Allen-Bradley

# Bulletin 1336 FORCE Adjustable Frequency AC Drive Series A, B, C, D

*A040 – A060*
*B060 – B125, BX150*
*C075 – C125*

# Service Manual

## Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Allen-Bradley does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* (available from your local Allen-Bradley office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.



Throughout this manual we use notes to make you aware of safety considerations:

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

Attention statements help you to:

- identify a hazard
- avoid the hazard
- recognize the consequences

**Important:** Identifies information that is critical for successful application and understanding of the product.

# Summary of Changes

The information below summarizes the changes to the company-wide templates since the last release.

## Updated Information

The derating tables in the Preface have been removed. Refer to the 1336 FORCE User Manual.

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## Control Logic Wiring and Adapters

### Chapter 1

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### Chapter 2

## Component Test Procedures

### Chapter 3



## Part Replacement Procedures

### Chapter 4

# Preface

## Manual Objective

The information in this manual is designed to help repair an Allen-Bradley Bulletin 1336 FORCE Adjustable Frequency AC Drive with ratings A040 – A060, B060 – B125, BX150, and C075 – C125.

## Who Should Use This Manual

This manual is intended for qualified service personnel responsible for repairing the 1336 FORCE Adjustable Frequency AC Drive. You should:

- Read this entire manual before performing maintenance or repairs to drives.
- Have previous experience with, and basic understanding of, electrical terminology, procedures, required equipment, equipment protection procedures and methods, and safety precautions.

This manual describes equipment and disassembly procedures. You begin with general illustrations and end with greater detail concerning replacement parts and part locations on the drives. Later chapters may refer you back to earlier chapters for information on basic equipment and steps necessary to perform detailed diagnostics and part replacement.

## Safety Precautions

**ATTENTION:** Some printed circuit boards and drive components may contain hazardous voltage levels. Remove and lock out power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 VDC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Potentially fatal voltages may result from improper usage of oscilloscope and other test equipment. The oscilloscope chassis may be at a potentially fatal voltage if not properly grounded. If an oscilloscope is used to measure high voltage waveforms, use only a dual channel oscilloscope in the differential mode with X 100 probes. It is recommended that the oscilloscope be used in the A minus B Quasi-differential mode with the oscilloscope chassis correctly grounded to an earth ground.

**ATTENTION:** Only personnel familiar with the 1336 FORCE Adjustable Frequency AC Drive and associated machinery should plan or implement the installation, start-up and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.

## Electrostatic Discharge Precautions

**ATTENTION:** This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Allen-Bradley Publication 8000–4.5.2, Guarding Against Electrostatic Damage, or any other applicable ESD protection handbook.

Electrostatic discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

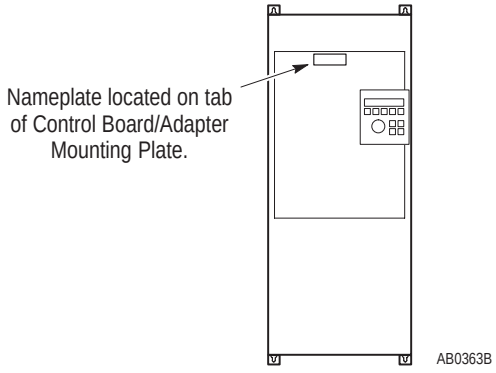
- Wear a wrist-type grounding strap that is grounded to the drive chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

## 1336 FORCE Product Identification

### Drive Nameplate Location

The drive nameplate is located on the face of the Control Board/Adapter Mounting Plate. The drive nameplate contains the drive's catalog number and other important drive information. Reference the catalog number when ordering replacement parts.

**Figure P.1**
**Drive Nameplate Location**



## Software Compatibility

**ATTENTION:** To guard against machine damage and/or personal injury, drives with ratings above 45 kW (60 HP) must not be used with software versions below 1.07. Refer to the table below.

| Three-Phase Drive Rating[1] | | | | |
|---|---|---|---|---|
| 200 – 240V | 380 – 480V | 500 – 600V | Compatible with Version | Frame Reference |
| 30 – 45 kW<br>40 – 60 HP | 45, 75, 94, 112 kW<br>60, 100, 125, 150 HP | 56 – 93 kW<br>75 – 125 HP | 2.01 & Up | D |
| — | 81 kW<br>75 HP | — | 2.04 & Up | D |

[1] kW and HP are constant torque (CT) ratings.

## Drive and Option Identification

The following is an explanation of the catalog numbering system for 1336 FORCE Adjustable Frequency AC Drives and options. The catalog number is coded to identify the drive power rating and can be found on the drive shipping carton and nameplate.

### 1336 FORCE Drive Catalog Numbers

**Table P.A**

| 1336S | – A040-AA | – EN | – L6 | – HA1 | – GM1 |
|---|---|---|---|---|---|
| BULLETIN NO. | RATING-ENCLOSURE (MUST BE SPECIFIED) | LANGUAGE MODULE[3] (MUST BE SPECIFIED) | CONTROL INTERFACE[3] (OPTIONAL) | HUMAN INTERFACE[3] (OPTIONAL) | COMMUNICATION CARD[3] (OPTIONAL) |

| 200 – 240V AC Input, Constant Torque Drive | | | | | | |
|---|---|---|---|---|---|---|
| Drive Rating[1] | | | Enclosures | | | |
| | | | Open IP00 No Enclosure | NEMA Type 1 IP20 General Purpose | NEMA Type 4 IP56 Resist Water, Dust | NEMA Type 12 IP54 Industrial Use |
| Frame Designation | Output Amps | Nominal HP | Code | Code | Code | Code |
| D | 120.3<br>149.2<br>180.4 | 40<br>50<br>60 | A040-AN<br>A050-AN<br>A060-AN | A040-AA<br>A050-AA<br>A060-AA | [2]<br>[2]<br>[2] | [2]<br>[2]<br>[2] |

**Table P.B**

| 1336S | – B060-AA | – EN | – L6 | – HA1 | – GM1 |
|---|---|---|---|---|---|
| BULLETIN NO. | RATING-ENCLOSURE (MUST BE SPECIFIED) | LANGUAGE MODULE [3] (MUST BE SPECIFIED) | CONTROL INTERFACE [3] (OPTIONAL) | HUMAN INTERFACE [3] (OPTIONAL) | COMMUNICATION CARD [3] (OPTIONAL) |

**380 – 480V AC Input, Constant Torque Drive**

| Drive Rating [1] | | | Enclosures | | | |
|---|---|---|---|---|---|---|
| | | | Open IP00 No Enclosure | NEMA Type 1 IP20 General Purpose | NEMA Type 4 IP56 Resist Water, Dust | NEMA Type 12 IP54 Industrial Use |
| Frame Designation | Output Amps | Nominal HP | Code | Code | Code | Code |
| D | 96.9 | 60 | B060–AN | B060–AA | [2] | [2] |
| | 120.3 | 75 | B075–AN | B075–AA | [2] | [2] |
| | 149.2 | 100 | B100–AN | B100–AA | [2] | [2] |
| | 180.4 | 125 | B125–AN | B125–AA | [2] | [2] |
| | 180.4 | 150 | BX150–AN | BX150–AA | [2] | [2] |

**Table P.C**

| 1336S | – C075-AA | – EN | – L6 | – HA1 | – GM1 |
|---|---|---|---|---|---|
| BULLETIN NO. | RATING-ENCLOSURE (MUST BE SPECIFIED) | LANGUAGE MODULE [3] (MUST BE SPECIFIED) | CONTROL INTERFACE [3] (OPTIONAL) | HUMAN INTERFACE [3] (OPTIONAL) | COMMUNICATION CARD [3] (OPTIONAL) |

**500 – 600V AC Input, Constant Torque Drive**

| Drive Rating [1] | | | Enclosures | | | |
|---|---|---|---|---|---|---|
| | | | Open IP00 No Enclosure | NEMA Type 1 IP20 General Purpose | NEMA Type 4 IP56 Resist Water, Dust | NEMA Type 12 IP54 Industrial Use |
| Frame Designation | Output Amps | Nominal HP | Code | Code | Code | Code |
| D | 85.8 | 75 | C075–AN | C075–AA | [2] | [2] |
| | 109.1 | 100 | C100–AN | C100–AA | [2] | [2] |
| | 138.6 | 125 | C125–AN | C125–AA | [2] | [2] |

[1] Drive rating is based on a carrier frequency of 4kHz maximum, an altitude of 1,000 meters or less, and a maximum ambient temperature of 40°C. Refer to Qualifications on page P–6.

[2] Not available.

[3] Refer to the Language Module and Options tables following these Catalog Number tables.

**Table P.D**

| Language Modules | |
|---|---|
| **Description** | **Option Code** |
| English/English | EN |
| English/French | FR |
| English/German | DE |
| English/Italian | IT |
| English/Japanese | JP |
| English/Spanish | ES |

**Table P.E**

| Options | | | |
|---|---|---|---|
| **Code**[1] | **Description**[2] | **Code** | **Description**[2] |
| Human Interface Modules, NEMA Type 1 (IP 20) | | Communication Options | |
| HAB | Blank – No Functionality | GM1 | Single Point Remote I/O |
| HAP | Programmer Only | GM2 | RS-232/422/485, DF1 |
| HA1 | Programmer, LCD/Analog Pot | GM3 | RS-232/422/485, DH485 |
| HA2 | Programmer, LCD/Digital Pot | | |
| Human Interface Modules, NEMA Type 4 (IP 56) | | Control Interface Options | |
| HFB | Blank – No Functionality | L4 | TTL Contacts |
| HFP | Programmer Only | L5 | 24V DC |
| HF1 | Programmer, LCD/Analog Pot | L6 | 115V AC |
| HF2 | Programmer, LCD/Digital Pot | | |
| Human Interface Modules, NEMA Type 12 (IP 54) | | | |
| HJB | Blank – No Functionality | | |
| HJP | Programmer Only | | |
| HJ1 | Programmer, LCD/Analog Pot | | |
| HJ2 | Programmer, LCD/Digital Pot | | |

[1] Must be used in conjunction with a standard adapter option –GT2EN

[2] For a more functionally complete description of each option refer to Publication 1336 FORCE-1.0.

## Drive Rating Qualifications

Several factors can affect drive rating. If more than one factor exists, derating percentages must be multiplied. For example, if a 14-amp drive is installed at a 2km (6,600 ft.) altitude and has a 2% high-input line voltage, the actual amp rating is:14 x 94% altitude derating x 96% high-input line derating = 12.6 amps

▶ Calculate the drive rating using the amp rating of your drive.

### Enclosure Type

The first character, A, indicates the Enclosure Code.

The second character indicates the type of enclosure shipped from the factory:

**Table P.F**
**Enclosure Type Code Description**

| Enclosure Type Code | Description |
|---|---|
| N | Open style (IP00) |
| A | NEMA Type 1 (IP20) |
| J | NEMA Type 12 (IP54) |

## Conventions

To help differentiate parameter names and display text from other text in this manual, the following conventions will be used:

- Parameter Names will appear in [brackets].
- Display Text will appear in “quotes”.

The following is a list of conventions used throughout this manual, and definitions of the conventions. For a list of terminology and definitions, refer to the Glossary in the back of this manual.

### Auxiliary Input

The Auxiliary Input is a terminal connection on the Control Interface Board. This connection provides an external input for use as an Auxiliary Interlock. Unless this interlock is closed, the drive will be faulted with an Auxiliary Fault.

### Auxiliary Interlock

The Auxiliary Interlock is a user supplied circuit consisting of reset, overload, or other interlocking circuitry. The Interlock is wired to the drive Auxiliary input.

### Bit

A bit is a single character or status point used in programmable logic. Eight bits form a BYTE, 16 bits form a word. Drive parameters are actually eight bits or 16 bit words.

### Check

To check means to examine either the physical condition of something or the setting of some control, such as a Parameter. Checking a drive board or component may also require measurements and tests.

### Connector

A connector connects one drive board to another. Connectors come in two designs, male and female. Male connectors are stationary and contain pins, which are sometimes joined by jumpers. Female connectors are at the ends of wires or ribbon cables and plug into male connectors.

### Default

When a drive function defaults, it automatically changes to a pre-programmed setting.

### Enable Input

The Enable Input is a terminal connection on the Control Interface Board. This connection provides an external input to enable or disable the Drive Output section. It must be true to permit the drive to operate.

### False

False refers to a logical false state. For instance, a Control Interface signal on TB3 is false when the input contact is open or the appropriate voltage is not applied to the Control Interface Board.

### Jumper

A jumper completes a circuit between two pins within a male connector on a drive board. In the absence of certain optional equipment using female connectors, jumpers are applied to certain pins within a male connector to complete specific and necessary circuits.

### Control Interface Board

A Control Interface Board plugs into connectors J10 and J12, located on the lower portion of the Standard Adapter Board. This board is identified as L4, L5 or L6 and provides optional control wiring configurations for a drive.

### Parameter

Parameters are programmable drive functions that define various operating functions or status displays of a drive. Refer to Bulletin 1336 FORCE Adjustable Frequency AC Drive User Manual for Parameter details.

### Press

Press a button on the Human Interface Module to change Parameter settings and drive functions.

### True

True refers to a logical true state. For instance, a Control Interface signal on TB3 is true when: L4 contact input is closed, L5 input terminal registers 24V, or L6 input terminal registers 115V AC.

## Related Publications

The following lists other Allen-Bradley publications that apply to the 1336 FORCE Adjustable Frequency AC Drives.

- Product Data Drive Tools Software (9303-2.0)
- Bulletin 1201 Graphic Programming Terminal User Manual (1201-5.0)
- Product Pricing Bulletin (1336 FORCE-3.0)
- 1336 FORCE Field Oriented Control User Manual (1336 FORCE-5.12)
- 1336 FORCE PLC Communications Adapter User Manual (1336 FORCE-5.13)
- Renewal Parts List (1336-6.5)
- Options Manuals/Instructions

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# Control Logic Wiring and Adapters

## Chapter Objectives

This chapter introduces you to terminal block locations and wiring, and adapter locations and functions.

## Chapter Overview

This chapter illustrates and describes Standard Adapter Board:

- Control Logic Interface Options L4, L5, and L6, including Terminal Block TB3
- TB3 input mode selections and functions
- TB3, TB5, TB6, TB7 terminal designations

This chapter illustrates and describes the following terminal designations for the PLC Comm Adapter Board:

- TB20
- TB21

**Important:** All printed circuit boards, except the Main Control Board assembly, are referenced to negative ground (–bus).

**ATTENTION:** Some printed circuit boards and drive components may contain hazardous voltage levels. Remove power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Allen-Bradley Publication 8000-4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

**Figure 1.1**
**Standard Adapter Terminal Block Locations**

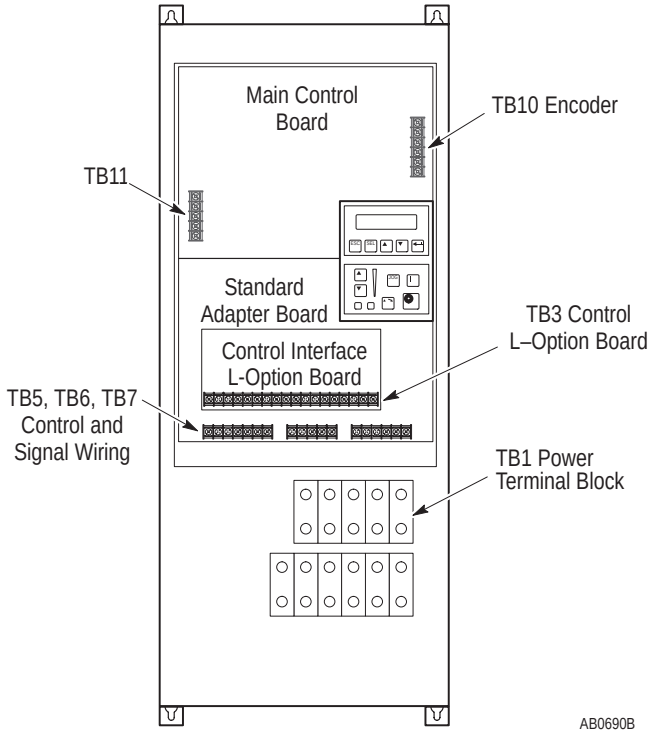
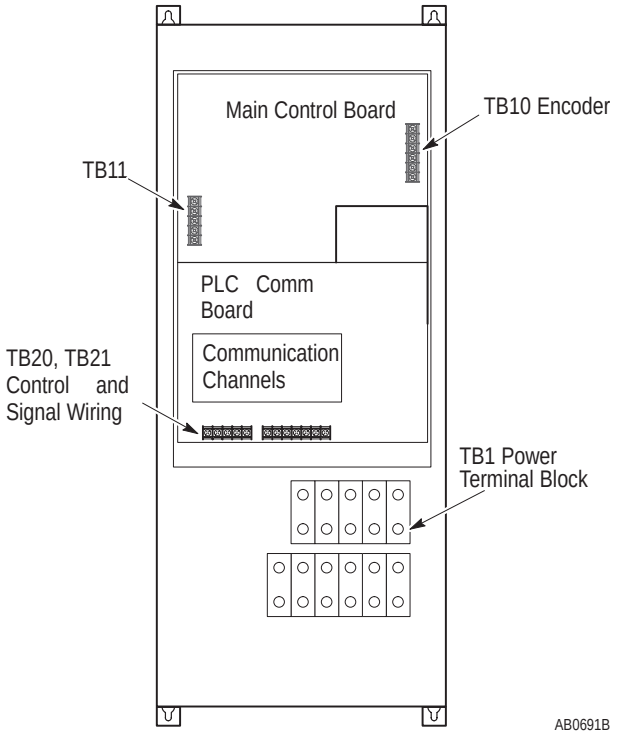



**Figure 1.2**
**PLC Comm Adapter Terminal Block Locations**



## Control Interface Option

The Control Interface L-Option Board provides a means of interfacing various signals and commands to the 1336 FORCE by using contact closures.

Three different versions of the option are available:

| | |
|---|---|
| L4 | Contact Closure Interface[1] |
| L5 | +24V AC/DC Interface |
| L6 | 115V AC Interface |

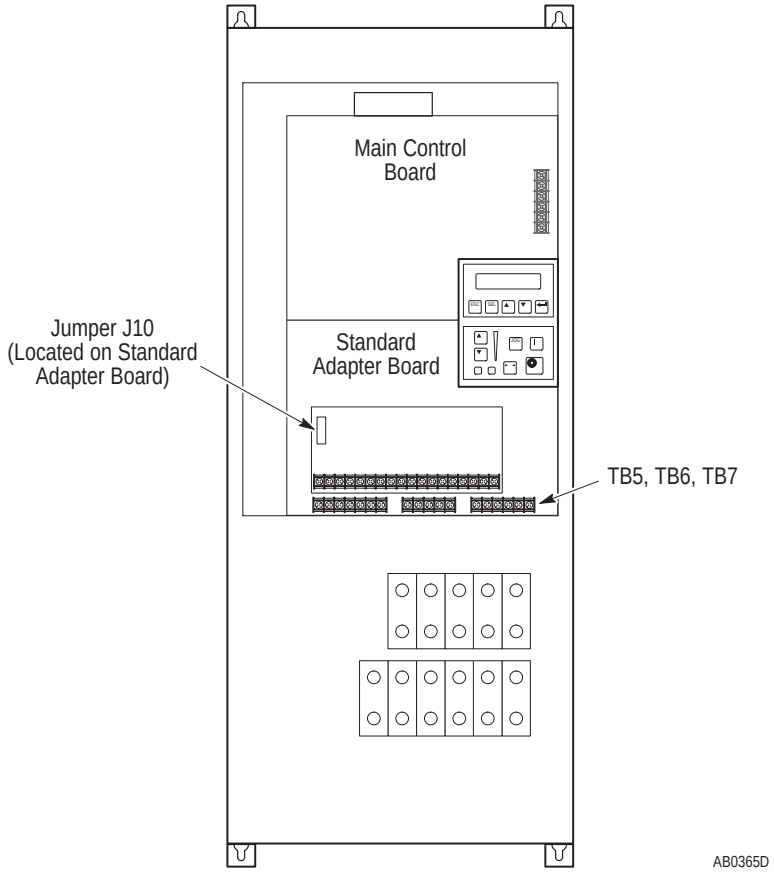
[1] Uses internal +5V DC supply.

The user inputs are connected to the option board through TB3. The L4, L5 and L6 options each have nine control inputs. The function each input must be selected through programming as explained later in this section.

### Control Interface L-Option Board Jumpers

**Important:** If the Control Interface Board is being installed, Standard Adapter Board jumpers at pins 3 & 4 and 17 & 18 of J10 must be removed. If this board is removed, these jumpers must be reinstalled and the [Input Mode] parameter must be programmed to “1”.

**Figure 1.3**
**Jumper Locations**




## Available Inputs

A variety of combinations made up of the following inputs are available.

| | |
|---|---|
| Start | Enable |
| Stop/Clear Fault | Auxiliary |
| Reverse | 2 Stop Mode Selects |
| Digital Potentiometer (MOP) | Run Forward |
| 2 Accel/Decel Rates | Run Reverse |
| 3 Speed Selects | Local Control |

The available combinations are shown in Figure 1.4. Programming the [Input Mode] parameter to one of the Input Mode numbers listed selects that combination of input functions.

**Important:** The [Input Mode] parameter can be changed at any time; however, programming changes will not take affect until power has been cycled to the drive. When changing an input mode, it is important to note that the corresponding inputs to TB3 may also change.

The programming options of the Control Interface Option allow the user to select an input combination to meet the needs of a specific installation. Appropriate selection of a combination may be done by using Table 1.A. First determine the type of start/stop/direction control desired. Then select the remaining control functions available. After selecting a group of Input Modes use Table 1.A for specific mode selection. Record the selected mode number below.

Selected Mode Number: _____

## Standard Adapter Local Programming

For local programming and control information, refer to the 1336 FORCE User Manual.

**Table 1.A**
**Input Mode Selection**

| Start/Stop Type | Direction Control | Communication Compatibility | Mode(s) to Use |
|---|---|---|---|
| Stop & Enable Only | None | Control must be provided by HIM or Communication Option. | 1 |
| Momentary Pushbutton (3 Wire) | Maintained Switch (Open-Forward, Closed-Reverse) | Start/Stop – works in parallel with HIM and Communication Options. Direction Control will not work in parallel with HIM or Communication Options. User must select direction control from either HIM and Communication Options or TB3 input. | 2–6 |
| Momentary Pushbutton (3 Wire) | Momentary Pushbuttons (Forward and Reverse) | Start/Stop – works in parallel with HIM and Communication Options. Direction – works in parallel with HIM or Communication Options. | 7–11 |
| Maintained switches for combined run and direction control (2 wire, Run Forward, Run Reverse) | | Start/Stop – not compatible with HIM or Communication Options. Direction – not compatible with HIM or Communication Options. | 12–16 |

The maximum and minimum wire sizes accepted by TB3 is 2.1 and 0.30 $mm^2$ (14 and 22 AWG). Maximum torque for all terminals is 0.9 – 1.13 N-m (8 – 10 in.-lb).

**Figure 1.4**
**TB3 Terminal Designations**

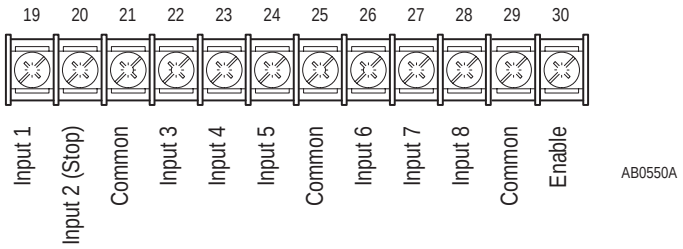


**Figure 1.5**
**Input Mode Selection and Typical TB3 Connections**

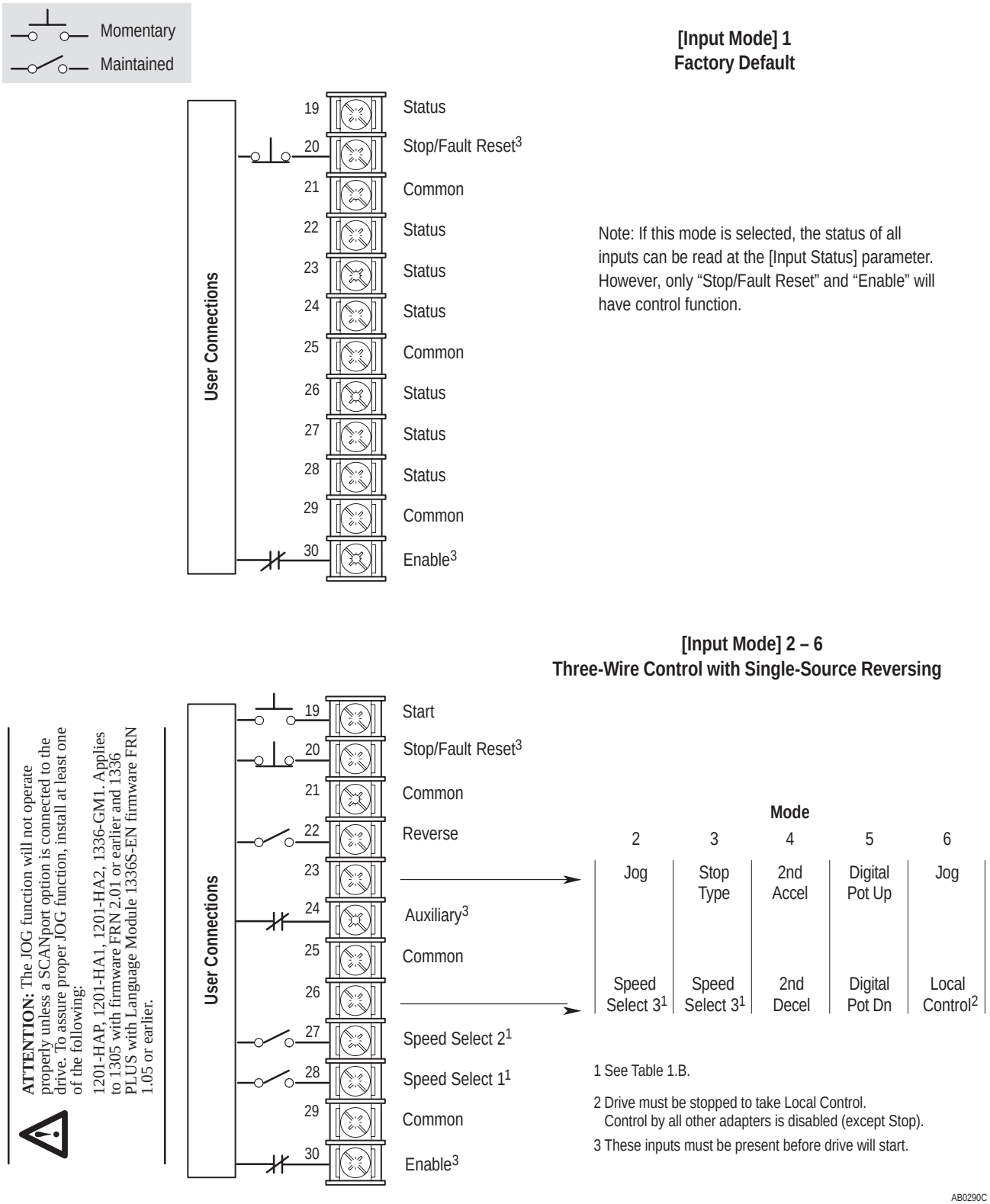
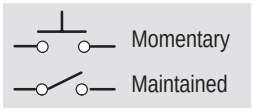
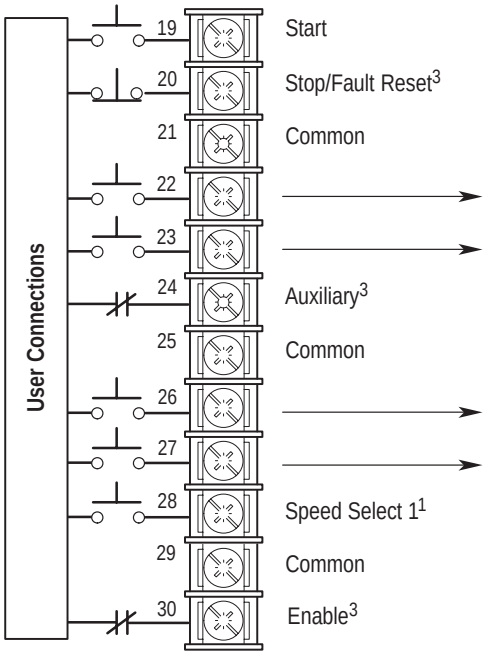


**Figure 1.5 (*continued*)**
**Input Mode Selection and Typical TB3 Connections**



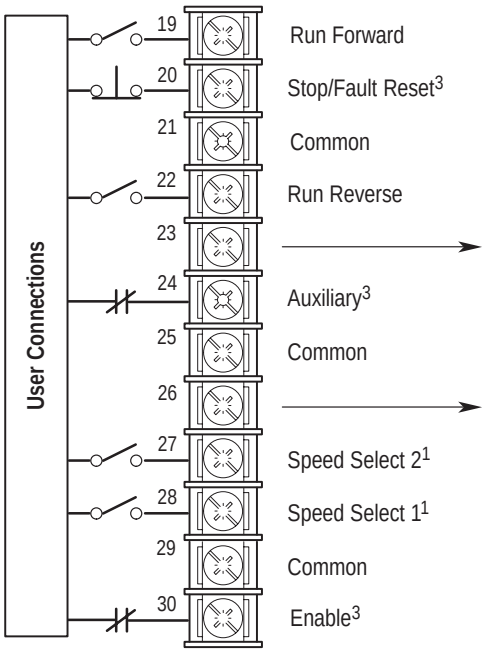

**ATTENTION:** The JOG function will not operate properly unless a SCANport option is connected to the drive. To assure proper JOG function, install at least one of the following:
1201-HAP, 1201-HA1, 1201-HA2, 1336-GM1. Applies to 1305 with firmware FRN 2.01 or earlier and 1336 PLUS with Language Module 1336S-EN firmware FRN 1.05 or earlier.

**[Input Mode] 7 – 11**
**Three-Wire Control with Multi-Source Reversing**




| | Mode | | | | |
|---|---|---|---|---|---|
| | 7 | 8 | 9 | 10 | 11 |
| 22 | Reverse | Reverse | Digital Pot Up | Reverse | 1st Accel |
| 23 | Forward | Forward | Digital Pot Dn | Forward | 2nd Accel |
| 26 | Jog | Speed Select 31 | Speed Select 31 | Digital Pot Up | 1st Decel |
| 27 | Speed Select 21 | Speed Select 21 | Speed Select 21 | Digital Pot Dn | 2nd Decel |

**[Input Mode] 12 – 16**
**Two-Wire Control, Single-Source Control**




| | Mode | | | | |
|---|---|---|---|---|---|
| | 12 | 13 | 14 | 15 | 16 |
| 23 | Local Control2 | Stop Type | 2nd Accel | Digital Pot Up | Local Control2 |
| 26 | Speed Select 31 | Speed Select 31 | 2nd Decel | Digital Pot Dn | Stop Type |

1 See Table 1.B.

2 Drive must be stopped to take Local Control. Control by all other adapters is disabled (except Stop).

3 These inputs must be present before drive will start.

AB0291B

The following table defines the input state of the Speed Select inputs for a desired frequency source.

**Table 1.B**
**Speed Select Input State vs. Frequency Source**

| Para 52 TB3 | Speed Select 3 Bit 14 Terminal 26 | Speed Select 2 Bit 13 Terminal 27 | Speed Select 1 B12 Terminal 28 | Velocity Reference Source |
|---|---|---|---|---|
| | O | O | O | Last State |
| | O | O | X | External Reference 1 |
| | O | X | O | Preset Speed 1 |
| | O | X | X | Preset Speed 2 |
| | X | O | O | Preset Speed 3 |
| | X | O | X | Preset Speed 4 |
| | X | X | O | Preset Speed 5 |
| | X | X | X | External Reference 2 |

O = Open — Input Removed

X = Closed — Input Present

**Figure 1.6**
**PLC Comm Adapter Reference Signal Connections**

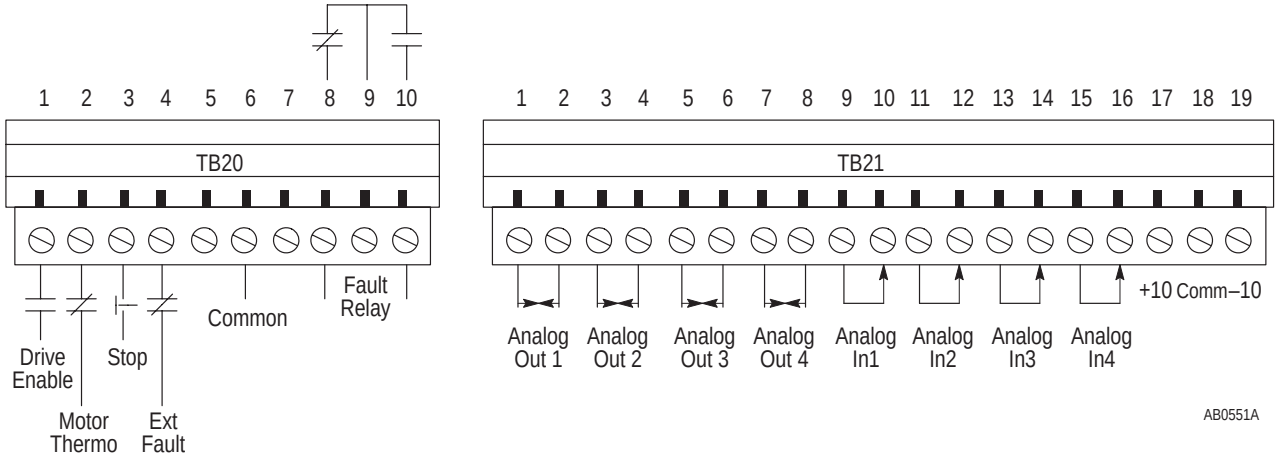


**Table 1.C**
**PLC Comm Adapter Reference Signal Connections**

| Terminal Block | Terminal Number(s) | Signal |
|---|---|---|
| TB20 | 1 | Drive Enable (NO) |
| | 2 | Motor Thermoguard (NC) |
| | 3 | Normal Stop (NC) |
| | 4 | External Fault (NC) |
| | 5 | |
| | 6 | Input Common |
| | 7 | |
| | 8 | Fault Output (NC) |
| | 9 | Fault Output (COM) |
| | 10 | Fault Output (NO) |
| TB21 | 1 | OUT 1 |
| | 2 | COM 1 |
| | 3 | COM 2 |
| | 4 | OUT 2 |
| | 5 | OUT 3 |
| | 6 | COM 3 |
| | 7 | OUT 4 |
| | 8 | COM 4 |
| | 9 | IN 1+ |
| | 10 | IN 1– |
| | 11 | IN 2+ |
| | 12 | IN 2– |
| | 13 | IN 3+ |
| | 14 | IN 3– |
| | 15 | IN 4+ |
| | 16 | IN 4– |
| | 17 | +10V |
| | 18 | COM |
| | 19 | –10V |

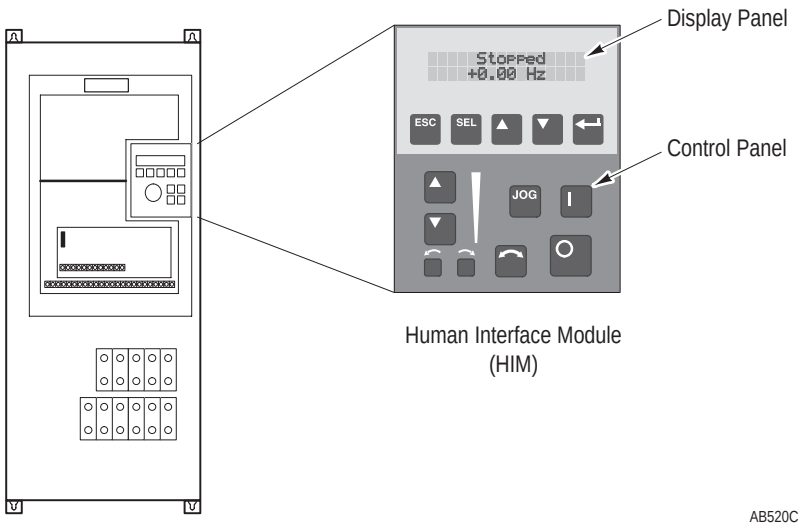
# Adapters and Communication Ports

## Human Interface Module

When the drive-mounted HIM is supplied, it will be connected as Adapter 1 (refer to Figures 1.7 and 1.8) and visible from the front of the drive. The HIM can be divided into two sections; Display Panel and Control Panel. The Display Panel provides a means of programming the drive and viewing the various operating parameters. The Control Panel allows different drive functions to be controlled. For HIM operation, refer to the 1336 FORCE Field Oriented Control User Manual.

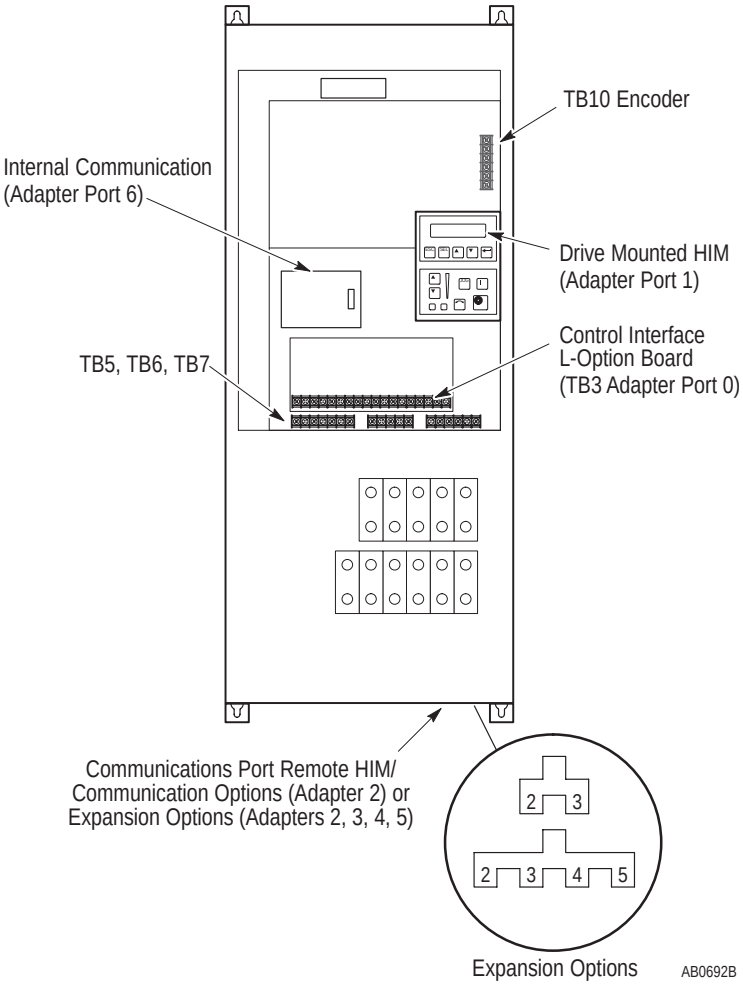
**Important:** The operation of HIM functions depends upon drive parameter settings. Default parameter values allow full HIM functionality.

**Figure 1.7**
**Human Interface Module, Standard Adapter Only**



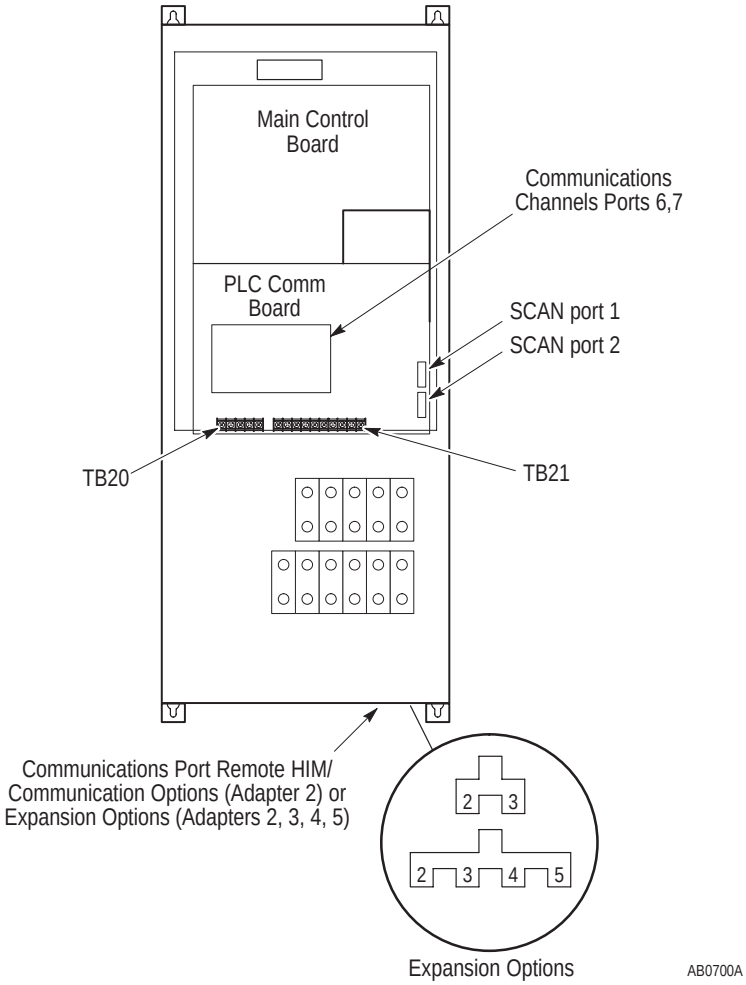
## Standard Adapter Ports

**Figure 1.8**
**Standard Adapter Board Port Locations**



## PLC Comm Adapter Ports

**Figure 1.9**
**PLC Comm Adapter Board Port Locations**




## HIM Removal

**ATTENTION:** Some voltages present behind the drive front cover are at incoming line potential. To avoid an electric shock hazard, use extreme caution when removing/replacing the HIM.

For handheld operation, the module can be removed and located up to 10 meters (33 feet) from the drive.

**Important:** Power must be removed from the drive or Bit 1 of the [Logic Mask] parameter must be set to “0” to allow removal of the HIM module without causing a Communication Fault. Setting Bit 1 of the [Logic Mask] parameter to “0” allows HIM removal while power is applied to the drive. Note that this also disables all HIM control functions except Stop.

To remove the module:

1. Ensure that power has been removed or [Logic Mask] has been set to “0”.
2. Open the Enclosure door.
3. Slide the module down and out of its cradle.
4. Reverse the above steps to replace the module. Apply power or reset Bit 1 of the [Logic Mask] parameter to “1” to enable HIM control.

## HIM Operation

When power is first applied to the drive, the HIM will cycle through a series of displays. These displays will show drive ID and communication status. Upon completion, the Status Display (see Figure 1.10) will be shown. This display shows the current status of the drive (i.e. Stopped, Running, etc.) or any faults that may be present (Not Enabled, etc.). Refer to the 1336 FORCE Field Oriented Control User Manual.

**Figure 1.10**
**Status Display**

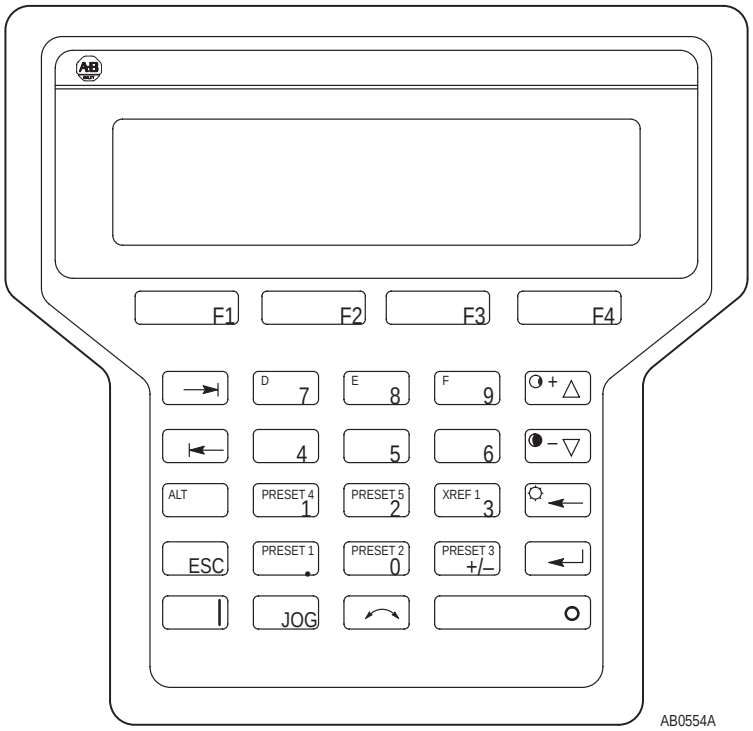
# Graphic Programming Terminal

## GPT Description

The optional GPT (Figure 1.11) is a remote device with a 1.8 meter (6 foot) long cable. The GPT offers a 40-by-8 character display that can also be used as a graphics display to show trending graphs. For GPT operation, refer to the 1336 FORCE Field Oriented Control User Manual. See also the 1201 GPT User Manual.

**Important:** Main Menu screens are dynamic and will change based on functionality provided by adapter and drive status.

**Figure 1.11**
**Graphic Programming Terminal**



## Drive Tools

Drive Tools software is a Windows 3.1 compatible family of application programs allowing the user to perform programming, monitoring, and diagnostic operations on Allen-Bradley AC and DC digital drive products. The software consists of five Windows applications. For operation, refer to the Product Data Drive Tools Software manual.

## Control Firmware Function

All control functions in the 1336 FORCE are performed through the use of parameters that can be changed with a programming terminal or Drive Tools. Refer to an overview Block Diagram of the Control Firmware Function in the 1336 FORCE Field Oriented Control User Manual.

Feedback information is derived from hardware devices as part of the process equipment used. Analog signals are converted to digital signals for use by the drive. Control signals may be provided to the drive by one of two Adapter Boards.

All setup and operation information used by the drive is stored in a system parameter table. Every parameter, including Setup and Configuration parameters (Sources and Sinks), has an entry in the parameter table. For example, parameter 101 is named the “Velocity Reference 1 HI (whole)” parameter and contains a number value representing the velocity reference. The velocity reference can originate from an external control device such as a potentiometer connected to the analog input of an Adapter board or a signal coming in via RIO from a PLC. Refer to the 1336 FORCE User Manual, Publication 1336 FORCE-5.12.

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# Disassembly and Access Procedures

## Chapter Objectives

This chapter describes general disassembly procedures required to access internal drive components.

## Disassembly and Access Overview

**ATTENTION:** Some printed circuit boards and drive components may contain hazardous voltage levels. Remove and lock out power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Servicing energized industrial control equipment can be hazardous. Electrical shock, burns, or unintentional actuation of controlled industrial equipment may cause death or serious injury. Follow the safety-related practices of NFPA 70E, Electrical Safety for Employee Workplaces, when working on or near energized equipment. Do not work alone on energized equipment.

## Electrostatic Discharge Precautions

**ATTENTION:** This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Allen-Bradley Publication 8000-4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

Electrostatic discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

- Wear a wrist-type grounding strap that is grounded to the chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

### Tools

You need the following tools to disassemble and assemble the drive:

- Pliers
- Phillips screwdrivers (medium and large)
- Standard screwdrivers (small, medium, and large)
- 10 mm socket
- 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in in.-lb or N-m
- Nylon tie wraps
- Side cutters
- 17 mm socket

# Fastener Torque Specifications

## Torque Sequence

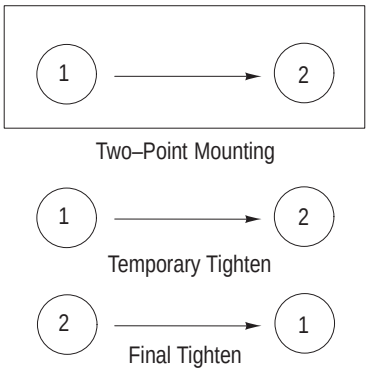
When mounting components to a drive's heat sink, component-fastener torque sequences and tolerances are crucial to component-to-heat sink heat dissipation.

**ATTENTION:** Component can be damaged if temporary tightening procedure is not performed to specification.

### Two-Point Mounting

The following illustrates temporary and final tightening sequences for components fastened to a heat sink using two screws. Temporary torque is 1/2 (50%) of final torque. The numeric illustration labels are for your assistance. Drive components do not carry these labels.

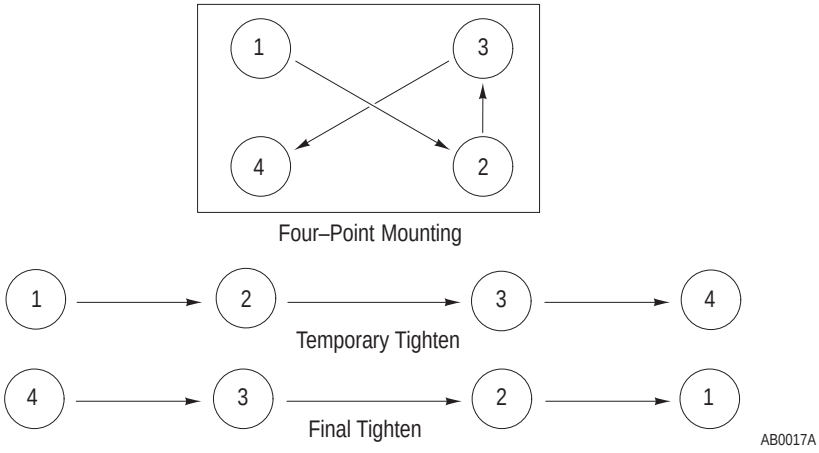
**Figure 2.1**
**Two-Point Mounting**



### Four-Point Mounting

The following illustrates temporary and final tightening sequences for components fastened to a heat sink using four screws. Temporary torque is 1/2 (50%) of final torque. The numeric illustration labels are for your assistance. Drive components do not carry these labels.

**Figure 2.2**
**Four-Point Mounting**




## Torque Specifications

The following table lists fastener locations by component, how the fasteners are used, and torque specifications. Refer to Torque Sequence in this chapter for fastening two-point and four-point components to the heat sink.

**Table 2.A**
**Fastener Torque Specifications — Parts Common to "D" Frame Drives**

| Component | Fastener Application | Fastener Used | Torque in.-lb | Torque N-m |
|---|---|---|---|---|
| Voltage Sharing Resistor (R1 – R3) | Resistor to Heat Sink | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |
| Snubber Resistor (R20 – R22) | Resistor to Heat Sink | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |
| Power Modules (Q1 – Q6) | Power Modules to Heat Sink | M6 x 16 mm Screw | 26 | 2.9 |
| Input Rectifiers (SCR1 – SCR6) | Rectifiers to Heat Sink | M6 x 16 mm Screw | 52 | 5.9 |
| Thermistor | Thermister to Heat Sink | Thermister | 14 | 1.6 |
| Fan Finger Guard | Guard to Chassis | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Fan Cover | Cover to Fan | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Fan Cover | Cover to Chassis | M4 x 12 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Capacitor Retainer (C1 – C9) | Retainer to Chassis | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Capacitor Bracket (C1 – C9) | Bracket to Capacitor Latch | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |
| MOV Surge Suppressor | Surge Suppressor to Chassis | M4 or M5 x 10 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Link Inductor (L1) | Inductor to Chassis | M5 x 10 mm Screw | 23 – 26 | 2.6 – 4.1 |
| Fan Capacitor (C-HB1) | Capacitor to Chassis | M8 Nut | 32 – 40 | 3.6 – 4.5 |
| Autotransformer (T1) | Autotransformer to Chassis | M5 x 10 mm Screw | 23 – 26 | 2.6 – 4.1 |
| LEM Support Plate | Support Plate to Chassis | M5 x 10 mm Screw | 23 – 26 | 2.6 – 4.1 |
| Motor Bus Bar Insulated Standoff | Standoff to Chassis | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |
| Capacitor Bus Bar (C1 – C9) | Bus Bar to Capacitors | M6 x 12 mm Screw | 55 | 6.2 |
| IGBT Bus Bar | Bus Bar to Motor Bus Bar | M5 x 10 mm Screw | 23 – 26 | 2.6 – 4.1 |
| IGBT Bus Bar | Bus Bar to Distribution Bus Bar | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |
| Motor Bus Bar | Bus Bar to Insulated Standoff | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |
| Distribution Bus Bar | Bus Bar to Capacitor Bus Bar | M10 x 20 mm Bolt | 97 – 111 | 11 – 12.5 |
| SCR Standoff (SCR1 – SCR6) | Standoff through Converter Bus Bar and Into SCR | SCR Standoff | 34 | 3.8 |
| Converter Snubber Board (A11) | Board to SCR Standoff | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Power Module Snubber Board (A20 – A22) | Board to IGBT Standoffs | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Bus Fuse (F1) | Fuse to Capacitor Bus Bar | M10 x 20 mm Bolt | 97 – 111 | 11 – 12.5 |
| Bus Fuse (F1) | Bus Fuse to Distribution Bus Bar | M8 or M10 x 20 mm Bolt | 97 – 111 | 11 – 12.5 |
| TB1 Terminal Block DIN Rail | DIN Rail to Chassis | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |
| Gate Driver Board Mounting Plate | Plate to Chassis | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |
| Main Control Board | Board to Mounting Plate | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Standard Adapter Board | Board to Mounting Plate | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| PLC Comm Adapter Board | Board to Mounting Plate | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| TE Ground Block | TE Ground Block to Gate Driver Board Sheet Metal | M2.5 x 12 mm Screw | 6 – 9 | 0.7 – 1.0 |
| Control Board Mounting Plate | Plate to Gate Driver Board Mounting Plate | M6 Nut | 23 – 36 | 2.6 – 4.1 |
| Control Board Mounting Plate | Plate to Gate Driver Board Mounting Plate | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| HIM Holder | HIM Holder to Control Board Sheet Metal | M4 x 20 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Capacitor Guard (C1 – C9) | Capacitor Guard to Capacitor Brackets | M4 x 20 mm Screw | 12 – 16 | 1.4 – 1.8 |
| Link Inductor Guard (L1) | Link Inductor Guard to Link Inductor | M6 Nut | 23 – 36 | 2.6 – 4.1 |
| Enclosure Bottom, Top, and Side Panels | Enclosure Sheet Metal | M5 x 10 mm Screw | 23 – 36 | 2.6 – 4.1 |

**Table 2.B**
**Fastener Torque Specifications — Parts Common to "D"**
**Frame Drives A040, A050, B060 – B100, C075, C100**

| Component | Fastener Application | Fastener Used | Torque in.-lb | Torque N-m |
|---|---|---|---|---|
| IGBT Standoff | Standoff Through IGBT Busbar and Into IGBT | IGBT Standoff | 36 – 44 | 2.6 – 4.1 |
| Power Module Snubber Board (A20 – A22) | Board to Gate and Emitter Connection on IGBT | M4 x 24 mm Screw | 12 – 16 | 1.4 – 1.8 |

**Table 2.C**
**Fastener Torque Specifications — Parts Common to "D"**
**Frame Drives A060, B125, BX150, C125**

| Component | Fastener Application | Fastener Used | Torque in.-lb | Torque N-m |
|---|---|---|---|---|
| IGBT Standoff | Standoff Through IGBT Bus Bar and Into IGBT | IGBT Standoff | 65 – 79 | 7.3 – 8.9 |
| Power Module Snubber Board (A20 – A22) (Present Design) | Board to Gate and Emitter Connection on IGBT | M4 x 35 mm Screw | 12 – 16 | 1.4 – 1.8 |
| *Power Module Snubber Board (A20 – A22) (Original Design) | Board to Gate and Emitter "C" Brackets | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |
| *Gate & Emitter Terminals (Original Design) | Gate and Emitter "C" Brackets to IGBTs | M4 x 8 mm Screw | 12 – 16 | 1.4 – 1.8 |

* Parts pertain only to original Snubber Board design which uses "C" shaped Gate and Emitter brackets. Refer to Power Modules in Chapter 4 – Part Replacement Procedures.

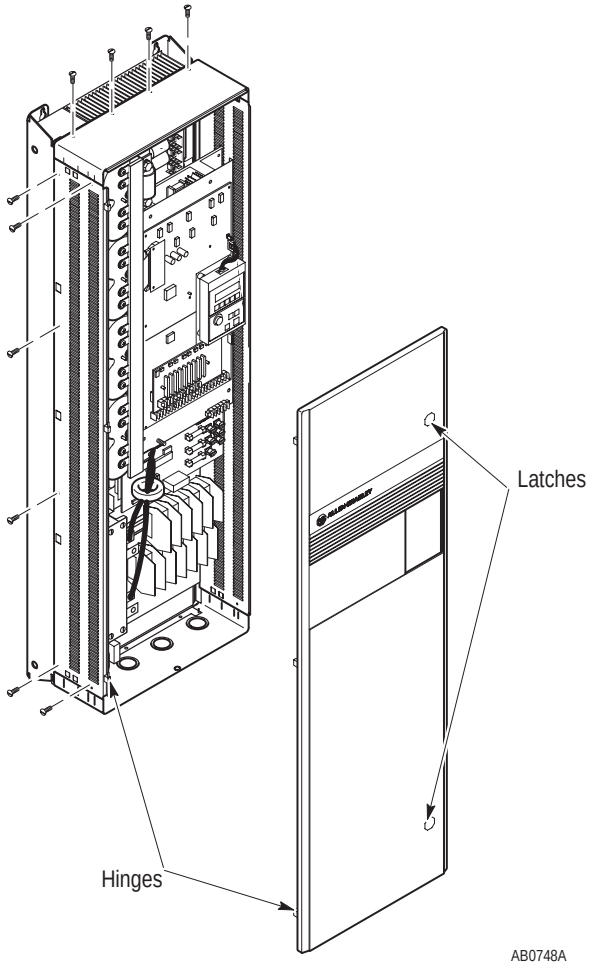
**Table 2.D**
**Fastener Torque Specifications — Wires Common to "D"**
**Frame Drives**

| Component | Fastener Application | Fastener Used | Torque in.-lb | Torque N-m |
|---|---|---|---|---|
| MOV Ground Wire (MOV1) | Wire to Chassis | M6 Nut | 23 – 36 | 2.6 – 4.1 |
| Drive Ground Wire | Wire to Chassis | M6 Nut | 23 – 36 | 2.6 – 4.1 |
| Ground Wire TE (Gate Driver Board) | Wire to TB1 Terminal TE | Compression | 6 – 8 | 0.7 – 0.9 |
| Link Inductor Wires | Wires to Link Inductor | M6 x 12 mm Screw | 50 – 72 | 5.6 – 8.1 |
| Capacitor Bus Bar Wires | Wires to Capacitor Bus Bar | M6 x 12 mm Screw | 50 – 72 | 5.6 – 8.1 |
| Converter Bus Bar Wires | Wires to Converter Bus Bar | M6 x 12 mm screw | 50 – 72 | 5.6 – 8.1 |
| Motor Bus Bar Wires | Wires to Motor Bus Bar | M6 x 12 mm Screw | 50 – 72 | 5.6 – 8.1 |
| TB1 Wires | Wires to TB1 | M8 Nut | 52 | 5.9 |
| TB20 Wires, PLC Comm Adapter Board | Wires to TB20 | Captive Screw | – | – |
| TB21 Wires, PLC Comm Adapter Board | Wires to TB21 on Main Control Board | Captive Screw | – | – |
| TB5 Wires, Standard Adapter Board | Wires to TB5 on Main Control Board | Captive Screw | 12 – 16 | 1.4 – 1.8 |
| TB6 Wires, Standard Adapter Board | Wires to TB6 on Main Control Board | Captive Screw | 12 – 16 | 1.4 – 1.8 |
| TB7 Wires, Standard Adapter Board | Wires to TB7 on Main Control Board | Captive Screw | 12 – 16 | 1.4 – 1.8 |
| TB3 Wires, Standard Adapter L–Option Board | Wires to TB3 on Control Interface Board | Captive Screw | 8 – 10 | 0.9 – 1.1 |
| Enclosure Door Ground Wire | Wire to Enclosure Door | M6 Nut | 23 – 36 | 2.6 – 4.1 |

# Disassembly and Access Procedures

## Opening the Drive Enclosure

**Figure 2.3**
**Drive Enclosure**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Turn the Enclosure door latches, located on the right side of the Enclosure door, 90 degrees counterclockwise.
3. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
4. Check for zero volts at TB1 terminals +DC and –DC.
5. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
6. Remove the ground wire from the Enclosure door.
7. Lift the Enclosure door toward the top of the drive to remove the door from the hinges.
8. Remove the customer-supplied wiring from the drive.
9. Remove the screws from the Enclosure top, bottom, and side panels to remove the panels.

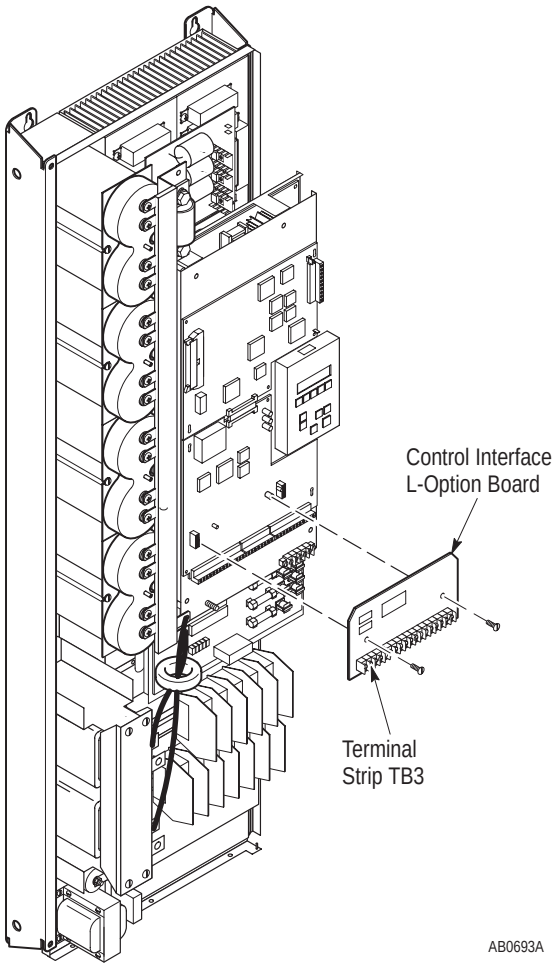
### Installation

Install the Enclosure in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing Control Interface L-Option Board MOD-L4, -L5, or -L6

**Figure 2.4**
**Control Interface L-Option Board**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at TB5, TB6, and TB7 on the Standard Adapter Board.
5. Remove all wires from the terminals on TB3.
6. Loosen the two captive screws fastening the Control Interface Board to the Standard Adapter Board.
7. Grip the right and left sides of the Control Interface Board and pull the board straight out from the Standard Adapter Board.

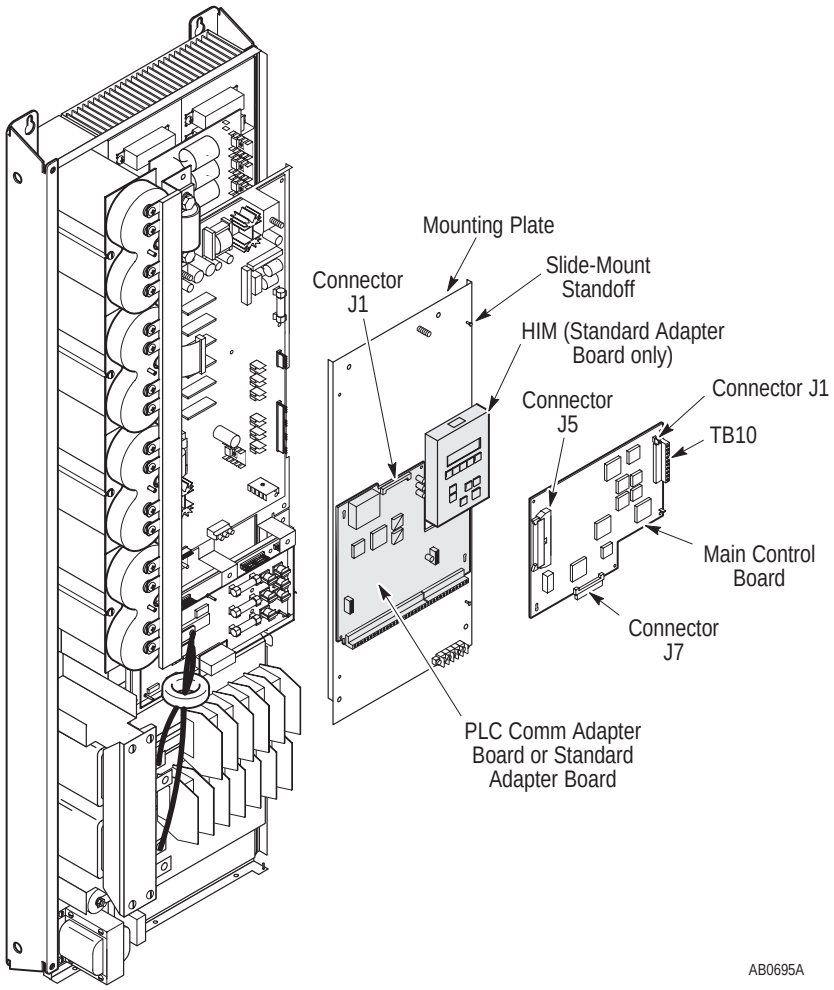
### Installation

Install the Control Interface Board in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the Main Control Board

**Figure 2.5**
**Main Control Board and Mounting Plate**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 Terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Disconnect the following from the Main Control Board:
   - J5 ribbon cable connector
   - Stake-on ground wire connector
   - All wires from TB10
6. Remove the screws fastening the Main Control Board to the Control Board/Adapter Mounting Plate.
7. Lift the Main Control Board upward to release it from the slide-mount stand-offs and connector J7.

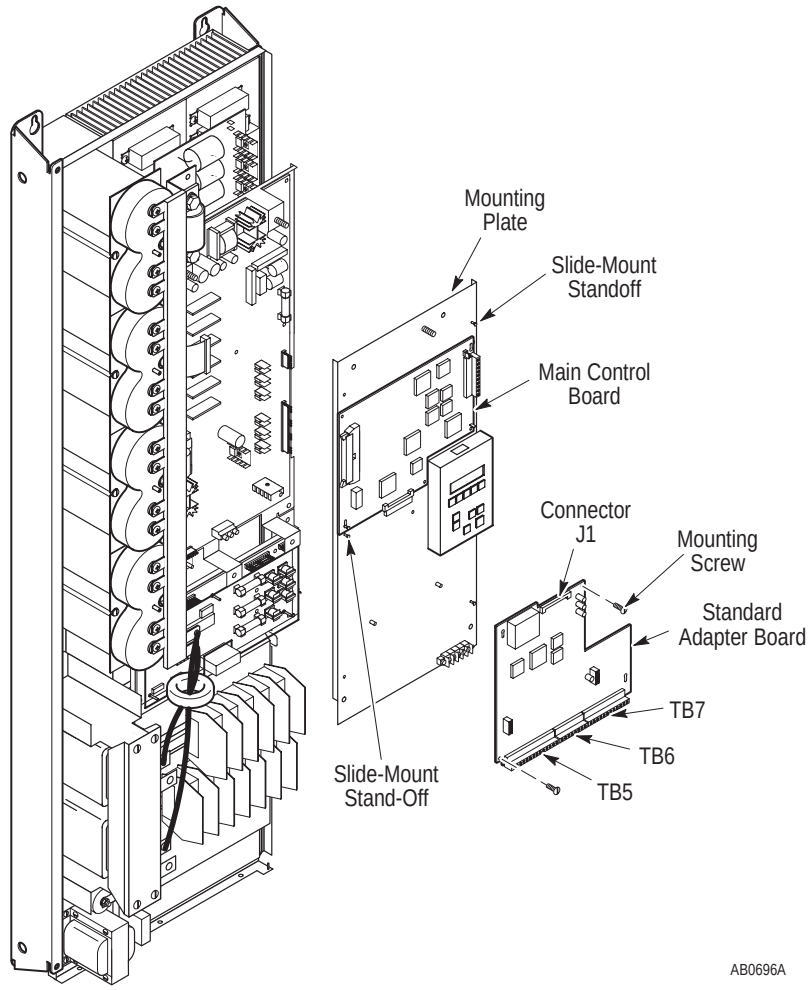
### Installation

Install the Main Control Board in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the Standard Adapter Board

**Figure 2.6**
**Standard Adapter Board**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

1. Remove power from the drive.
2. Open the Enclosure door.
3. Check for zero volts at TB1 Terminals +DC and –DC.

4. Check for the absence of control voltage at TB5, TB6, and TB7 on the Standard Adapter Board.
5. Disconnect the following from the Standard Adapter Board:
   - Stake-on ground wire connector
   - All wires from TB5, TB6, and TB7
6. Remove the Control Interface Board. Refer to Removing the Control Interface L-Option Board in this chapter.
7. Remove the two screws fastening the Standard Adapter Board to the mounting plate.
8. Pull the Standard Adapter Board down to release it from the slide-mount stand-offs and connector J1.

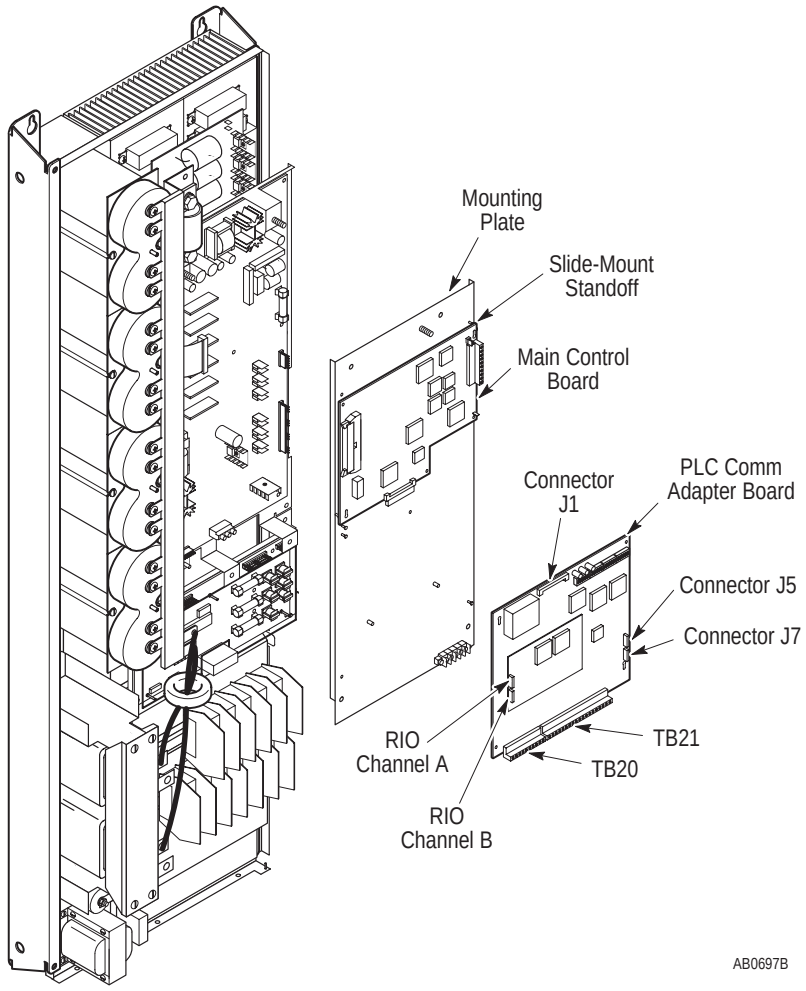
### Installation

Install the Standard Adapter Board in reverse order of removal.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the PLC Comm Adapter Board

**Figure 2.7**
**PLC Comm Adapter Board**




**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Enclosure Door in this chapter.
3. Check for zero volts at TB1 Terminals +DC and –DC.

4. Check for the absence of control voltage at TB20 and TB21 on the PLC Comm Adapter Board.
5. Disconnect the following from the PLC Comm Adapter Board:
   - All wires from TB20 and TB21
   - Stake-on ground wire connector
   - J5 connector
   - J7 connector
   - Communication channel A and B connectors
6. Remove the screws fastening the PLC Comm Adapter Board to the mounting plate.
7. Pull the PLC Comm Adapter Board down to release it from the slide-mount stand-offs and connector J1.

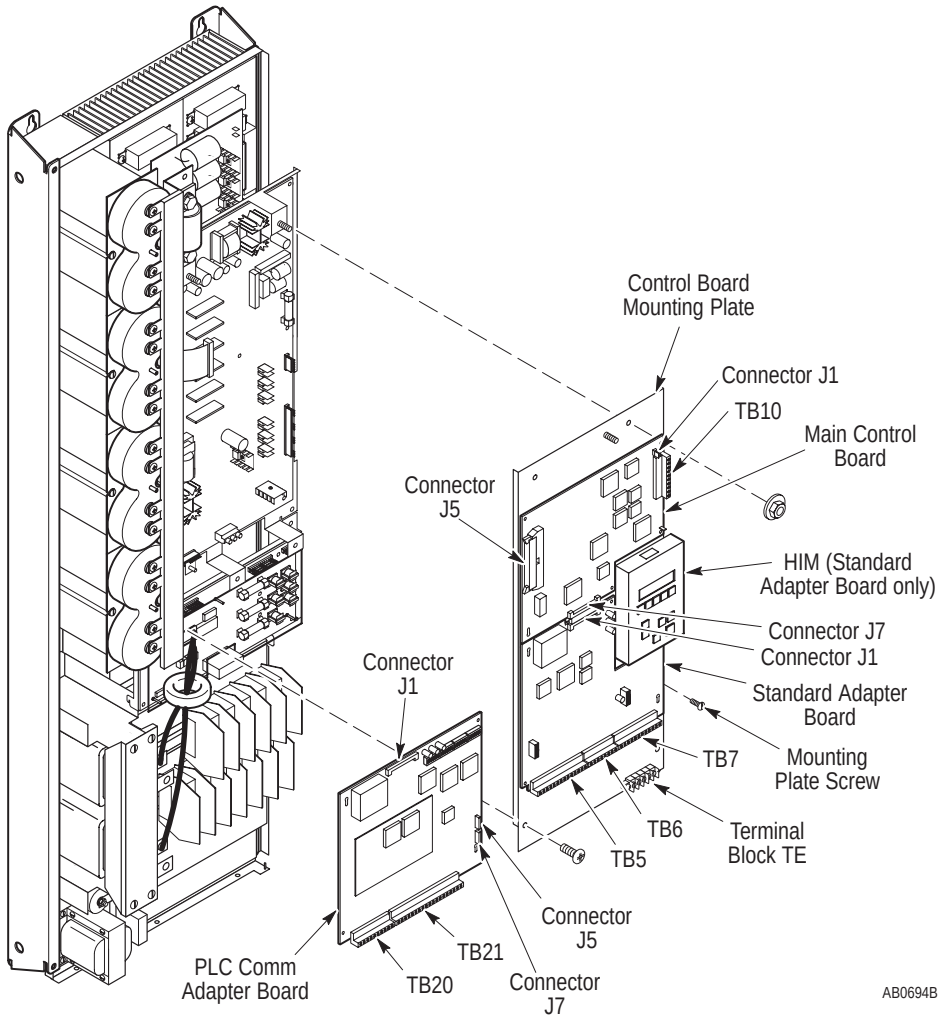
### Installation

Install the PLC Comm Adapter Board in reverse order of removal.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the Control Board/Adapter Mounting Plate

**Figure 2.8**
**Control Board/Adapter Mounting Plate**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Remove the wires and connectors from the Standard or PLC Comm Adapter Board.

   This drive may have either a Standard Adapter Board or a PLC Comm Adapter Board. Refer to Removing the Standard Adapter Board or Removing the PLC Comm Adapter Board in this chapter.
6. Remove the nuts at the top of the Control Board/Adapter Mounting Plate.
7. Remove the two screws at the bottom of the Control Board/Adapter Mounting Plate.
8. Lift the Control Board/Adapter Mounting Plate out of the drive.

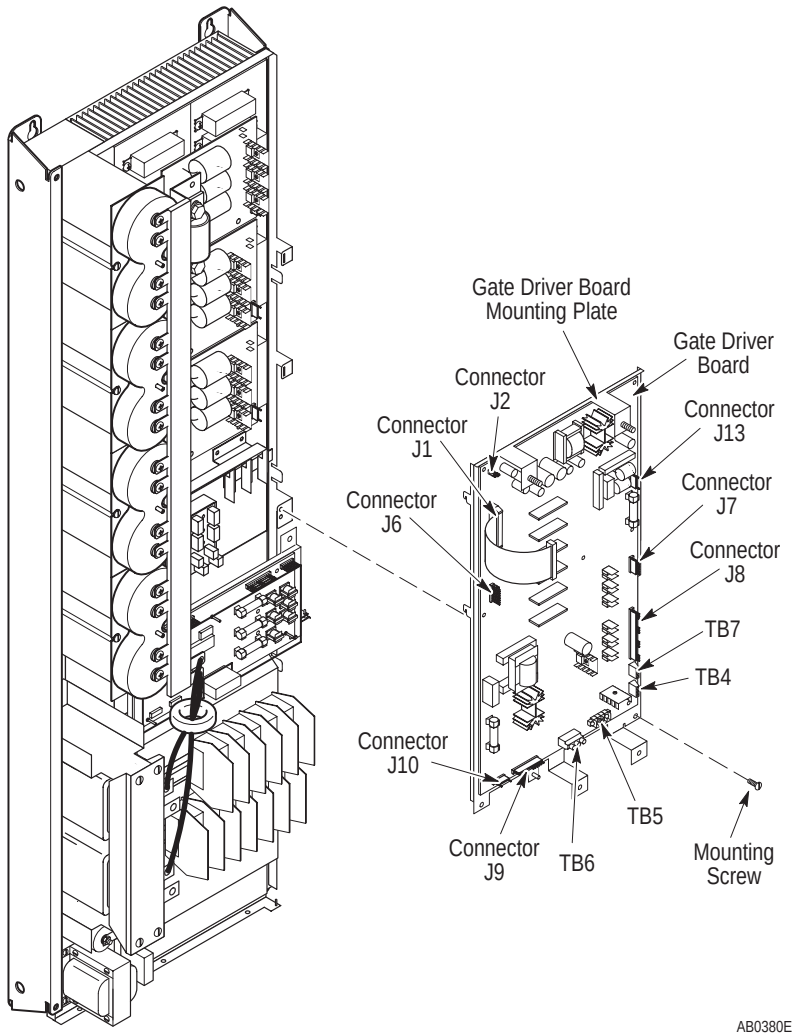
### Installation

Install the Control Board/Adapter Mounting Plate in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the Gate Driver Board Mounting Plate

**Figure 2.9**
**Gate Driver Board Mounting Plate**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Remove the Control Board/Adapter Mounting Plate. Refer to Removing the Control Board/Adapter Mounting Plate in this chapter.
6. Remove Gate Driver Board connections:
   - TB7 ground wire
   - J2 Ground Sense CT connector
   - J13 connector
   - J7 Power Module connector
   - J8 Power Module connector
   - J10 Bus Capacitor Bank connector
   - J6 connector
   - J9 Precharge Board connector
   - TB6 Fan connector if applicable
7. Remove the screws fastening the bottom of the mounting plate to the drive.

8. Slide the plate toward the top of the drive until the tabs disengage from the slots.
9. Lift the plate out of the drive.

### Installation

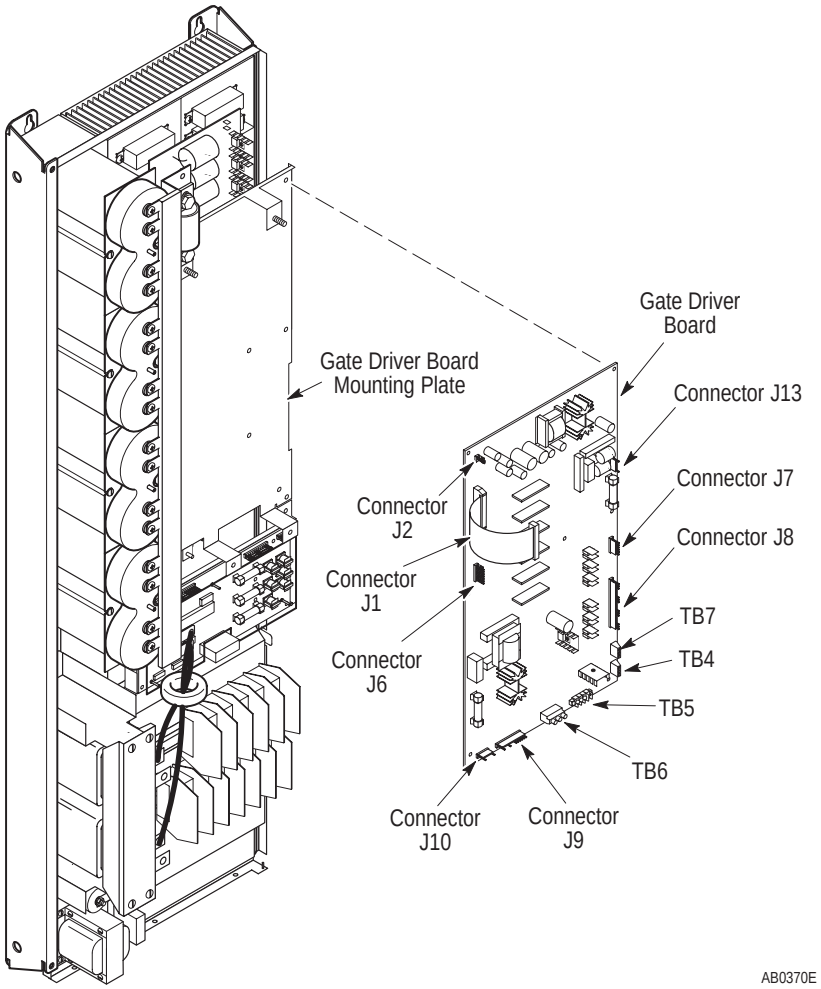
Install the Gate Driver Board Mounting Plate in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**ATTENTION:** When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the Gate Driver Board

**Figure 2.10**
**Gate Driver Board**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Remove the Control Board/Adapter Mounting Plate. Refer to Removing the Control Board/Adapter Mounting Plate in this chapter.
6. Disconnect the following from the Gate Driver Board:
   - J9 Precharge Board connector
   - J10 Bus Capacitor Bank connector
   - J2 Ground Sense CT connector
   - J7 Power Module connector
   - J8 Power Module connector
   - J6 LEM harness connector
   - TB6 Fan connector
   - J13 connector
   - Ground wire from TB7.

7. Turn the eight stand-off screws, fastening the Gate Driver Board to the Mounting Plate, 1/4 turn counterclockwise.
8. Remove the Gate Driver Board from the enclosure.

### Installation

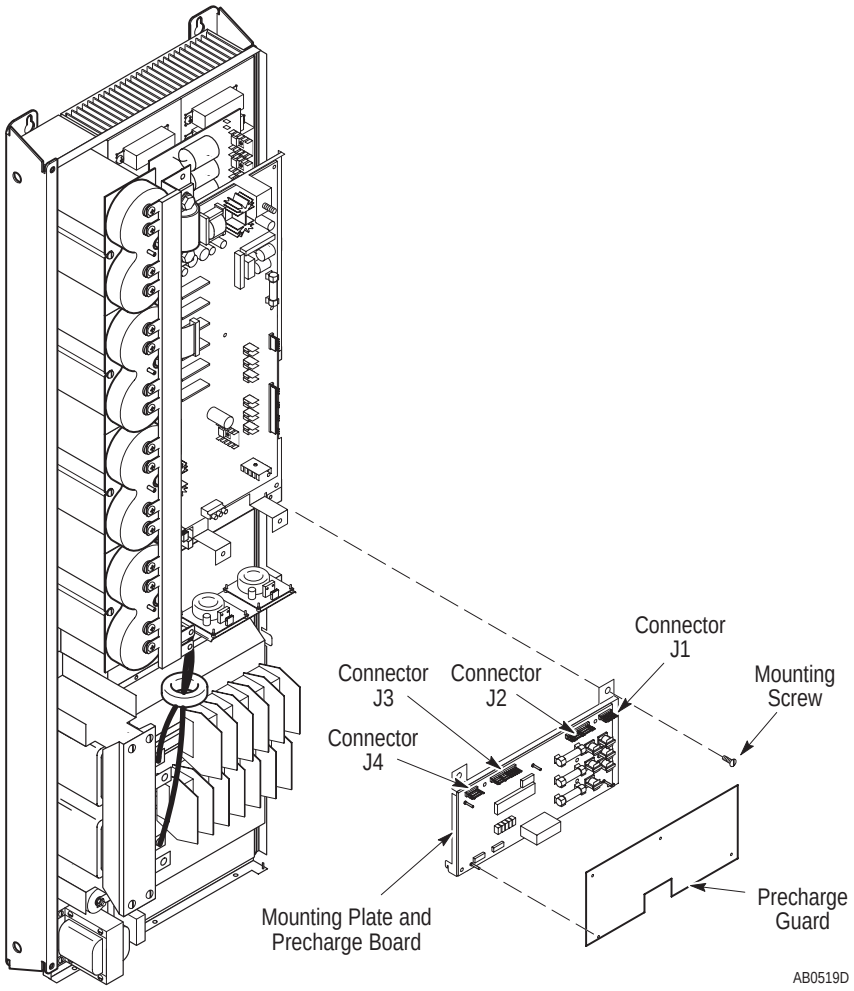
Install the Gate Driver Board in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**ATTENTION:** When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the Precharge Board Mounting Plate

**Figure 2.11**
**Precharge Board and Mounting Plate**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Remove the guard from the Precharge Board.
6. Disconnect the following from the Precharge Board:
   - J1 connector
   - J2 connector
   - J3 connector
   - J4 connector
7. Remove the screws fastening the top of the Mounting Plate to the drive.
8. Lift the Precharge Board and Mounting Plate out of the enclosure.

### Installation

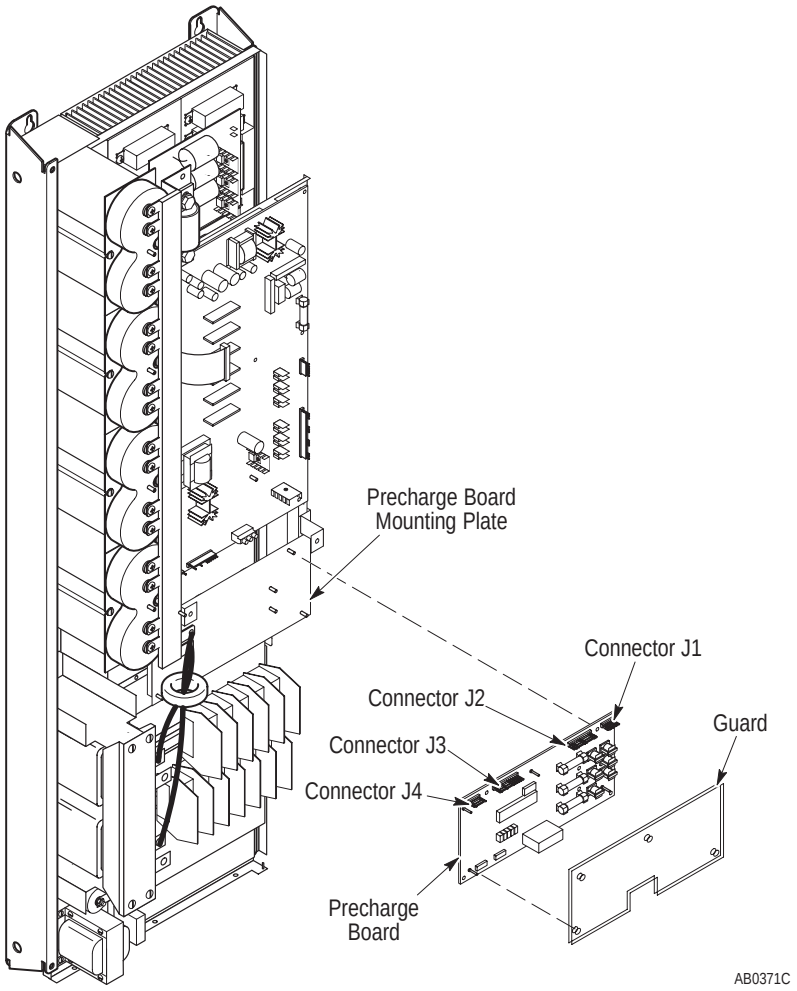
Install the Precharge Board Mounting Plate in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**ATTENTION:** When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the Precharge Board

**Figure 2.12**
**Precharge Board**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Disconnect the following from the Precharge Board:
   - J1 connector
   - J2 connector
   - J3 connector
   - J4 connector
6. Turn the six stand-off screws, fastening the Precharge Board to the mounting plate, 1/4 turn counterclockwise.
7. Remove the Precharge Board from the Mounting Plate.

### Installation

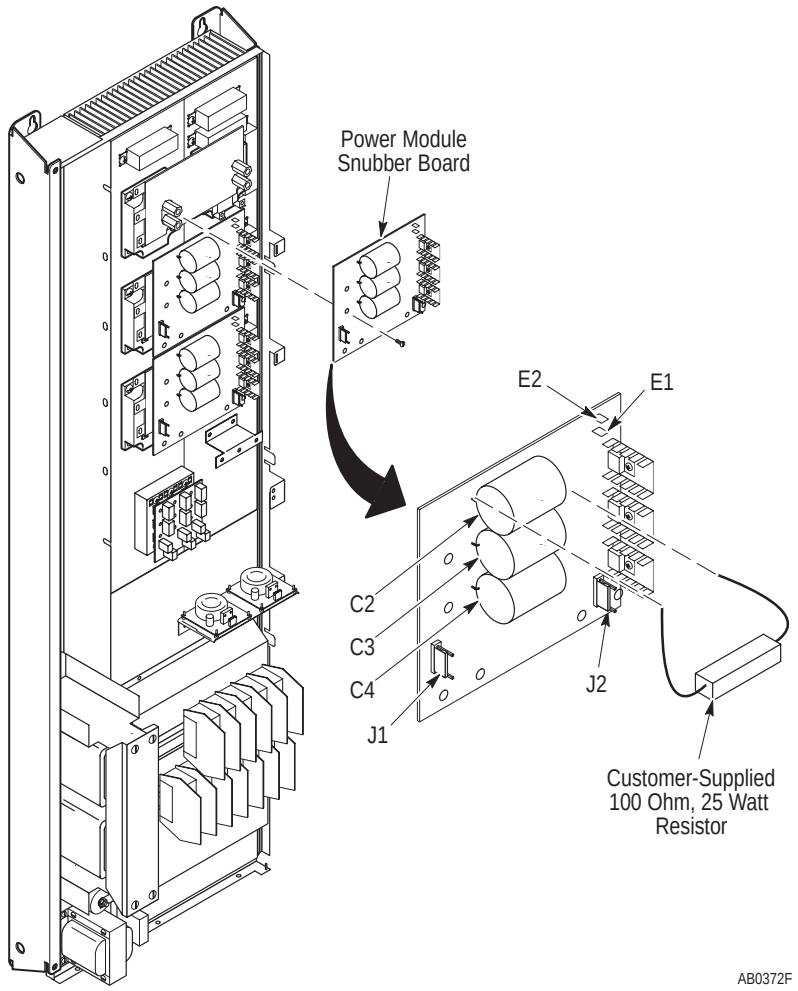
Install the Precharge Board in reverse order of removal.

**ATTENTION:** When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing a Power Module Snubber Board

**Figure 2.13**
**Power Module Snubber Board**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Remove the Gate Driver Board Mounting Plate. Refer to Removing the Gate Driver Board Mounting Plate in this chapter.
6. Remove the wires from Power Module Snubber Board stake-on connectors E1 and E2.
7. Remove J1 and J2 connectors.
8. Remove the eight screws fastening the Snubber Board to the Power Module.

### Installation

**ATTENTION:** Do not substitute longer or shorter hardware when fastening the Power Module Snubber Boards to the Power Modules. Use the same size fastener to fasten the components as was originally used. Using different fastener lengths will damage the Power Modules.

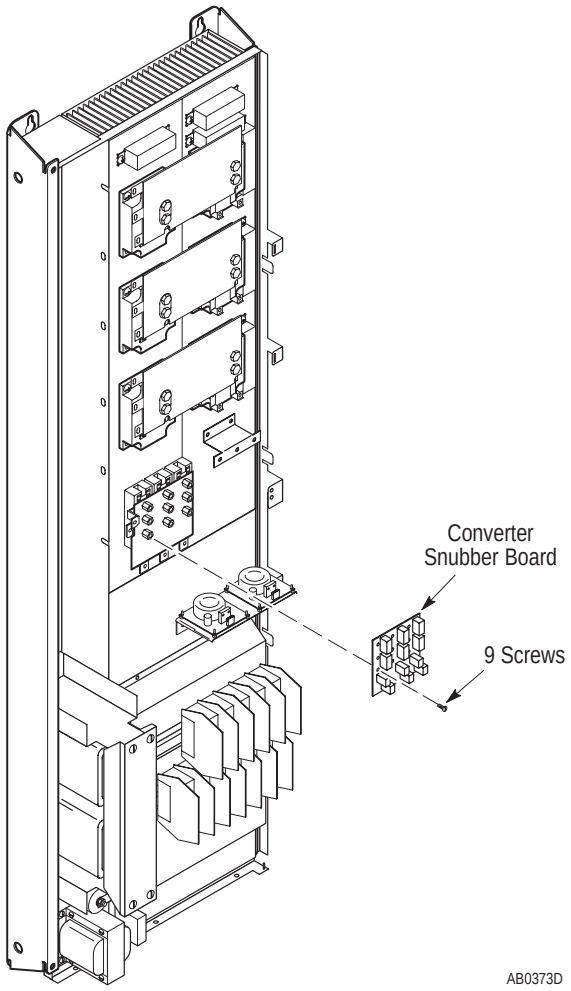
Install the Power Module Snubber Board in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**Important:** Line up the bottom edge of the Snubber Board with the metal posts on the Power Module Brackets.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Removing the Converter Snubber Board

**Figure 2.14**
**Converter Snubber Board**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Open the Enclosure door. Refer to Opening the Drive Enclousre in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Remove the Gate Driver Board Mounting Plate. Refer to Removing the Gate Driver Board Mounting Plate in this chapter.
6. Remove the Precharge Board Mounting Plate. Refer to Removing the Precharge Board Mounting Plate in this chapter.
7. Remove the nine screws fastening the Converter Snubber Board to the Input Rectifier.

### Installation

Install the Converter Snubber Board in reverse order of removal. Refer to Fastener Torque Specifications in this chapter.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Accessing Power Plane Components

To access the power plane components located on the chassis, refer to Removing a Power Module Snubber Board in this chapter.

# Component Test Procedures

## Chapter Objectives

The following tests help you troubleshoot A040 – A060, B060 – B125, BX150, and C075 – C125 drives.

## Component Test Overview

In some cases, different tests troubleshoot components of the same name.

These similar tests vary according to the rating of the drive being tested. Verify that the rating on the drive matches the rating for the test you are performing.

The procedures in this chapter assume that the drive you are servicing either has no enclosure or that the enclosure is opened. For more information on opening the Drive Enclosure, refer to Chapter 2 – Disassembly and Access Procedures, Opening the Drive Enclosure.

**ATTENTION:** Some printed circuit boards and drive components may contain hazardous voltage levels. Remove and lock out power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Servicing energized industrial control equipment can be hazardous. Electrical shock, burns, or unintentional actuation of controlled industrial equipment may cause death or serious injury. Follow the safety-related practices of NFPA 70E, Electrical Safety for Employee Workplaces, when working on or near energized equipment. Do not work alone on energized equipment.

## Electrostatic Discharge Precautions

**ATTENTION:** This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Allen-Bradley Publication 8000-4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

Electrostatic discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

- Wear a wrist-type grounding strap that is grounded to the chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

### Tools

You need the following tools to disassemble and assemble the drive:

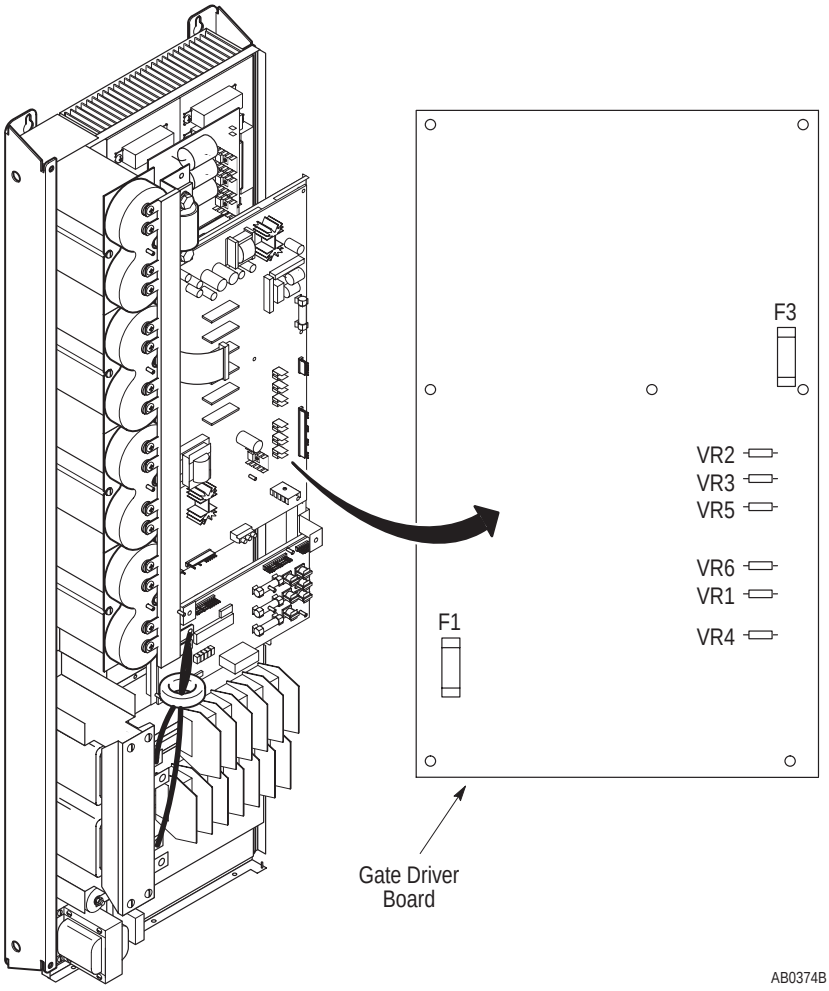
- Pliers
- Phillips screwdrivers (medium and large)
- Standard screwdrivers (small, medium, and large)
- 10 mm socket
- 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in in.-lb or N-m
- Nylon tie wraps

- Side cutters
- 17 mm socket

## Test 1 Testing the Gate Driver Board

The Gate Driver Board is located between the Main Control Board and the Main Chassis. If one or more Power Modules has been replaced, you must test the Gate Driver Board.

**Figure 3.1**
**Gate Driver Board Test**



**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Control Board/Adapter Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Control Board/Adapter Mounting Plate.
5. Set your meter to test resistance.
6. Test Fuses F1 and F3 for an open condition. Replace the Gate Driver Board if either fuse shows an open condition.
7. Set your meter to test diodes.
8. Test VR1 – VR6. The following table shows meter connections at the components and ideal meter readings for those connections. Refer to the former illustration for component locations.

**Table 3.A**
**Gate Driver Board Test**

| Component | Meter (+) Lead | Meter (–) Lead | Nominal Meter Reading |
|---|---|---|---|
| **VR1 – VR6** | +<br>– | –<br>+ | 0.9<br>1.5 |

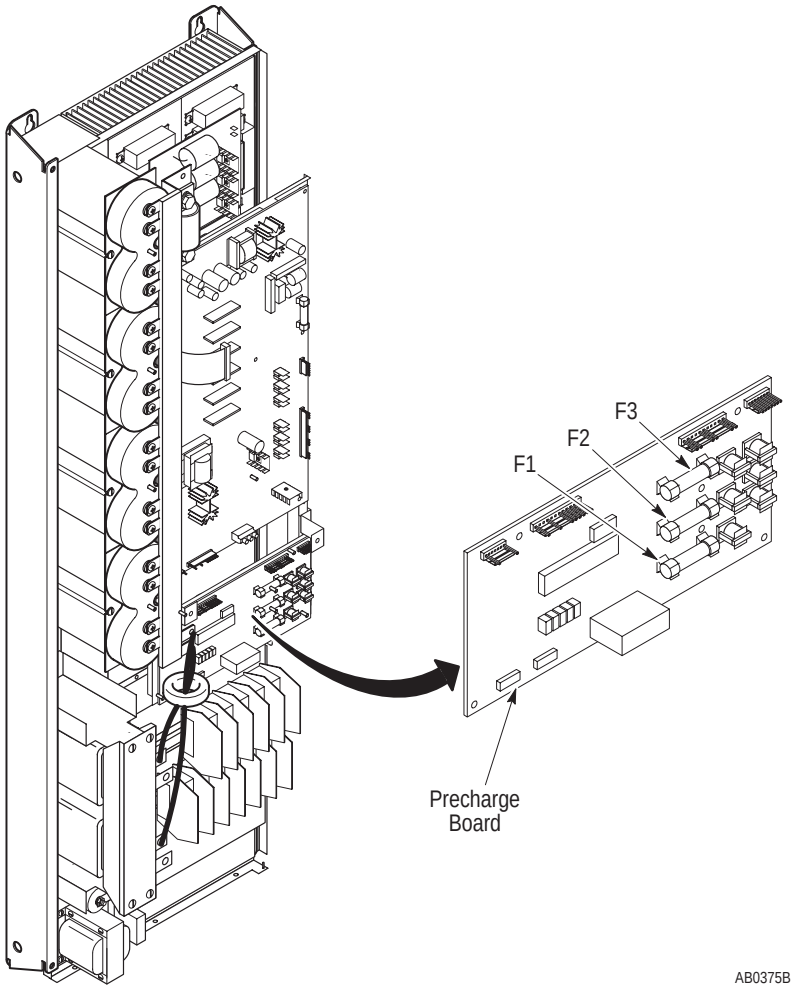
Note: Typical Malfunction is shorted in both directions.

9. Replace the Gate Driver Board if your readings do not match the table readings. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver Board.
10. Assemble the drive in reverse order or disassembly.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Test 2 Testing the Precharge Board

**Figure 3.2**
**Precharge Board Test**




**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

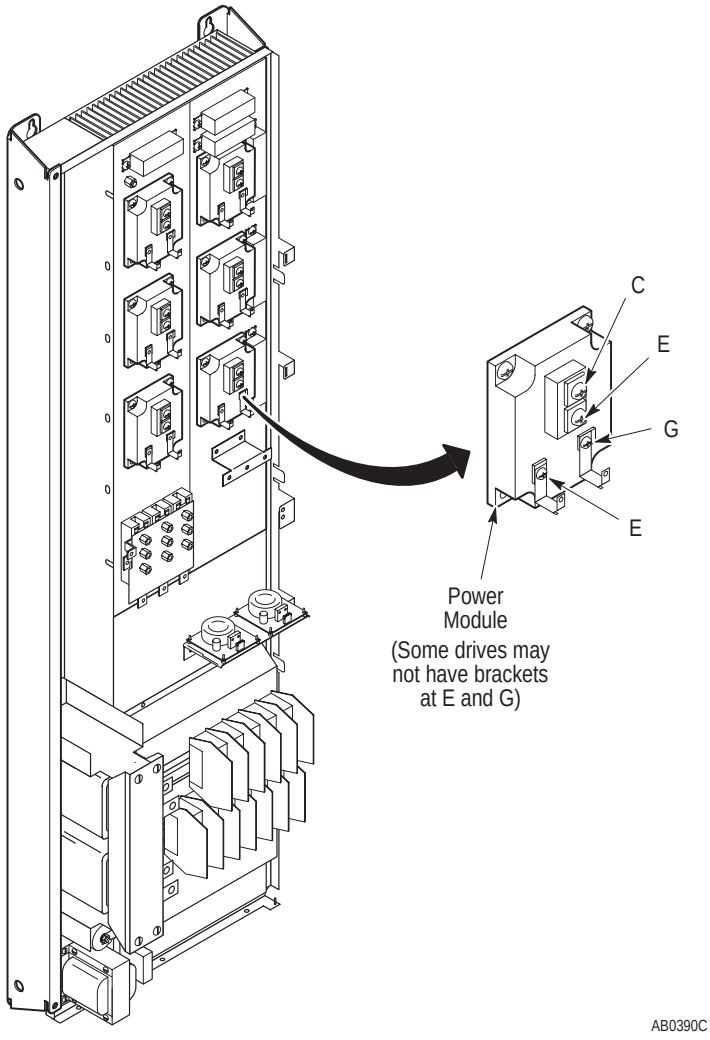
1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Set your meter to test resistance.
5. Test fuses F1, F2, and F3 for open conditions.
6. Replace the Precharge Board if any fuse shows an open condition. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Precharge Board.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Test 3 Testing the Power Modules

The Power Modules are located near the top of the heat sink.

**Figure 3.3**
**Power Module Test**




**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Control Board/Adapter Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Control Board/Adapter Mounting Plate.
5. Remove the Gate Driver Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver Board Mounting Plate.
6. Remove the Power Module Snubber Boards. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.
7. Remove the Inverter Bus Bar. Refer to Chapter 4 – Part Replacement Procedures, Power Modules.
8. Set your meter to test diodes.
9. Test the Power Modules. The following table shows meter connections and ideal meter readings for those connections. Refer to the former illustration for meter connection locations.

**Table 3.B**
**Power Modules**

| Meter (+) Lead | Meter (–) Lead | Nominal Meter Reading |
|---|---|---|
| E | C | 0.318 |
| E | B | Infinite |
| C | E | Infinite |
| C | B | Infinite |
| B | E | Infinite |
| B | C | Infinite |

**10.** Replace both Power Modules in the same phase if meter readings are not as shown. Refer to Chapter 4 – Part Replacement Procedures, Power Modules.

**11.** If one or more Power Modules is replaced, test the Gate Driver Board. Refer to Testing the Gate Driver Board in this chapter.

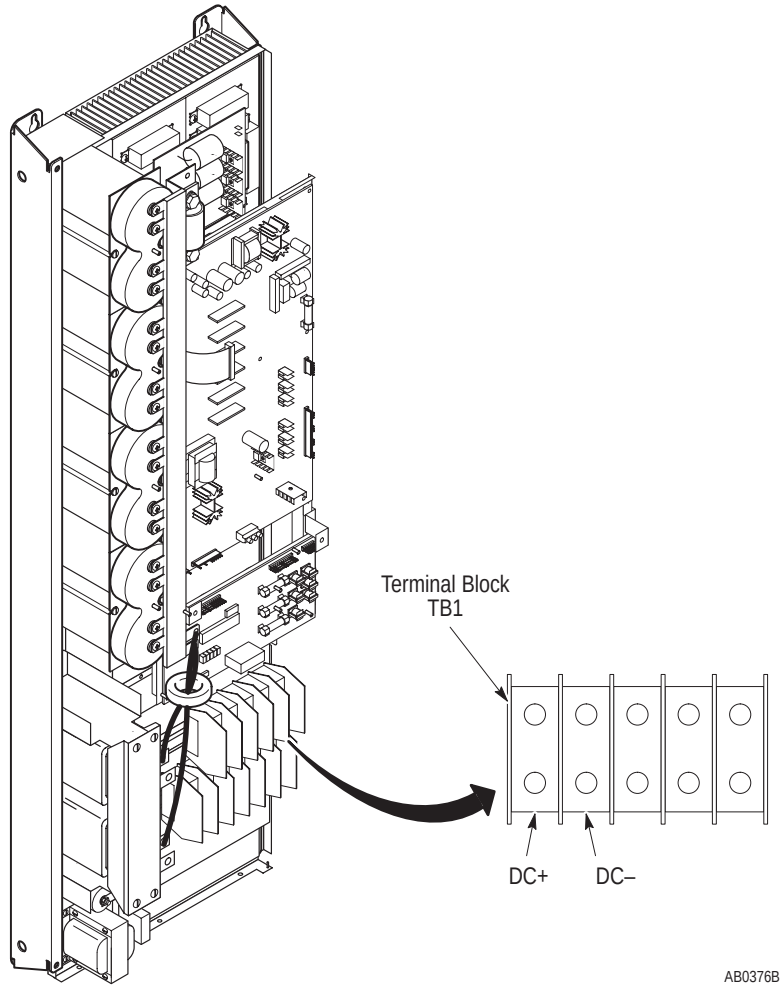
**12.** Assemble the drive in reverse order of disassembly.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Test 4 Testing the Bus Capacitors

The Bus Capacitor Bank is located on the left side of the Main Chassis.

**Figure 3.4**
**Bus Capacitor Bank Test**



**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the guard from the bus capacitors.
5. Set your meter to test voltage.
6. Connect the negative (–) lead of your meter to the (–) DC Bus terminal on TB1 and the positive lead to the (+) DC Bus terminal. Refer to the following tables and former illustration for meter readings and terminal locations.

**ATTENTION:** Servicing energized industrial control equipment can be hazardous. Electrical shock, burns, or unintentional actuation of controlled industrial equipment may cause death or serious injury. Follow the safety-related practices of NFPA 70E, Electrical Safety for Employee Workplaces, when working on or near energized equipment. Do not work alone on energized equipment.

**7.** Apply power **AFTER** the meter is connected, otherwise your meter will read zero volts. Expand readings for all input voltage ratings.

**Table 3.C**
**Bus Capacitor Bank Test**

| Drive Rating | Input Volts | Meter Reading |
|---|---|---|
| A | 200 | 280V DC +/–10% |
| | 230 | 322V DC +/–10% |
| | 240 | 336V DC +/–10% |
| B | 380 | 535V DC +/–10% |
| | 415 | 580V DC +/–10% |
| | 480 | 650V DC +/–10% |
| C | 500 | 700V DC +/–10% |
| | 575 | 800V DC +/–10% |
| | 600 | 850V DC+/–10% |

**8.** If the voltage is out of tolerance, check the following:

- An open condition at an Input Rectifier.
- A voltage drop due to Bus Inductor L1 resistance.
- A voltage drop between an Input Rectifier and the bus capacitors due to loose or resistive wires or connections.
- Precharge circuit problems.

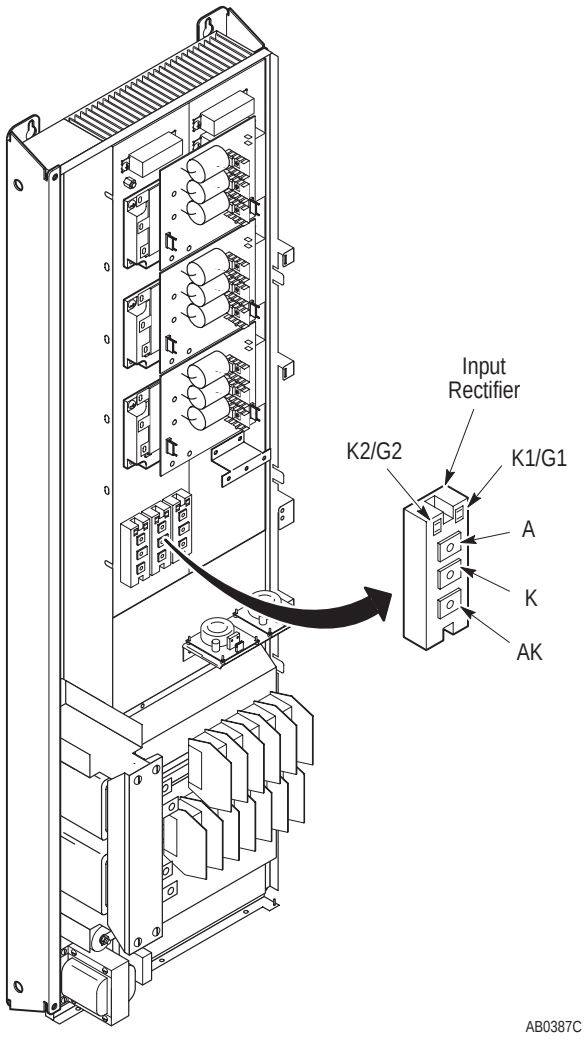
**9.** If the above check does not reveal a problem, replace the Bus Capacitor Bank and Load-Sharing Resistors. Refer to Chapter 4 – Part Replacement Procedures, Bus Capacitor Bank.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Test 5
## Testing the Input Rectifiers

The Input Rectifiers are located on the bottom of the heat sink.

**Figure 3.5**
**Input Rectifier Test**




**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver Board Mounting Plate.
5. Remove the Precharge Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Precharge Board Mounting Plate.
6. Remove the Converter Snubber Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Converter Snubber Board.
7. Remove the Converter Bus Bar.
8. Set your meter to test diodes.
9. The following table shows meter connections and ideal meter readings for those connections. Refer to the former illustration for meter connection locations.

**Table 3.D**
**Input Rectifier Test**

| Meter (+) Lead | Meter (–) Lead | Nominal Meter Reading |
|---|---|---|
| AK | K | Infinite |
| AK | A | Infinite |
| K | A | Infinite |
| K | AK | Infinite |
| A | AK | Infinite |
| A | K | Infinite |
| G1 | K1 | 0.008 |
| K1 | G1 | 0.008 |
| G2 | K2 | 0.008 |
| K2 | G2 | 0.008 |

**10.** Replace the Input Rectifier if any meter readings are not as shown. Refer to Chapter 4 – Part Replacement Procedures, Input Rectifiers.

**11.** If the Input Rectifier shorted, check the Power Modules for damage. Refer to Testing the Power Modules in this chapter.

**12.** Assemble the drive in reverse order of disassembly.

# Part Replacement Procedures

## Chapter Objective

This chapter describes procedures required to replace drive components. This chapter references Chapter 2 – Disassembly and Access Procedures for basic drive component access.

## Part Replacement Overview

The part replacement procedures in this chapter assume that the drive you are servicing either has no enclosure or that the enclosure is open. For more information on opening the Drive Enclosure, refer to Chapter 2 – Disassembly and Access Procedures, Opening the Drive Enclosure.

## Safety Precautions

**ATTENTION:** Some printed circuit boards and drive components may contain hazardous voltage levels. Remove power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

## Electrostatic Discharge Precautions

**ATTENTION:** This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Allen-Bradley Publication 8000-4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

Electrostatic discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

- Wear a wrist-type grounding strap that is grounded to the chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

### Tools

- You need the following tools to disassemble and assemble the drive:
- Pliers
- Phillips screwdrivers (medium and large)
- Standard screwdrivers (small, medium, and large)
- 10 mm socket
- 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in in.-lb or N-m
- Nylon tie wraps
- Side cutters
- 17 mm socket

## Major Component Replacement

This section explains in detail how to replace the following drive components:

- Bus Capacitors
- Thermistor
- Power Modules
- Input Rectifiers
- Fan Assembly
- Autotransformer
- DC Bus Inductor L1
- Ground Sense CT
- Bus Fuse
- LEMs
- MOV Surge Suppressor

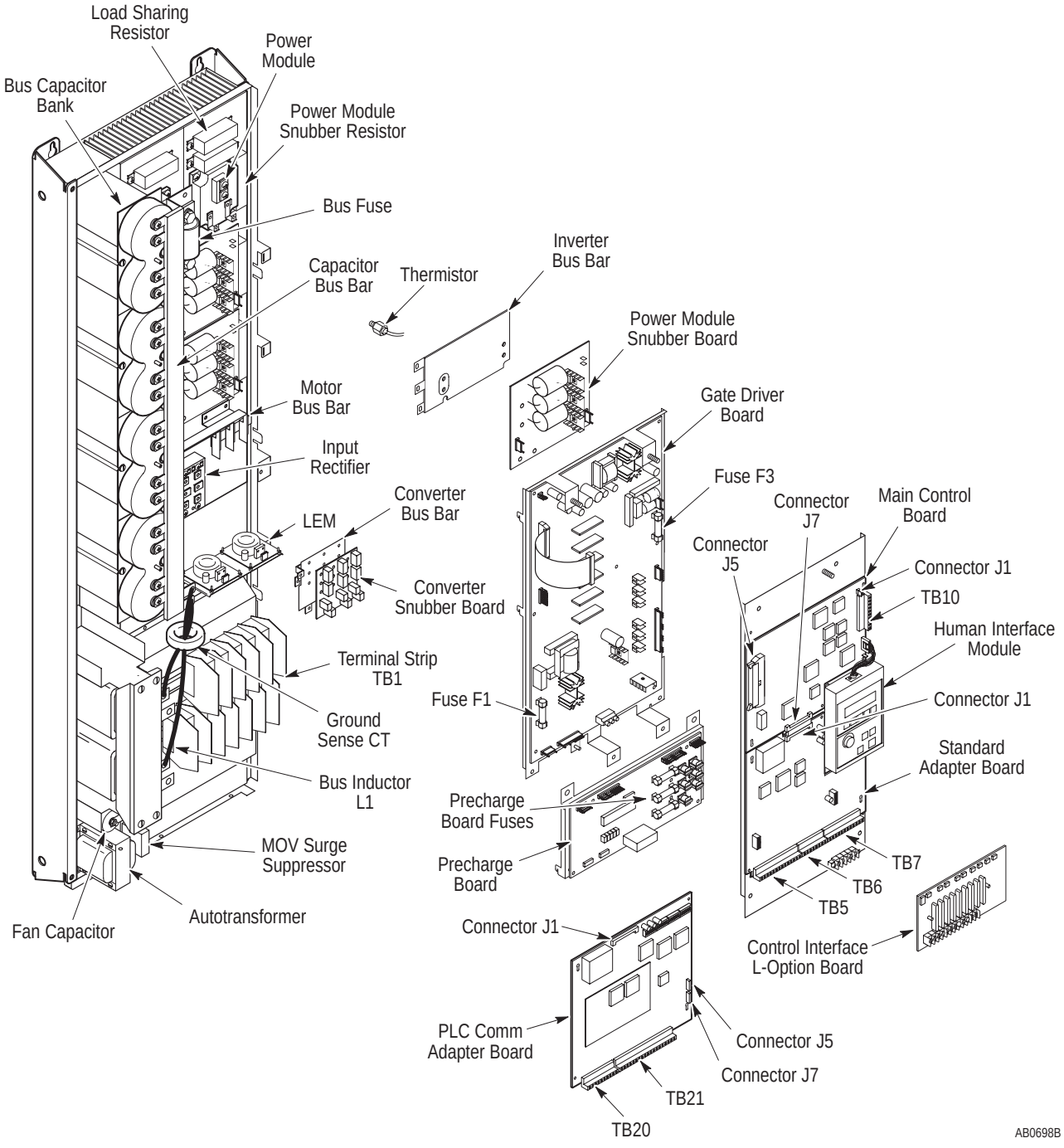
For Gate Driver Board, Precharge Board, Main Control Board, Standard Adapter Board, PLC Comm Adapter Board, Snubber Board, and Control Interface Board installation and removal procedures, refer to Chapter 2 – Disassembly and Access Procedures.

## Detailed Product Identification

Allen-Bradley Adjustable Frequency AC Drives are modular by design to enhance troubleshooting and spare parts replacement, thereby helping reduce production down-time.

The following illustration calls out the main components of a typical drive. Component designs vary slightly among the different drive ratings, but component locations are identical.

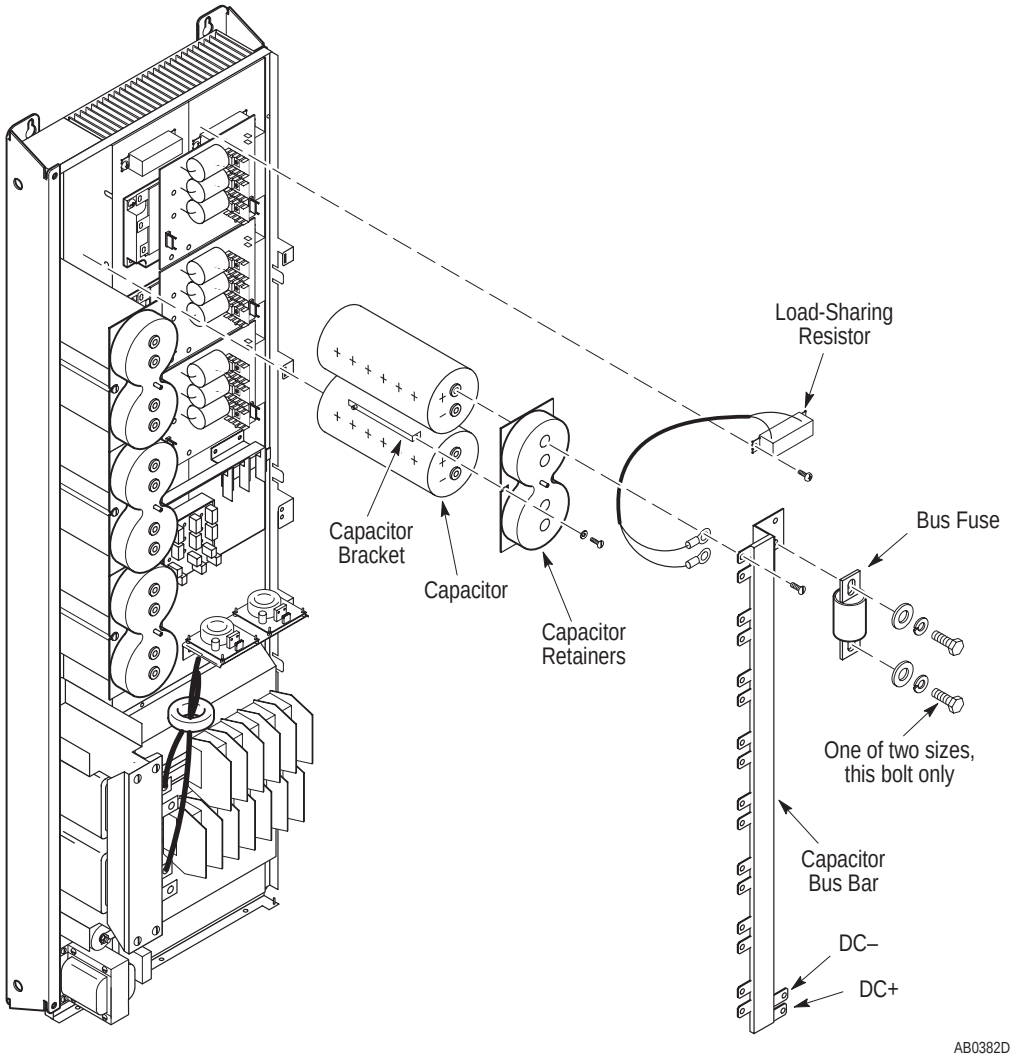
**Figure 4.1**
**Main Drive Components**



## Bus Capacitor Bank

The Bus Capacitor Bank is located on the left side of the Main Chassis.

**Figure 4.2**
**Bus Capacitor Bank**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

Access the Capacitors:

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the screws fastening the Bus Capacitor Guard to the Capacitor Bank.
5. Slide the Capacitor Guard toward the center of the drive to disengage the tabs.
6. Lift the Capacitor Guard out of the Drive.
7. Remove the Bus Fuse. Refer to Bus Fuse in this chapter.

Remove the Capacitors:

1. Remove the bolt and washer assembly fastening the Capacitor Bus Bar to the Transition Bus Bar. The Transition Bus Bar assembly is located under, and attached to, the Bus Fuse.
2. Remove the Load-sharing Resistor wires and the Capacitor Bus Bar screws.
3. Remove the Bus Inductor L1 cables and Bus Voltage wire harness from the Capacitor Bus Bar.

4. Remove the Capacitor Bus Bar.
5. Loosen the screws on the Capacitor Brackets.
6. Slide the brackets away from the Capacitor Retainers and down to remove.
7. Remove the Capacitor Retainers.
8. Lift the Bus Capacitors out of the Drive.

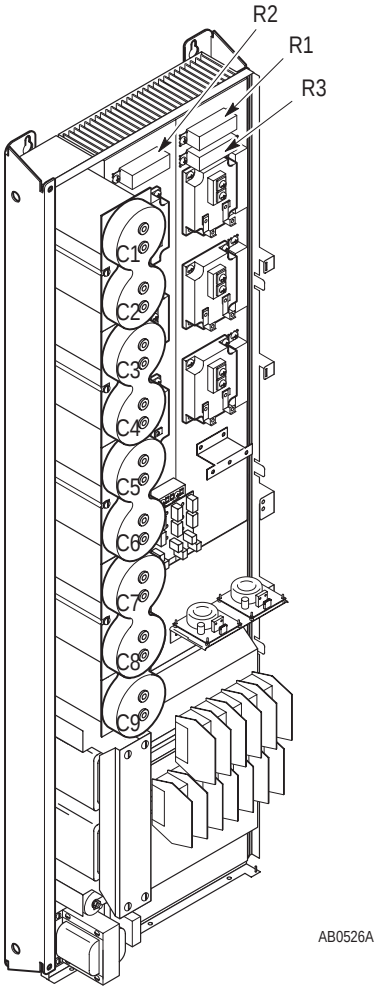
### Installation

1. Fasten the capacitor assembly in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

   **Important:** Refer to Bus Fuse in this chapter for correct Bus Fuse fastener size and type.

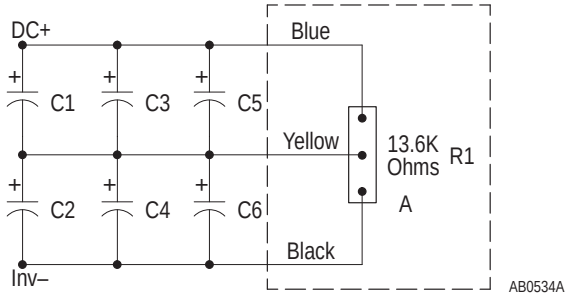
2. Connect the Load-sharing Resistors to the Bus Capacitors according to the following diagrams.

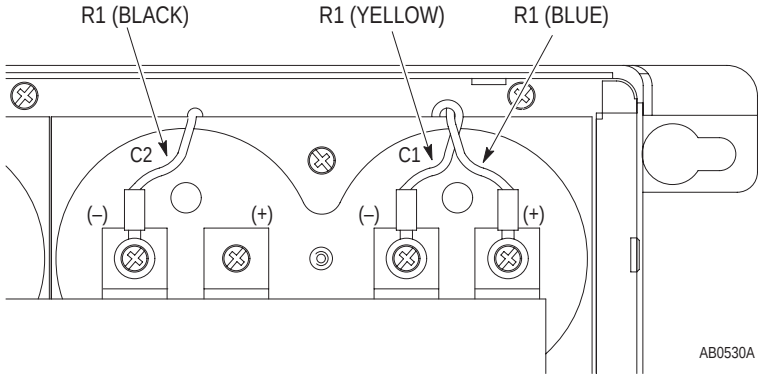
**Figure 4.3**
**Load-Sharing Resistor Connections to Bus Capacitors**



Load-sharing resistor R1 has three color coded leads coming out of the resistor body. Connect as shown in Figure 4.4.

**Figure 4.4**
**Wiring Detail for A040, A050, B060, B075, and B100 Drives**

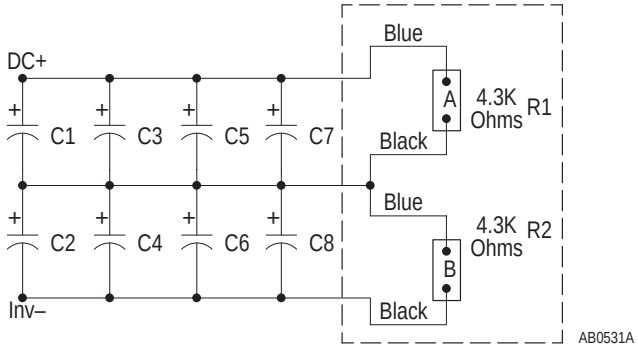


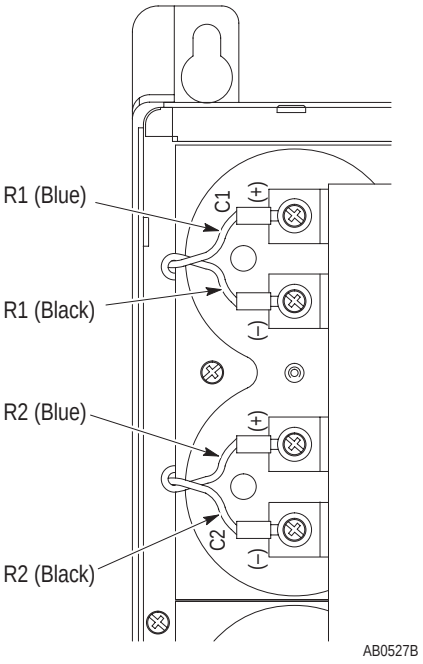




**ATTENTION:** The Capacitor Bus must connect a positive (+) capacitor terminal to a negative (–) capacitor terminal. Capacitors not connected correctly will explode and cause death or serious injury.

Load-sharing resistors R1 and R2 have two color coded leads coming out of each resistor body. Connect as shown in Figure 4.5.

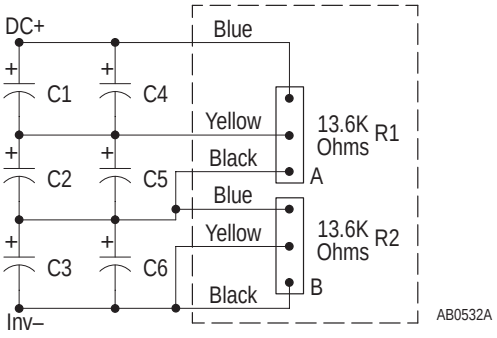
**Figure 4.5**
**Wiring Detail for A060, B125, and BX150 Drives**

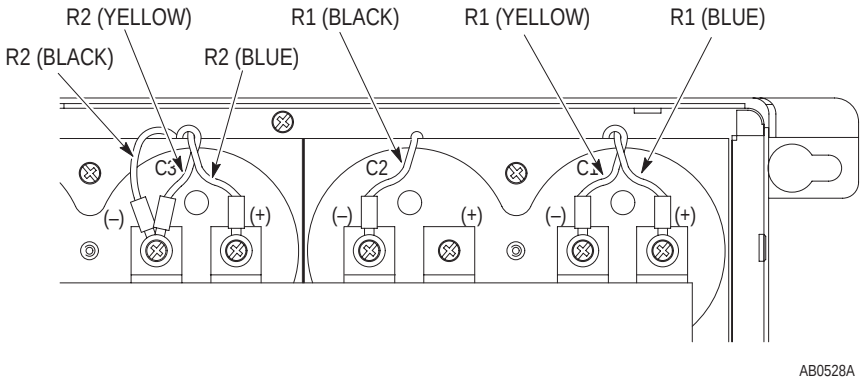


Load sharing resistors R1 and R2 have three color coded leads coming out of each resistor body. Connect as shown in Figure 4.6.

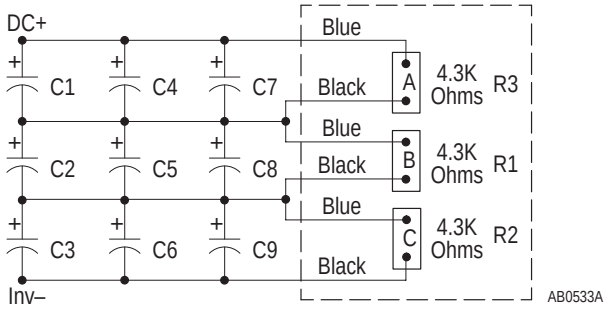
**Figure 4.6**
**Wiring Detail for C075 and C100 Drives**

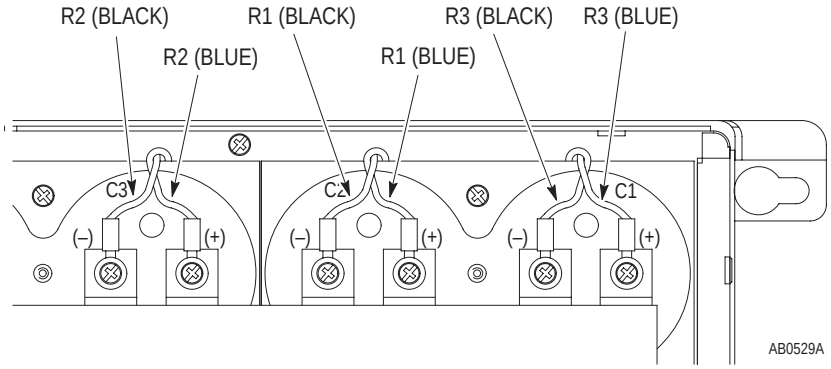


Load-sharing resistors R1, R2, and R3 have two color coded leads coming out of each resistor body. Connect as shown in Figure 4.7.

**Figure 4.7**
**Wiring Detail for C125 Drives**

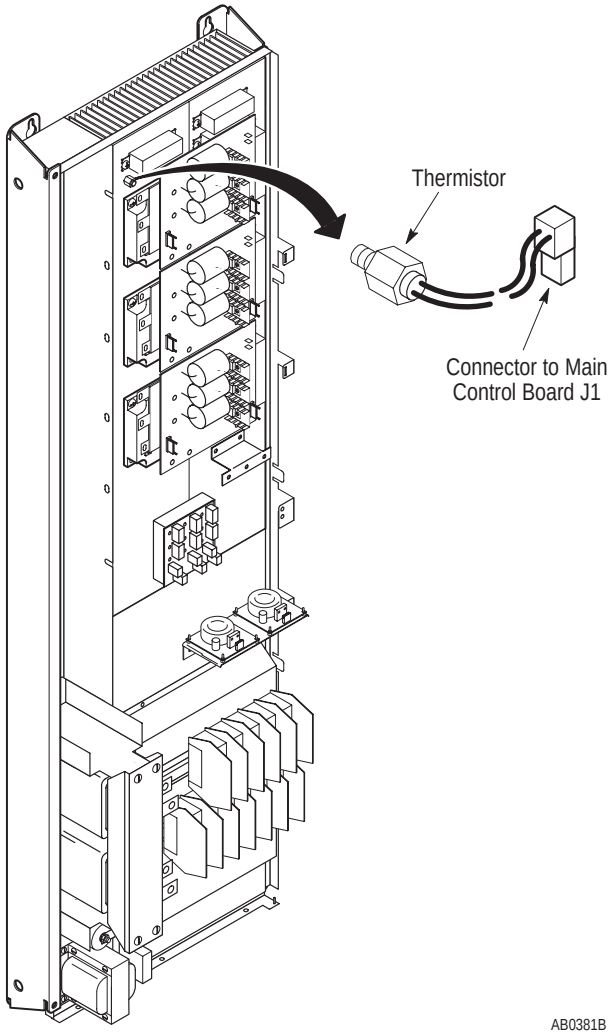


## Thermistor

The Thermistor is located on the top-left corner of the heat sink.

**Figure 4.8**
**Thermistor**




## Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Disconnect the Thermistor connector at J1 on the Main Control Board.
5. Remove the Gate Driver Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver Board Mounting Plate.
6. Cut and remove tie wraps along the wire routing path of the Thermistor.
7. Remove the Thermistor from the heat sink.

### Installation

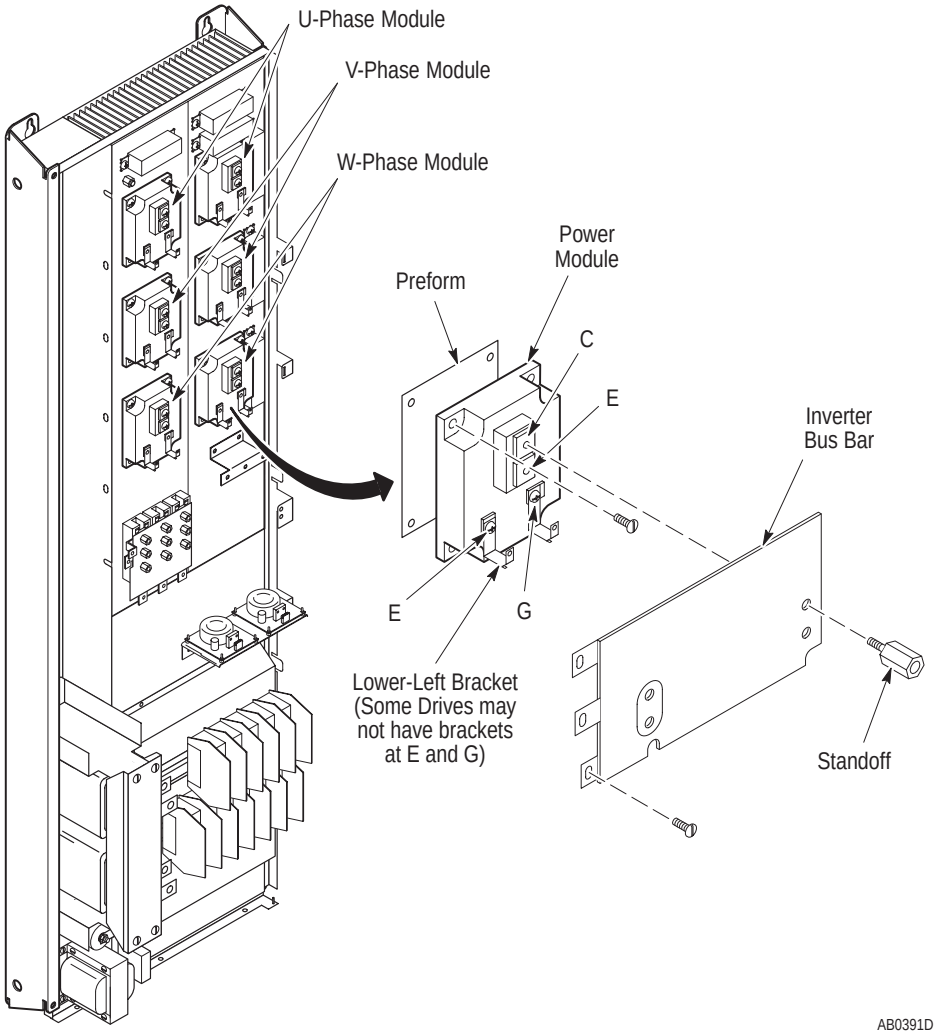
Install the Thermistor in reverse order of removal, replacing tie wraps as needed. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Power Modules

The Power Modules are located near the top of the heat sink.

**Figure 4.9**
**Power Modules**



### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver Board Mounting Plate.
5. Remove the Power Module Snubber Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.
6. Remove the three screws located at (+), (–), and MTR on the Inverter Bus Bar.

7. Remove the four standoffs from the Inverter Bus Bar.
8. Remove the four screws fastening the Power Module to the Drive.

### Installation

1. Clean all surfaces between the Power Module and the heat sink using a soft, clean cloth.
2. Replace the Preform between the Power Module and the heat sink.
3. Install the Power Module in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

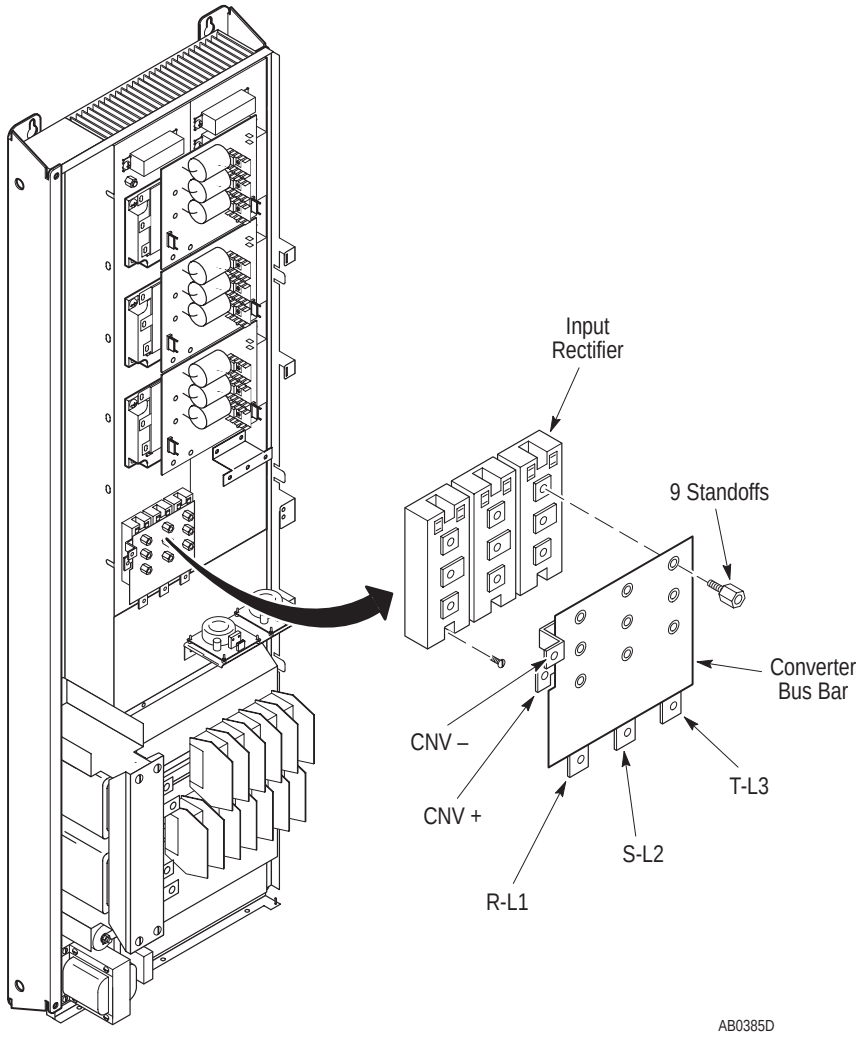
**Important:** Slide the MTR tab on the Inverter Bus Bar under the corresponding tab on the Transition Bus Bar.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Input Rectifiers

The Input Rectifiers are located at the bottom of the heat sink.

**Figure 4.10**
**Input Rectifiers**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver Board Mounting Plate.
5. Remove the Precharge Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Precharge Board Mounting Plate.
6. Remove the Converter Snubber Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Converter Snubber Board.
7. Remove all cable connections from the Converter Bus Bars.
8. Remove the standoffs and the Converter Bus Bar from the rectifiers.
9. Remove the screws fastening the Input Rectifier to the drive.

### Installation

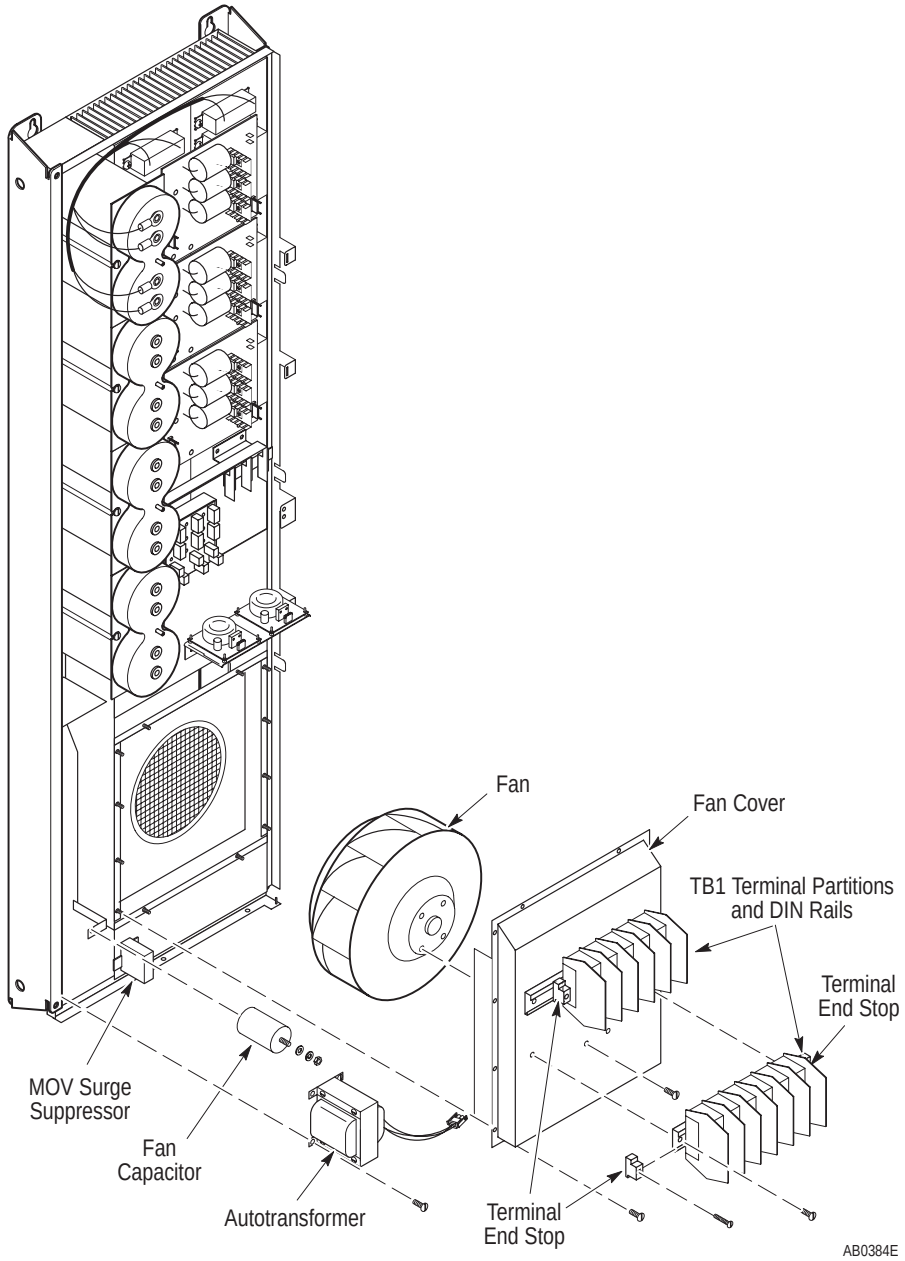
1. Clean all surfaces between the Input Rectifier and the heat sink using a soft, clean cloth.
2. Replace the Preform between the Input Rectifier and the heat sink.
3. Install the Input Rectifier in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Fan Assembly

The Fan is located under TB1 at the bottom of the Main Chassis. The Autotransformer and Fan Capacitor are located in the bottom left corner of the Main Chassis.

**Figure 4.11**
**Fan Assembly**



### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

Access the Drive:

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Disconnect the wiring as follows:
   - Wire harness connecting the Fan to the Autotransformer
   - Ground wire from the ground stud
   - MOV Surge Suppressor wire from the ground stud
   - All wires from TB1

Remove the Upper DIN Rail:

1. Loosen the screw fastening the Terminal End Stop to the left side of the Upper DIN Rail to remove the end stop, exposing a screw on the DIN rail.
2. Remove the exposed screw from the DIN rail.
3. Slide the TB1 terminals to the left to expose the other screw on the Upper DIN Rail.
4. Remove the exposed screw from the DIN rail to remove the Upper DIN Rail from the Fan Cover.

Remove the Lower DIN Rail:

1. Loosen the screw fastening the Terminal End Stop to the right side of the Lower DIN Rail to remove the end stop.
2. Slide TB1 terminal W-M3 off the DIN rail to expose a screw on the DIN rail.
3. Remove the exposed screw from the DIN rail.
4. Slide the TB1 terminals to expose the other screw on the lower DIN rail.
5. Remove the exposed screw from the DIN rail to remove the lower DIN rail from the Fan Cover.
6. Remove the screws fastening the Fan Cover to the Main Chassis.
7. Lift the fan and cover from the Drive.
8. Remove the screws fastening the Fan to the Fan Cover to remove the Fan from the cover.
9. Remove the nut fastening the Fan Capacitor to the bracket to remove the capacitor.

### Installation

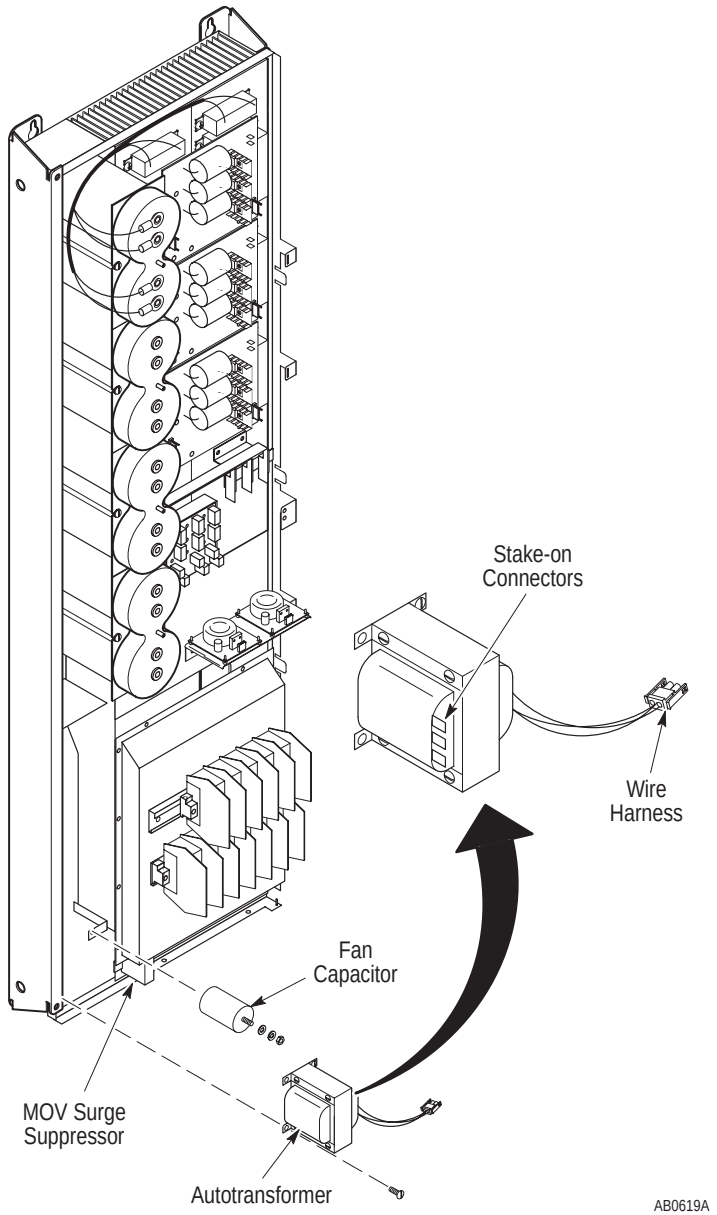
1. Thread the Fan wire through the hole in the Fan Cover.
2. Fasten the Fan to the Fan Cover.
3. Install the Fan and capacitor in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Autotransformer

The Autotransformer and Fan Capacitor are located in the bottom left corner of the Main Chassis.

**Figure 4.12**
**Autotransformer**



### Removal

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Autotransformer wire from TB1 terminal S-L2.
5. Remove the wire from the Autotransformer stake-on connector. Note the location of the stake-on connector for installation.
6. Disconnect the wire harness connecting the Autotransformer to the Fan.
7. Remove the screws fastening the Autotransformer to the chassis.

### Installation

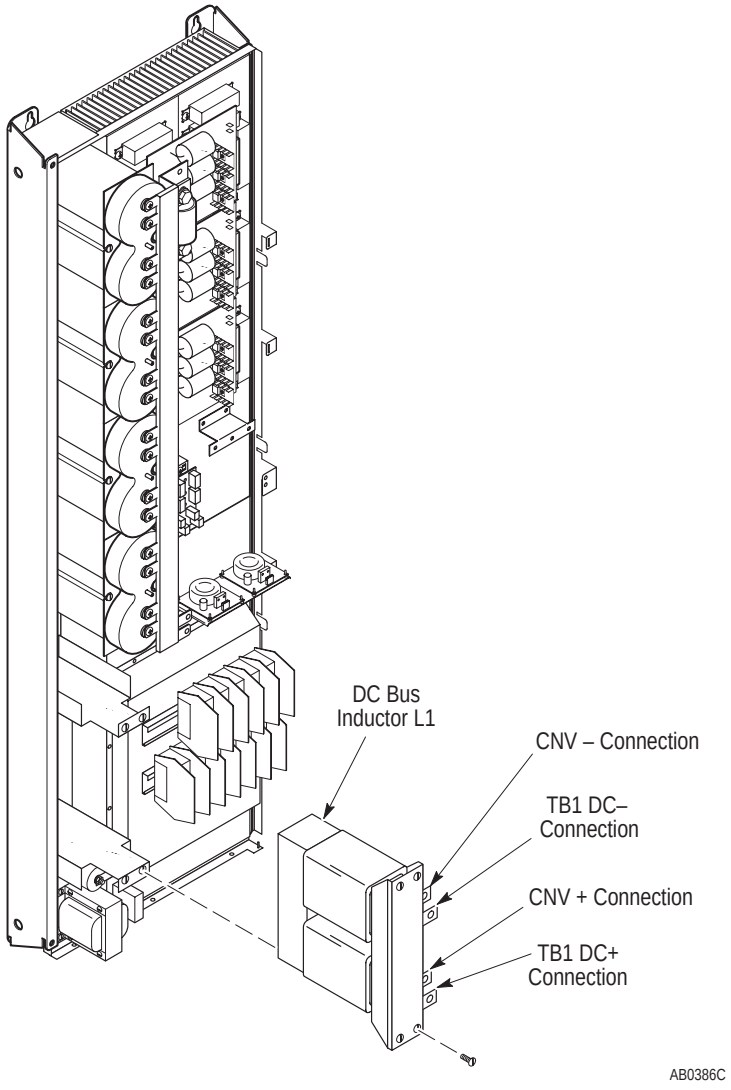
Install the Autotransformer in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

**Important:** On the replacement Autotransformer, connect the wire from Removal Step 5, above, to the same stake-on connector from which the wire was removed. Refer to the Fan wiring diagram in the Schematics section of this manual for correct transformer-tap voltage.

## DC Bus Inductor L1

DC Bus Inductor L1 is located on the lower left corner of the Drive.

**Figure 4.13**
**DC Bus Inductor L1**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the guard.
5. Remove the wires from the Bus Inductor terminals.
6. Remove the four screws fastening the Bus Inductor to the drive.
7. Lift the Bus Inductor out of the drive.

### Installation

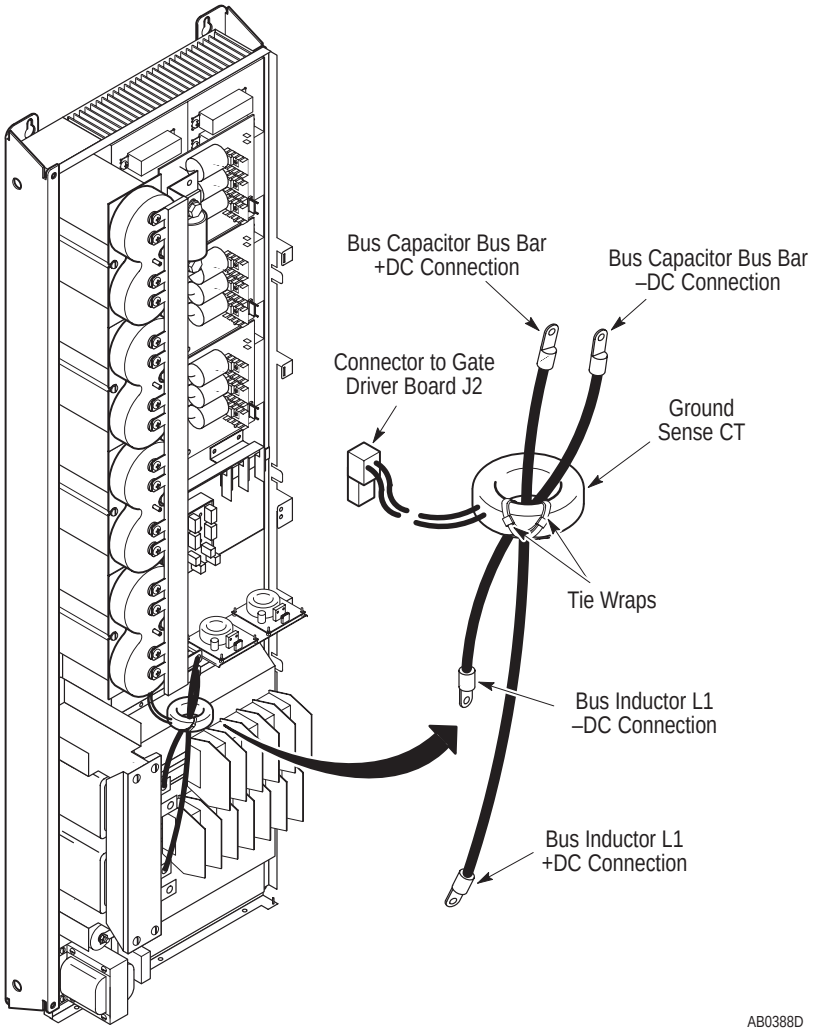
1. Lower the inductor into the Main Chassis, inserting the inductor into the bottom inductor bracket.
2. Install DC Bus Inductor L1 in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Ground Sense CT

The Ground Sense CT is located in the lower left of the Drive.

**Figure 4.14**
**Ground Sense CT**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Disconnect the Ground Sense CT from Gate Driver Board connector J2.
5. Remove the Bus Capacitor Guard.
6. Remove the following:
   - Bus Capacitor Bus Bar DC+ wire.
   - Bus Capacitor Bus Bar DC– wire.
   - Bus Voltage Wire Harness
7. Cut the tie wraps from the Ground Sense CT.
8. Slide the Ground Sense CT off the Bus Capacitor wires.

### Installation

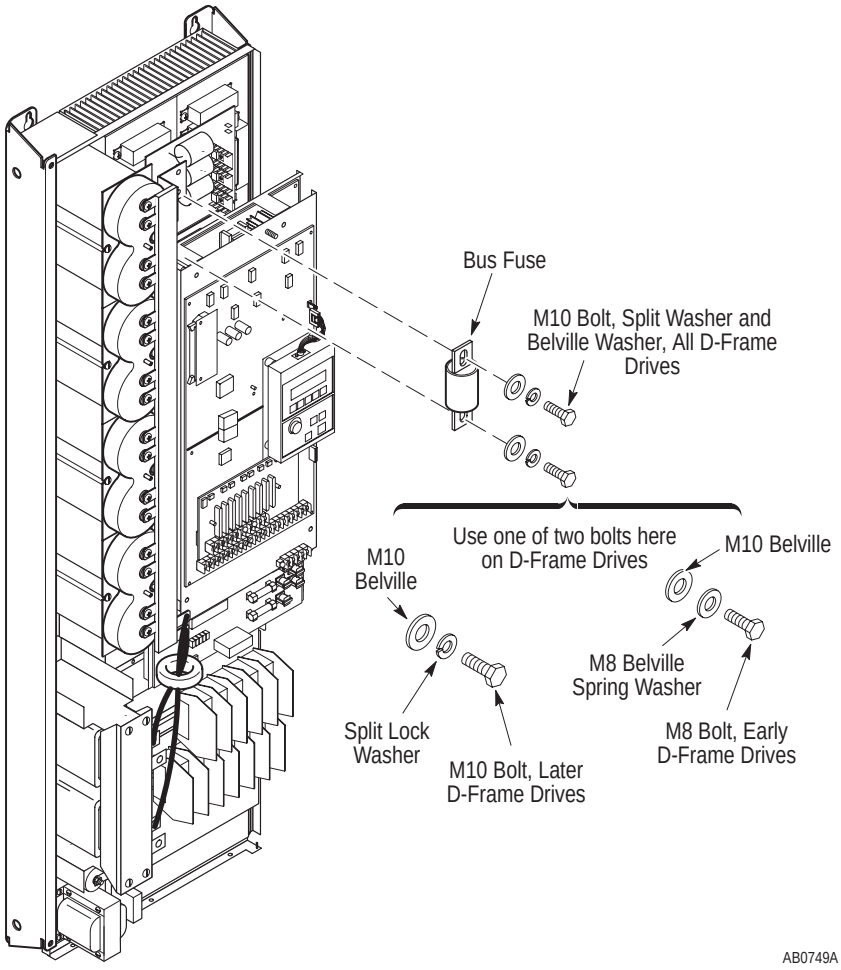
1. Place the Bus Capacitor wires through the center of the Ground Sense CT.
2. Install the Ground Sense CT in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## Bus Fuse

The Bus Fuse is located at the top-center of the Drive.

**Figure 4.15**
**Bus Fuse**




### Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Bus Capacitor Guard. Refer to Bus Capacitor Bank in this chapter.
5. Remove the two bolt-and-washer assemblies fastening the Bus Fuse to the drive.

### Installation

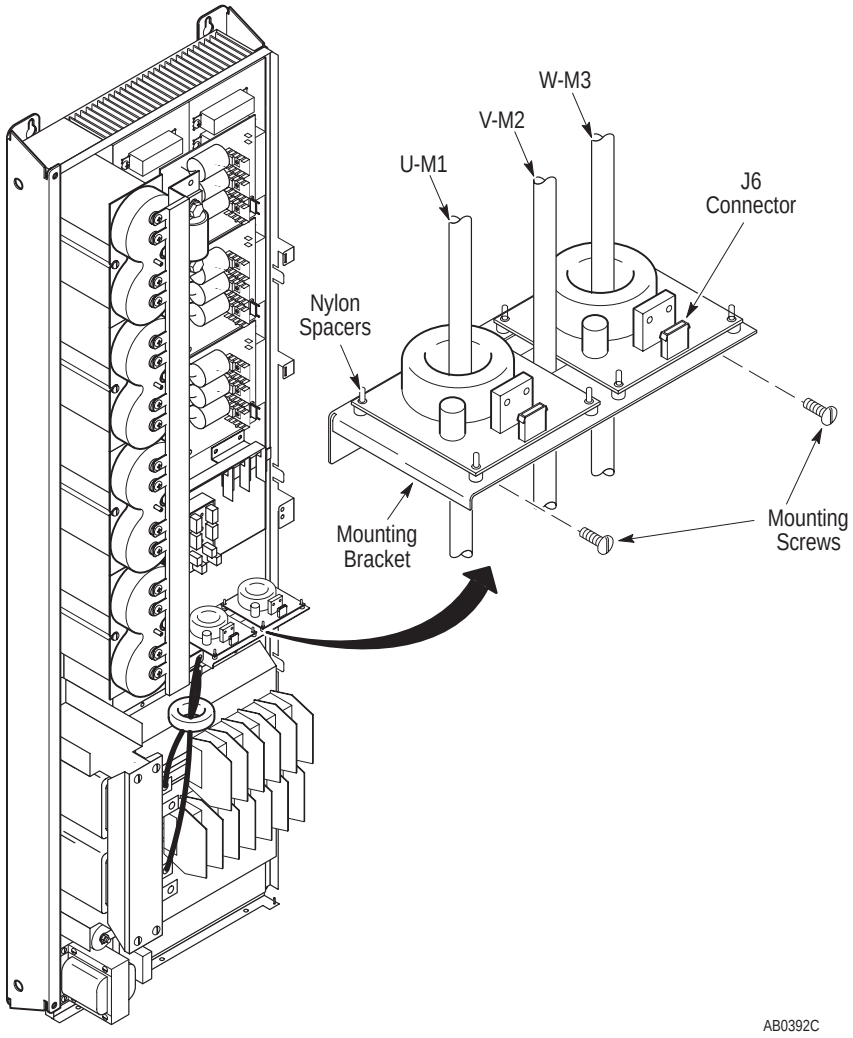
Install the Bus Fuse in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## LEMs

The LEMs are located near the bottom of the heat sink.

**Figure 4.16**
**LEMs**




## Removal

**ATTENTION:** Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Precharge Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Precharge Board Mounting Plate.
5. Remove Gate Driver Board Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver Board Mounting Plate.
6. Disconnect the Inverter output wires, running through the LEMs, from Motor Bus Bar terminals:
   - U-M1
   - V-M2
   - W-M3
7. Disconnect the J6 Connector wiring harness from the LEMs.
8. Remove the screws fastening the LEM mounting bracket to the heat sink.

**9.** Slide the LEM mounting bracket off of Inverter output wires.

**10.** Compress the tabs on the nylon spacers to remove the LEM from the mounting bracket.

### Installation

Install the LEMs in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

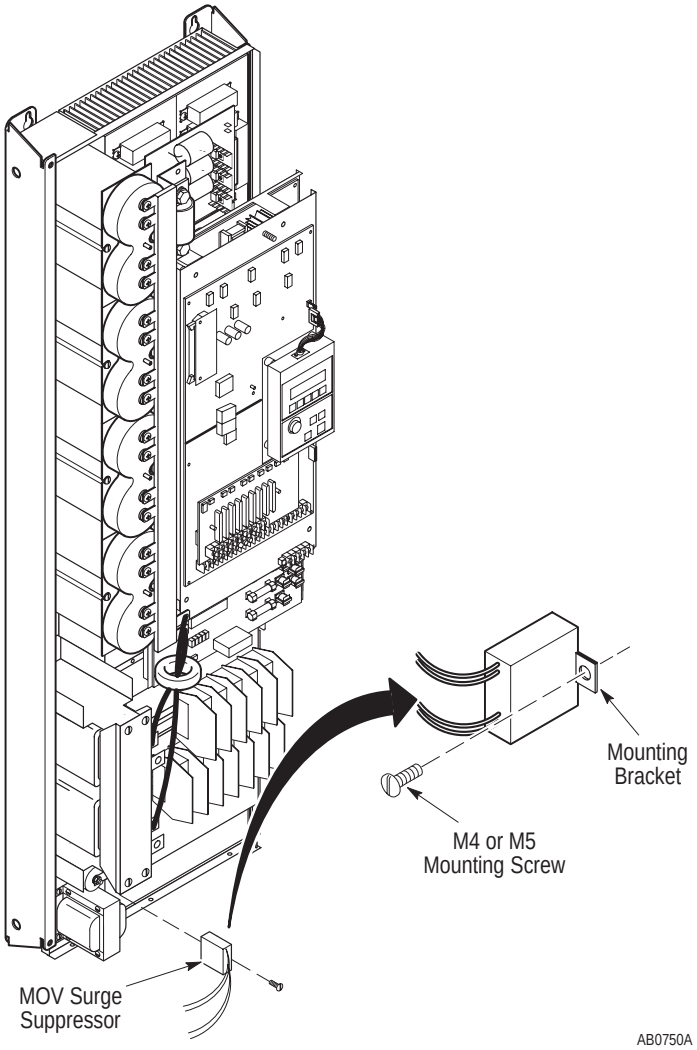
**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

## MOV Surge Suppressor

The MOV Surge Suppressor is located in the bottom-left corner of the Drive near the Autotransformer and Fan Capacitor.

The MOV protects the drive from high voltage surges above approximately 1,000 volts. Replace the MOV if it is burned, expanded, or ruptured after such events as a lightening strike or inadvertent connection of the drive input to a voltage source substantially above nameplate voltage.

**Figure 4.17**
**MOV Surge Suppressor**



### Removal

**ATTENTION:** Hazard of electric shock exists. Up to 1,000 V DC may be present on Snubber Capacitors. Measure for zero V DC across capacitors C2, C3, and C4. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

**ATTENTION:** Wear a wrist-type grounding strap when servicing 1336 FORCE Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

**Important:** Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Disconnect the MOV wires from TB1 terminals L1, L2, and L3 (R, S, and T).
5. Disconnect the MOV wire from the ground stud.
6. Remove the screw fastening the MOV to the Main Chassis.

### Installation

Install the MOV Surge Suppressor in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.

**Important:** Install the MOV using the same M4 or M5 screw as was removed.

**ATTENTION:** Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

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# Replacement Parts List

## Chapter Objectives

This chapter illustrates and lists replacement parts for the 1336 FORCE Drives rated A040 – A060, B060 – B125, BX150, and C075 – C125 and describes replacement parts ordering procedures.

The following illustration and table show you parts, part names, part numbers, locations, and chapters for replacement procedures.

## Ordering Replacement Parts

For your convenience, the Allen-Bradley Drives Division and the Allen-Bradley Support Division provide efficient and convenient repair and exchange for eligible equipment.

A product service report number is required to return any equipment for repair. Your local Allen-Bradley distributor or area sales and support office can provide you with a product service report number.

You should return equipment to be repaired to the area sales and support center nearest you. Reference the product service report number on the carton and packing slip. Include:

- Your company name
- Your company address
- The repair purchase order number
- A brief description of the problem

Contact your local Allen-Bradley distributor or sales office for a complete listing of area sales and support centers near you.

For parts catalog numbers, refer to the 1336 FORCE Spare Parts Pricing publication included with your drive documentation set.

# Replacement Parts Listing

**Figure 5.1**
**Parts for A040 – A060, B060 – B125, BX150, and C075 – C125 Drives**

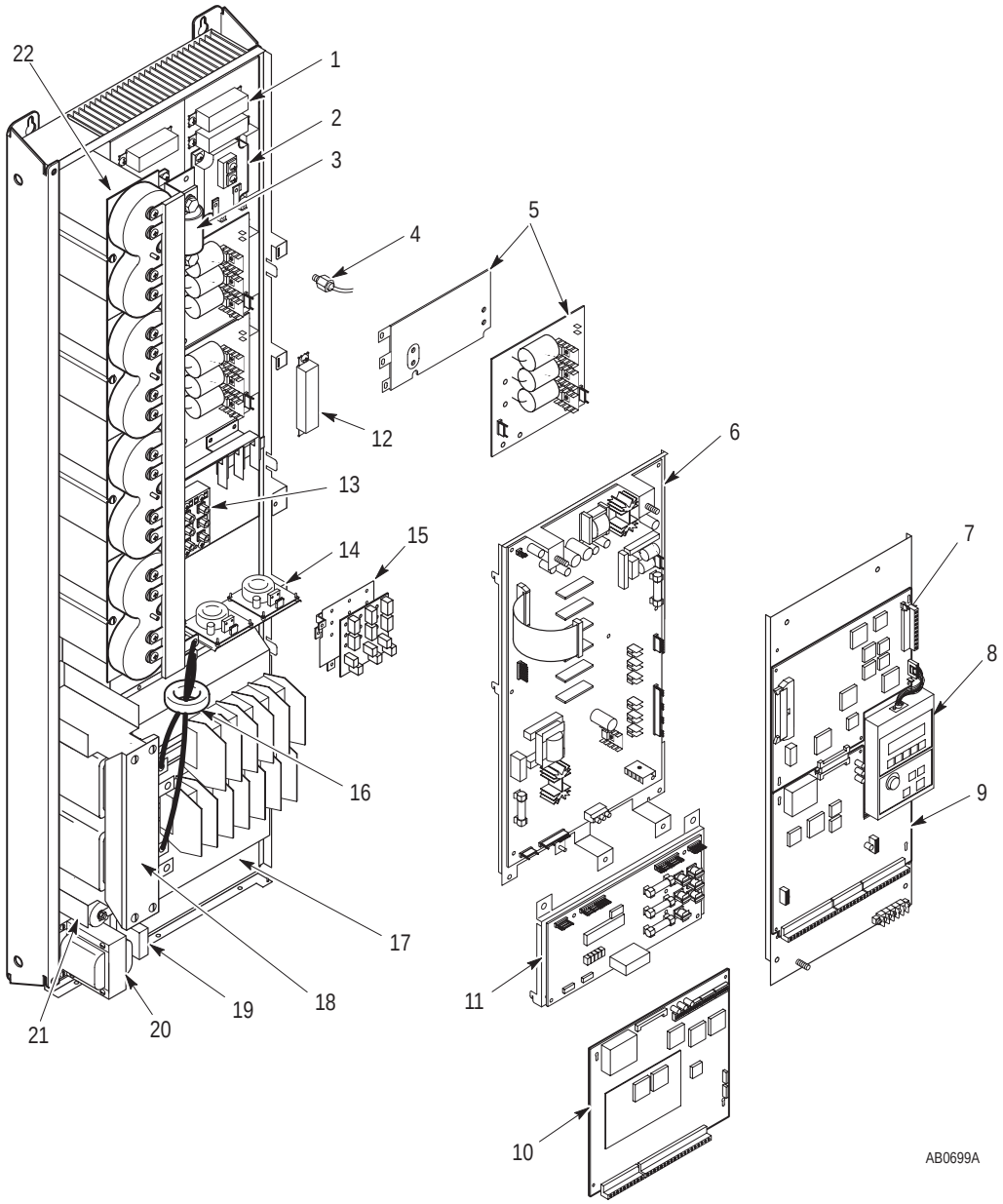

**Table 5.A**
**Replacement Parts for A040 – A060, B060 – B125, BX150, and C075 – C126 Drives**

| Callout | Symbol | Description | Location | Replacement Procedures |
|---|---|---|---|---|
| 1 | R1 – R3 | Load-Sharing Resistor | Main Chassis | Chapter 4, Bus Capacitor Bank |
| 2 | Q1 – Q6 | IGBT | Heat Sink | Chapter 4, Power Modules |
| 3 | F1 | Bus Fuse | Cap Bus Bar | Chapter 4, Bus Fuse F1 |
| 4 | ST NTCI | Thermistor | Heat Sink | Chapter 4, Thermistor |
| 5 | SNUBBER BOARD | Inverter Bus Bar and Snubber Board | Heat Sink | Chapter 2, Removing a Power Module Snubber Board |
| 6 | BASEDR/PWRSPLY | Gate Driver Board | Gate Driver Board Mounting Plate | Chapter 2, Removing the Gate Driver Board |
| 7 | MAIN CTL | Main Control Board | Control Board/Adapter Mounting Plate | Chapter 2, Removing the Main Control Board |
| 8 | HIM | Human Interface Module | Control Board/Adapter Mounting Plate | Chapter 1, Module Removal |
| 9 | GT2 | Standard Adapter Board | Control Board/Adapter Mounting Plate | Chapter 2, Removing the Standard Adapter Board |
| 10 | GT1 | PLC Comm Adapter Board | Control Board/Adapter Mounting Plate | Chapter 2, Removing the PLC Comm Adapter Board |
| 11 | PRECHARGE | Precharge Board | Precharge Board Mounting Plate | Chapter 2, Removing the Precharge Board |
| 12 | R20 – R22 | Power Module Snubber Resistor | Main Chassis | Chapter 2, Removing a Power Module Snubber Board |
| 13 | SCR1 – SCR3 | Input Rectifier | Heat Sink | Chapter 4, Input Rectifiers |
| 14 | CT1, CT2 | LEM | Main Chassis | Chapter 4, LEMs |
| 15 | SCR SNUBBER BOARD | Converter Snubber Board | Heat Sink | Chapter 2, Removing the Converter Snubber Board |
| 16 | CT3 | Ground Sense CT | — | Chapter 4, Ground Sense CT |
| 17 | FAN | Fan | Main Chassis | Chapter 4, Fan and Transformer |
| 18 | L1 | DC Bus Inductor | Main Chassis | Chapter 4, DC Bus Inductor L1 |
| 19 | MOV1 | MOV Surge Suppressor | Main Chassis | Chapter 4, Autotransformer |
| 20 | T1 | Autotransformer | Main Chassis | Chapter 4, Autotransformer |
| 21 | C-HB1 | Fan Capacitor | Main Chassis | Chapter 4, Autoransformer |
| 22 | C1 – C6 | Bus Capacitors | Main Chassis | Chapter 4, Bus Capacitor Bank |

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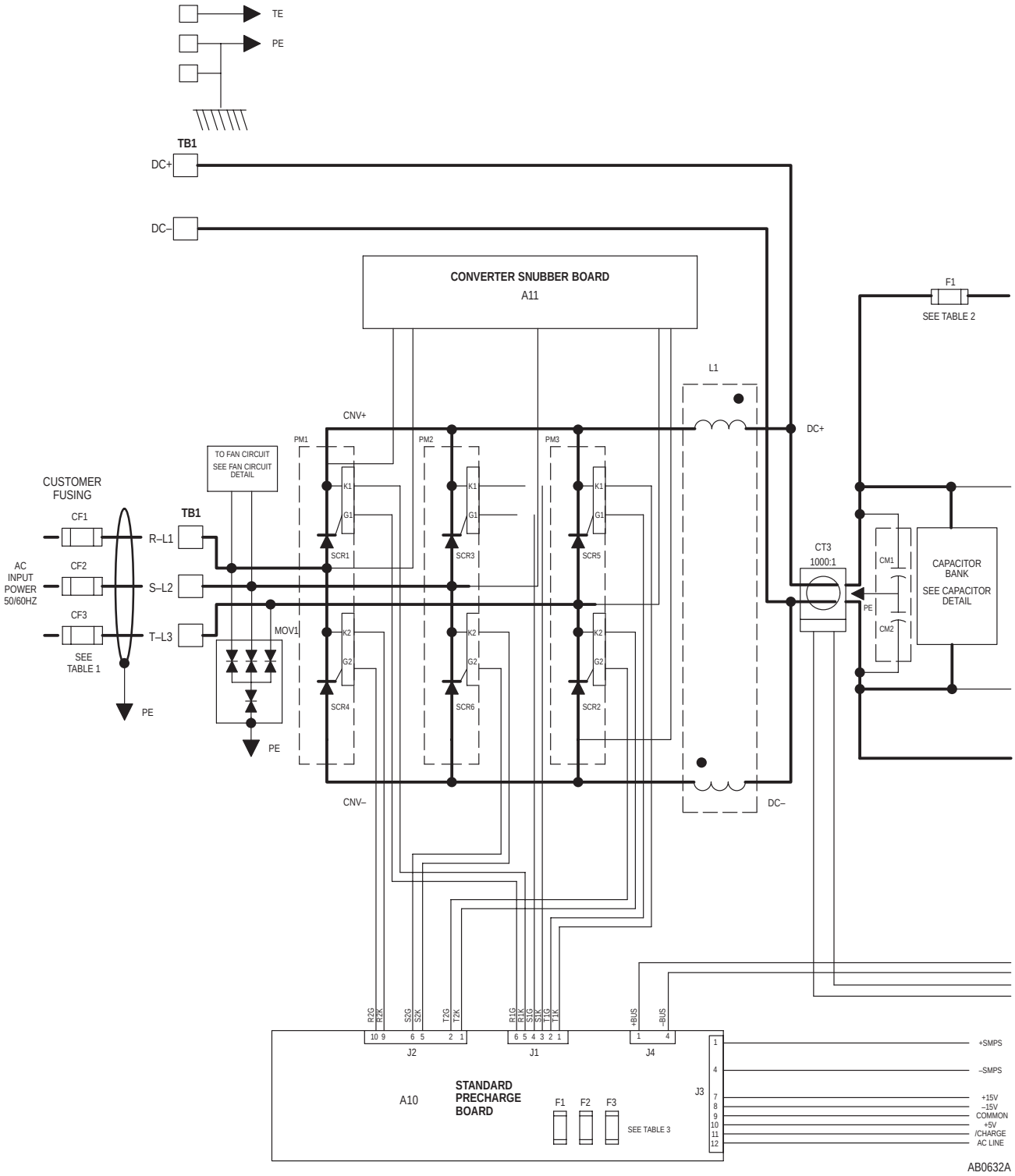
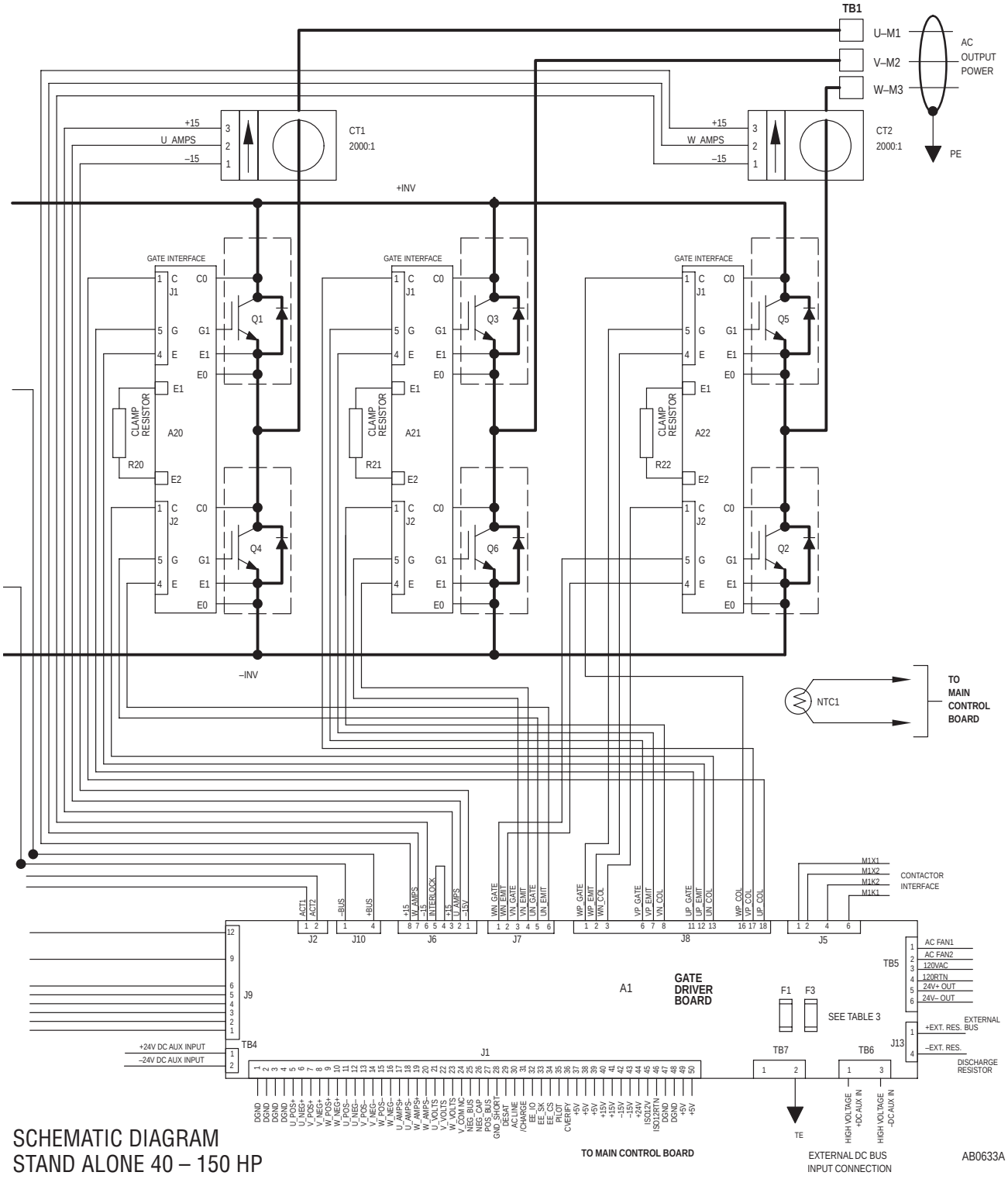
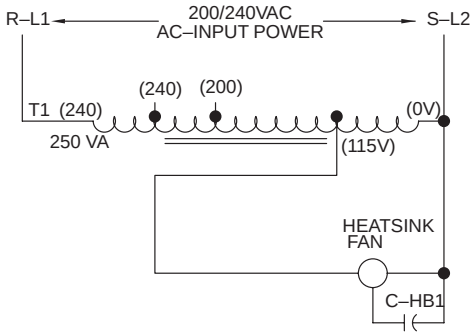
# Schematics — 40 – 150 HP 1336 FORCE Drives


TE
PE
TB1
DC+
DC–
CONVERTER SNUBBER BOARD
A11
F1
SEE TABLE 2
L1
CNV+
PM1
PM2
PM3
DC+
TO FAN CIRCUIT
SEE FAN CIRCUIT DETAIL
CUSTOMER FUSING
CF1
CF2
CF3
AC INPUT POWER 50/60HZ
R–L1
S–L2
T–L3
SEE TABLE 1
PE
MOV1
K1
G1
K2
G2
SCR1
SCR3
SCR5
SCR4
SCR6
SCR2
CT3
1000:1
CM1
CM2
CAPACITOR BANK
SEE CAPACITOR DETAIL
CNV–
DC–
R2G
R2K
S2G
S2K
T2G
T2K
R1G
R1K
S1G
S1K
T1G
T1K
+BUS
–BUS
J2
J1
J4
J3
A10
STANDARD PRECHARGE BOARD
F1
F2
F3
SEE TABLE 3
+SMPS
–SMPS
+15V
–15V
COMMON
+5V
/CHARGE
AC LINE
AB0632A

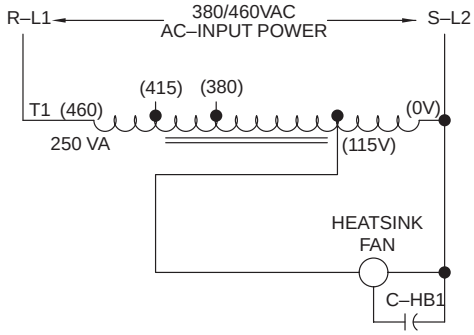



SCHEMATIC DIAGRAM
STAND ALONE 40 – 150 HP

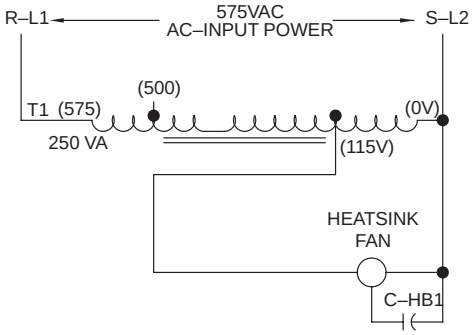
## Fan Circuit Detail




200/240V




380/460V




575V

## Capacitor Detail

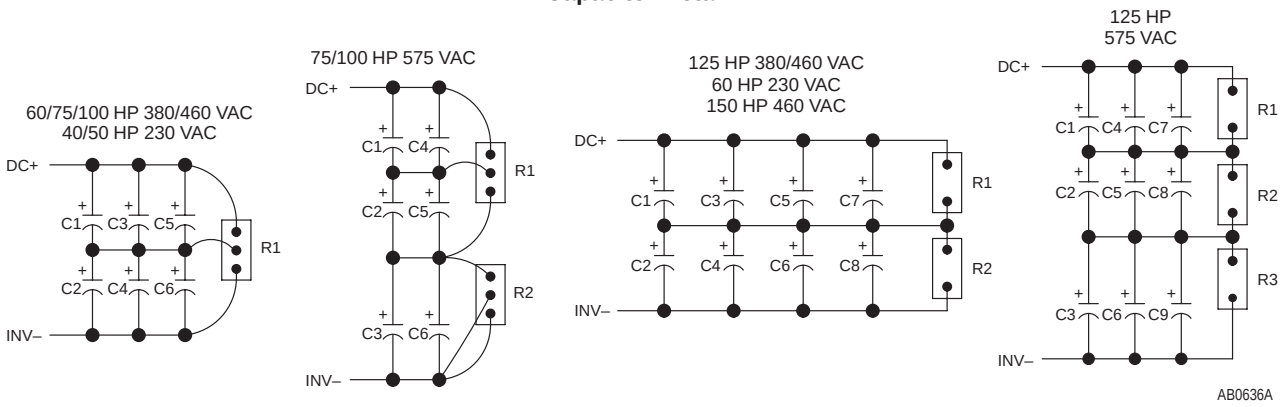


TABLE 1: CUSTOMER FUSING
BASED ON MAXIMUM DRIVE RATING THE FOLLOWING FUSES OR APPROVED EQUIVALENT MUST BE USED:

| HORSEPOWER | 230VAC FUSE CURRENT/TYPE | 380/460VAC FUSE CURRENT/TYPE | 575VAC FUSE CURRENT/TYPE |
|---|---|---|---|
| 40 | 150 AMP, CLASS T, JJS | – | – |
| 50 | 200 AMP, CLASS T, JJS | – | – |
| 60 | 250 AMP, CLASS T, JJS | 125 AMP, CLASS T, JJS | – |
| 75 | – | 150 AMP, CLASS T, JJS | 110 AMP, CLASS T, JJS |
| 100 | – | 200 AMP, CLASS T, JJS | 150 AMP, CLASS T, JJS |
| 125 | – | 250 AMP, CLASS T, JJS | 175 AMP, CLASS T, JJS |
| 150 | – | 250 AMP, CLASS T, JJS | |

TABLE 2: BASED ON DRIVE HORSEPOWER, THE INVERTER DC + BUS FUSE WILL CHANGE AMP RATING. THE TABLE BELOW DEFINES THE FUSE RATING.

| DRIVE HORSEPOWER, INPUT VOLTAGE | FUSE INFORMATION | | |
|---|---|---|---|
| | RATING | TYPE | P/N |
| 40HP, 230VAC | 150 AMP | A70Q150–4 | 25178–310–10 |
| 50HP, 230VAC | 200 AMP | A70Q200–4 | 25178–310–12 |
| 60HP, 230VAC | 250 AMP | A70Q250–4 | 25178–310–13 |
| 60HP, 380VAC | 125 AMP | A70Q125–4 | 25178–310–09 |
| 75HP, 380/460VAC | 150 AMP | A70Q150–4 | 25178–310–10 |
| 75HP, 575VAC | 125 AMP | A70Q125–4 | 25178–310–09 |
| 100HP, 380/460VAC | 200 AMP | A70Q200–4 | 25178–310–12 |
| 100HP, 575VAC | 175 AMP | A70Q175–4 | 25178–310–11 |
| 125HP, 380/460VAC | 250 AMP | A70Q250–4 | 25178–310–13 |
| 125HP, 575VAC | 200 AMP | A70Q200–4 | 25178–310–12 |
| 150HP, 460VAC | 250 AMP | A70Q250–4 | 25178–310–13 |

TABLE 3: THE FOLLOWING IS A LISTING OF ALL PRINTED CIRCUIT ASSEMBLIES VERSUS FUSE & DOCUMENTATION INFORMATION.

| ITEM | B/M | SCHEMATIC DIAGRAM | FUSE INFORMATION | | | |
|---|---|---|---|---|---|---|
| | | | DESIGNATOR | RATING | TYPE | P/N |
| A1 | 74101–169–XX | 74101–167 | F1 | 1.0A/600V | KTK–R | 25172–260–08 |
| | | | F3 | 1.5A/600V | KTK–R | 25172–260–09 |
| A10 | 74101–181–XX | 74101–179 | F1–F3 | 1.5A/600V | KTK–R | 25172–260–09 |
| A11 | 74101–099–51 | 74101–077 | NONE | – | – | – |
| A20–22 | 74101–032–XX | 74101–022 | NONE | – | – | – |
| | | | | | | |
| | | | | | | |

AB0635A

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# Glossary

**AC Contactor:** An alternating-current (AC) contactor is designed for the specific purpose of establishing or interrupting an AC Power circuit.

**Adjustable Speed:** The concept of varying the speed of a motor, either manually or automatically. The desired operating speed (set speed) is relatively constant regardless of load.

**Adjustable Speed Drive (Electrical):** The adjustable speed drive is comprised of the motor, drive controller and operator's controls (either manual or automatic).

**Ambient Temperature:** The temperature of the medium (air, water, earth) into which the heat of the equipment is dissipated.

**Base Speed:** The manufacturer's nameplate rating where the motor will develop rated power at rated load and voltage. With DC drives, it is commonly the point where full armature voltage is applied with full-rated field excitation. With AC systems, it is commonly the point where 60 Hz is applied to the induction motor.

**BR:** Refer to *Bridge Rectifier.*

**Braking:** A method of stopping or reducing the time required to stop an AC motor, and can be accomplished in several ways:

1. DC-Injection braking (AC drives) — A method which produces electromagnetic braking forces in the motor by removing 2 AC motor (stator) phases and injecting DC current. The result is a linear braking characteristic (ramp) that does not diminish with motor speed. Application is normally limited to 10–20% of rated motor speed due to increased heating in the rotor.
2. Dynamic braking (AC drives) — A method which produces electromagnetic braking forces in the motor by dissipating generated power into the DC bus through a resistive load. Braking force remains constant and is only limited by the thermal capacity of the resistors. The result is a linear braking characteristic (ramp) that does not diminish with motor speed.
3. Regenerative braking — A method which produces electromagnetic braking forces in the motor by electronically controlling the return of generated power to the AC supply. The result is a controllable linear braking characteristic (ramp) that does not diminish with motor speed.

4. Motor-mounted or separately-mounted brake — A positive-action, mechanical friction device. Normal configuration is such that when the power is removed, the brake is set. This can be used as a holding brake. (Note: A separately mounted brake is not one which is located on some part of the mechanical drive train other that the motor.)

**Breakaway Torque:** The torque required to start a machine from standstill. Breakaway torque is always greater than the torque needed to maintain motion.

**Breakdown Torque:** The breakdown torque of an AC motor is the maximum torque which it will develop with rated voltage applied at rated frequency.

**Bridge Rectifier (Diode, SCR):** A non-controlled, full-wave rectifier that produces a constant, rectified, DC voltage. An SCR bridge rectifier is a full-wave rectifier with a DC output that can be controlled by switching on the gate control element.

**Bridge Rectifier:** A full-wave rectifier that conducts current in only one direction of the input current. AC applied to the input results in approximate DC at the output.

**British Thermal Unit (BTU):** The quantity of heat required to raise one pound of water by one degree Fahrenheit.

**BTU:** Refer to *British Thermal Unit*.

**Bus:** A single path or multiple parallel paths for power or data signals to which several devices may be connected at the same time. A bus may have several sources of supply and/or several sources of demand.

**Bus Sense:** A signal transducer that generates a signal proportional to the current in the drive's DC bus. The control logic uses this signal to sense the presence or absence of bus voltage.

**CEMF:** Refer to *Counter Electromotive Force*.

**CMOS:** Complimentary Metallic Oxide Semiconductor. A semiconductor device in which an electric field controls the conductance of a channel under a metal electrode called a gate.

**Cogging:** A condition in which a motor does not rotate smoothly but steps or jerks from one position to another during shaft revolution. Cogging is most pronounced at low motor speeds and can cause objectionable vibrations in the driven machinery.

**Constant Torque Range:** A speed range in which a motor is capable of delivering a constant torque, subject to cooling limitations of the motor.

**Constant Voltage Range:** (AC Drives) The range of motor operation where the drive's output voltage is held constant as output frequency is varied. This speed range produces motor performance similar to a DC drive's constant horsepower range.

**Constant Volts per Hertz (V/Hz):** The V/Hz relationship exists in AC drives where the output voltage is directly proportional to frequency. This type of operation produces constant rated torque as the motor's speed varies.

**Continuous Duty (CONT):** A motor that can continue to operate without stopping and remain within the insulation temperature limits after it has reached normal operating (equilibrium) temperature.

**Converter:**

1. A device for changing AC to DC. This is accomplished through use of a diode rectifier or thyristor rectifier circuit.
2. A device for changing AC to DC to AC (e.g., adjustable frequency drive). A frequency converter, such as that found in an adjustable frequency drive, consists of a rectifier, a DC intermediate circuit, an inverter, and a control unit.

**Counter Electromotive Force (CEMF):** The product of a motor armature rotating in a magnetic field. This generating action takes place whenever a motor is rotating. Under stable motoring conditions the generated voltage (CEMF) is equal to the voltage supplied to the motor minus small losses. However, the polarity of the CEMF is opposite to that of the power being supplied to the armature.

**Current Limiting:** An electronic method of limiting the maximum current available to the motor. This is adjustable so that the motor's maximum current can be controlled. It can also be preset as a protective device to protect both the motor and the control from extended overloads.

**DC Boost:** Compensates for the voltage drop across the resistance of an AC motor circuit and the resulting reduction in torque.

**DC Bus:** A drive's power structure that transmits a rectified AC line power from the bridge rectifier to the output transistors.

**DC Hold:** Describes a "holding brake" function to stop motor rotation after a ramp-to-stop function is activated.

**Diode:** A solid-state uni-directional conductor.

**Drift:** A slow change in some characteristic of a device. For a drive, it is the deviation from the initial set speed with no load change over a specific time period. Normally the drive must be operated for a specified warm-up time at a specified ambient temperature before drift specifications apply. Drift is normally caused by random changes in operating characteristics of various control components.

**Drive Controller (Variable Speed Drive) (Drive):** An electronic device that can control the speed, torque, horsepower, and direction of an AC or DC motor.

1. PWM drive — is a motor drive using pulse-width modulation techniques to control power to the motor. A high-efficiency drive used for high-response applications.
2. SCR drive — is a motor drive that uses SCRs as the power control elements. Usually used for low-bandwidth high-power applications.
3. Servo drive — is a motor drive that uses internal feedback loops for motor current and/or velocity.
4. Vector drive — is an AC static motor drive using power-control techniques that produce motor performance similar to DC static drives.

**Duty Cycle:**

1. The ratio of working time to total time for an intermittently operating device. Usually expressed as a percentage.
2. The ratio of pulse width to the interval between like portions of successive pulses. Usually expressed as a percentage.

**Dynamic Braking:** Refer to *Braking*.

**Efficiency:** Ratio of output to input, indicated by a percentage. In a motor, it is the effectiveness with which the motor converts electrical energy into mechanical energy. In a power supply, it is the effectiveness with which the power supply converts AC power into DC power.

**Electrostatic Discharge (ESD):** A static-electricity discharge that may damage drive components. Refer to the ESD precautions found in this manual to guard against damage to drive components.

**Enable:** To activate logic by the removal of a suppression signal.

**Enclosure:** The housing in which equipment is mounted. They are available in designs for various environmental conditions. Refer to NEMA standard for specifications of different types of enclosures.

**ENUM (Enumeration):** An ANSI C standard extension to the C language. An ENUM is a set of named integer constants that specify all the legal values a variable of a given type may have. The keyword ENUM signals the start of an enumeration type.

**ESD:** Refer to *Electrostatic Discharge*.

**Floating Ground:** An electrical circuit common which is not at earth ground potential or the same ground potential as circuitry with which it interfaces. A voltage difference can exist between the floating ground and earth ground.

**Force:** The tendency to change the motion of an object with an exertion of energy from a separate source.

**Full Load Torque:** The full-load torque of a motor is the torque necessary to produce rated horsepower at full-load speed.

**Gate:**

1. A logic element that blocks or passes a signal, depending on the status of specified input signals.
2. The control element of an SCR.

**GND Sense:** A current transducer that detects an unequal or imbalanced current in the three-phase AC line or DC bus of the drive. The imbalance indicates an output ground fault condition.

**Horsepower (hp):** A unit of power: 1 hp = 33,000 ft-lb/min. = 746 watts.

**IEC:** International Electrotechnical Commission.

**IGBT:** Refer to *Insulated Gate Bipolar Transistor.*

**Induction Motor:** An induction motor is an alternating-current motor in which the primary winding on one member is connected to the power source. A secondary winding on the other member carries the induced current. There is no physical electrical connection to the secondary winding; its current is induced.

**Inertia:** A measure of a body's resistance to change in velocity, whether a body is at rest or moving at a constant velocity. The velocity can be either linear or rotational. The moment of inertia ($WK^2$) is the product of the weight (W) of an object and the square of the radius of gyration ($K^2$). The radius of gyration is a measure of how the mass of the object is distributed about the axis of rotation. $WK^2$ is usually expressed in units of lb-$ft^2$.

**Insulated Gate Bipolar Transistor (IGBT):** A type of transistor commonly used in drive-control devices.

**Integral-Horsepower Motor:** A motor that has a continuous rating of 1 hp or more, built into a frame.

**International Organization for Standards (ISO):** An organization established to promote development of international standards.

**Interposing Relay:** An interposing relay is a relay that accepts control signals of one logic level in order to provide isolated contact signals in a circuit operating at a different logic level.

**Inverter:**

1. An AC adjustable frequency drive.
2. A particular section of an AC drive. This section uses the DC voltage from a previous circuit stage (intermediate DC circuit) to produce a pulse-width-modulated or stepped AC current or voltage waveform that has characteristics similar to the desired sine-wave frequency.
3. A circuit whose output signal is the inverse of its input (a positive-going pulse is inverted to a negative-going pulse, and vise versa).

**ISO:** Refer to *International Organization for Standards*.

**Isolation Transformer:**

1. A transformer that provides DC isolation from other equipment not connected to that transformer secondary.
2. A transformer that provides noise isolation between the primary and secondary by such means as a Faraday shield.

**Jogging:**

1. In a numerical control system, an operator manually generating motion (continuously or incrementally) by closing a switch.
2. An operator generating motion by closing a switch.

**Kinetic Energy:** The energy of motion of a moving body.

**LAD:** Refer to *Linear Acceleration/Deceleration*.

**LEM:** A hall-effect current transducer that senses drive output current and generates a signal for the control logic.

**Linear Acceleration/Deceleration (LAD):** A circuit that controls the rate at which a motor is allowed to accelerate to a set speed or decelerate to zero speed. On most drives, this circuit is adjustable and can be set to accommodate a particular application.

**Linearity:** A measure of how closely a characteristic follows a straight-line function.

**Locked-Rotor Current:** Steady-state current taken from the line current with the a rotor at standstill (at rated voltage and frequency). This is the current when starting the motor and load.

**Locked-Rotor Torque:** The minimum torque that a motor will develop at rest for all angular positions of the rotor (with rated voltage applied at rated frequency).

**Meggar Test:** A test used to measure an insulation system's resistance. This is usually measured in megohms by applying a high voltage.

**MOV:** Refer to *Surge Protection*.

**National Electrical Code (NEC):** A set of regulations governing the construction and installation of electrical wiring and apparatus, established by the National Fire Protection Association and suitable for mandatory application by governing bodies exercising legal jurisdiction. It is widely used by state and local authorities within the United States.

**National Electrical Manufacturer's Association (NEMA):** A non-profit organization organized and supported by electrical equipment and supply manufacturers. Some NEMA motor standards include horsepower (hp) ratings, speeds, frame sizes and dimensions, torques, and drive enclosures.

**NEC:** Refer to *National Electrical Code*.

**Negative Slope:** The location on a V/Hz curve where the break voltage exceeds the base voltage.

**NEMA:** Refer to *National Electrical Manufacturer's Association*.

**Offset:** The steady-state deviation of a controlled variable from a fixed setpoint.

**Op Amp:** An operational amplifier. A high-gain stable linear DC amplifier that is designed to be used with external circuit elements.

**Open Loop System:** A control system that has no means of comparing the output with the input for control purposes.

**Overload Capacity:** The ability of the drive to withstand currents beyond the system's continuous rating. It is normally specified as a percentage of full-load current endured for a specified time period. Overload capacity is defined by NEMA as 150% of rated full load current for one minute for "standard industrial DC motors."

**PC:**

**1.** Personal Computer.

**2.** Programmable Controller.

**3.** Printed Circuit.

**Plugging:** A type of motor braking provided by reversing either line voltage polarity or phase sequence so that the motor develops a counter torque that exerts a retarding force to brake the motor.

**Pot:** A potentiometer, or variable resistor.

**Power:** Work done per unit of time. Measured in horsepower (hp) or watts (W): 1 hp = 33,000 ft-lb/min. = 746 W.

**Power Factor (Displacement):** A measurement of the time phase difference between the fundamental voltage and fundamental current in an AC circuit. It represents the cosine of the phase angle difference.
$Fp = \cos(\alpha - \beta)$

**Power Factor (Distortion):** A measurement of the ratio of the real power (kW) to the apparent power (kVA). Distortion power factor takes into account harmonic voltage and current distortion as well as voltage-to-current displacement.

**Preform:** A flexible material used between an electronic component and the heat sink to which the component is attached. Preform provides maximum heat dissipation from the component to the heat sink.

**Preset Speed:** Describes one or more fixed speeds at which a drive operates.

**Programmable Controller:** A solid-state control system that has a user-programmable memory for storage of instructions to implement specific functions such as I/O control, logic, timing, counting, report generation, communication, arithmetic, and data file manipulation. A controller consists of a central processor, input/output interface, and memory. A controller is designed as an industrial control system.

**Pull-In Torque:** The maximum constant torque to which a synchronous motor accelerates into synchronism at rated voltage and frequency.

**Pull-Out Torque:** The maximum running torque of a synchronous motor.

**Pull-Up Torque:** The torque required to accelerate the load from standstill to full speed (where breakdown torque occurs), expressed in percent of running torque. It is the torque required not only to overcome friction, windage, and product loading but also to overcome the inertia of the machine. The torque required by a machine may not be constant after the machine has started to turn. This load type is characteristic of fans, centrifugal pumps, and certain machine tools.

**PWM:** Pulse-width Modulation. A technique used to eliminate or reduce unwanted harmonic frequencies when inverting DC voltage to sine wave AC.

**Reactance:** Pure inductance or capacitance, expressed in ohms, in a circuit. It is the component of impedance to alternating current that is not resistance.

**Rectifier:** A device that conducts current in only one direction, thereby transforming alternating current to direct current.

**Regeneration:** (AC drives) When the rotor synchronous frequency is greater than the applied frequency.

**Regenerative Braking:** Slows or stops a motor through regeneration. Refer to *Regeneration* and *Braking*.

**Resolution:** The smallest distinguishable increment into which a quantity can be divided (e.g., position or shaft speed). It is also the degree to which nearly equal values of a quantity can be discriminated. For rotary encoders, it is the number of unique electrically identified positions occurring in 360 degrees of input shaft rotation. For D/A or A/D conversion, may be expressed as the number of bits in the digital value that corresponds to a full-scale analog value.

**SCR:** Silicon Controlled Rectifier. A solid-state uni-directional latching switch.

**Service Factor:** When used on a motor nameplate, a number that indicates how much above the nameplate rating a motor can be loaded without causing serious degradation (i.e., a motor with 1.15 S-F can produce 15% greater torque than one with 1.0 S-F).

**Set Speed:** The desired operating speed.

**Shock Load:** The load seen by a clutch, brake, or motor in a system that transmits high peak loads. This type of load is present in crushers, separators, grinders, conveyors, winches, and cranes.

**Slip:** The difference between rotating magnetic field speed (synchronous speed) and rotor speed of AC induction motors. Usually expressed as a percentage of synchronous speed.

**Slip Compensation:** Monitors motor current and compensates for speed lost due to increased motor slip. The amount of slip is proportional to the motor load.

**Speed Range:** The speed minimum and maximum at which a motor must operate under constant or variable torque load conditions. A 50:1 speed range for a motor with top speed 1800 rpm means the motor must operate as low as 36 rpm and still remain within regulation specification. Controllers are capable of wider controllable speed ranges than motors because there is no thermal limitation, only electrical. Controllable speed range of a motor is limited by the ability to deliver 100% torque below base speed without additional cooling.

**Speed Regulation:** The numerical measure (percent) of how accurately the motor speed can be maintained. It is the percentage of change in speed between full load and no load. The ability of a drive to operate a motor at constant speed (under varying load), without "hunting" (alternately speeding up and slowing down). It is related to both the characteristics of the load being driven and electrical time constants in the drive regulator circuits.

**Surge Protection:** The process of absorbing and clipping voltage transients on an incoming AC power line or control circuit. Surge protectors include MOVs (Metal Oxide Varistors) and specially designed R-C networks.

**Synchronous Speed:** The speed of an AC induction motor's rotating magnetic field. It is determined by the frequency applied to the stator and the number of magnetic poles present in each phase of the stator windings. Mathematically, it is expressed as: Sync Speed (rpm) = 120 x Applied Freq. (Hz) / Number of poles per phase.

**Torque:** A turning force applied to a shaft, tending to cause rotation. Torque is equal to the force applied, times the radius through which it acts. Torque is measured in pound-feet, ounce-inches, Newton-meters, or gram-centimeters.

**Transducer:** A device that converts one energy form to another (e.g., mechanical to electrical). When a transducer is actuated by signals from one system or medium, it can supply a related signal to the other system or medium.

**Transient:** A momentary power deviation in an electrical or mechanical system.

**Transistor:** An active solid-state semiconductor device.

**Work:** A force moving an object over a distance. (work = force x distance)

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