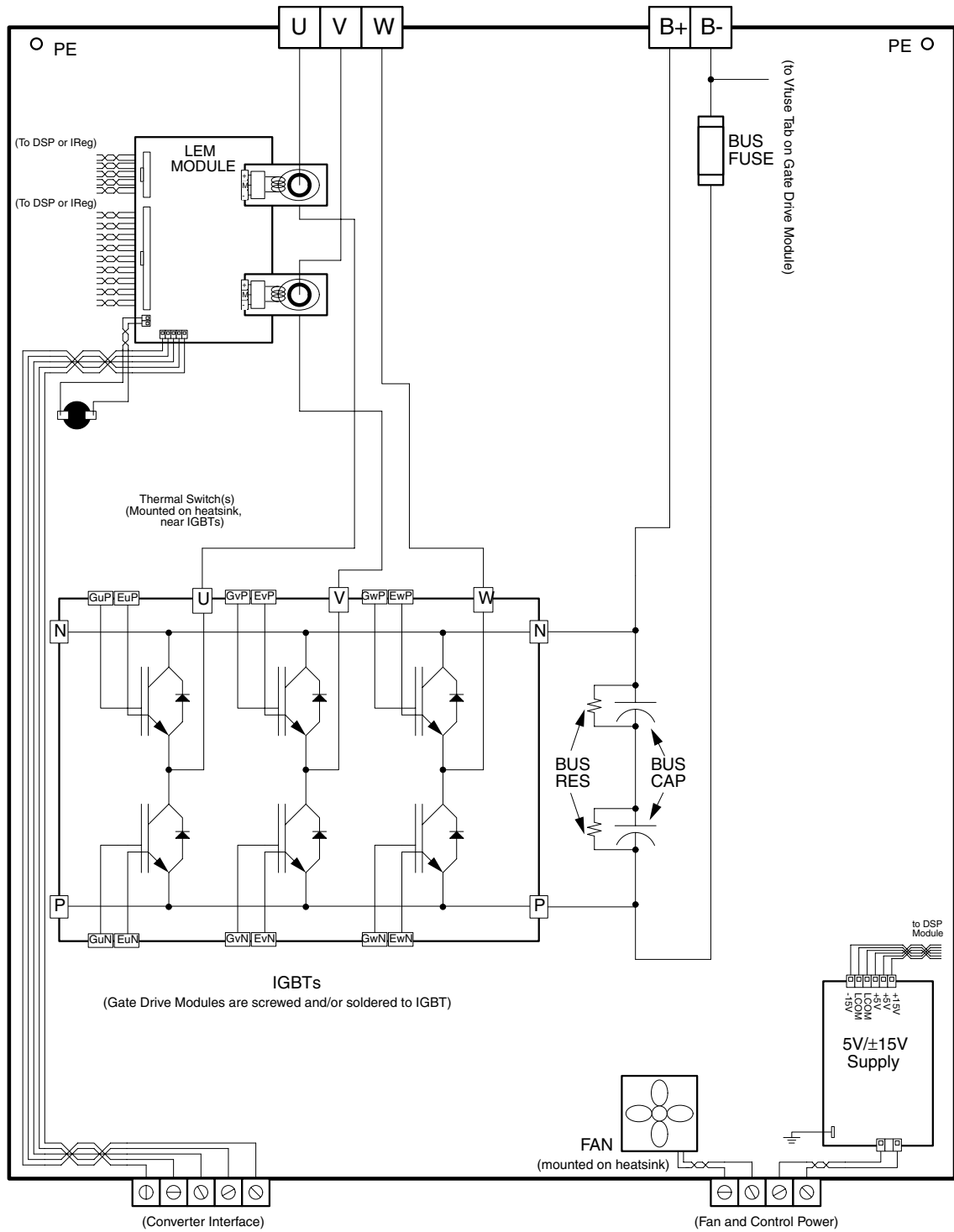


Figure 5-2—2400 Block Diagram (Form 3)

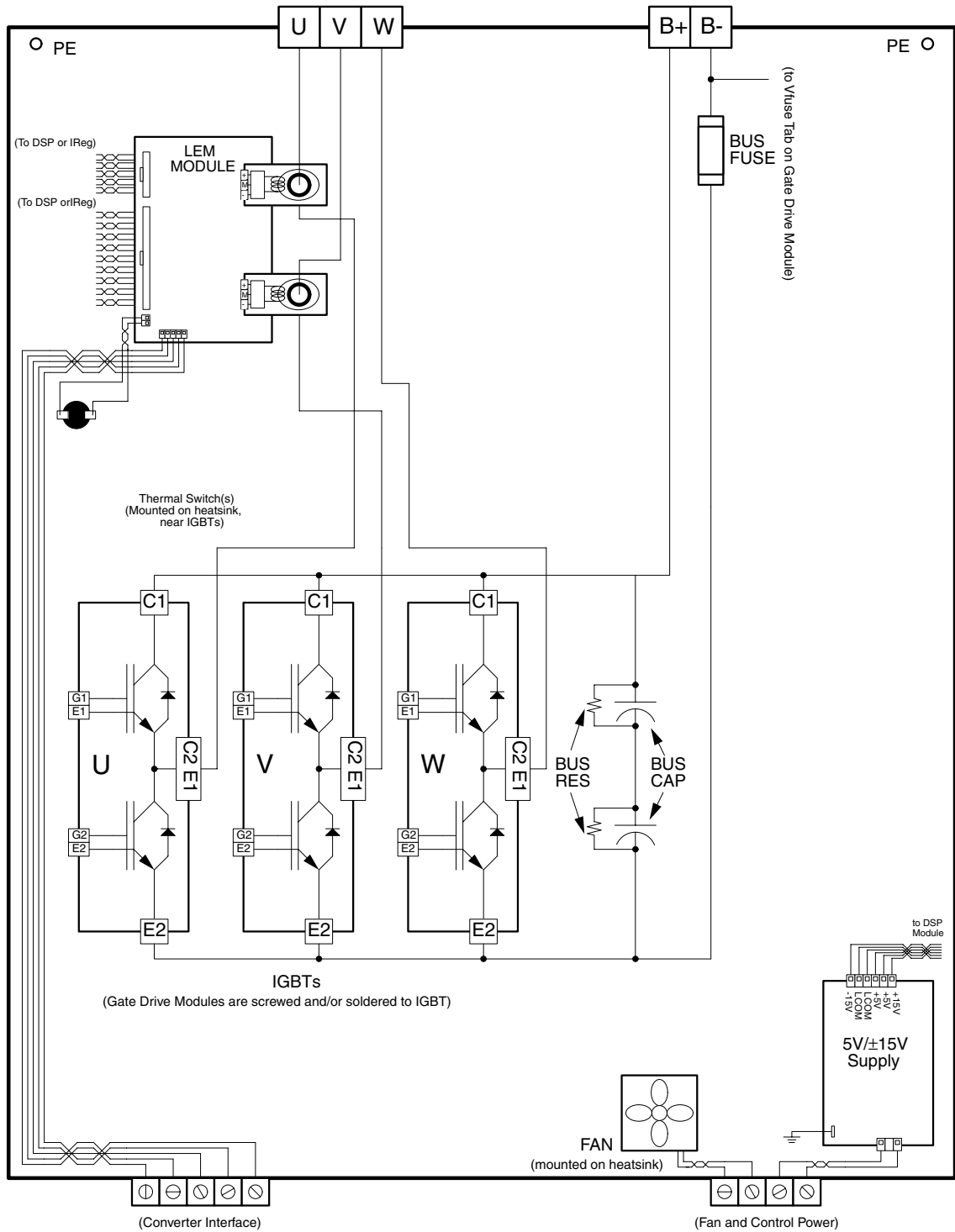


Figure 5-3—2400 Block Diagram (Form 4)

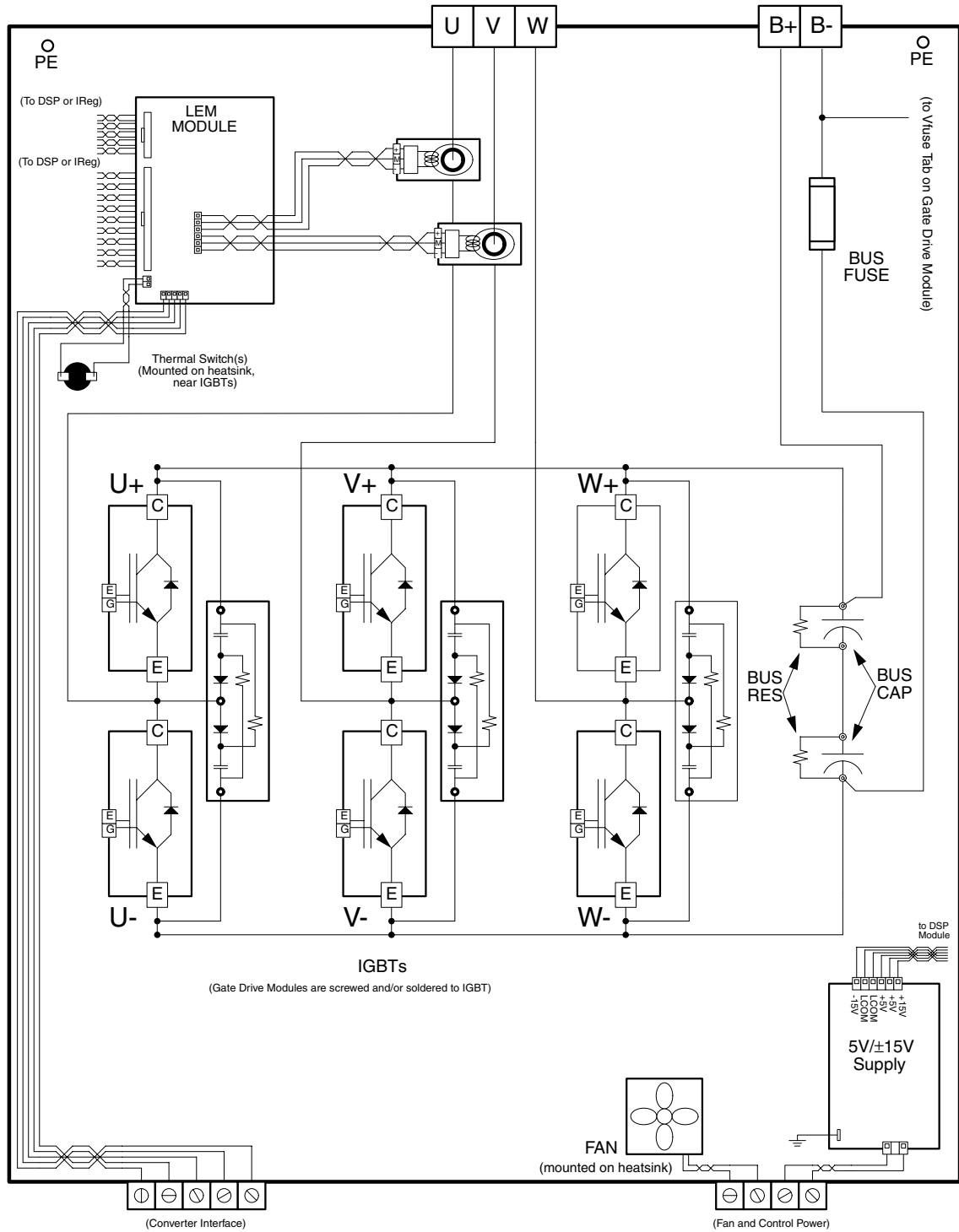


Figure 5-4—2400 Block Diagram (Form 5)

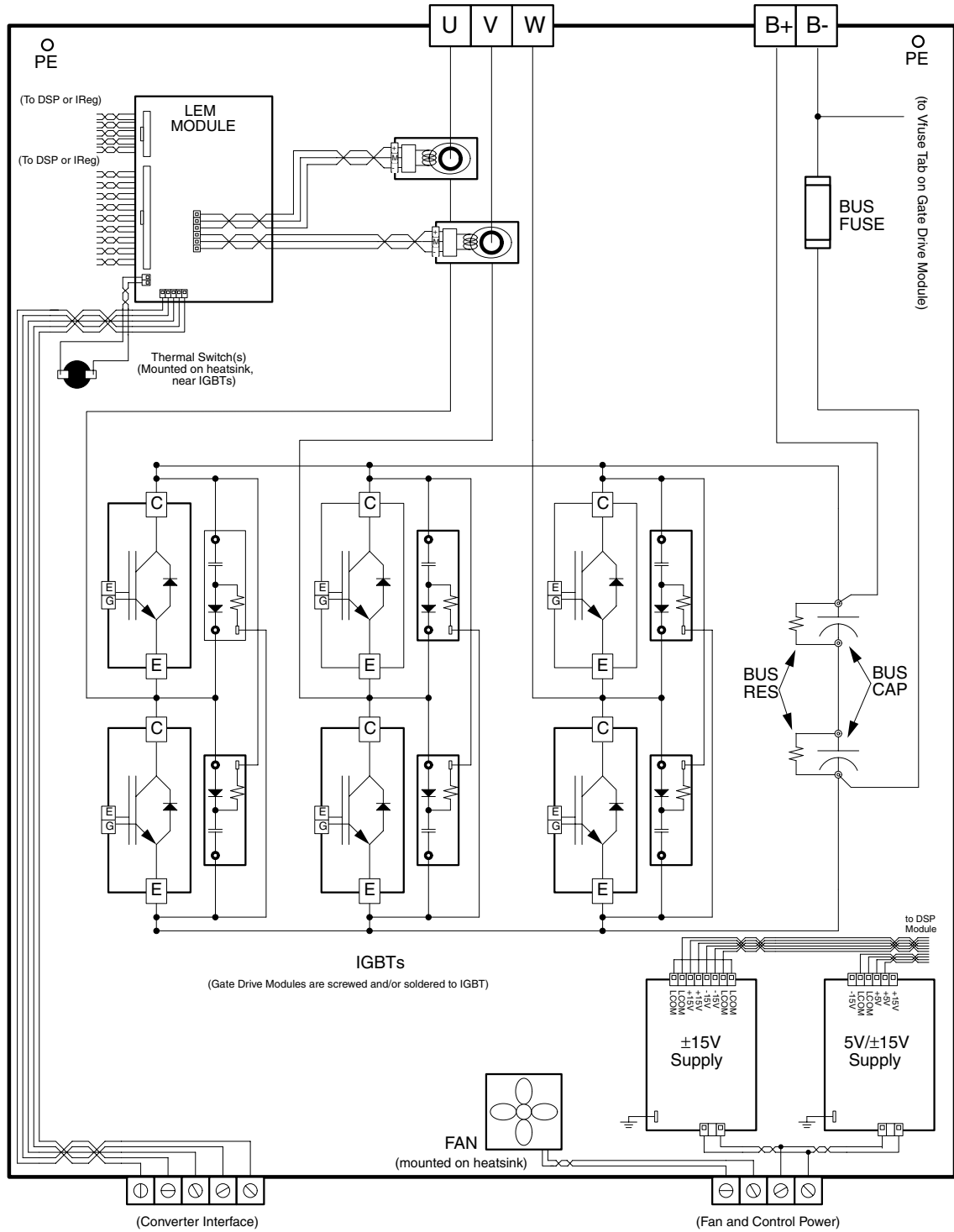


Figure 5-5—2420 Block Diagram (Form 3)

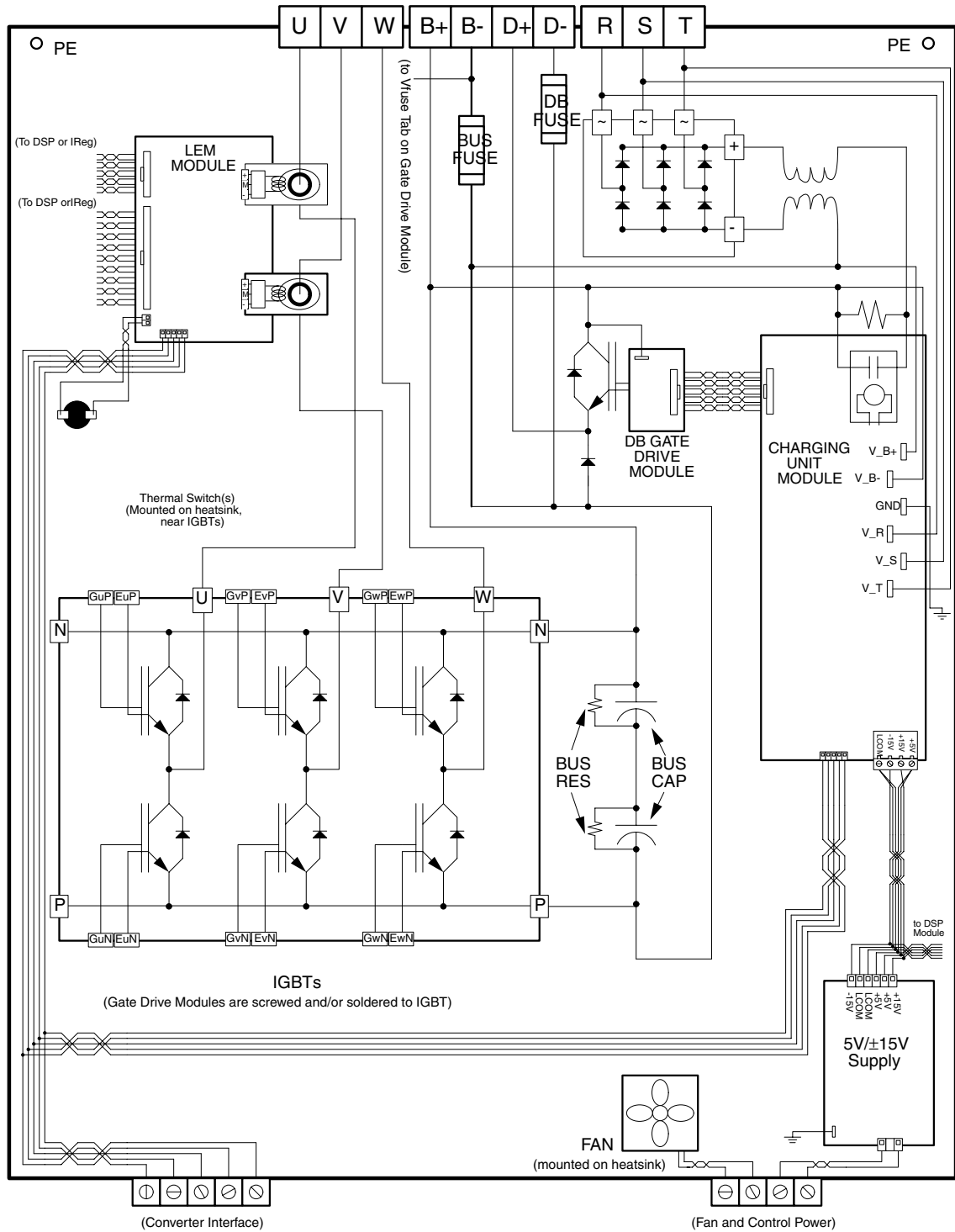


Figure 5-6—2420 Block Diagram (Form 4)

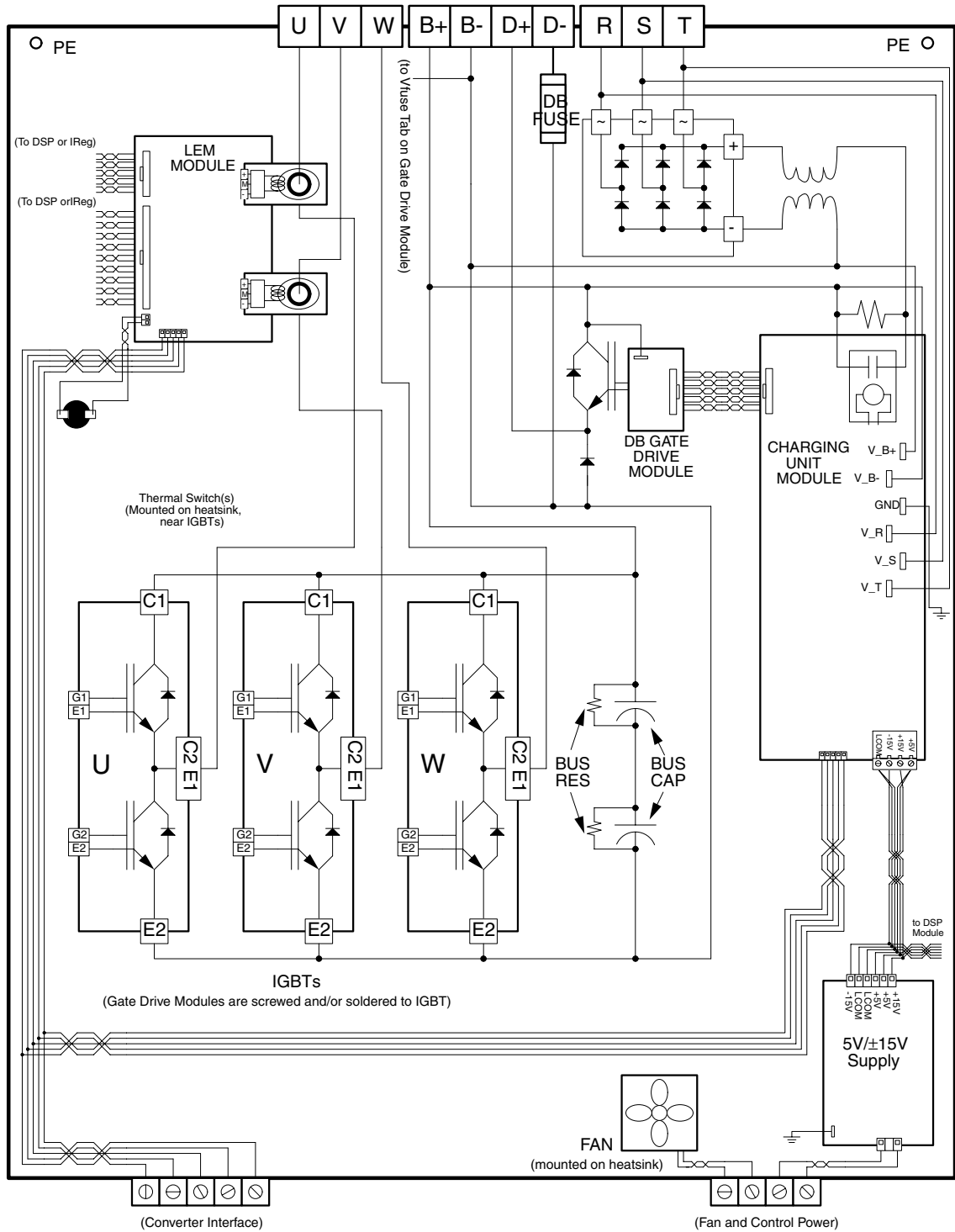


Figure 5-7—2490 Block Diagram (Form 2)

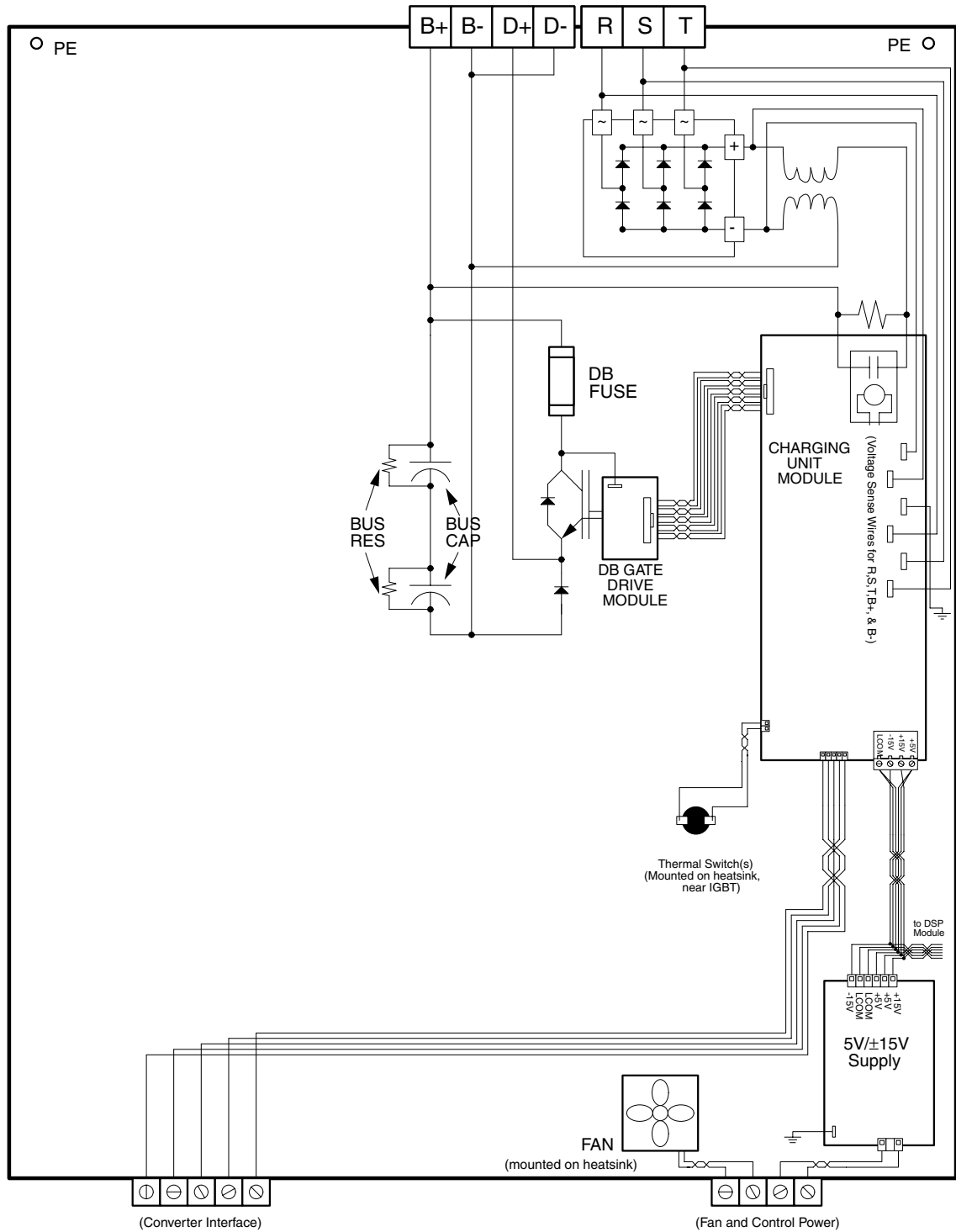


Figure 5-8—2490 Block Diagram (Form 3)

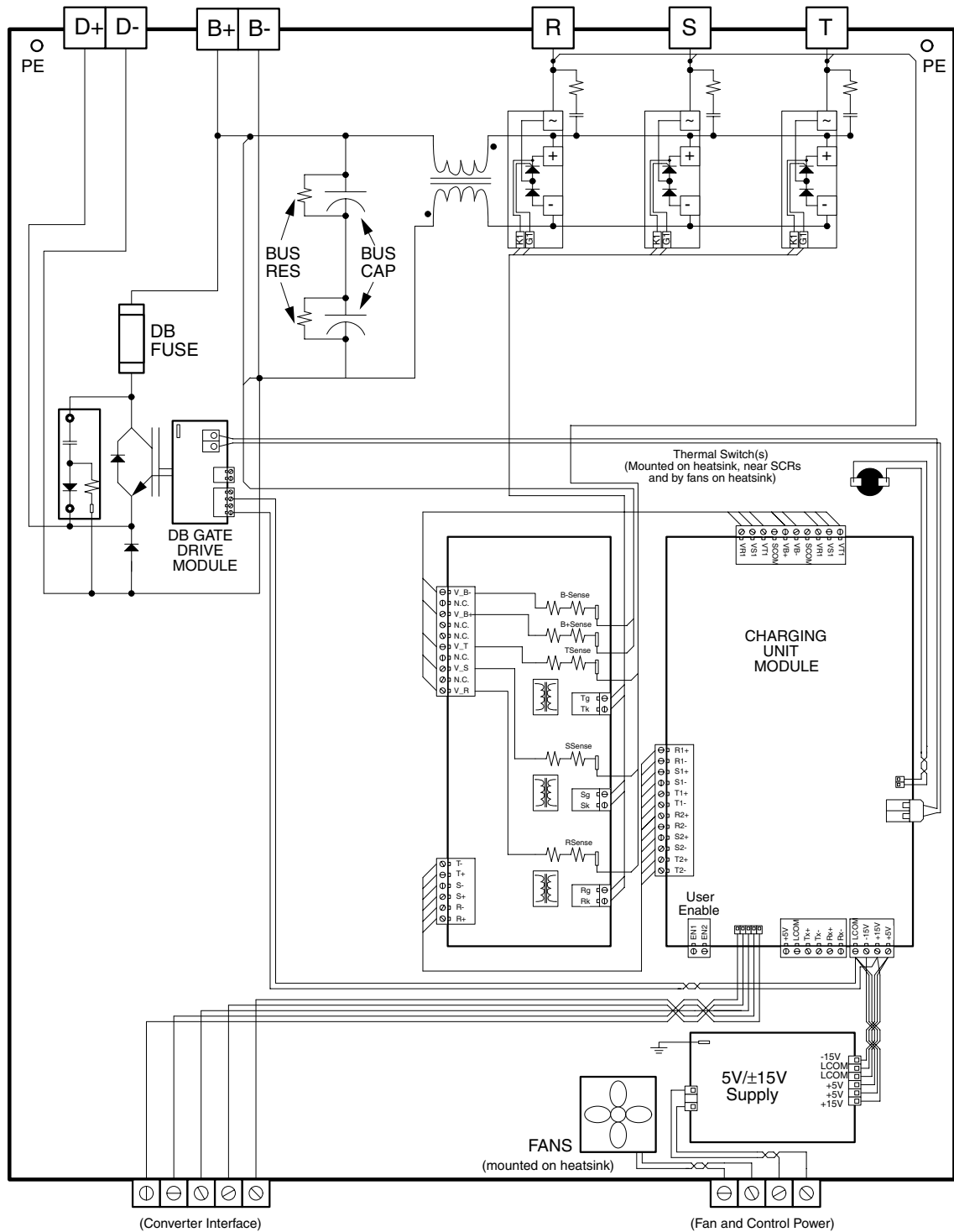


Figure 5-9—2490 Block Diagram (Form 4)

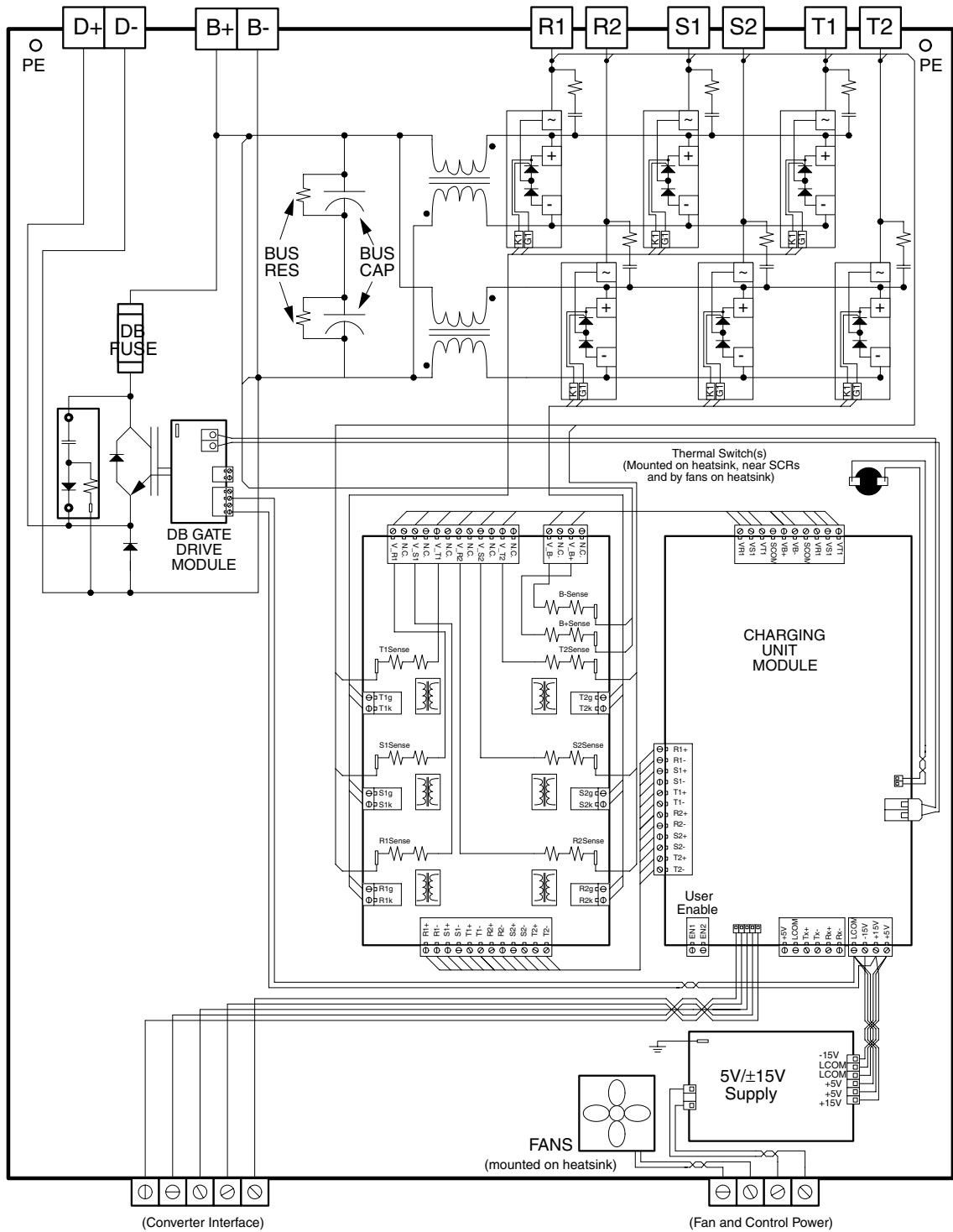


Figure 5-10—2490 Block Diagram (Form 5 / 250 to 400 hp)

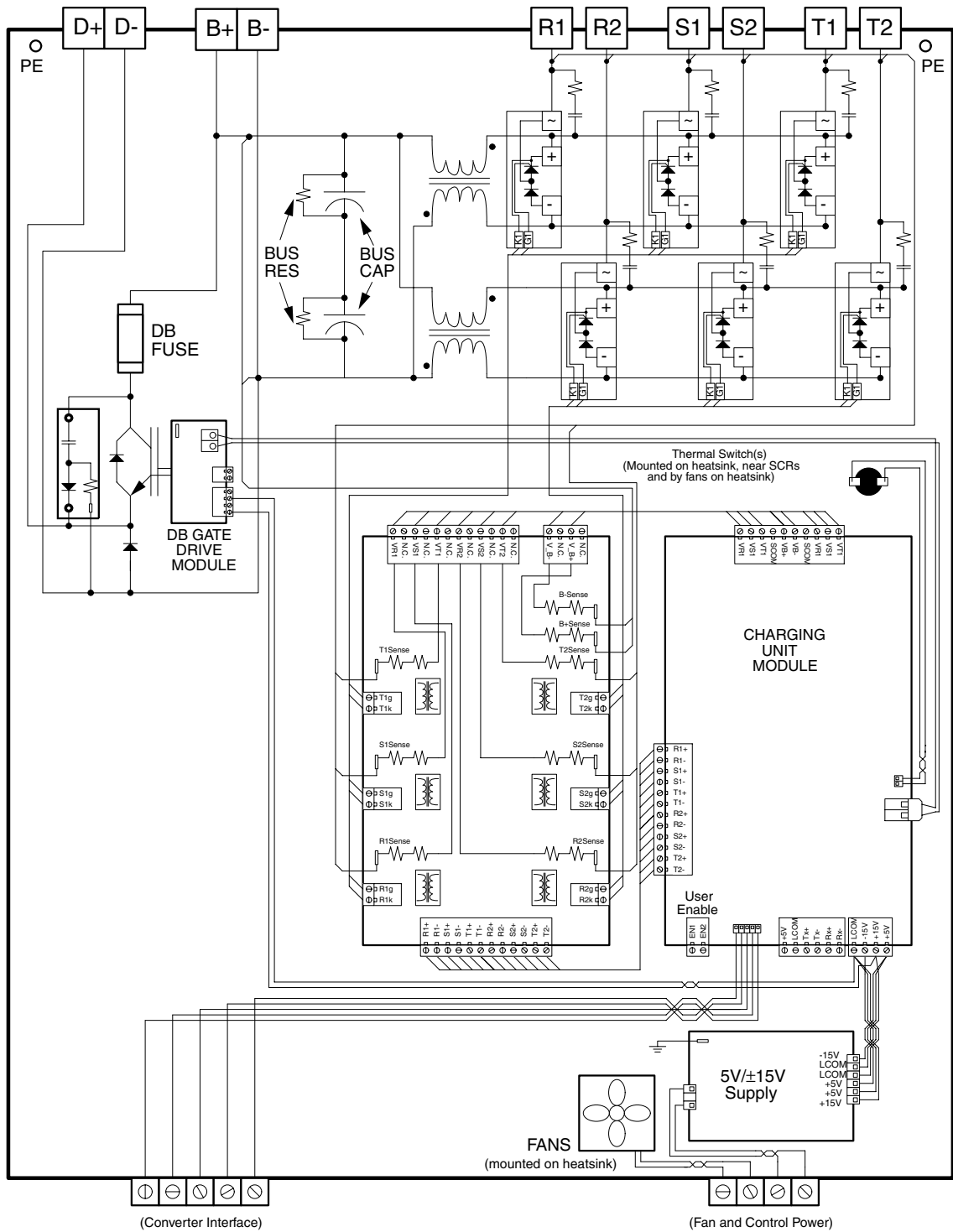
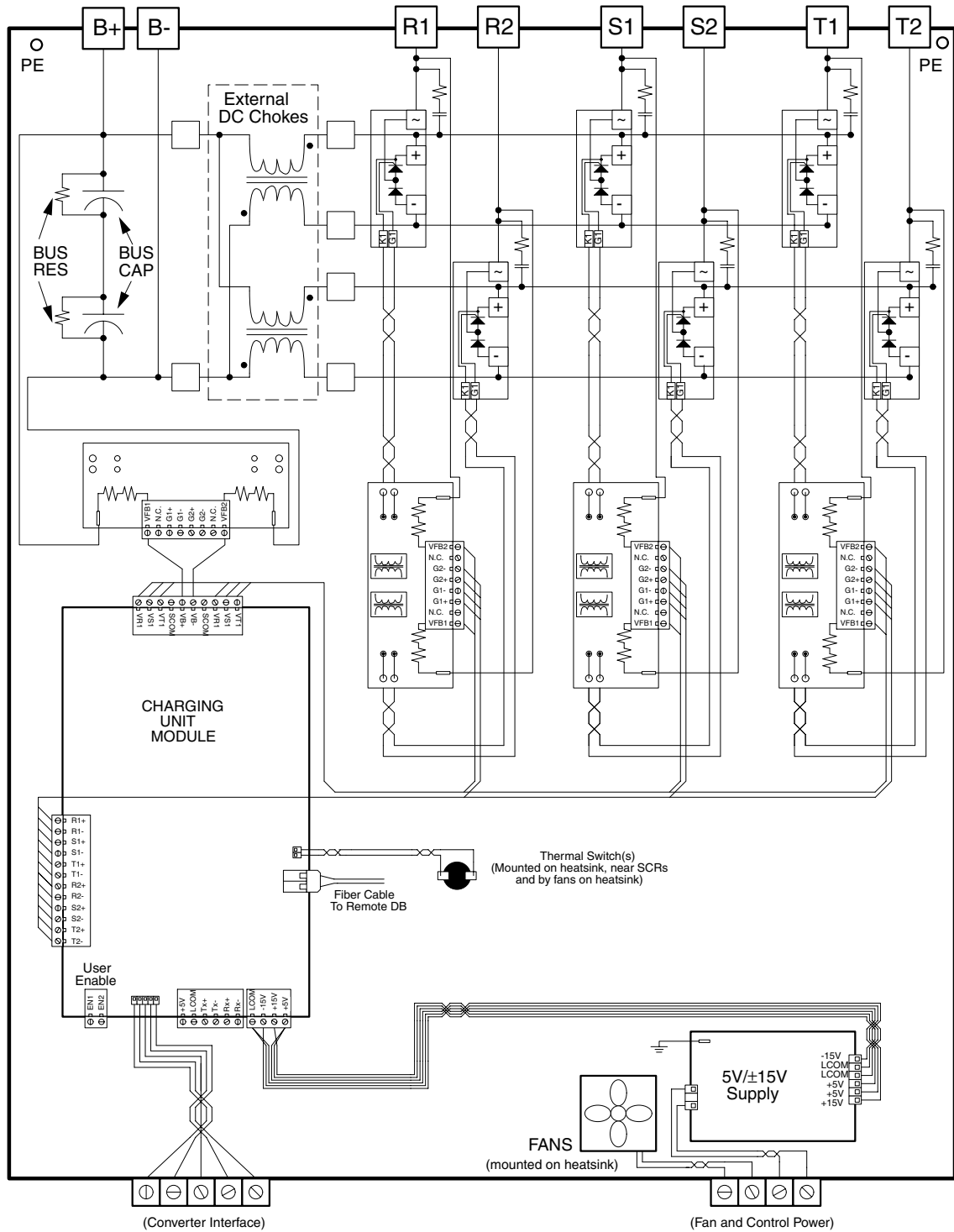


Figure 5-11—2490 Block Diagram (Form 5 / 500 to 1000 hp)



5.2.2 Rectifier Checking Procedure (2420 and 2490)

The rectifier bridge diodes or SCRs can be checked using a multimeter set on 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 unit.

[2] **Disconnect power board**

Disconnect all wires from terminals R, S, and T. If the converter is diode-based (2420 and Form 2 2490 units), disconnect bridge rectifier leads B+ and B- from the diodes.

[3] **Take readings**

Using a digital ohmmeter set on diode range, take each of the readings indicated in either Table 5-1 (for diode-based converters) or Table 5-2 (for SCR-based converters). Compare the readings with the proper values indicated in the table.

[4] **Replacement**

Any meter reading other than that specified indicates a defective diode or SCR. Replace the defective component or the entire unit.

[5] **Reconnect**

When the test is complete, replace all wires to terminals R, S, and T. For diode-based units, replace the B+ and B- bridge rectifier leads as well.

Table 5-1—Rectifier Diode Checking Readings

| Ohmmeter (+) Lead | Ohmmeter (-) Lead | Proper Meter Reading | Diode Checked |
|-------------------|-------------------|----------------------|---------------|
| B+ | R | Open | DR+ |
| B+ | S | Open | DS+ |
| B+ | T | Open | DT+ |
| R | B- | Open | DR- |
| S | B- | Open | DS- |
| T | B- | Open | DT- |
| R | B+ | 0.25 V to 0.40 V | DR+ |
| S | B+ | 0.25 V to 0.40 V | DS+ |
| T | B+ | 0.25 V to 0.40 V | DT+ |
| B- | R | 0.25 V to 0.40 V | DR- |
| B- | S | 0.25 V to 0.40 V | DS- |
| B- | T | 0.25 V to 0.40 V | DT- |

Table 5-2—Rectifier SCR Checking Readings

| Ohmmeter (+) Lead | Ohmmeter (-) Lead | Proper Meter Reading | SCR Checked |
|-------------------|-------------------|----------------------|--------------|
| B+ | R or R1, R2 | ≥ 0.30 V | SCR R1+, R2+ |
| B+ | S or S1, S2 | ≥ 0.30 V | SCR S1+, S2+ |
| B+ | T or T1, T2 | ≥ 0.30 V | SCR T1+, T2+ |
| R or R1, R2 | B- | ≥ 0.30 V | DR1-, DR2- |
| S or S1, S2 | B- | ≥ 0.30 V | DS1-, DS2- |
| T or T1, T2 | B- | ≥ 0.30 V | DT1-, DT2- |
| R or R1, R2 | B+ | 0.20 V to 0.40 V | SCR R1+, R2+ |
| S or S1, S2 | B+ | 0.20 V to 0.40 V | SCR S1+, S2+ |
| T or T1, T2 | B+ | 0.20 V to 0.40 V | SCR T1+, T2+ |
| B- | R or R1, R2 | 0.20 V to 0.40 V | DR1-, DR2- |
| B- | S or S1, S2 | 0.20 V to 0.40 V | DS1-, DS2- |
| B- | T or T1, T2 | 0.20 V to 0.40 V | DT1-, DT2- |

5.2.3 Transistor Checking Procedure (2400 and 2420)

The inverter IGBTs can be checked using a multimeter set on 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 inverter.

[2] **Disconnect wires**

Disconnect all wires from terminals D+ (on 2420 units), U, V, and W and remove the inverter bridge B+ and B- leads from the transistors. Do not remove the bus links that go between the converter and the inverter.

[3] **Take readings**

Using a digital ohmmeter on diode range, take each of the readings indicated in Table 5-3. Compare the readings with the proper values indicated in the table.

[4] **Replacement**

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

[5] **Reconnect**

When the test is complete, replace all wires to terminals D+, U, V, and W as well as to the inverter bridge B+ and B- leads.

Table 5-3—Transistor Checking Readings

| Ohmmeter (+) Lead | Ohmmeter (-) Lead | Proper Meter Reading | Transistor Checked |
|-------------------|-------------------|----------------------|--------------------|
| B+ | D+ (2420 only) | Open | QSR+ |
| B+ | U | Open | QU+ |
| B+ | V | Open | QV+ |
| B+ | W | Open | QW+ |
| U | B- | Open | QU- |
| V | B- | Open | QV- |
| W | B- | Open | QW- |
| D+ (2420 only) | B+ | 0.25 V to 0.40 V | QSR+ |
| U | B+ | 0.25 V to 0.40 V | QU+ |
| V | B+ | 0.25 V to 0.40 V | QV+ |
| W | B+ | 0.25 V to 0.40 V | QW+ |
| B- | U | 0.25 V to 0.40 V | QU- |
| B- | V | 0.25 V to 0.40 V | QV- |
| B- | W | 0.25 V to 0.40 V | QW- |

5.3 Maintenance

Drive units require virtually no maintenance. Once a 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 excluding 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.

5.3.4 Spare Parts

Spare and replacement parts are available directly from the factory or through your value-added reseller. Complete drive unit assemblies are identified by part number in Table 5-4 through Table 5-7. Please consult the factory regarding assemblies designated “c. f.” Field-replaceable control and interface modules are listed in Table 5-8 and Table 5-9.

Table 5-4—2400, 2420, and 2450 Assemblies

| Power | P a r t N u m b e r | | | | | | | | |
|----------------|---------------------|-----------------------|-----------------|---------------------|-----------------------|-----------------|---------------------|-----------------------|-----------------|
| | 2400 | | | 2420 | | | 2450 | | |
| CT | Standard Controller | Expandable Controller | Dual Controller | Standard Controller | Expandable Controller | Dual Controller | Standard Controller | Expandable Controller | Dual Controller |
| 230 V | | | | | | | | | |
| 1 1/2 (1.1) | c. f. | 109421 | c. f. | c. f. | 109410 | c. f. | c. f. | c. f. | c. f. |
| 2 (1.5) | c. f. | 109422 | c. f. | c. f. | 109411 | c. f. | c. f. | c. f. | c. f. |
| 3 (2.2) | c. f. | 109423 | c. f. | c. f. | 109412 | c. f. | c. f. | c. f. | c. f. |
| 5 (3.7) | c. f. | 109424 | c. f. | c. f. | 109413 | c. f. | c. f. | c. f. | c. f. |
| 7 1/2 (5.5) | 110180 | 109425 | c. f. | c. f. | 109414 | c. f. | c. f. | c. f. | c. f. |
| 10 (7.5) | c. f. | 109426 | c. f. | c. f. | 109415 | c. f. | c. f. | c. f. | c. f. |
| 15 (11) | c. f. | 109427 | c. f. | c. f. | 109180 | c. f. | c. f. | c. f. | c. f. |
| 20 (15) | c. f. | 109428 | c. f. | c. f. | 109416 | c. f. | c. f. | c. f. | c. f. |
| 25 (18) | c. f. | 109429 | c. f. | c. f. | 109417 | c. f. | 110139 | c. f. | c. f. |
| 30 (22) | c. f. | 109430 | c. f. | — | — | — | c. f. | c. f. | c. f. |
| 40 (30) | c. f. | 109431 | c. f. | — | — | — | c. f. | 110428 | c. f. |
| 50 (37) | c. f. | 109432 | 110914 | — | — | — | c. f. | c. f. | c. f. |
| 60 (45) | c. f. | 109433 | c. f. | — | — | — | c. f. | c. f. | c. f. |
| 75 (55) | c. f. | 109434 | c. f. | — | — | — | c. f. | c. f. | c. f. |
| 100 (75) | — | — | — | — | — | — | c. f. | c. f. | c. f. |
| 125 (90) | — | — | — | — | — | — | c. f. | 110858 | c. f. |
| 150 (110) | — | — | — | — | — | — | c. f. | c. f. | c. f. |

(continued)

Table 5-4—2400, 2420, and 2450 Assemblies (continued)

| Power CT | P a r t N u m b e r | | | | | | | | |
|----------------|------------------------|--------------------------|--------------------|------------------------|--------------------------|--------------------|------------------------|--------------------------|--------------------|
| | 2400 | | | 2420 | | | 2450 | | |
| hp (kW) | Standard Controller | Expandable Controller | Dual Controller | Standard Controller | Expandable Controller | Dual Controller | Standard Controller | Expandable Controller | Dual Controller |
| 460 V | | | | | | | | | |
| 1 1/2 (1.1) | c. f. | 109144 | c. f. | c. f. | 109218 | c. f. | c. f. | c. f. | c. f. |
| 2 (1.5) | c. f. | 109420 | c. f. | c. f. | 109408 | c. f. | c. f. | c. f. | c. f. |
| 3 (2.2) | 110426 | 109204 | c. f. | c. f. | 109219 | c. f. | c. f. | c. f. | c. f. |
| 5 (3.7) | 110437 | 109205 | c. f. | 109353 | 109220 | c. f. | c. f. | 110125 | c. f. |
| 7 1/2 (5.5) | 110386 | 109145 | c. f. | 110327 | 109221 | c. f. | c. f. | c. f. | c. f. |
| 10 (7.5) | 110879 | 109146 | c. f. | 109354 | 109222 | c. f. | c. f. | 110127 | c. f. |
| 15 (11) | 110442 | 109197 | c. f. | 109355 | 109223 | c. f. | c. f. | c. f. | c. f. |
| 20 (15) | c. f. | 109174 | c. f. | 109356 | 109224 | c. f. | c. f. | 110129 | c. f. |
| 25 (18) | c. f. | 109181 | c. f. | 109366 | 109225 | 110146 | c. f. | 110131 | c. f. |
| 30 (22) | 110602 | 109206 | 110917 | 109367 | 109226 | c. f. | c. f. | c. f. | c. f. |
| 40 (30) | c. f. | 109207 | 110609 | 109368 | 109227 | 110153 | c. f. | 110133 | c. f. |
| 50 (37) | 110195 | 109147 | 110264 | 109369 | 109228 | c. f. | c. f. | c. f. | c. f. |
| 60 (45) | 110161 | 109872 | c. f. | — | — | — | c. f. | c. f. | c. f. |
| 75 (55) | 110867 | 110208 | 110930 | — | — | — | c. f. | c. f. | c. f. |
| 100 (75) | 109563 | 109564 | 110685 | — | — | — | c. f. | 110270 | c. f. |
| 125 (90) | 110490 | 109639 | 110688 | — | — | — | 110554 | 110137 | c. f. |
| 150 (110) | 110502 | 109640 | 110689 | — | — | — | c. f. | 110225 | c. f. |
| 200 (150) | 110489 | 110273 | 109642 | — | — | — | c. f. | c. f. | c. f. |
| 250 (185) | c. f. | 110016 | c. f. | — | — | — | c. f. | 110014 | c. f. |
| 300 (225) | 109561 | 109962 | 110087 | — | — | — | c. f. | c. f. | c. f. |
| 350 (262) | 110690 | 109874 | 110046 | — | — | — | c. f. | c. f. | c. f. |
| 400 (300) | 109562 | 110272 | 109643 | — | — | — | c. f. | c. f. | c. f. |
| 500 (375) | 110833 | 110604 | c. f. | — | — | — | c. f. | c. f. | c. f. |
| 600 (450) | c. f. | c. f. | c. f. | — | — | — | c. f. | c. f. | c. f. |
| 700 (525) | c. f. | c. f. | c. f. | — | — | — | c. f. | c. f. | c. f. |
| 800 (600) | 110158 | 109352 | c. f. | — | — | — | c. f. | c. f. | c. f. |

(continued)

Table 5-4—2400, 2420, and 2450 Assemblies (continued)

| Power CT | P a r t N u m b e r | | | | | | | | |
|---------------|------------------------|--------------------------|--------------------|------------------------|--------------------------|--------------------|------------------------|--------------------------|--------------------|
| | 2400 | | | 2420 | | | 2450 | | |
| hp (kW) | Standard Controller | Expandable Controller | Dual Controller | Standard Controller | Expandable Controller | Dual Controller | Standard Controller | Expandable Controller | Dual Controller |
| 460 V | | | | | | | | | |
| 900 (675) | 110196 | c. f. | c. f. | — | — | — | — | — | — |
| 1000 (750) | 110445 | c. f. | c. f. | — | — | — | — | — | — |
| 575 V | | | | | | | | | |
| 125 (90) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 150 (110) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 200 (150) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 250 (185) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 300 (225) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 350 (262) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 400 (300) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 500 (375) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 600 (450) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 700 (525) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 800 (600) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 900 (675) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 1000 (750) | c. f. | c. f. | c. f. | — | — | — | — | — | — |
| 1100 (825) | 110356 | c. f. | c. f. | — | — | — | — | — | — |

Table 5-5—2490 Assemblies

| Power | Type | Part Number | |
|----------------|---------------|--------------------|---------------|
| CT | Bridge | w/DB | w/o DB |
| <i>hp (kW)</i> | | | |
| 230 V | | | |
| 10 (7.5) | Diode | c. f. | 108516 |
| 20 (15) | Diode | c. f. | 108532 |
| 40 (30) | SCR | c. f. | c. f. |
| 75 (55) | SCR | 110440 | 110439 |
| 460 V | | | |
| 20 (15) | Diode | c. f. | 110510 |
| 40 (30) | Diode | c. f. | 108534 |
| 75 (55) | SCR | 110171 | 109631 |
| 150 (110) | SCR | 110170 | 109437 |
| 250 (185) | SCR | 110403 | 110284 |
| 400 (300) | SCR | 110404 | 110285 |
| 500 (375) | SCR | c. f. | c. f. |
| 600 (450) | SCR | c. f. | c. f. |
| 800 (600) | SCR | 109406 | c. f. |
| 575 V | | | |
| 150 (110) | SCR | 110940 | c. f. |
| 250 (185) | SCR | c. f. | c. f. |
| 400 (300) | SCR | c. f. | c. f. |
| 500 (375) | SCR | c. f. | c. f. |
| 600 (450) | SCR | c. f. | c. f. |
| 800 (600) | SCR | c. f. | c. f. |
| 1000 (750) | SCR | c. f. | c. f. |

Table 5-6—2491 Assemblies

| Power | Rating | Part Number |
|----------------|----------------|------------------------|
| <i>hp (kW)</i> | <i>hp (kW)</i> | |
| 460 V | | |
| 400 (300) | 100 (75) | 109612 |
| 600 (450) | 150 (112) | 109613 |
| 800 (600) | 200 (150) | 109614 |
| 575 V | | |
| 600 (450) | 150 (112) | 109599 |
| 800 (600) | 200 (150) | 109610 |
| 1000 (750) | 250 (187) | 109611 |

Table 5-7—2493 Assemblies

| Size | Part Number |
|--------------|------------------------|
| <i>μfd</i> | |
| 230 V | |
| 26,400 | 108096 |
| 44,000 | 109305 |
| 132,000 | 109311 |
| 220,000 | 109308 |
| 460 V | |
| 6,600 | 108771 |
| 11,000 | 109306 |
| 33,000 | 109312 |
| 55,000 | 109309 |
| 575 V | |
| 6,900 | 109307 |
| 20,700 | 109313 |
| 34,500 | 109310 |

Table 5-8—Control and Interface Modules

| Component | Order Code | Part Number |
|--|------------|-------------|
| Control Modules | | |
| Standard Control Module (AC) | S00 | 319729 |
| Standard Control Module (DC) | S00 | 320801 |
| Expandable Control Module | E00 | 318725 |
| Dual Control Module | D00 | 318803 |
| Keypad/Display | | |
| Keypad/Display Unit | — | 316466 |
| I/O Fanning Strips | | |
| 16-Bit Fanning Strip | — | 320102 |
| 32-Bit Fanning Strip (Forms ② and ③) | — | 320146 |
| 32-Bit Fanning Strip (Forms ④ through ⑦) | — | 319437 |
| Feedback Modules | | |
| Incremental Encoder Interface Module (5 V) | F01 | 317685 |
| Incremental Encoder Interface Module (15 V) | F06 | 320106 |
| Incremental Encoder Interface Module with Repeater (5 V) | F02 | 317241 |
| Asynchronous Serial Sincos Encoder Interface Module | F08 | 320448 |
| Synchronous Serial Sincos Encoder Interface Module | F07 | 322173 |
| Resolver Interface Module (4 V) | F03 | 320176 |
| Resolver Interface Module (4 V dual) | F04 | 320315 |
| Resolver Interface Module (2 V) | F10 | 322195 |
| Resolver Interface Module (2 V dual) | F11 | 322197 |
| Serial Absolute Encoder Interface Module | F05 | 321849 |
| Analog Interface Module | F09 | 319354 |
| Communication Modules | | |
| Serial Communication Module | _01 | 318826 |
| Fiber-Optic Communication Module | _02 | 318816 |
| Remote I/O Communication Module | _03 | 317848 |
| Modbus Plus Communication Module | _04 | 319788 |
| ControlNet Communication Module | _05 | 321812 |
| Profibus Communication Module | _06 | 321560 |
| Ethernet Communication Module | _07 | 321228 |

Table 5-9—I/O Converter Modules

| Device | Voltage Range | Order Code | Part Number |
|-----------------------|-----------------------------|-------------------|--------------------|
| Input converter | 90 to 140 V AC | AI1 | 912688 |
| Input converter | 180 to 280 V AC | AI2 | 919808 |
| Output converter | 12 to 140 V AC | AO1 | 913108 |
| Output converter | 180 to 280 V AC | AO2 | 919809 |
| Input converter | 2.5 to 28 V DC | DCI | 913109 |
| Output converter | 5 to 60 V DC | DCO | 913110 |
| Normally open relay | 0 to 30 V DC, 0 to 250 V AC | NOR | 915282 |
| Normally closed relay | 0 to 30 V DC, 0 to 250 V AC | NCR | 921332 |

UNICO-Worldwide

**Corporate
Headquarters**

UNICO, Inc.
3725 Nicholson Road
P. O. Box 0505
Franksville, Wisconsin
53126-0505
USA

voice: 262.886.5678
fax: 262.504.7396

www.unicous.com

United States

Novi, Michigan
248.380.7610

New Lenox, Illinois

815.485.5775
Sandy, Utah
801.501.7586

Canada

Mississauga,
Ontario
905.602.4677

South America

El Tigre, Venezuela
58.83.414.024

Europe

Milton Keynes,
England
44.1.908.260000
Siegen, Germany
49.271.5015.0

Asia

Osaka, Japan
81.66.945.0077
Beijing, China
86.106.218.6365