

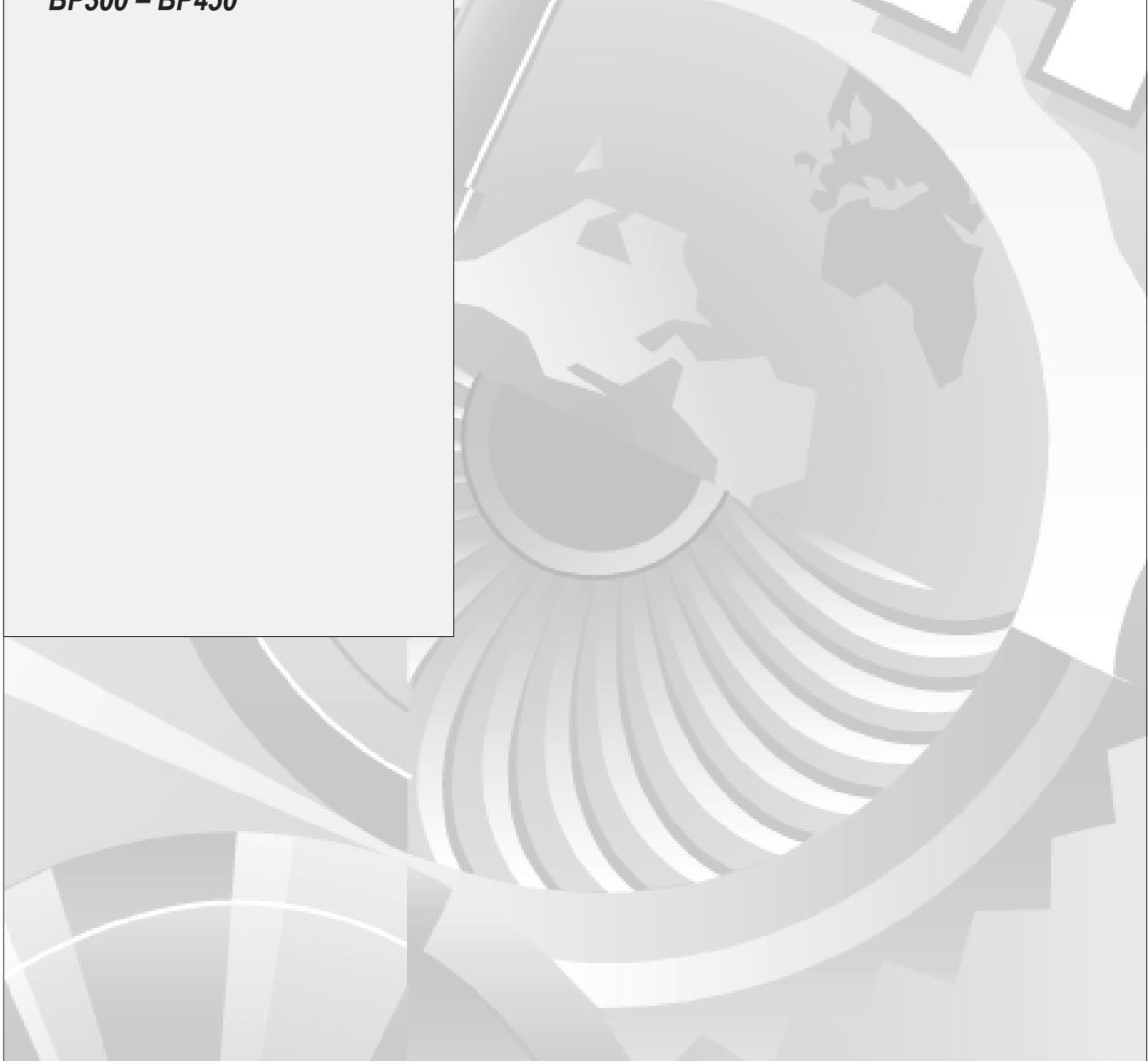


Allen-Bradley

***1336 FORCE
Adjustable
Frequency
AC Drive***

BP300 – BP450

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, Rockwell Automation does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Rockwell Automation publication SGI-1.1, *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* (available from your local Rockwell Automation 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.

Reproduction of the contents of this copyrighted publication, in whole or in part, without written permission of Rockwell Automation, is prohibited.

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.

This Page Intentionally Left Blank

Table of Contents

Preface

Manual Objective	P-1
Who Should Use This Manual	P-1
Safety Precautions	P-1
Electrostatic Discharge Precautions	P-2
1336 FORCE Product Identification	P-3
Drive Nameplate Location	P-3
Software Compatibility	P-3
Drive and Option Identification	P-4
1336 FORCE Drive Catalog Numbers	P-4
Adapter Options – Factory Installed (Select One)	P-4
Drive Rating Qualifications	P-5
Enclosure Type	P-5
Conventions	P-6
Auxiliary Input	P-6
Auxiliary Interlock	P-6
Bit	P-6
Check	P-6
Connector	P-6
Control Interface L-Option Board	P-7
Default	P-7
Enable Input	P-7
False	P-7
Jumper	P-7
Parameter	P-7
Press	P-7
True	P-8
Related Publications	P-8

Control Logic Wiring and Adapters

Chapter 1

Chapter Objectives	1-1
Chapter Overview	1-1
Control Interface Option	1-3
Control Interface Board Jumpers	1-4
Available Inputs	1-5
Local Programming	1-5
Adapters and Communication Ports	1-11
Human Interface Module	1-11
Standard Adapter Ports	1-12
PLC Comm Adapter Ports	1-12
HIM Removal	1-13
HIM Operation	1-14

Disassembly and Access Procedures

Graphic Programming Terminal	1-15
GPT Description	1-15
Drive Tools	1-16
Control Firmware Function	1-16

Chapter 2

Chapter Objectives	2-1
Disassembly and Access Overview	2-1
Electrostatic Discharge Precautions	2-1
Tools	2-2
Fastener Torque Specifications	2-2
Torque Sequence	2-2
Torque Specifications	2-3
Disassembly and Access Procedures	2-5
Removing the High Voltage Guard	2-5
Removal	2-6
Installation	2-6
Removing Control Interface L-Option Board MOD-L4, -L5, or -L6	2-7
Removal	2-7
Installation	2-8
Removing the Circuit Board Platform	2-9
Removal	2-9
Installation	2-11
Removing the Main Control Board	2-12
Removal	2-13
Installation	2-14
Removing the Standard Adapter Board	2-15
Removal	2-15
Installation	2-16
Removing the PLC Comm Adapter Board	2-17
Removal	2-17
Installation	2-18
Removing the Control Board/Adapter Mounting Plate	2-19
Removal	2-19
Installation	2-20
Removing the Gate Driver Board from the Mounting Plate	2-21
Removal	2-21
Installation	2-23
Removing the Precharge Board from the Mounting Plate	2-24
Removal	2-24
Installation	2-25
Removing a Power Module Snubber Board	2-26
Removal	2-26
Installation	2-28

Component Test Procedures	Chapter 3	
	Chapter Objectives	3-1
	Component Test Overview	3-1
	Electrostatic Discharge Precautions	3-2
	Tools	3-2
	Test 1 – Testing the Gate Driver Board	3-3
	Test 2 – Testing the Precharge Board	3-6
	Test 3 – Testing the Power Modules	3-8
	Test 4 – Testing the Bus Capacitors	3-12
	Test 5 – Testing the Input Rectifiers	3-15
Part Replacement Procedures	Chapter 4	
	Chapter Objective	4-1
	Safety Precautions	4-1
	Electrostatic Discharge Precautions	4-1
	Tools	4-2
	Major Component Replacement	4-2
	Detailed Product Identification	4-3
	Bus Capacitor Bank	4-4
	Removal	4-5
	Installation	4-7
	Thermistor	4-8
	Removal	4-8
	Installation	4-9
	Power Modules	4-10
	Removal	4-10
	Installation	4-12
	Bus Fuses F1	4-13
	Removal	4-13
	Installation	4-14
	Input Fuses	4-15
	Removal	4-15
	Installation	4-16
	Ground Fault CT	4-17
	Removal	4-17
	Installation	4-19
	Input Rectifiers	4-20
	Removal	4-20
	Installation	4-22

LEMs	4-23
Removal	4-23
Installation	4-25
MOV Surge Suppressor	4-26
Removal	4-26
Installation	4-27
Fan and Transformer Assembly	4-28
Removal	4-28
Installation	4-30
DC Bus Inductor L1	4-32
Removal	4-32
Installation	4-34

Replacement Parts List**Chapter 5**

Chapter Objectives	5-1
Ordering Replacement Parts	5-1
Replacement Parts Listing	5-2

**Schematics — 250 – 450 HP
1336 FORCE Drives****Chapter 6****Index**

Preface

Manual Objective

The information in this manual is designed to help repair a Rockwell Automation Bulletin 1336 FORCE Adjustable Frequency AC Drive with ratings BP300 – BP450.

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 troubleshooting 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 the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



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 Rockwell Automation 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:

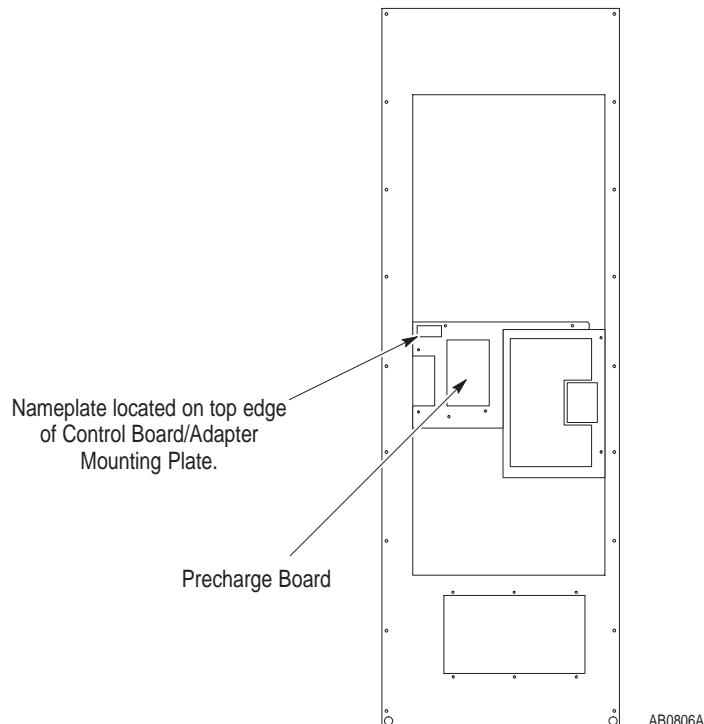
- Wear a wrist-type grounding strap that is grounded to the drive chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

1336 FORCE Product Identification

Drive Nameplate Location

The drive nameplate is located on the face of the Main Control Board 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

Three-Phase Drive Rating^①

380 – 480V	Compatible with Version	Frame Reference
187 – 336 kW 250 – 450 HP	Standard Adapter Board: 4.xx & Up PLC Comm Adapter Board: 3.02 & Up	F

^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

1336T	- B007	- AA	- GT2EN	- L6
BULLETIN NO.	DRIVE RATING (MUST BE SPECIFIED)	ENCLOSURE STYLE (MUST BE SPECIFIED)	ADAPTER ^[4] (MUST BE SPECIFIED)	OPTIONS (AS REQUIRED)

Adapter Options – Factory Installed (Select One)^[1]

Description ^[4]	Option Code
PLC®Communication Adapter English	- GT1EN
Standard Adapter English	- GT2EN
No Adapter	- GTO ^[4]

380 – 480V AC Input, Constant Drive

Drive Rating ^[1]			Enclosures			
			Open IP00 No Enclosure	NEMA Type 1 IP20 General Purpose	NEMA Type 4 IP65 Resist Water, Dust	NEMA Type 12 IP54 Industrial Use
Frame Designation	Constant Torque		Code	Code	Code	Code
	Output Amps	Nominal HP				
F	406.4	300	BP300-AN ^[5]	BP300-AA ^[5]	[3]	[3]
	459.2	350	BP350-AN ^[5]	BP350-AA ^[5]	[3]	[3]
	481.0	400	BP400-AN ^[5]	BP400-AA ^[5]	[3]	[3]
	531.7	450	BP450-AN ^[5]	BP450-AA ^[5]	[3]	[3]

^[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.

^[2] Refer to the Language Module and Options tables following these Catalog Number tables.

^[3] Not available in this rating.

^[4] An adapter Board (see Adapter Options – Factory Installed table) is required to make the drive functional. If the “-GTO option” (no adapter) is chosen, then the Adapter Kit must be added after shipment.

^[5] A “Common Mode Choke” option (-CM) or “No Common Mode Choke” option (-NCM) must be specified with each F-Frame Drive.

Table P.B

Options			
Code ^[1]	Description ^[2]	Code	Description ^[2]
Human Interface Module, 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 & DH485
HA1	Programmer/Controller w/Analog Pot	GM3	DeviceNet
HA2	Programmer/Controller w/Digital Pot		
Human Interface Module, NEMA Type 12 (IP 54)			Control Interface Options
HJP	Programmer Only	L4	TTL Contact
HJ2	Programmer/Controller w/Digital Pot	L4E	TTL Contact & Encoder Feedback
		L5	24V AC/DC
		L5E	24V AC/DC & Encoder Feedback
		L6	115V AC
		L6E	115V AC & Encoder Feedback

^[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

Enclosure Type

The first character, A, indicates the Enclosure Code.

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

Table P.C
Enclosure Type Code Description

Enclosure Type Code	Description
N	Open style (IP 00)
A	NEMA Type 1 (IP 20)
F	NEMA Type 4 (IP 65)
J	NEMA Type 12 (IP 54)

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 L-Option 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.

Control Interface L-Option Board

A Control Interface L-Option Board plugs into connectors J7 and J9, located on the lower portion of the Main Control Board. This board is identified as L4/4E, L5/5E or L6/6E and provides optional control wiring configurations for a drive.

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 L-Option 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 L-Option 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.

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/L4E contact input is closed, L5/L5E input terminal registers 24V, or L6/L6E input terminal registers 115V AC.

Related Publications

The following lists other Rockwell Automation 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 FORCE-6.0)
- Options Manuals/Instructions

Control Logic Wiring and Adapters

Chapter Objectives

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

Chapter Overview

This chapter illustrates and describes the 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).

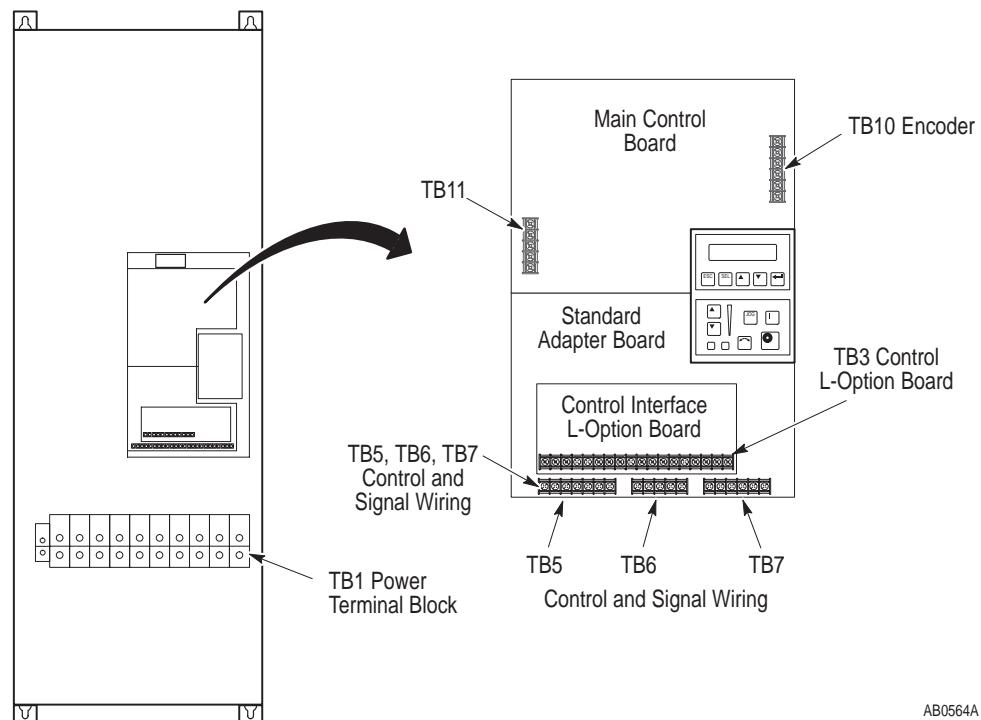


ATTENTION: Some printed circuit boards and drive components may contain hazardous voltage levels. Remove power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt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



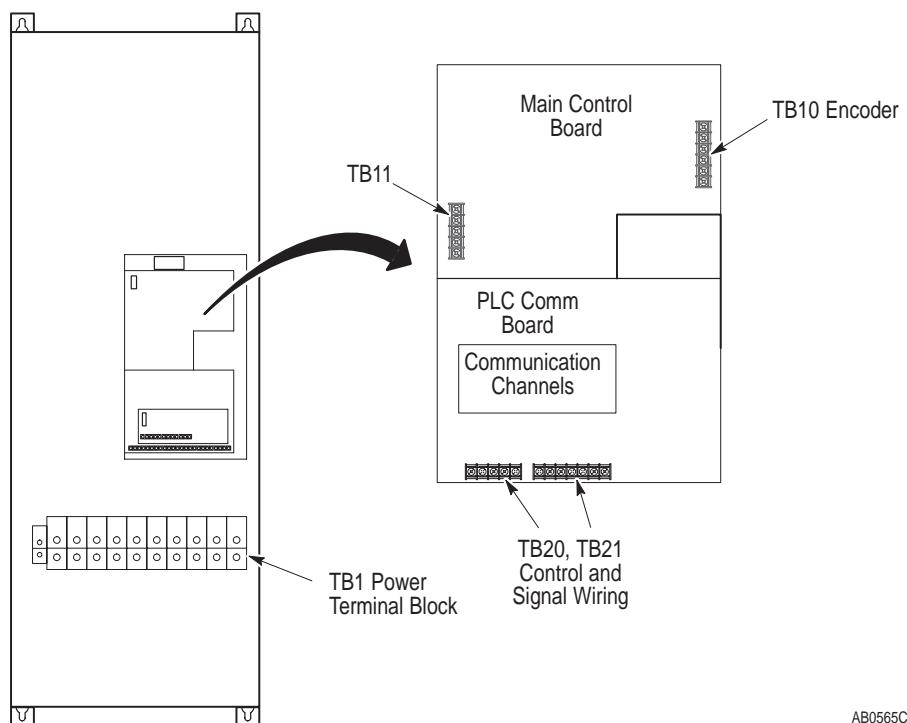
ATTENTION: This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control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

Figure 2.1
Standard Adapter Terminal Block Locations



AB0564A

Figure 2.2
PLC Comm Adapter Terminal Block Locations



AB0565C



ATTENTION: The National Electrical Code (NEC) and local codes outline provisions for safely installing electrical equipment. Installation must comply with specifications regarding wire types, conductor sizes, branch circuit protection and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

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.

Six different versions of the option are available:

- | | |
|-----|---|
| L4 | Contact Closure Interface ¹ |
| L4E | Contact Closure Interface with Encoder Feedback Inputs ¹ |
| L5 | +24V AC/DC Interface |
| L5E | +24V AC/DC Interface with Encoder Feedback Inputs |
| L6 | 115V AC Interface |
| L6E | 115V AC Interface with Encoder Feedback Inputs |

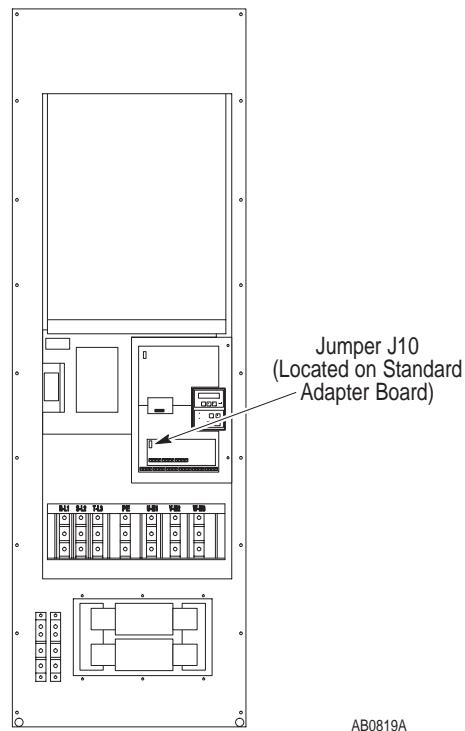
¹ Uses internal +5V DC supply.

The user inputs are connected to the Control Interface L-Option Board through TB3. The L4, L5 and L6 options each have nine control inputs. The function of each input must be selected through programming as explained later in this section. The L4E, L5E and L6E options are similar to L4, L5 and L6 with the addition of encoder feedback inputs.

Control Interface Board Jumpers

Important: If the Control Interface L-Option 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 2.3
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 2.5. 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: _____

Local Programming

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

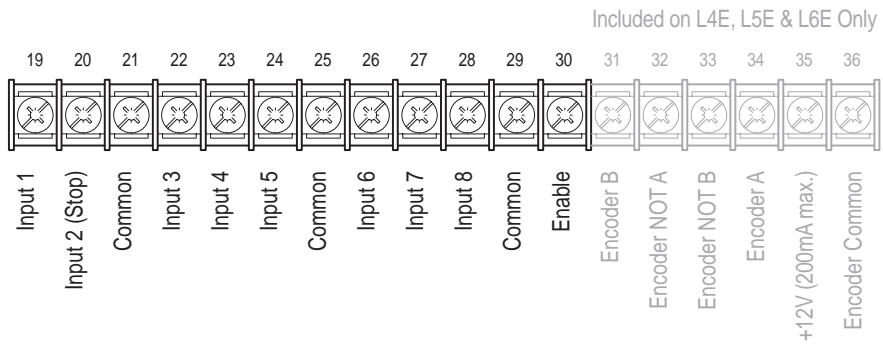
Table 2.A
Input Mode Selection

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 – works differently than three-wire control. ^① Direction – works differently than three-wire control. ^① Stop – always works.	12 – 16

^① Refer to two-, three-wire notes in the user manual.

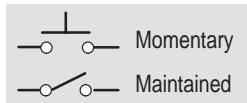
Figure 2.4 provides the terminal designations for TB3. The maximum and minimum wire sizes accepted by TB3 are 2.1 and 0.30 mm² (14 and 22 AWG). Recommended torque for all terminals is 0.9 – 1.13 N·m (8 – 10 lb-in.). Use Copper wire only.

Figure 2.4
TB3 Terminal Designations

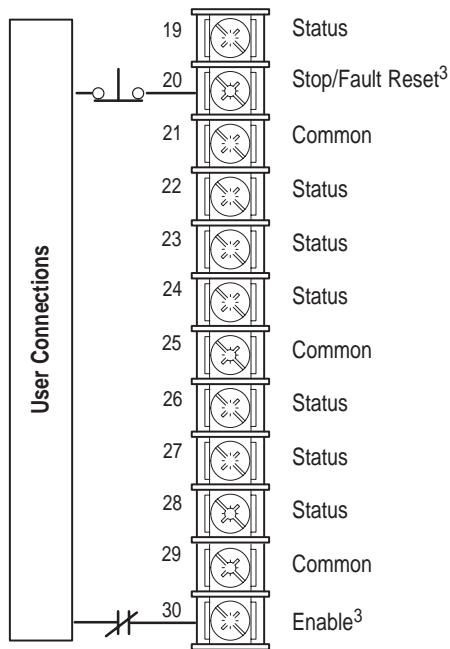


AB0293B

Figure 2.5
Input Mode Selection and Typical TB3 Connections



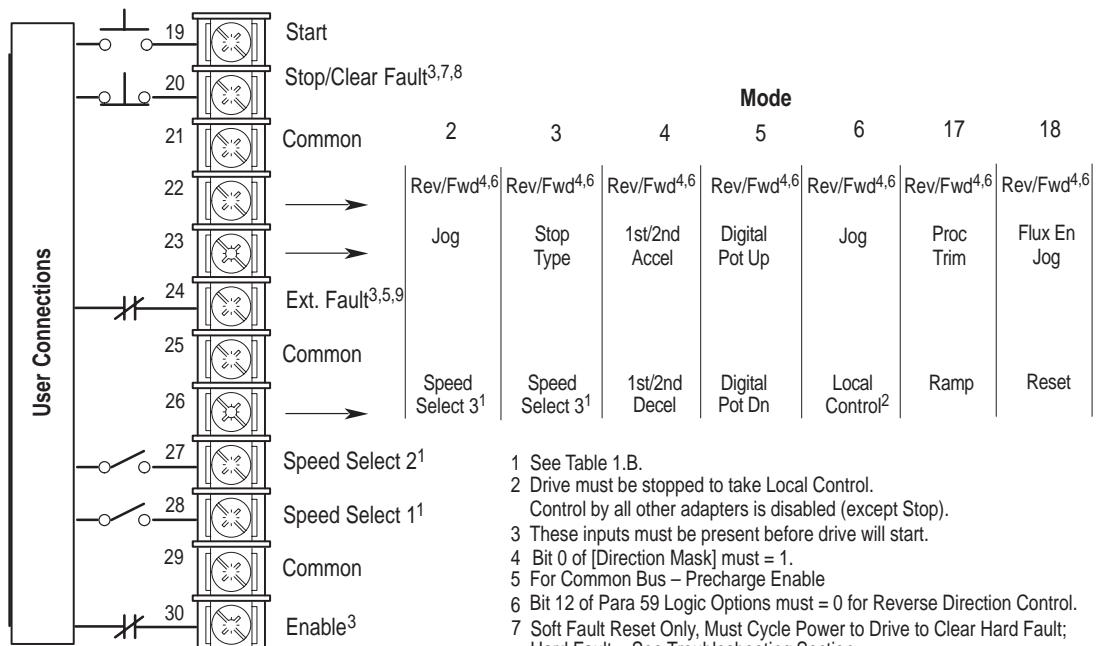
[Input Mode] 1
Factory Default



Note: If this mode is selected, the status of all inputs can be read at the [Input Status] parameter. However, only "Stop/Fault Reset" and "Enable" will have control function.

[Input Mode] 2 – 6
Three-Wire Control with Single-Source Reversing

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-GMI. Applies to 1305 with firmware FRN 2.01 or earlier and 1336 PLUS with Language Module 1336S-EN firmware FRN 1.05 or earlier.



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.

4 Bit 0 of [Direction Mask] must = 1.

5 For Common Bus – Precharge Enable

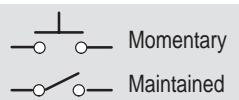
6 Bit 12 of Para 59 Logic Options must = 0 for Reverse Direction Control.

7 Soft Fault Reset Only, Must Cycle Power to Drive to Clear Hard Fault;
Hard Fault = See Troubleshooting Section.

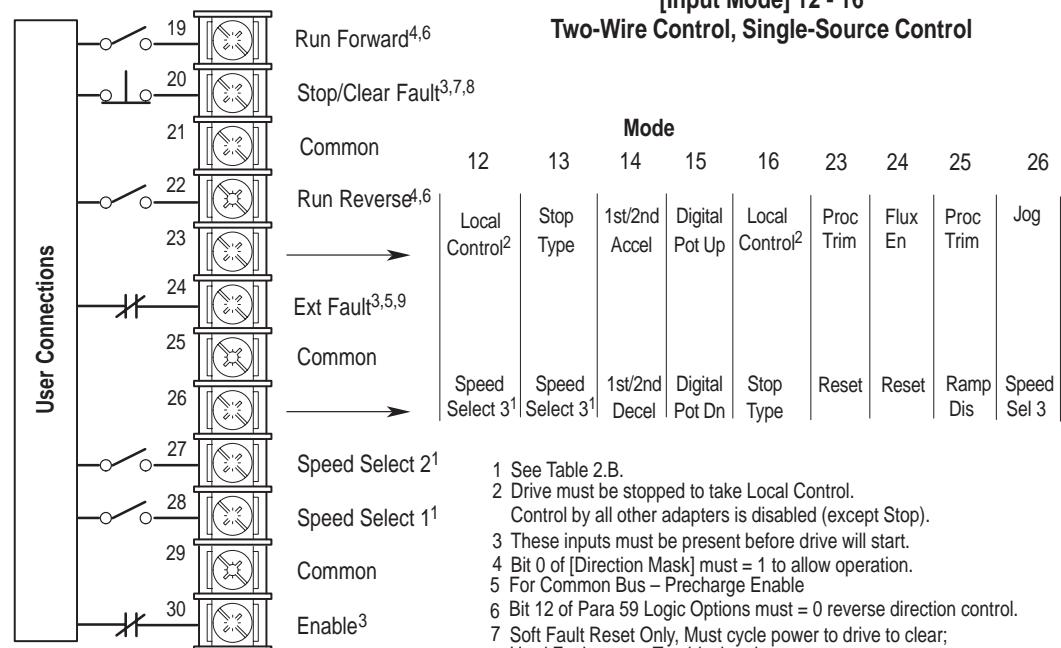
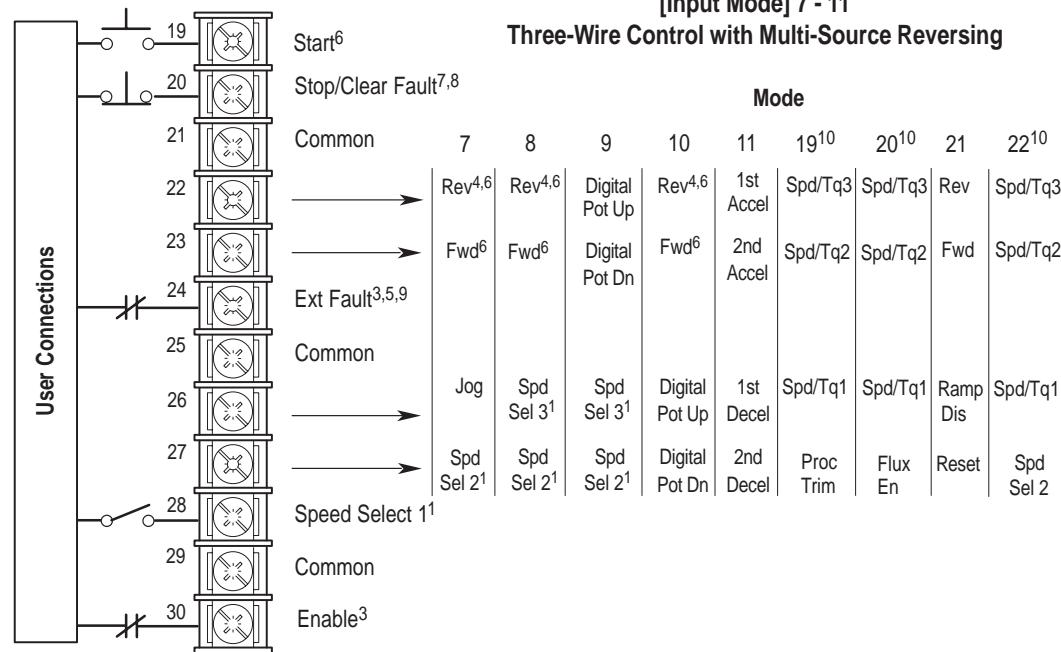
8 Soft Fault Refer to Para 59 to Configure Start & Stop Type.

9 Can be masked out.

AB0290B



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.



1 See Table 2.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.

4 Bit 0 of [Direction Mask] must = 1 to allow operation.

5 For Common Bus – Precharge Enable

6 Bit 12 of Para 59 Logic Options must = 0 reverse direction control.

7 Soft Fault Reset Only, Must cycle power to drive to clear; Hard Fault — see Troubleshooting.

8 Refer to Para 59 to configure Start & Stop type.

9 Can be masked out.

10 Parameter 53 (Spd/Tq Mode Sel) becomes read only.

AB0291B

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

Table 2.B
Speed Select Input State vs. Velocity Reference Source

Speed Select 3	Speed Select 2	Speed Select 1	Velocity Reference Source	
TB3	Terminal 26	Terminal 27	Terminal 28	Interface Option (MOD L4, L5, L6)
	O	O	O	Ext Ref 1 Para 101 ¹
	O	O	X	Preset Speed Ref 1 (P 119)
	O	X	O	Preset Speed Ref 2 (P120)
	O	X	X	Preset Speed Ref 3 (P 121)
	X	O	O	Preset Speed Ref 4 (P 122)
	X	O	X	Preset Speed Ref 5 (P 123)
	X	X	O	External Reference 2 (P 104)
	X	X	X	Last State

Equivalent truth table implemented in Parameter 52 Logic Command Word

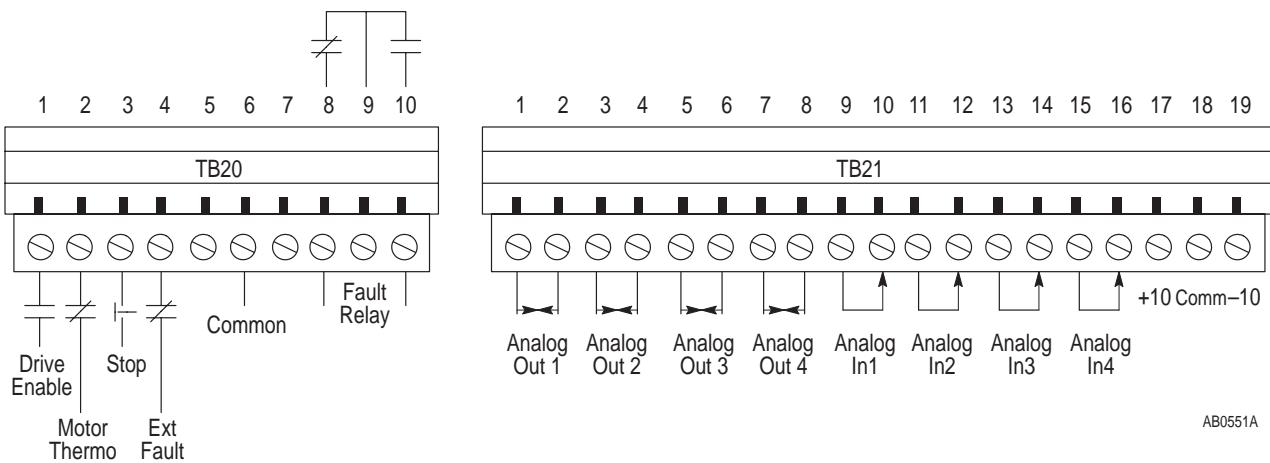
Para 52	Bit 14	Bit 13	Bit 12	Velocity Reference Source Bits
	O	O	X	Ext Ref 1 (P 101)
	O	X	O	Preset Speed Ref 1 (P 119)
	O	X	X	Preset Speed Ref 2 (P120)
	X	O	O	Preset Speed Ref 3 (P 121)
	X	O	X	Preset Speed Ref 4 (P 122)
	X	X	O	Preset Speed Ref 5 (P 123)
	X	X	X	External Reference 2 (P 104)
	O	O	O	No Reference or Last State

O = Open — Input Removed

X = Closed — Input Present

¹ Unless otherwise configured, this will default to the HIM speed reference input.

Figure 2.6
PLC Comm Adapter Reference Signal Connections



AB0551A

Table 2.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

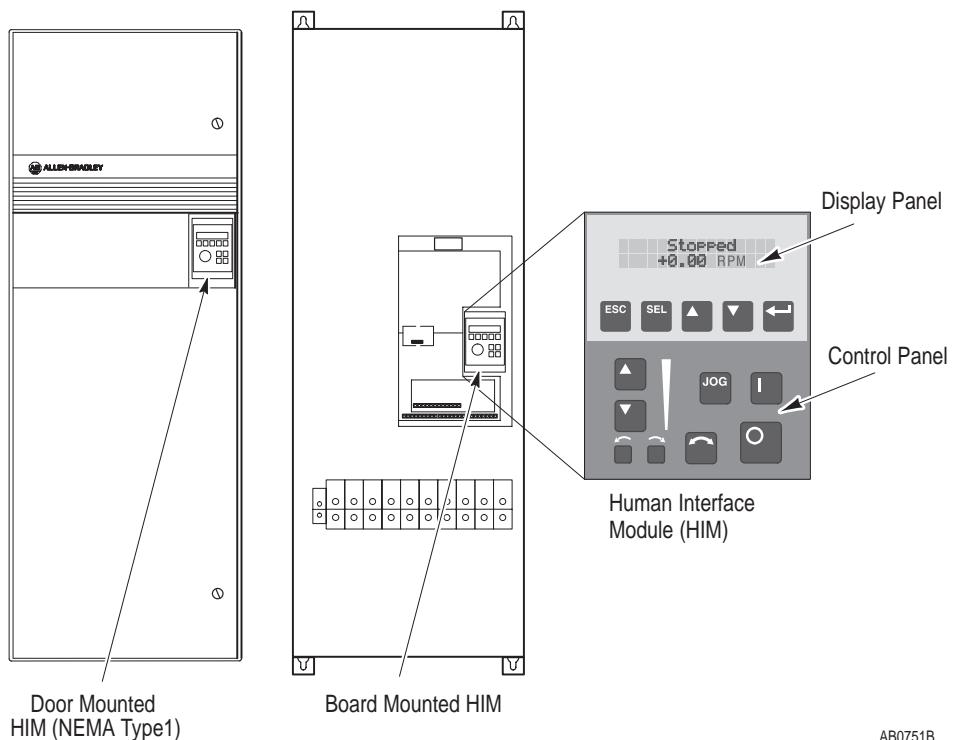
Adapters and Communication Ports

Human Interface Module

When the drive-mounted HIM is supplied, it will be connected as Port 1 (refer to Figure 2.8) 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. Refer to the 1336 FORCE User Manual for HIM operation.

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

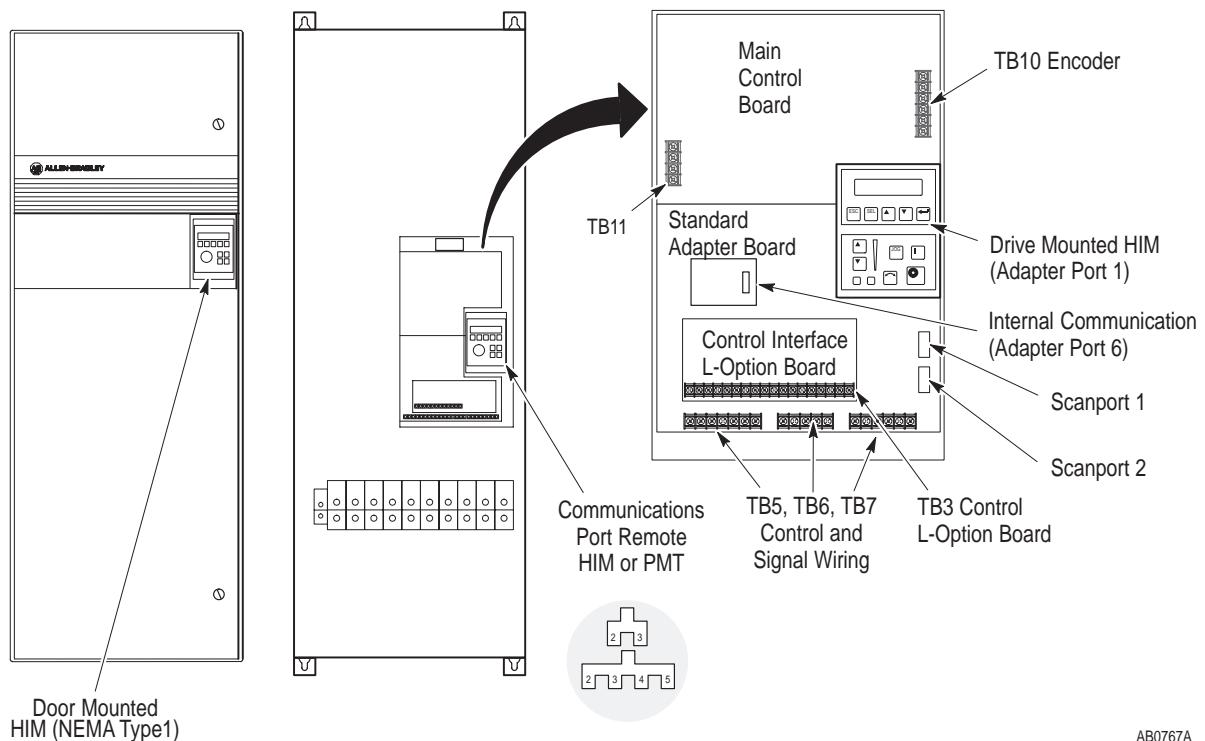
Figure 2.7
Human Interface Module, Standard Adapter Only



AB0751B

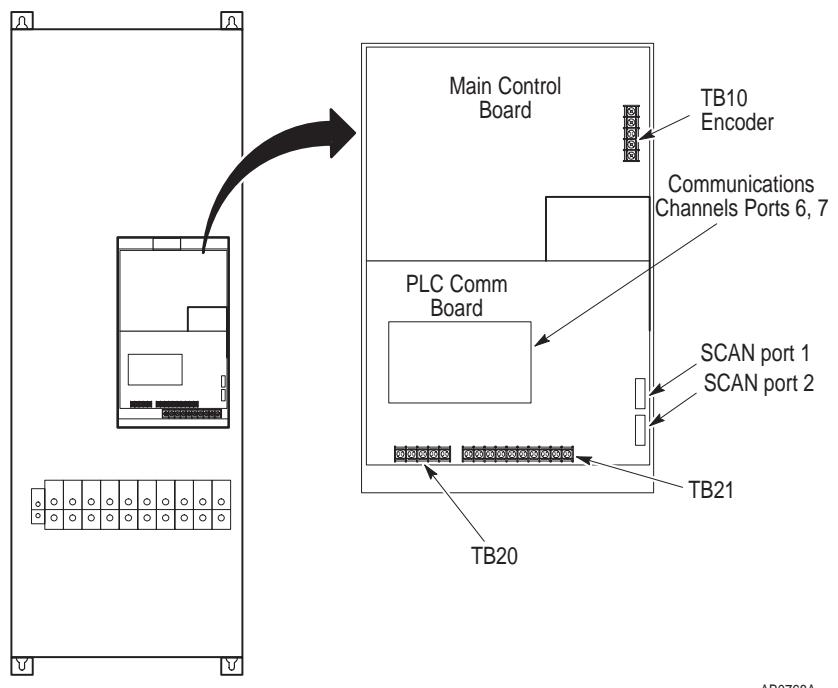
Standard Adapter Ports

Figure 2.8
Standard Adapter Board Port Locations



PLC Comm Adapter Ports

Figure 2.9
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 SCANport Port Enable Mask (330) 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 SCANport Port Enable Mask (330) has been set to “0”.
2. Take the drive front cover off and simply slide the module down and out of its cradle. Remove cable from module.
3. Connect the appropriate cable between the HIM and the Communications Port (Adapter 2, 3, 4, or 5).
4. Reverse the above steps to replace the module. Apply power or reset Bit 1 of the SCANport Port Enable Mask (330) 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 (refer to Figure 2.10) 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 for HIM operation.

Figure 2.10
Status Display



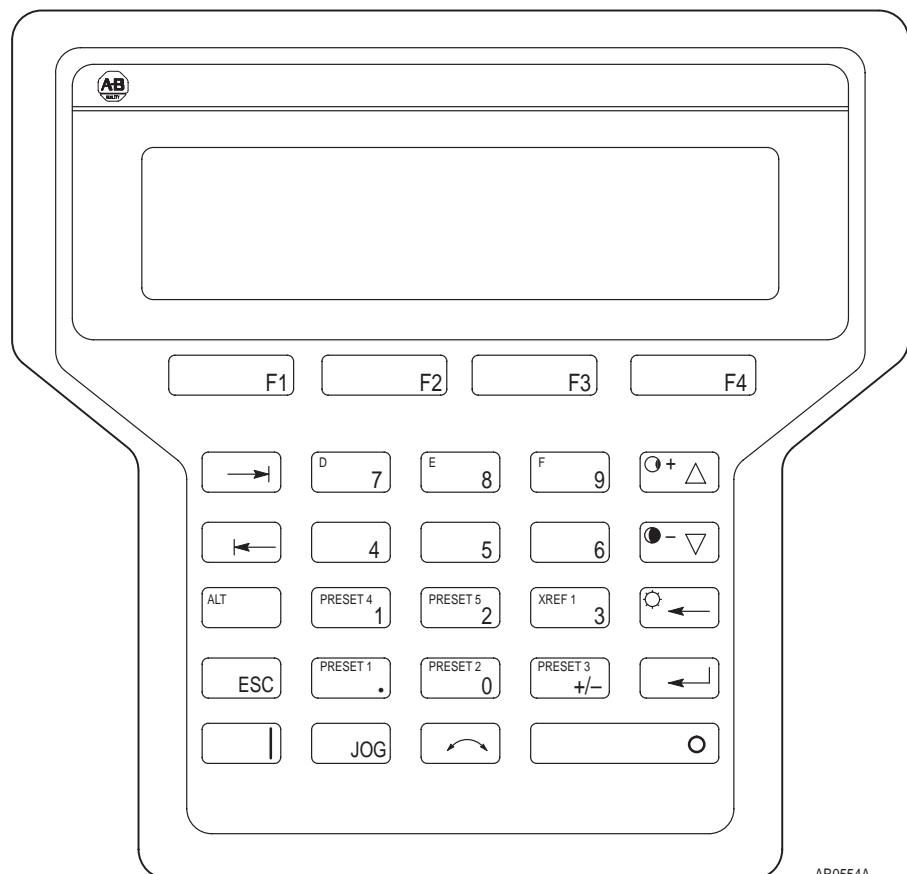
Graphic Programming Terminal

GPT Description

The optional GPT (Figure 2.11) 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 2.11
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 Rockwell Automation 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.

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 the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



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 Rockwell Automation 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 (small, medium, and large)
- Standard screwdrivers (small, medium, and large)
- 25/64-inch or 10 mm socket
- 7/16-inch or 11 mm socket
- 33/64-inch or 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in lb-in. or N-m
- Nylon tie wraps

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.

The following illustrates temporary and final tightening sequences for components fastened to a heat sink using two, four, and six screws. Temporary torque is 1/3 (33%) of final torque, except six-point mountings, which require 0.5 N-m (4 lb-in.). The numeric illustration labels are for your assistance. Drive components do not carry these labels.

Figure 3.1
Two-Point Mounting

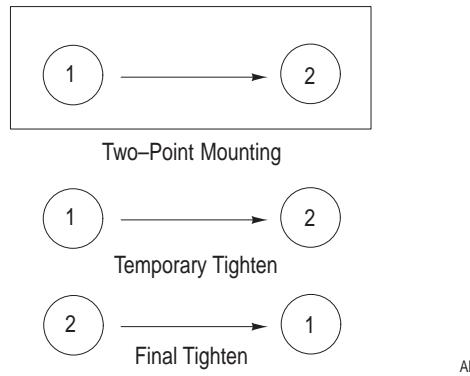


Figure 3.2
Four-Point Mounting

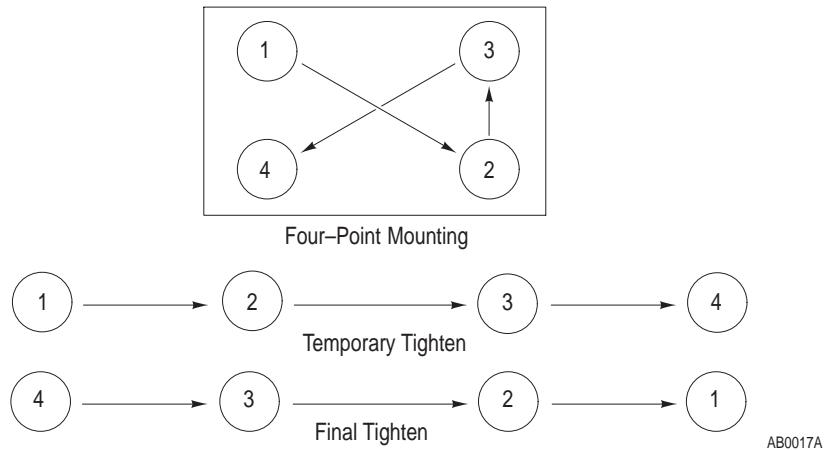
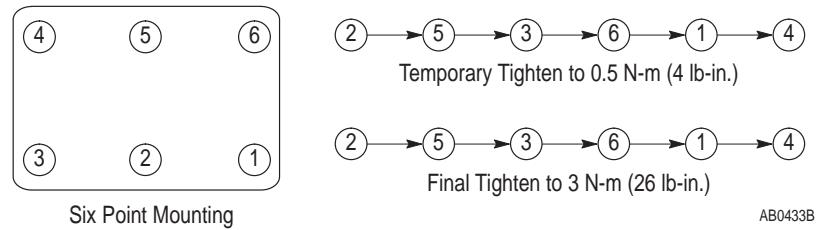


Figure 3.3
Six-Point Mounting



Important: Do not exceed 0.5 Newton-meters (4 lb-in.) on initial torque of all six screws.

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, four-point and six-point components to the heat sink.

Table 3.A
Fastener Torque Specifications

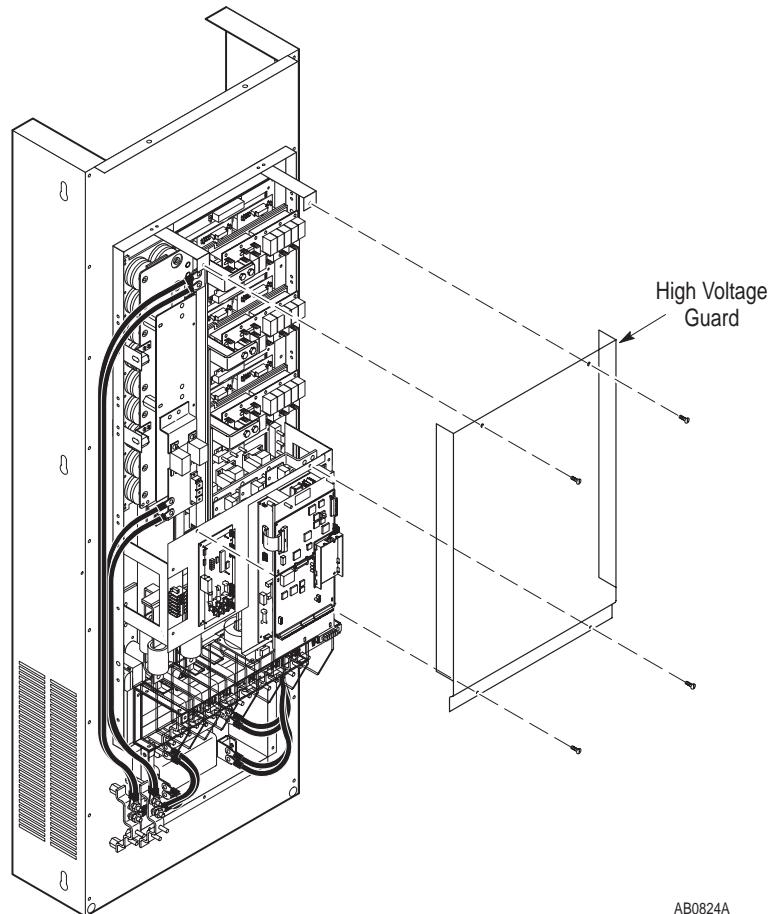
Component	Fastener Application	Torque lb-in.	Torque N-m
Fan Motor	Motor to Fan Cover Assembly	14	2
Fan Cover Assembly	Assembly to chassis	26	3
Fan Transformer	Transformer to chassis	26	3
Fan Capacitor	Capacitor to chassis		Hand-tighten
MOV Surge Suppressor	MOV to chassis	14	2
Snubber Resistor	Resistor to heat sink	26	3
Snubber Resistor	Wires to Capacitor Bus Bar Assembly	50	6
Snubber Bracket	Bracket to Power Module	80	9
Snubber Board	Board to Brackets	50	6
Snubber Board	Board to Input Rectifier	50	6
Volt Sharing Resistor	Resistor to heat sink	26	3
Volt Sharing Resistor	Wires to Capacitor Bus Bar Assembly	50	6
Thermistor	Thermistor to heatsink	14	2
Bus Capacitor Holder	Holder to Bus Capacitors	26	3
Capacitor Bus Bar Assembly	Assembly to Bus Capacitors	50	6
Power Module Gate Interface Board	Board to Power Modules	14	2
Power Module Bus Bar	Bus Bar to Power Modules	80	9
Power Module	Module to heat sink		Refer to Figure 3.3
DIN Rail (TB1)	Rail to chassis	50	6
PE Shortening Bar	Bar to TB1	80	9
Input Rectifier	Rectifier to heat sink	50	6
Input Fuse	Fuse to Input Bus Bar	208	23
Transitional Bus Bar Assembly	Assembly to Power Module Bus Bar Assembly	208	23
Bus Fuse F1	Fuse to Transitional Bus Bar Assembly	80	9
DC Bus Inductor L1	Inductor to chassis	50	6
Bus Bar Cable Adaptor	Adaptor to Transitional Bus Bar Assembly and DC Bus Inductor	208	23
Converter Bus and Motor Bus Bars	Bus Bars to all connections	208	23
Wires (PE)	Wires to Ground Stud	80	9
Wires	Wires to TB1	80	9
Wire (TE)	Wire to TB1	50	6
Wires	Wires to TB2	7	0.8
Wires	Wires to TB3	8 – 10	0.9 – 1.1
LEM Mounting Plate	Mounting Plate to LEM Clamping Plate	14	2
Power Cables	Cables to terminals	208	23
Control Board Platform	Plates to chassis	26	3
High Voltage Guard	Guard to chassis	26	3

Disassembly and Access Procedures

Removing the High Voltage Guard

The High Voltage Guard is a clear plastic guard covering the Bus Capacitor Bank and the Power Module Assembly.

Figure 3.4
High Voltage Guard



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 the +DC/-DC Brake Terminals. 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.

1. Remove power from the drive.
2. Check for zero volts at:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the four nuts fastening the High Voltage Guard to the standoffs.
5. Pull the guard away from the drive.

Installation

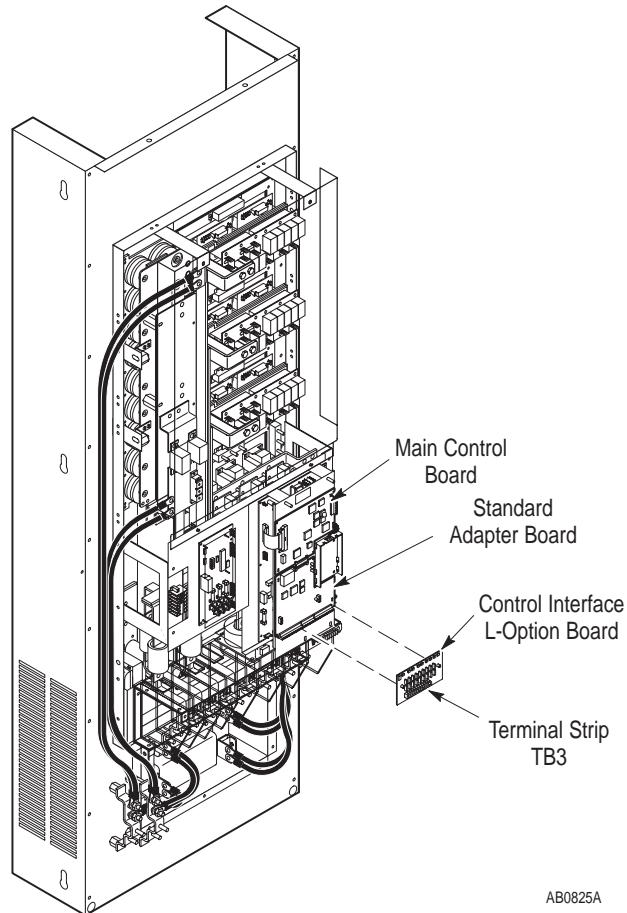
Install the High Voltage Guard in reverse order of removal. Refer to Table 3.A – Fastener Torque Specifications.



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 3.5
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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB5, TB6, and TB7 on the Standard Adapter Board
 - TB3 on the Control Interface L-Option Board
4. Remove all wires from the terminals on TB3.
5. Loosen the two captive screws fastening the Control Interface L-Option Board to the Standard Adapter Board.
6. Grip the right and left sides of the Control Interface L-Option Board and pull the board straight outward from the Standard Adapter Board.

Installation

Install the Control Interface L-Option Board in reverse order of removal.

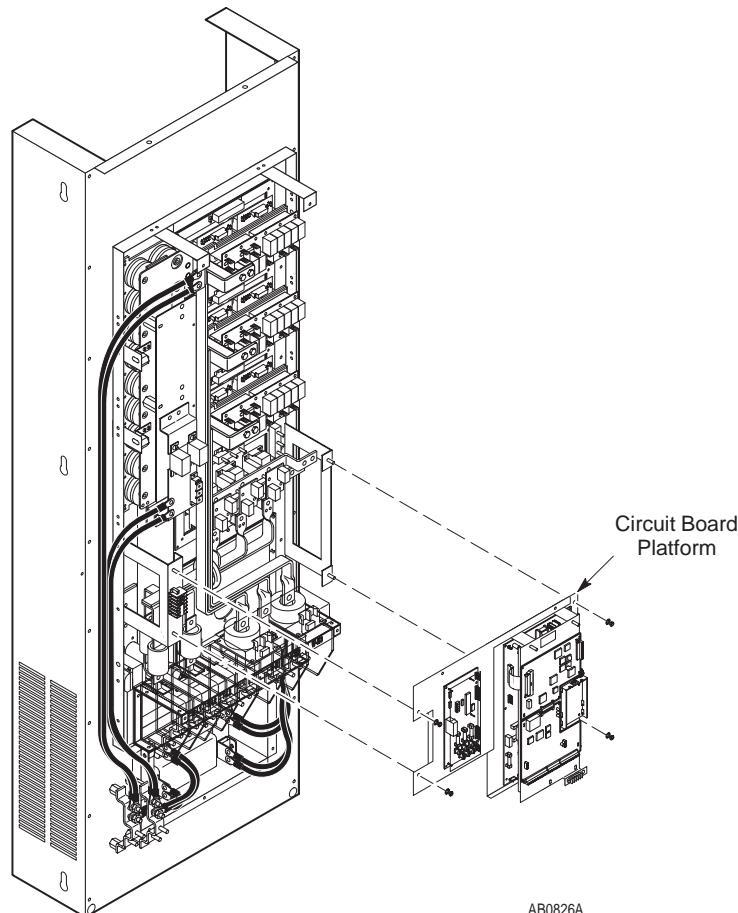


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing the Circuit Board Platform

The Circuit Board Platform contains the Main Control Board, the Gate Driver Board, and the Precharge Board.

Figure 3.6
Circuit Board Platform



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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Disconnect both ground wires from TB5 located in the lower right-hand corner of the the Main Control Board Mounting Plate.
5. Disconnect the following from the Main Control Board:
 - J1 connector
 - J2 connector
 - TB3, if Control Interface L-Option Board is used
 - any optional boards
6. Remove the two nuts from the top and the bottom of the Main Control Board Mounting Plate.
7. Pull the Main Control Board Mounting Plate straight out and remove the plate from the drive.
8. Disconnect the following from the Gate Driver Board:
 - J2 connector
 - J7 connector
 - J8 connector
 - J10 connector
9. Disconnect the following from the Precharge Board:
 - J1 connector
 - J2 connector
 - J4 connector
10. Disconnect the two LEM wire harness plugs.

11. Remove the four nuts fastening the Circuit Board Platform to the drive.

12. Pull the Circuit Board Platform straight out and remove the platform from the drive.

Installation

Install the Circuit Board Platform in reverse order of removal.



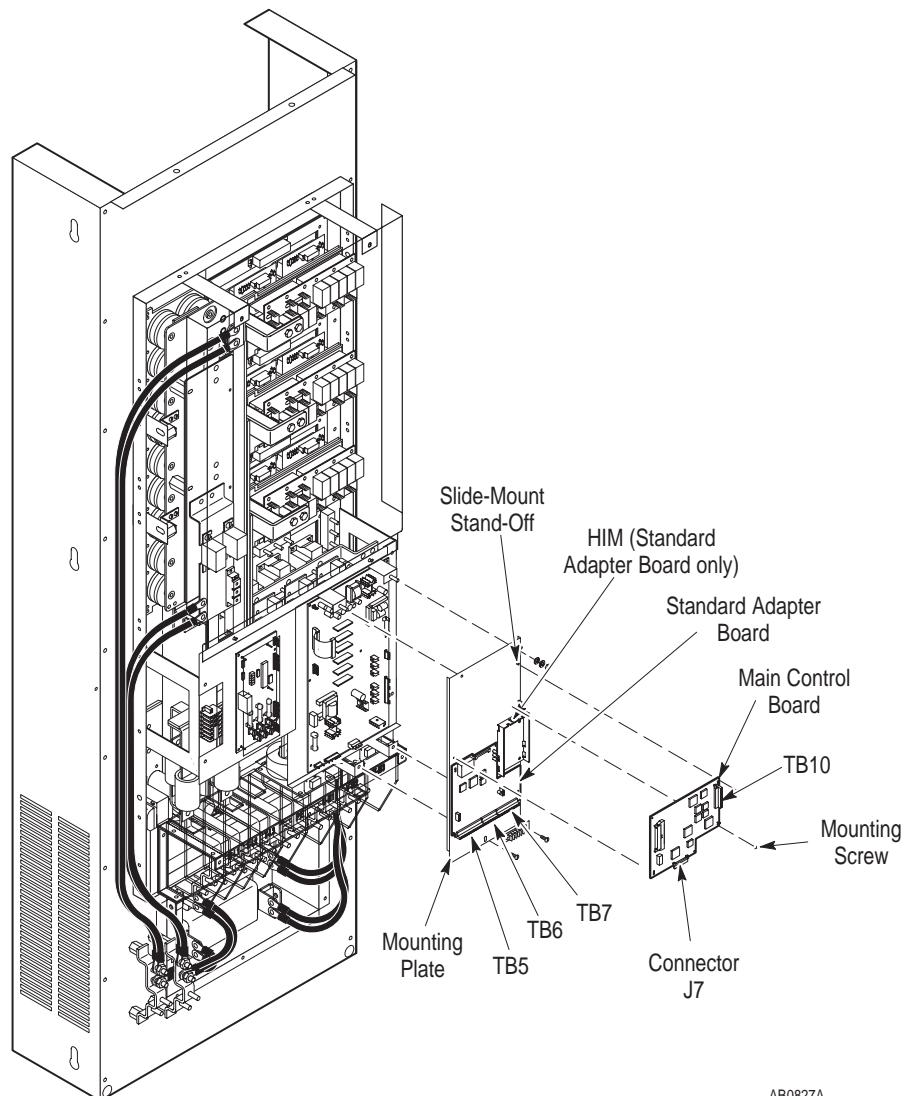
ATTENTION: When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.



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

Removing the Main Control Board

Figure 3.7
Main Control Board



AB0827A

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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove all wires from terminal strip TB3 if a Control Interface Board is used.
5. Disconnect the following from the Main Control Board:
 - J1 connector
 - J2 ribbon cable connector
 - J6 connector
 - J8 connector
 - 8-pin connector from HIM Mounting Plate
 - Ground wire at stake-on connector J10
 - All wires from terminals on TB2

6. Remove the five screws fastening the Main Control Board to the mounting plate.
7. Slide the Main Control Board toward the top of the drive to release it from the slide-mount stand-offs.
8. Lift the Main Control Board away from the mounting plate.

Installation

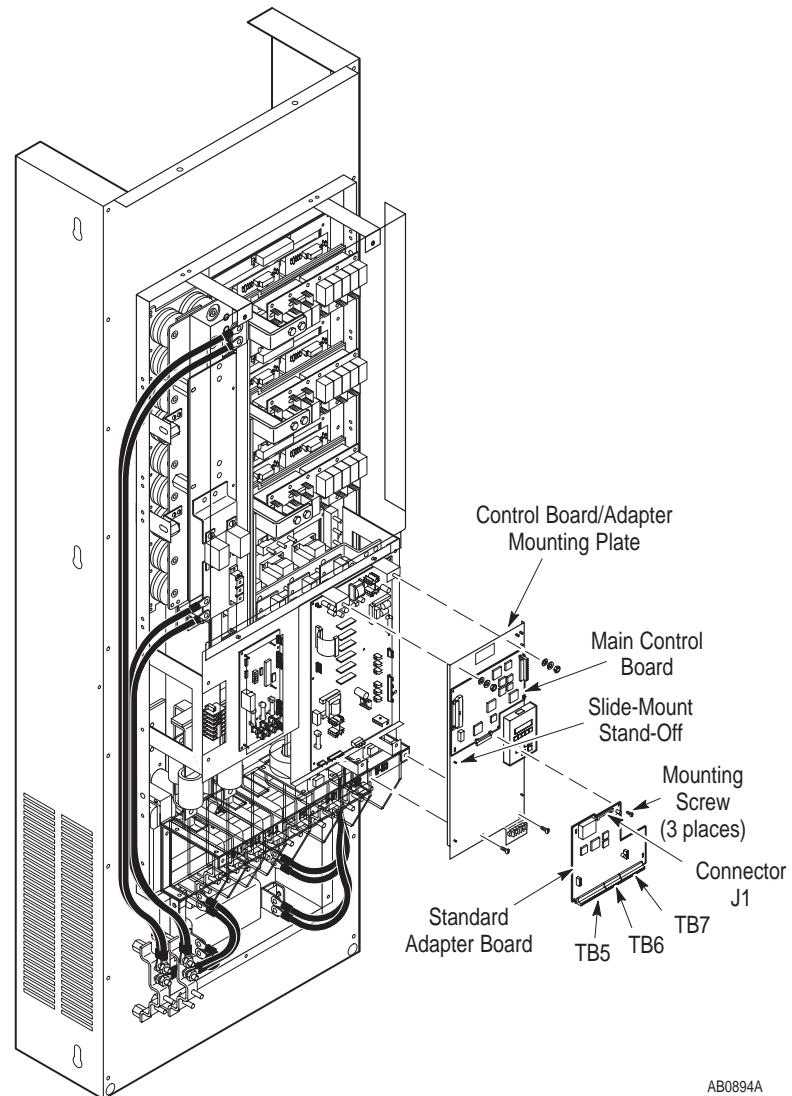
Install the Main Control Board in reverse order of removal.



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

Removing the Standard Adapter Board

Figure 3.8
Main Control Board and 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 the +DC /–DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

1. Remove power from the drive.
2. Check for zero volts at:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB5, TB6, and TB7 on the Standard Adapter Board
 - TB3 the Control Interface L-Option Board
4. Disconnect the following from the Standard Adapter Board:
 - Stake-on ground wire connector
 - All wires from TB5, TB6, and TB7 by separating the mating connectors with wires from the Adapter Board
5. Remove the Control Interface L-Option Board. Refer to Removing the Control Interface L-Option Board in this chapter.
6. Remove the two screws fastening the Standard Adapter Board to the Control Board/Adapter Mounting Plate.
7. Pull the Standard Adapter Board up to release it from the slide mount stand-offs and connector J1.

Installation

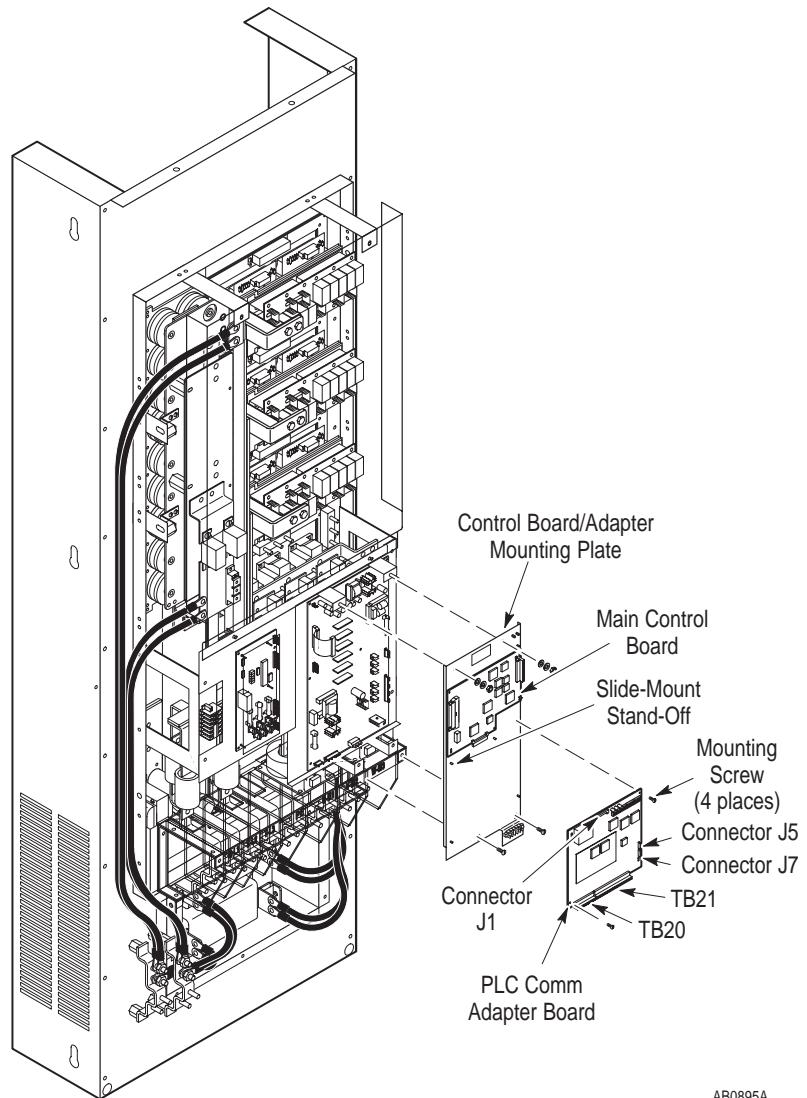
Install the Standard Adapter Board in reverse order of removal.



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 3.9
Main Control Board and PLC Comm Adapter Board



AB0895A

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 the +DC/-DC Brake Terminal. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

1. Remove power from the drive.
2. Check for zero volts at:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on the PLC Comm Adapter Board
4. Disconnect the following from the PLC Comm Adapter Board:
 - All wires from TB20 and TB21 by separating the mated connectors with wires from the adapter board
 - Stake-on ground wire connector
 - J5 connector
 - J7 connector
 - Communication channel A and B connectors
5. Remove the screws fastening the PLC Comm Adapter Board to the Control Board/Adapter Mounting Plate.
6. Pull the PLC Comm Adapter Board down to release it from the slide-mount stand-offs and connector J1.

Installation

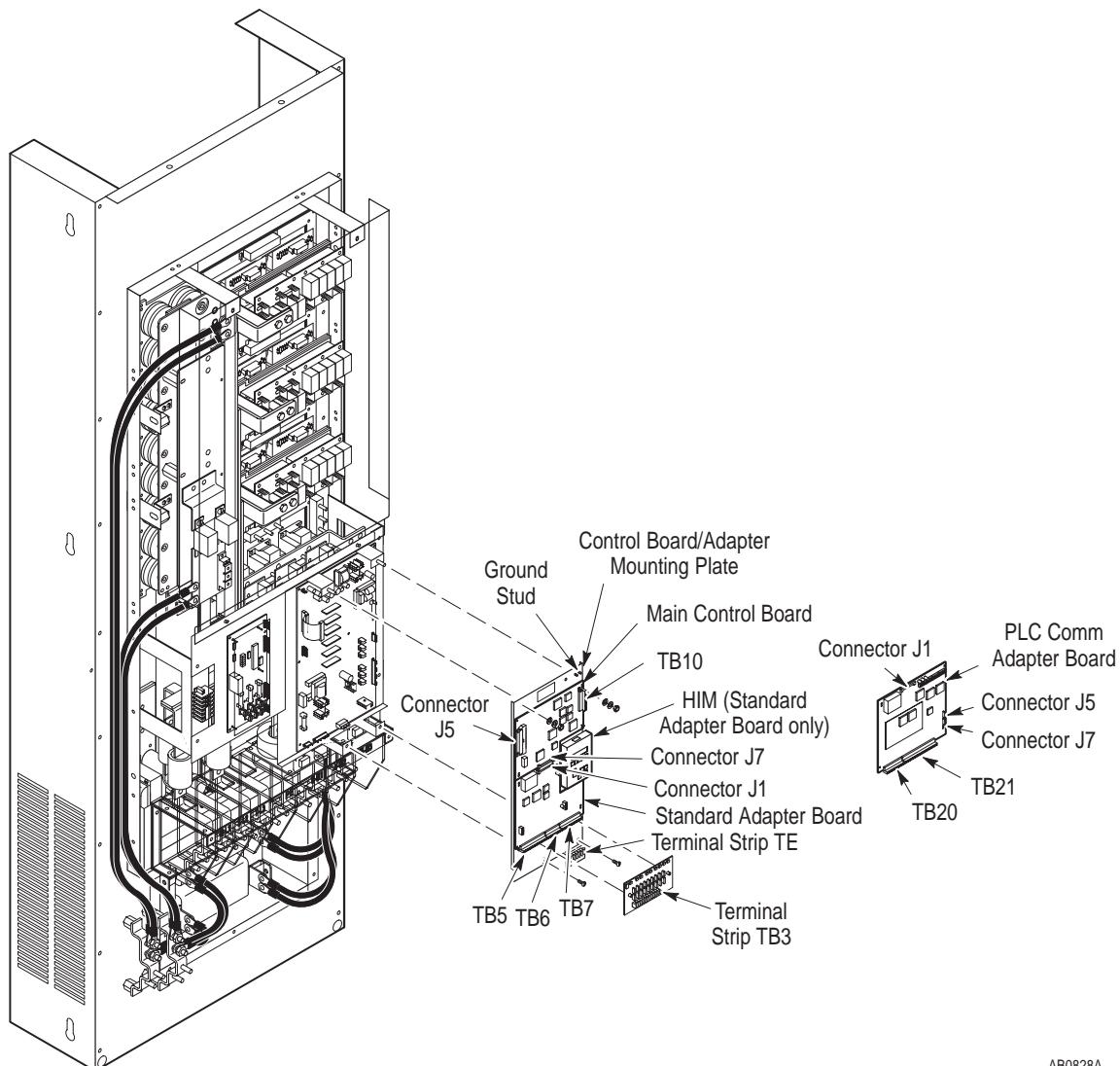
Install the PLC Comm Adapter Board in reverse order of removal.



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 3.10
Control Board/Adapter Mounting Plate



AB0828A

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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on the PLC Comm Adapter Board
4. Disconnect the following from the Main Control Board:
 - J1 connector
 - J5 ribbon cable connector
 - Stake-on ground wire connector
 - All wire from TB10
5. Remove the two screws fastening the bottom of the Main Control Board Mounting Plate to the Circuit Board Platform.
6. Remove the nuts fastening the top of the Main Control Board Mounting Plate to the Circuit Board Platform.
7. Lift the Main Control Board Mounting Plate out of the drive.

Installation

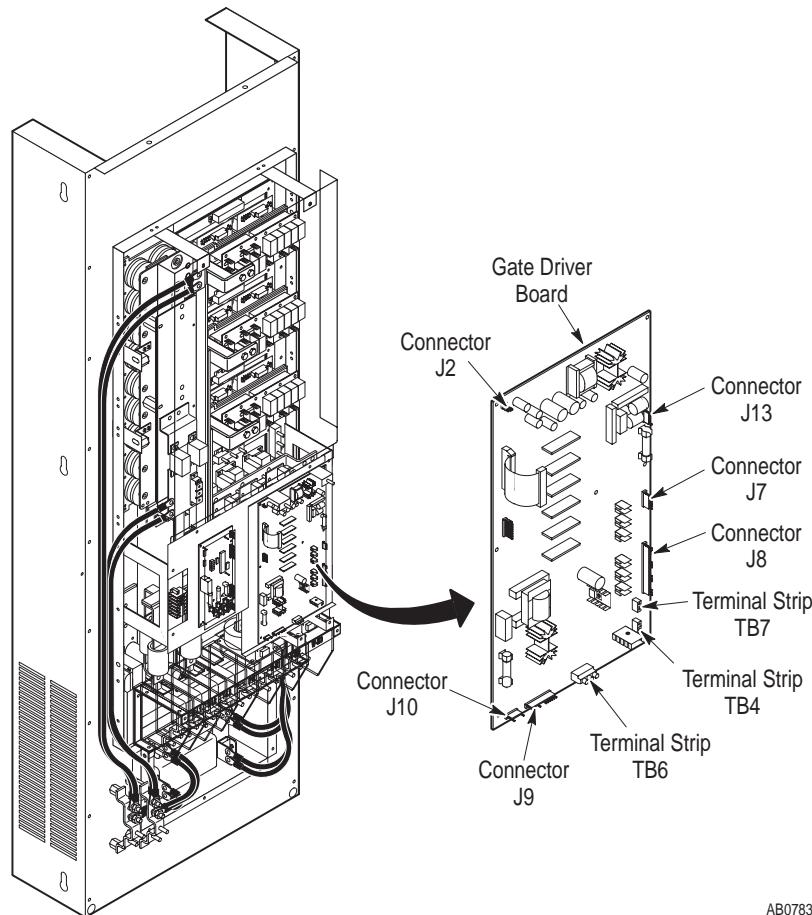
Install the Main Control Board Mounting Plate in reverse order of removal. Refer to Table 3.A – Fastener Torque Specifications.



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 from the Mounting Plate

Figure 3.11
Gate Driver Board and Mounting Plate



AB0763A

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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the Control Board/Adapter Mounting Plate. Refer to Removing the Control Board Adapter Mounting Plate in this chapter.
5. Disconnect the following from the Gate Driver Board:
 - J2 connector
 - J6 connector
 - J7 connector
 - J8 connector
 - J9 connector
 - J10 connector
 - J13 connector
 - TB4 – 24 VDC Auxiliary Input
 - Ground wire from TB7 on the Gate Driver Board
6. Turn the eight standoff screws, fastening the Gate Driver Board to the mounting plate, 1/4 turn counterclockwise.
7. Pull the Gate Driver Board away from the mounting plate.

Installation

Install the Gate Driver Board in reverse order of removal.



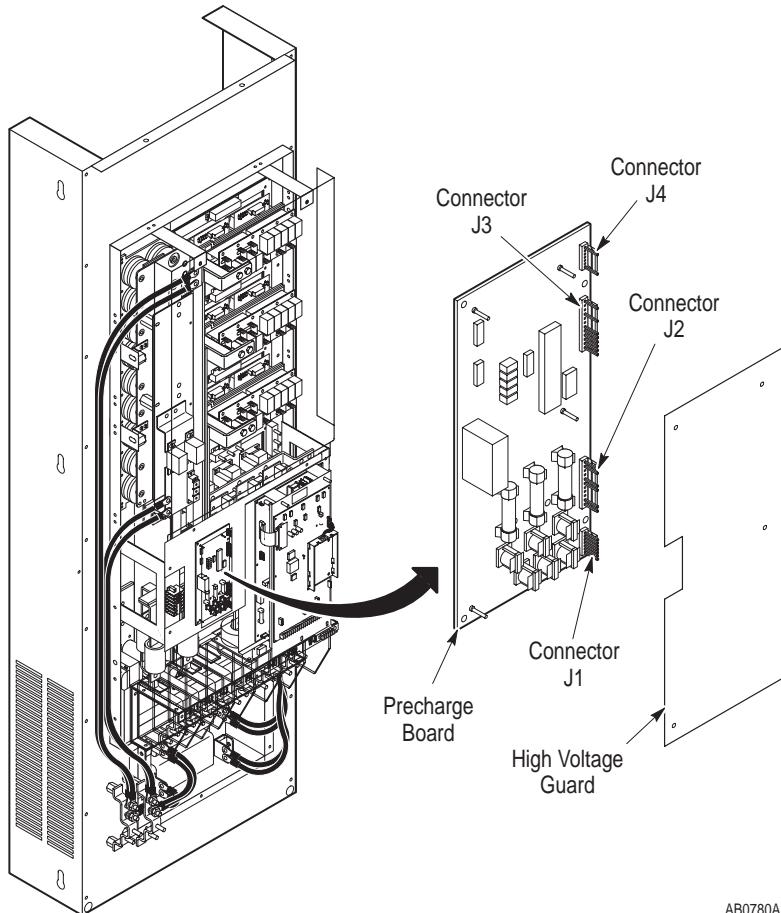
ATTENTION: When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.



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

Removing the Precharge Board from the Mounting Plate

Figure 3.12
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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Disconnect the following from the Precharge Board:
 - J1 connector
 - J2 connector
 - J3 connector
 - J4 connector
5. Pull the Precharge High Voltage Guard away from the four nylon spacers.
6. Turn the six standoff screws, fastening the Precharge Board to the mounting plate, 1/4 turn counterclockwise.
7. Pull the Precharge Board away 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.

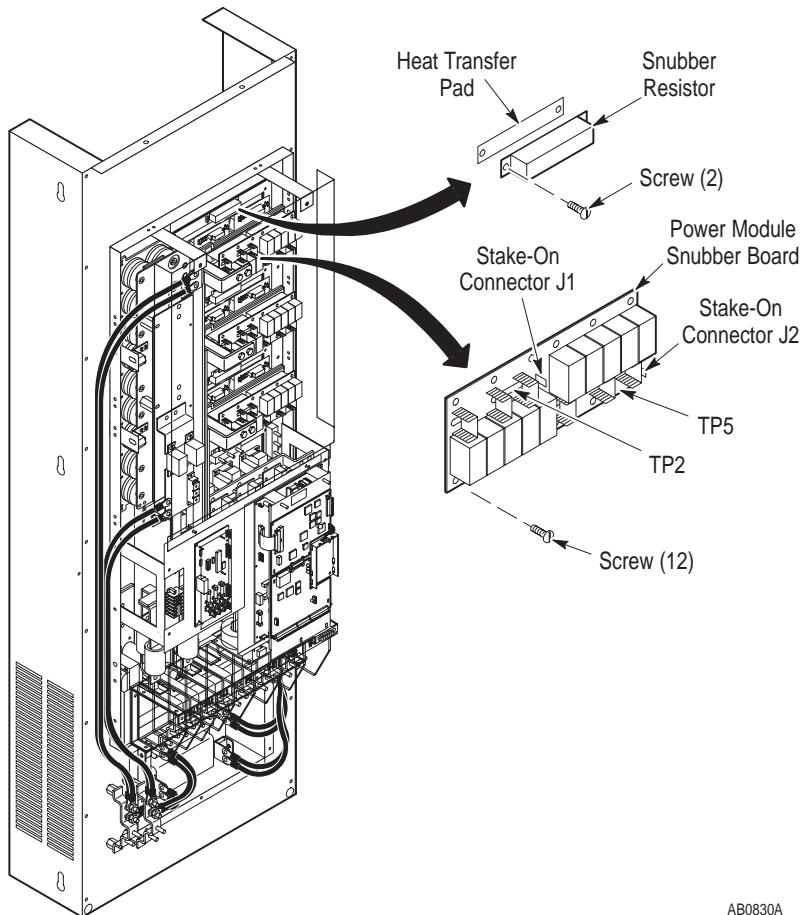


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing a Power Module Snubber Board

The Power Module Snubber Boards are located on the upper right side of the chassis.

Figure 3.13
Power Module Snubber Board



AB0830A

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 the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to FORCE (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and FORCE (+) bus to discharge any voltage.



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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the High Voltage Guard. Refer to Removing the High Voltage Guard in this chapter.
5. Measure the DC voltage from TP5 on the Power Module Snubber Board to TP2 (-DC Bus). If voltage greater than 50 VDC is still present, follow the directions in the Electric Shock Hazard Attention shown above.
6. Remove the Snubber Resistor wire from the Power Module Snubber Board stake-on connectors J1 and J2.
7. Remove the twelve screws fastening the Power Module Snubber Board to the snubber bracket to remove the snubber boards.
8. Check Snubber Resistor with VOM. The reading should be 8 ohms. If open, replace resistor.

Installation



ATTENTION: Do not substitute longer or shorter hardware when fastening the Power Module components 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 Snubber Board in reverse order of removal. Refer to Table 3.A – Fastener Torque Specifications.

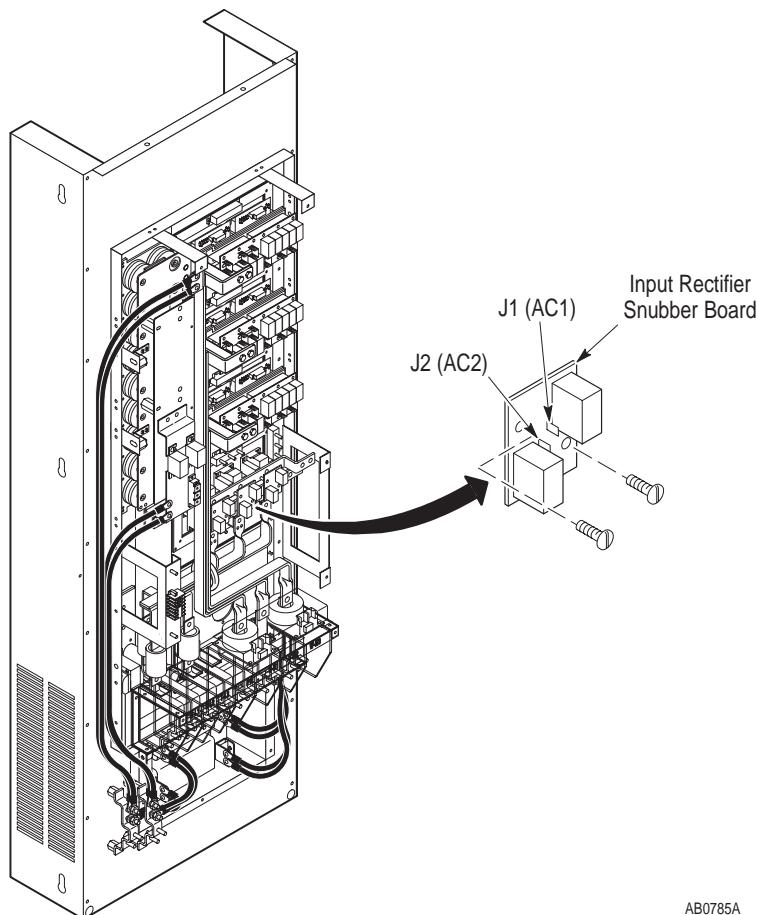


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing an Input Rectifier Snubber Board

The Input Rectifier Snubber Boards are located under the Circuit Board Platform.

Figure 3.14
Input Rectifier 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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the Circuit Board Platform. Refer to Removing the Circuit Board Platform in this chapter.
5. Remove the wire from Input Rectifier Snubber Board stake-on connectors J1 (AC1) and J2 (AC2).
6. Remove the two screws fastening the Snubber Board to the Converter Bus Bar.

Installation

Install the Snubber Board in reverse order of removal. Refer to Table 3.A – Fastener Torque Specifications.

Important: Verify that the snubber resistor wiring is reconnected to the proper phase snubber board.



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 BP300 – BP450 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.



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 the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



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 Rockwell Automation 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 metalic 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

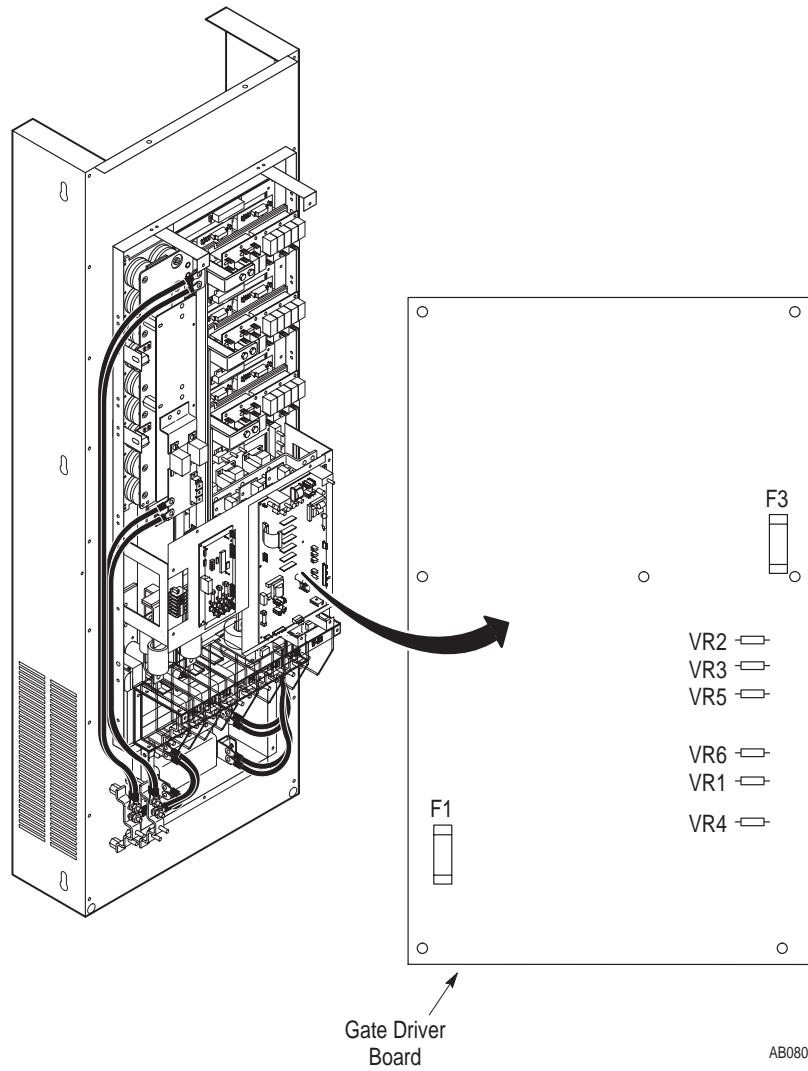
You need the following tools to disassemble and assemble the drive:

- Pliers
- Phillips screwdrivers (medium and large)
- Standard screwdrivers (small, medium, and large)
- 25/64-inch or 10 mm socket
- 7/16-inch or 11 mm socket
- 33/64-inch or 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in lb-in. or N-m
- Nylon tie wraps

Test 1 – Testing the Gate Driver Board

The Gate Driver Board is located beneath the Main Control Board. If modules have been replaced, you must test the Gate Driver Board.

Figure 4.1
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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
5. Check for 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 Control Board/Adapter Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Main Control Board Mounting Plate.
7. Unplug the connectors from the Gate Driver Board.
8. Set your meter to test resistance.
9. Test Fuses F1 and F3 for an open condition. Replace the Gate Driver Board if either fuse shows an open condition.
10. Set your meter to test diodes.
11. Test VR1 – VR6. The following table shows meter connections at the components and ideal meter readings for those connections. Refer to Figure 4.1 for component locations.

Table 4.A
Gate Driver Board Test

Component	Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading *
VR1	+	-	1.06
	-	+	1.8
VR2	+	-	1.06
	-	+	1.8
VR3	+	-	1.06
	-	+	1.8
VR4	+	-	1.06
	-	+	1.8
VR5	+	-	1.06
	-	+	1.8
VR6	+	-	1.06
	-	+	1.8

Note: Typical malfunction is shorted in both directions.

* Meter Used: Fluke® Model 87, set to "Diode" range.

- 12.** 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.

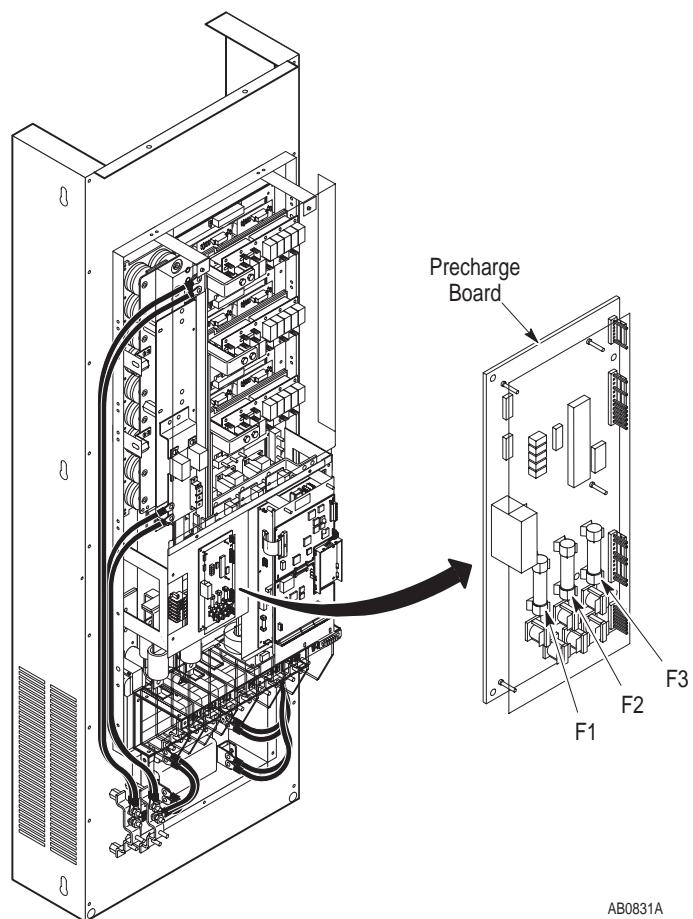


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Test 2 – Testing the Precharge Board

If Input Rectifier modules have been replaced, you must check the Input Rectifier Snubber Board and the Precharge Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing an Input Rectifier Snubber Board and Removing the Precharge Board.

Figure 4.2
Precharge Board Test



AB0831A



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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Set your meter to test resistance.
5. Test fuses F1, F2, and F3 through the access holes in the Precharge Board High Voltage Guard and check 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.

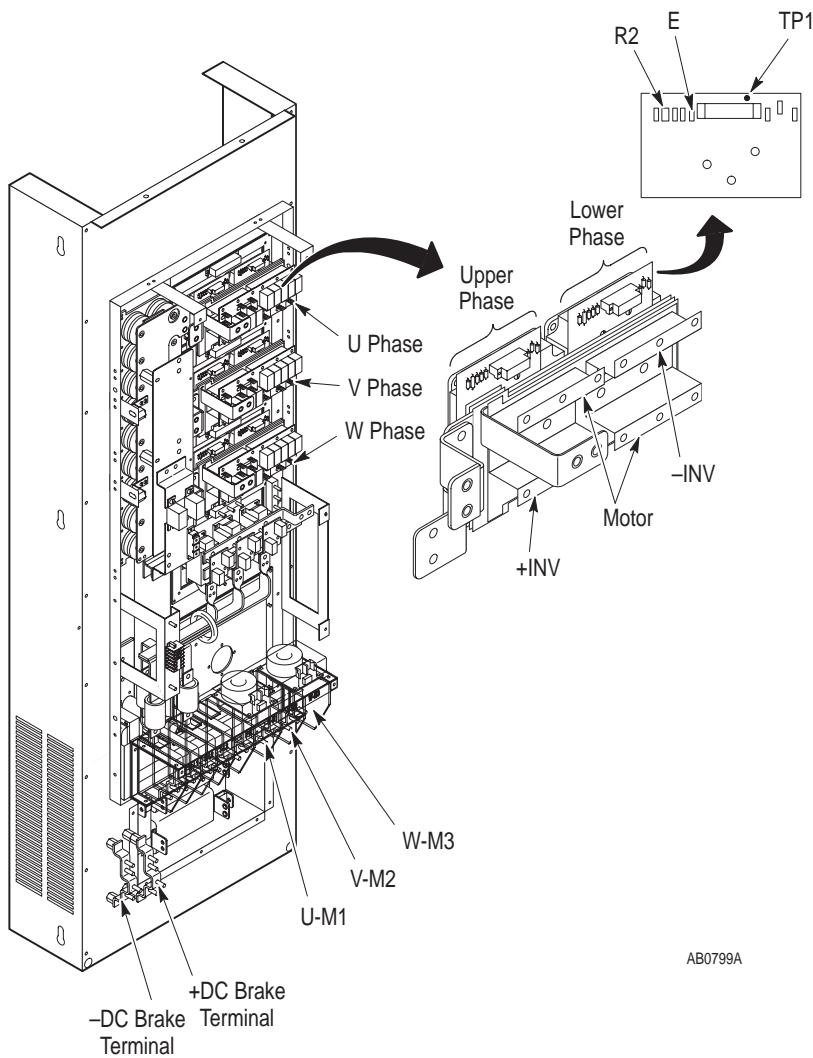
Test 3 – Testing the Power Modules

The Power Modules are located on the upper right side of the heat sink. If modules have been replaced, you must check the Power Module Snubber Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus to discharge any voltage. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

Figure 4.3
Power Module Test



AB0799A



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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the motor leads from TB1-U, V and W terminals of the drive.
5. Set your meter to test diodes.

6. Test the output sections of the drive. This should indicate if any of the drive's output phases has a problem. Table 4.B shows meter connections and ideal meter readings for those connections. Refer to Figure 4.3 for meter connection locations.

**Table 4.B
Output Sections**

Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading	Phase with Problem
+DC Brake	U-M1	Infinite	U
+DC Brake	V-M2	Infinite	V
+DC Brake	W-M3	Infinite	W
U-M1	+DC Brake	0.318	U
V-M2	+DC Brake	0.318	V
W-M3	+DC Brake	0.318	W
-DC Brake	U-M1	0.318	U
-DC Brake	V-M2	0.318	V
-DC Brake	W-M3	0.318	W
U-M1	-DC Brake	Infinite	U
V-M2	-DC Brake	Infinite	V
W-M3	-DC Brake	Infinite	W

Note: Typical malfunction is shorted in both directions.

* Meter Used: Fluke® Model 87, set to "Diode" range.

7. If the readings are not approximately the same as in Table 4.B, the last column identifies the phase with a potential problem. If the readings are not correct, continue with the test procedure to check the individual phase or phases in question.
8. Remove the High Voltage Guard. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
9. Remove the Power Module Snubber Boards. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

- 10.** Test the Power Module phases that did not pass the Table 4.B tests. Table 4.C shows meter connections and ideal meter readings for those connections. Refer to Figure 4.3 for meter connection locations.

Table 4.C
Power Modules

		Upper Phase		
Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading	Type of Reading	
Motor	+INV	0.289v	Diode	
+INV	Motor	Infinite	Diode	
E	TP1	0.289v	Diode	
TP1	E	Infinite	Diode	
E	Motor	0 ohms	Resistance	
TP1	+INV	0 ohms	Resistance	
E	R2	10k ohms	Resistance	
		Lower Phase		
Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading	Type of Reading	
-INV	Motor	0.289v	Diode	
Motor	-INV	Infinite	Diode	
E	TP1	0.289v	Diode	
TP1	E	Infinite	Diode	
E	-INV	0 ohms	Resistance	
TP1	Motor	0 ohms	Resistance	
E	R2	10k ohms	Resistance	

Note: Typical malfunction for diode test is shorted in both directions.

Note: Select meter to read appropriate type of measurement where needed.

* Meter Used: Fluke® Model 87, set to "Diode" range.

- 11.** Replace the Power Module phase if the meter readings are not approximately as shown. Refer to Chapter 4 – Part Replacement Procedures, Power Modules.

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

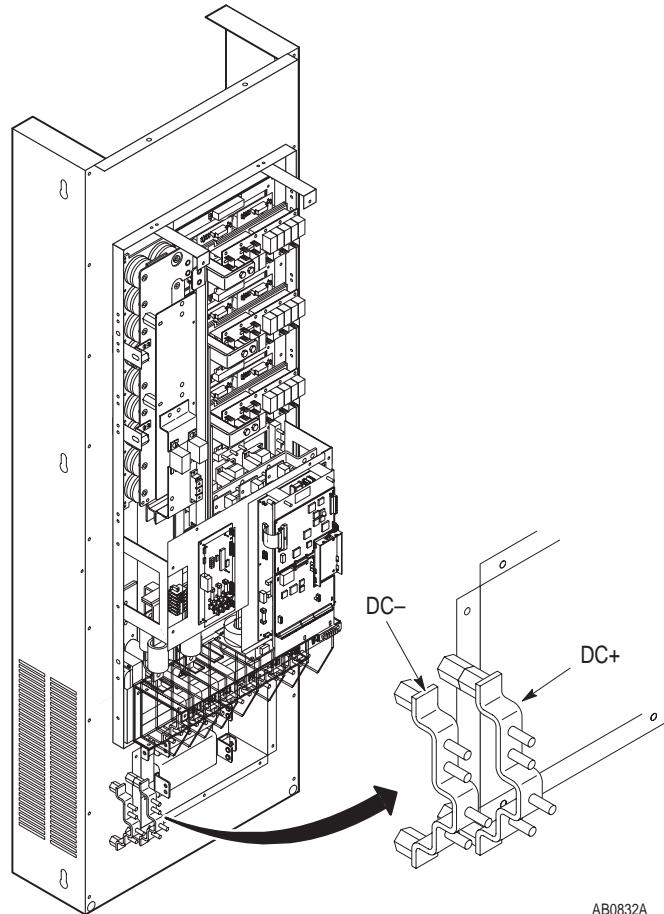


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Test 4 – Testing the Bus Capacitors

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

Figure 4.4
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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Set your meter to test DC voltage.
5. Connect the negative lead of your meter to the -DC Brake Terminal on TB1 and the positive lead to the +DC Brake Terminal. Refer to the following tables and Figure 4.4 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.

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

Table 4.D
Bus Capacitor Bank Test

Drive Rating	Input Volts	Meter Reading
A	200	283V DC +/-10%
	230	325V DC +/-10%
	240	339V DC +/-10%
B	380	537V DC +/-10%
	415	587V DC +/-10%
	480	679V DC +/-10%
C	500	707V DC +/-10%
	575	813V DC +/-10%
	600	848V DC +/-10%

7. 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.
8. 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.

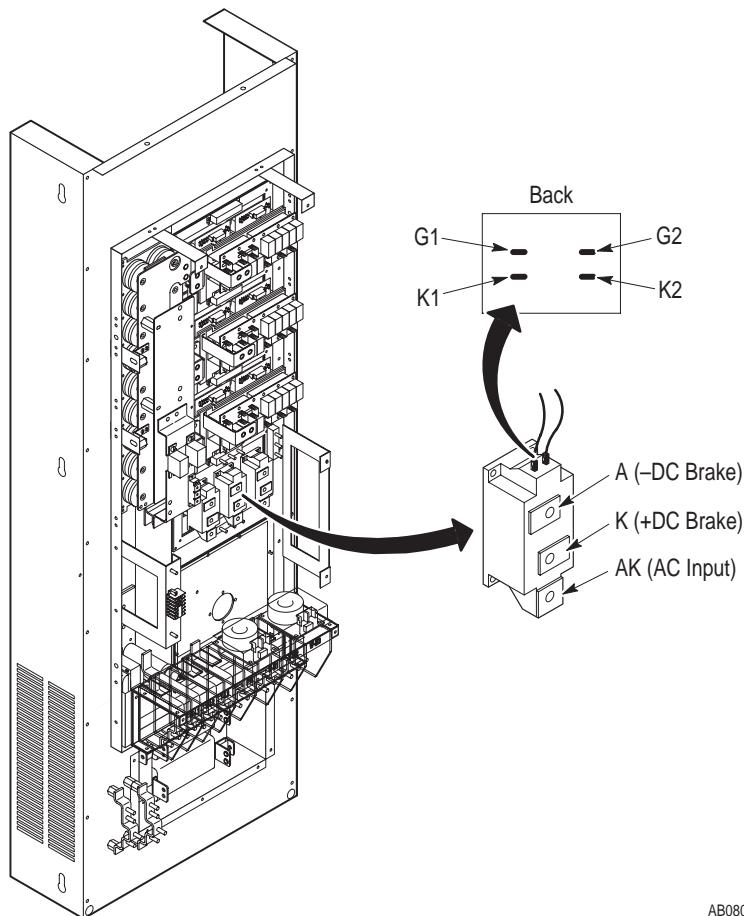


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Test 5 – Testing the Input Rectifiers

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

Figure 4.5
Input Rectifier Test



AB0802A



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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for the absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Check for 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 Circuit Board Platform. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
6. Remove the Input Rectifier Snubber Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Input Rectifier Snubber Board.
7. Set your meter to test diodes.
8. The following table shows meter connections and ideal meter readings for those connections. Refer to Figure 4.5 for meter connection locations.

Table 4.E
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	0.011
K1	G1	0.011
G2	K2	0.011
K2	G2	0.011

Note: Typical malfunction is shorted in both directions.

* Meter Used: Fluke® Model 87, set to "Diode" range.

9. Replace the Input Rectifier if any meter readings are not as shown. Refer to Chapter 4 – Part Replacement Procedures, Input Rectifiers.
10. If the Input Rectifier shorted, check the Power Modules for damage. Refer to Testing the Power Modules in this chapter.

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.

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 the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

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 Rockwell Automation 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 (small, medium, and large)
- Standard screwdrivers (small, medium, and large)
- 25/64-inch or 10 mm socket
- 7/16-inch or 11 mm socket
- 33/64-inch or 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in lb-in. or N-m
- Nylon tie wraps

Major Component Replacement

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

- Bus Capacitor Bank
- Thermistor
- Power Modules
- Bus Fuses F1
- Input Fuses
- Ground Fault CT
- Input Rectifiers
- LEMs
- MOV Surge Suppressor
- Fan and Transformer Assembly
- DC Bus Inductor L1

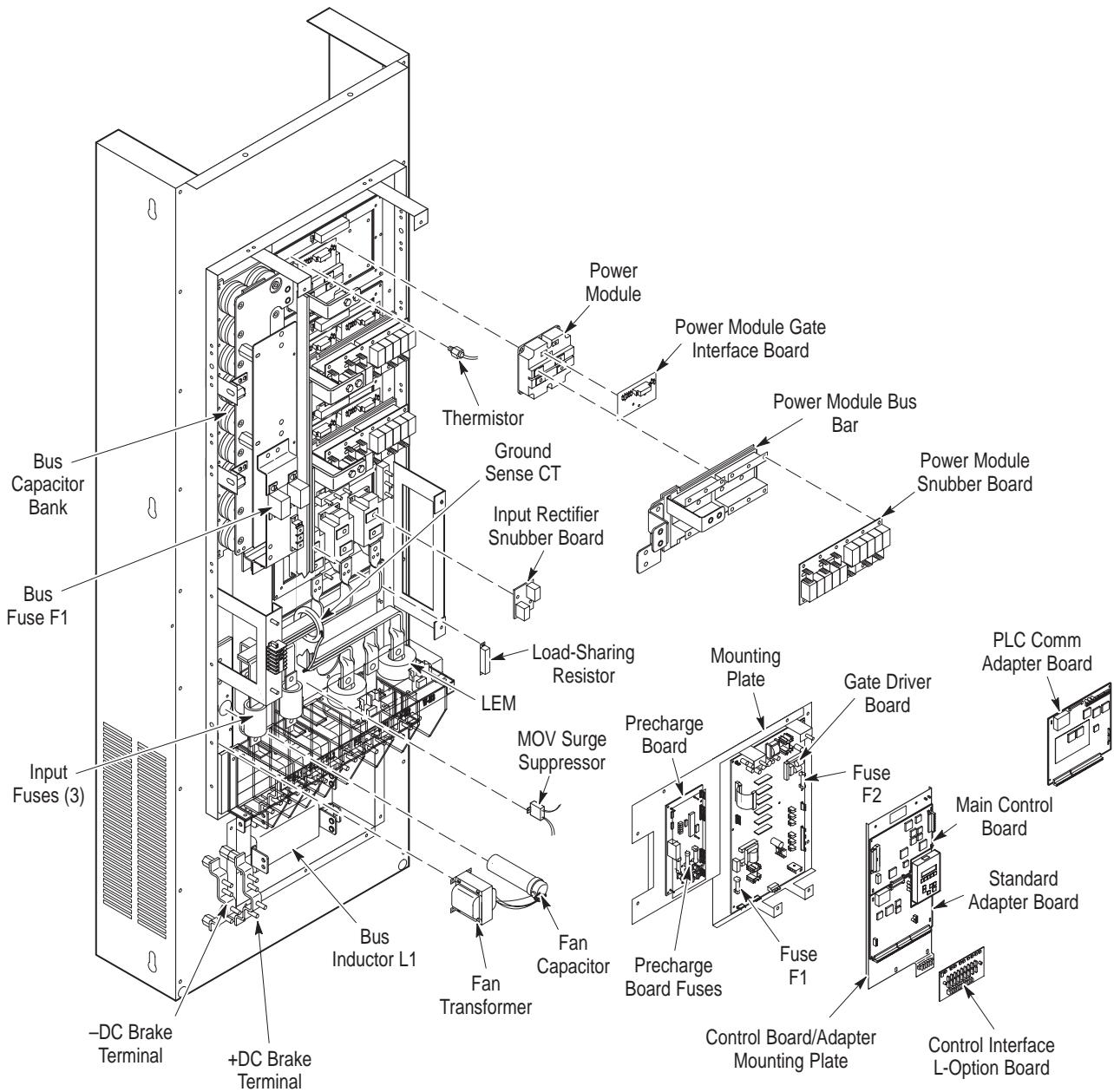
For Main Control Board, PLC Comm Adapter Board, Standard Adapter Board, Gate Driver Board, Precharge Board, Snubber Boards, and Control Interface Board installation and removal procedures, refer to Chapter 2.

Detailed Product Identification

Rockwell Automation 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 5.1
Main Drive Components

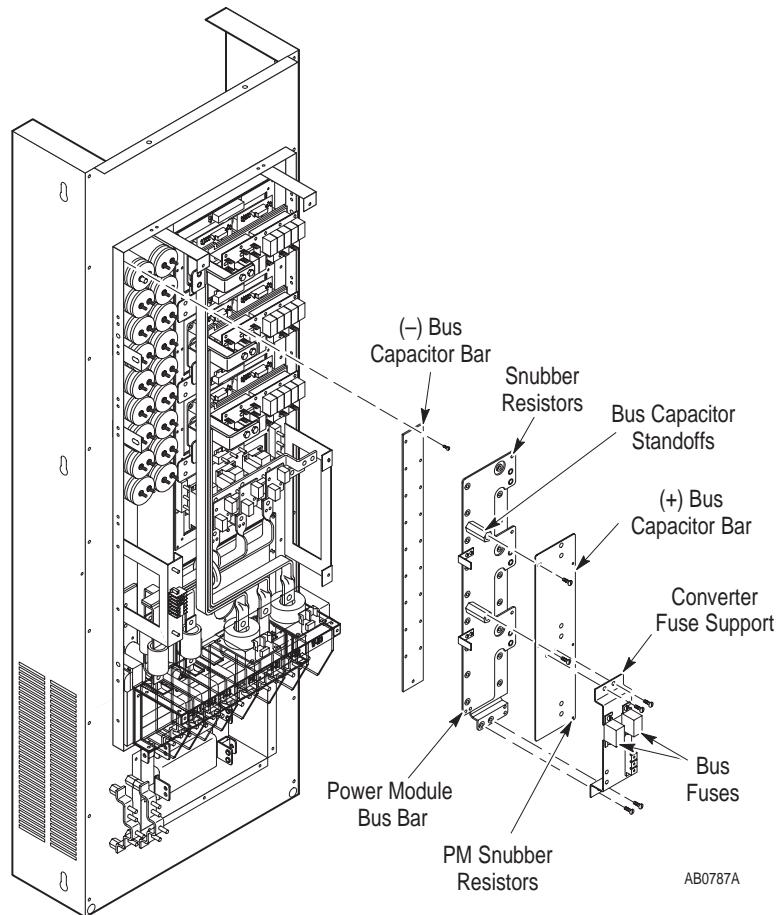


AB0822A

Bus Capacitor Bank

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

Figure 5.2
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 the +DC/-DC Brake Terminals. 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 Main Chassis:

1. Remove power from the drive.
2. Check for zero volts at:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
5. Remove the Circuit Board Platform. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Circuit Board Platform.

Access the Bus Capacitor Bank:

1. Remove the (+) Bus Capacitor Bar:

- A. Remove the two sets of bolts fastening the power cables to the top and bottom of the Bus Capacitor Bank.
- B. Remove the four bolts fastening the Converter Fuse Support to the (+) Bus Capacitor Bar and Power Module Bus Bar.
- C. Pull the Converter Fuse Support, with bus fuses attached, from the drive.
- D. Remove the six bolts (2 per phase) fastening the (+) Bus Capacitor Bar to the Power Module Bus Bar.
- E. Remove the two bolts fastening the (+) Bus Capacitor Bar to the Bus Capacitor Inverter Standoffs.
- F. Remove the three screws fastening the (+) Bus Capacitor Bar to the Power Module Snubber Resistors.
- G. Pull the (+) Bus Capacitor Bar from the drive.

2. Remove the Power Module Bus Bar:

- A. Remove the six screws fastening the Power Module Bus Bar to the (-) Bus Capacitor Bar.
- B. Remove the eighteen nuts fastening the Power Module Bus Bars to the (-) Bus Capacitor Bar.
- C. Remove the five screws fastening the Power Module Bus Bar to the Snubber Resistors.
- D. Remove the two bolts fastening the Power Module Bus Bar to the drive.
- E. Pull the Power Module Bus Bar from the drive.

3. Remove the Bus Capacitors:

- A. Remove the eighteen nuts fastening the (-) Bus Capacitor Bar to the Bus Capacitors.
- B. Pull the (-) Bus Capacitor Bar from the drive.
- C. Remove the Bus Capacitors from the drive.

Installation

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

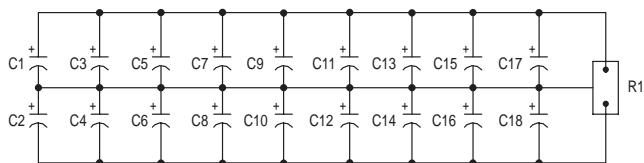
Important: Orient the notch and vent hole on the Bus Capacitors to the top of the drive.

2. Connect the Load-Sharing Resistors to the Bus Capacitors according to the diagram in Figure 5.3. Refer to the schematic diagrams in this manual for more information on component configurations.

Important: Check the Load-Sharing Resistors for an open condition and replace any open resistors.

Important: If the drive is equipped with PEM nuts on the Cap Bus bar, use them instead of capacitor studs to make the electrical connection.

Figure 5.3
Load-Sharing Resistor Connections to Bus Capacitors



AB0820A

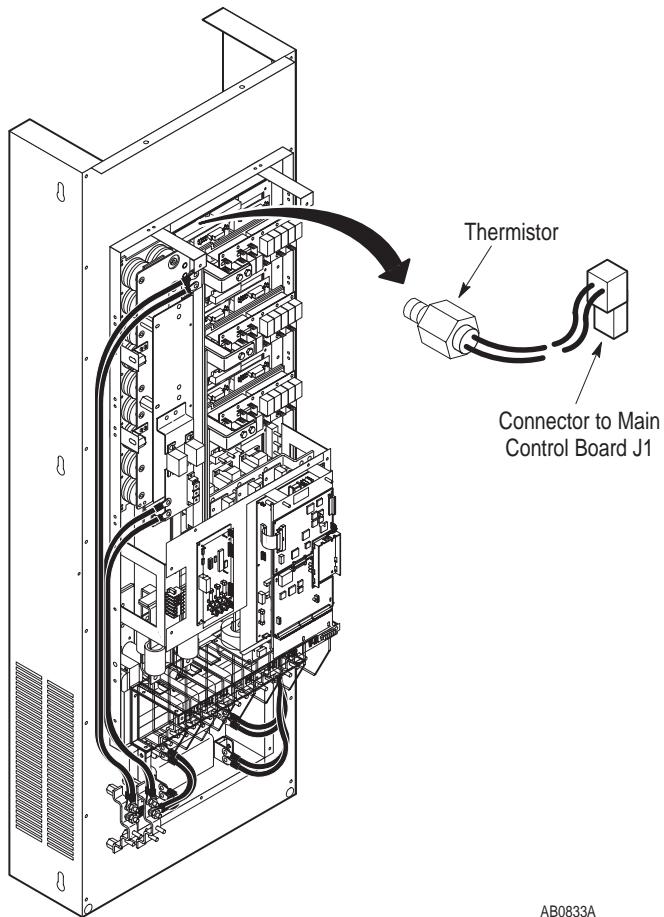


ATTENTION: Capacitors not installed correctly will erupt or vent and could cause injury and equipment damage. Observe correct polarities.

Thermistor

The Thermistor is located on the heat sink at the top-middle of the drive.

Figure 5.4
Thermistor



AB0833A

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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the screws fastening the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
5. Disconnect the Thermistor connector at J1 on the Main Control Board.
6. Unscrew the Thermistor from the heat sink.

Installation

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

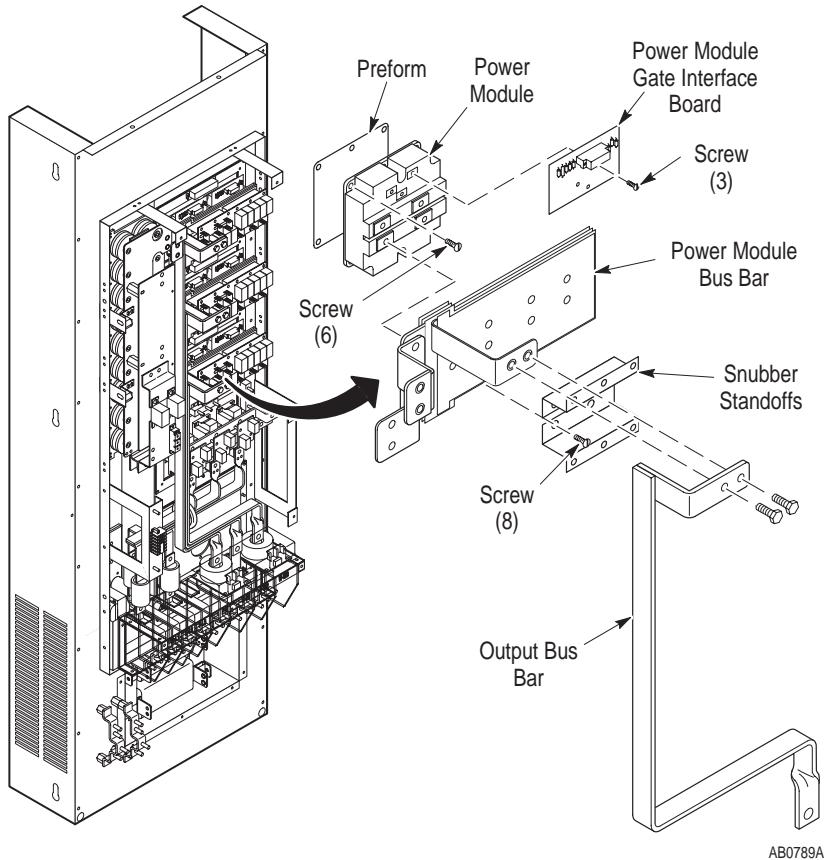


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Power Modules

The Power Modules are located near the top of the heat sink. If one or more Power Modules is replaced, you must check the Power Module Snubber Board and the Precharge Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Precharge Board.

Figure 5.5
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 the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
5. Remove the Circuit Board Platform. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
6. Remove the six bolts fastening the three Output Bus Bars to the Power Module Assembly and TB1.
7. Remove the Power Module Snubber Boards. Refer to Chapter 2 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

8. Remove the bolts fastening the Power Module Bus Bar to the Bus Capacitor Bank.
9. Remove the eight screws fastening the Snubber Standoffs to the Power Module Bus Bar. Remove the standoffs.
10. Slide the Power Module Bus Bar to the right and remove the bus bar from the drive.
11. Remove the three screws fastening the Power Module Interface Board to the Power Module.
12. Remove the six screws fastening the Power Module to the heat sink.
13. Pull the Power Module away from the heat sink.

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: Remove the copper shorting strip from the Power Module before replacing the Power Module Interface Board.



ATTENTION: Do not substitute longer or shorter hardware when fastening the Power Module components 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.

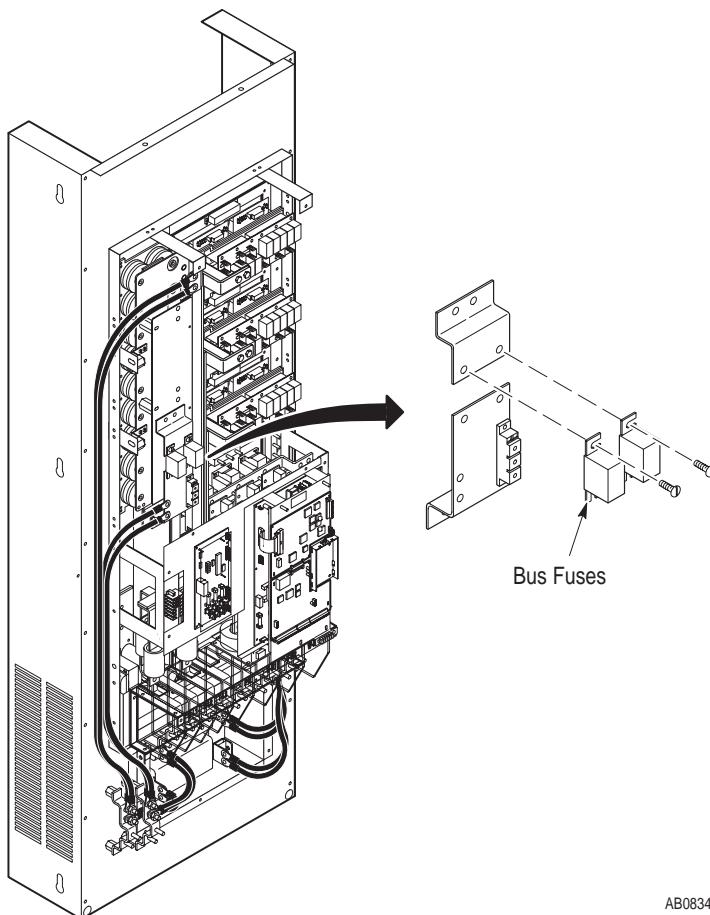


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Bus Fuses F1

The Bus Fuses are located on the Bus Capacitor Bank Assembly.

Figure 5.6
Bus Fuses F1



AB0834A

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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the screws fastening the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
5. Remove the screws fastening the two Bus Fuses to the drive.
6. Pull the fuses out from the drive.

Important: When one fuse blows, you must replace both fuses. Also replace the Bus Fuse Diode Module in parallel.

Installation

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

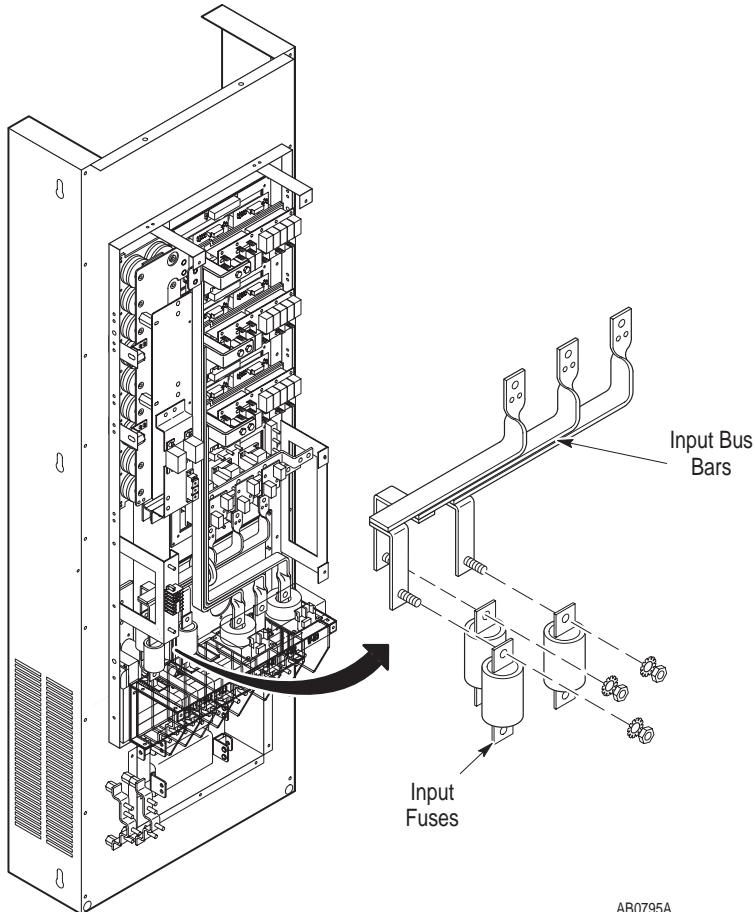


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Input Fuses

The Input Fuses are located on the bottom left-hand side of the chassis above TB1.

Figure 5.7
Input Fuses



AB0795A

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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the nuts fastening the Input Fuse to the Input Bus Bar and TB1.
5. Pull the blown fuse out from the drive.

Installation

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

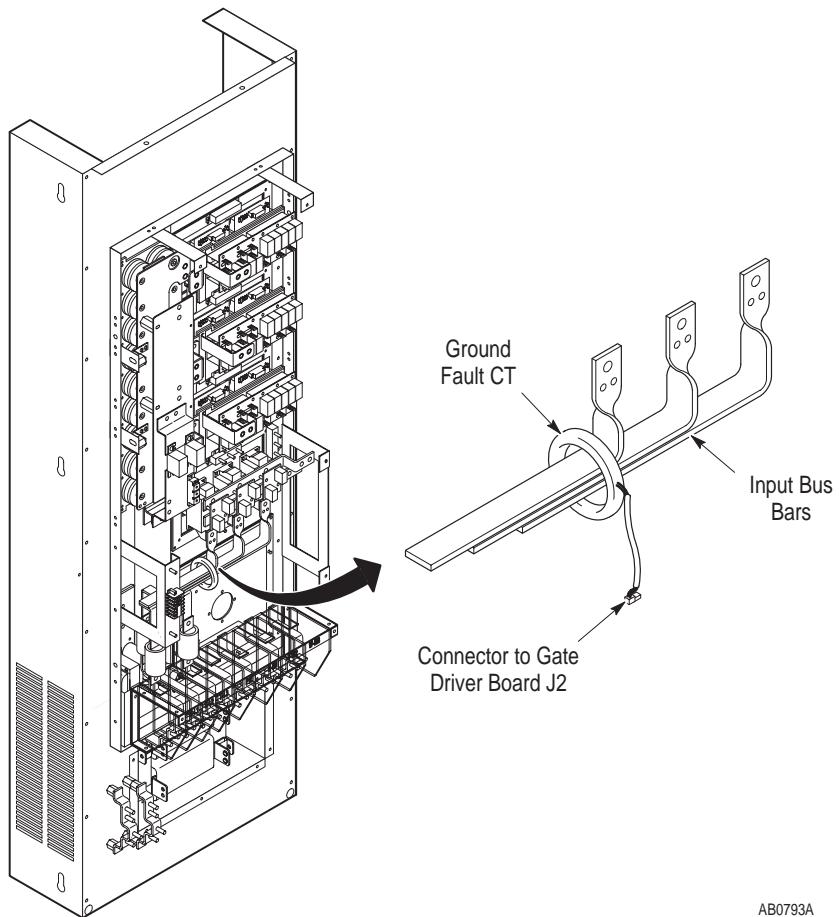


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Ground Fault CT

The Ground Fault CT encircles the Input Bus Bars and is located between the Input Fuse Assembly and the Input Rectifier Assembly.

Figure 5.8
Ground Fault CT



AB0793A

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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the screws fastening the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
5. Remove the Circuit Board Platform. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
6. Remove the six screws fastening the Input Rectifier wiring to the Input Bus Bars.
7. Remove the six bolts fastening the Input Bus Bars to the Input Rectifier Assembly and the Input Fuse Assembly.
8. Slide the Input Bus Bars to the right to remove the bus bars and the Ground Fault CT, which encircles the bus bars, from the drive.
9. Slide the Ground Fault CT off the bus bars.

Installation

Install the Ground Fault CT in reverse order of removal, inserting the Input Bus Bars through the center of the Ground Fault CT. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.



ATTENTION: A possible short-circuit hazard exists. Position the fuse-to-inductor wire with the shrink-wrapped end of the wire connected to the Bus Inductor. Failure to position the wire as illustrated may result in serious injury or equipment damage.

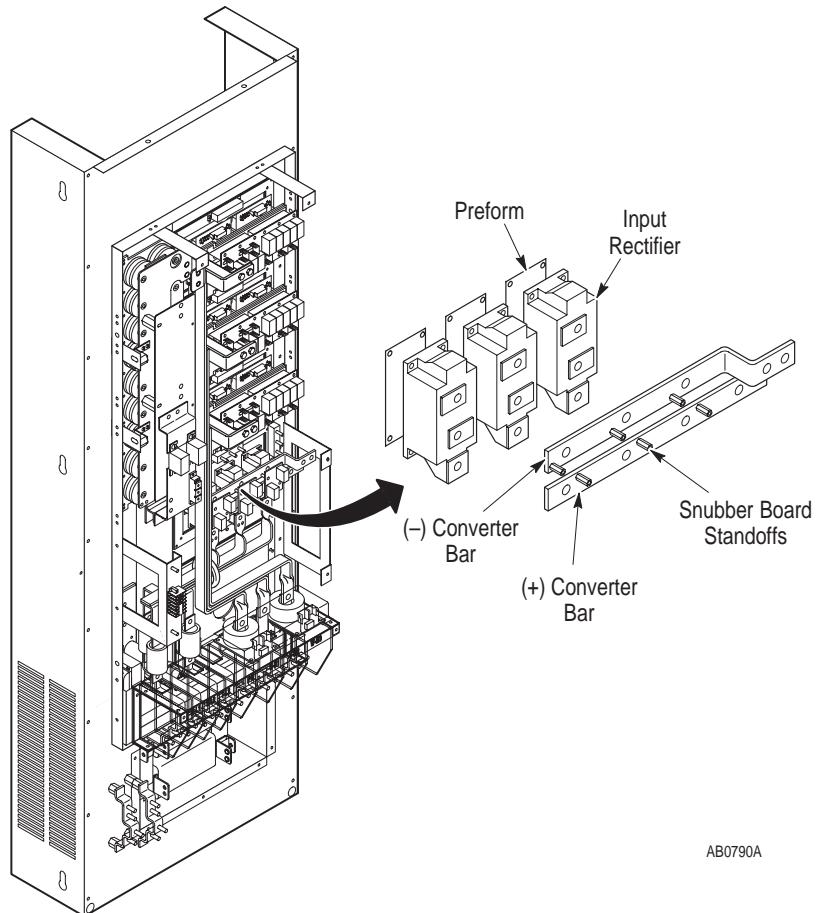


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Input Rectifiers

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

Figure 5.9
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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
- 3.** Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
- 4.** Remove the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
- 5.** Remove the Circuit Board Platform. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
- 6.** Remove the Input Rectifier Snubber Boards. Refer to Chapter 2 – Disassembly and Access Procedures, Removing an Input Rectifier Snubber Board.
- 7.** Remove the three bolts fastening the Input Bus Bars to the Input Rectifiers.
- 8.** Remove the six Allen-head screws fastening the positive and negative Converter Bus Bars to the Input Rectifiers.
- 9.** Remove the Precharge Wiring Harness from the top of the rectifiers.
- 10.** Remove the four screws fastening the Input Rectifier to the heat sink.
- 11.** Pull the Input Rectifier away from the heat sink.

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.

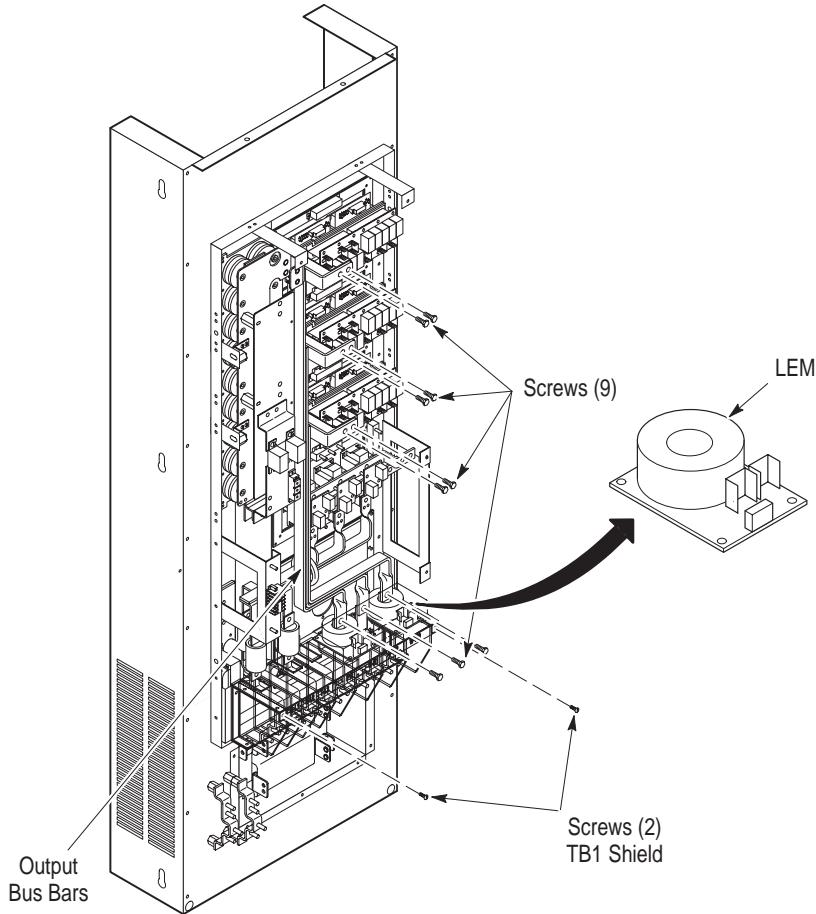


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

LEMs

The two LEMs are located above TB1 on the right side of the chassis.

Figure 5.10
LEMs



AB0796A

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 the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
5. Remove the Circuit Board Platform. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
6. Remove the nine bolts fastening the Output Bus Bars to the Power Module Assembly and TB1.
7. Pull the Output Bus Bars out from the drive.
8. Remove the two screws fastening the TB1 shield to the TB1 Assembly.

- 9.** Pull the TB1 shield away from the drive.
- 10.** Remove the four screws fastening the LEM Interface Board to the standoffs.
- 11.** Lift the LEM up and away from the drive.

Installation

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

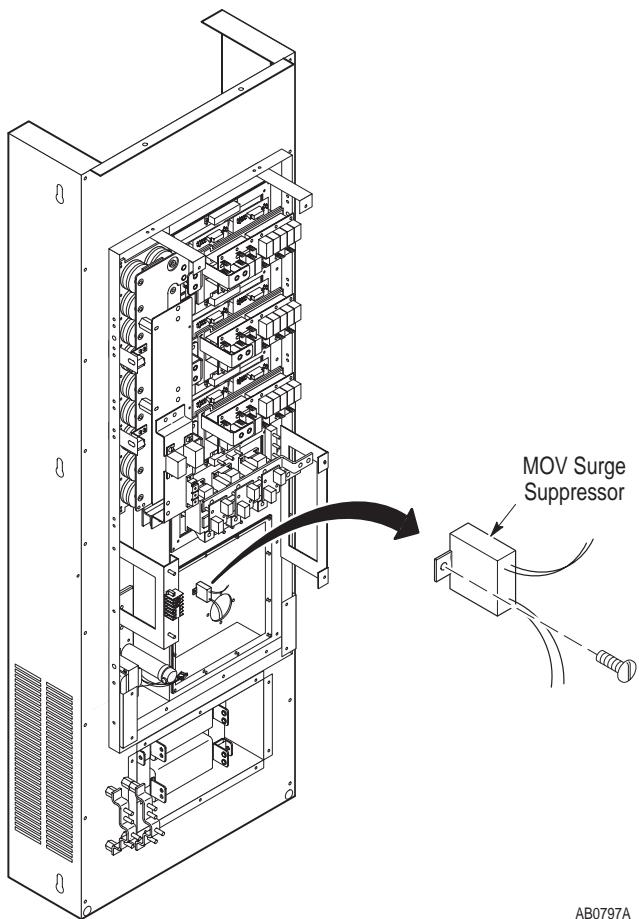


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

MOV Surge Suppressor

The MOV Surge Suppressor is located on top of the Fan Cover Plate. The MOV protects the drive from high voltage surges above approximately 1,000 volts. Replace it if it is burned, expanded, or ruptured after such events as a lightning strike, or inadvertent connection of the drive input to a voltage source substantially above nameplate voltage.

Figure 5.11
MOV Surge Suppressor



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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
5. Remove the Circuit Board Platform. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
6. Remove the three screws fastening the MOV Surge Suppressor wires to the Input Bus Bars.
7. Remove the screw fastening the MOV Surge Suppressor wire to TB1 terminal PE.
8. Remove the screw fastening the MOV Surge Suppressor to the chassis.
9. Pull the MOV Surge Suppressor from the drive.

Installation

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

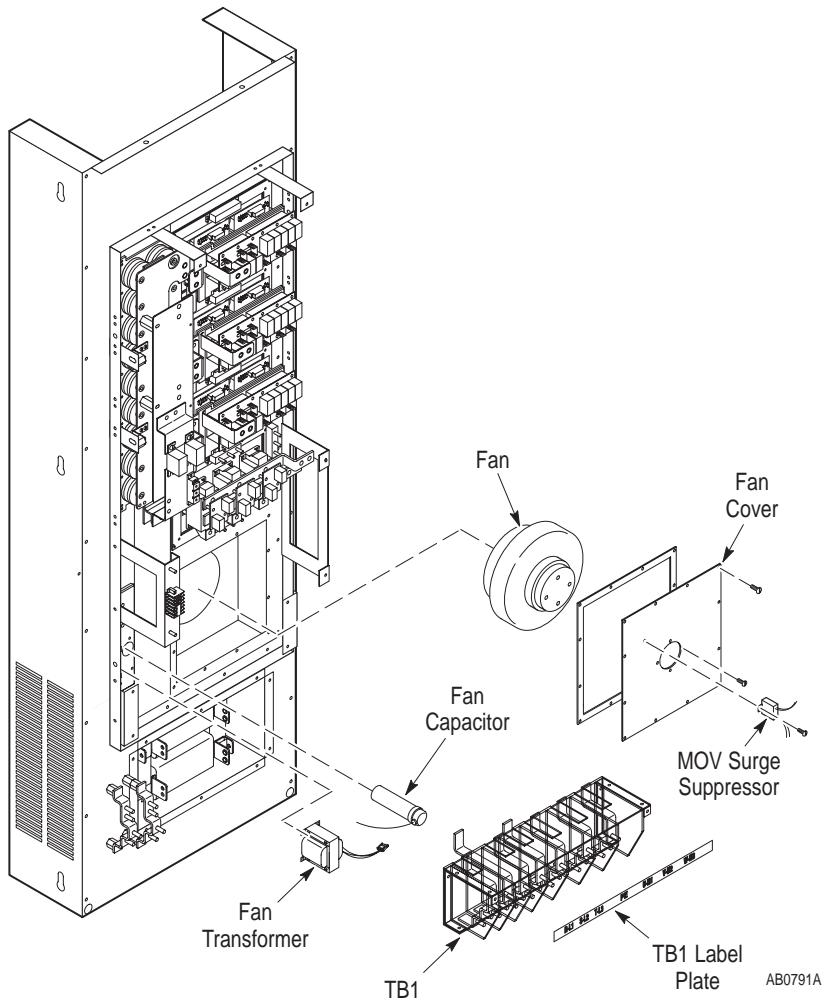


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Fan and Transformer Assembly

The Fan is located in the chassis and under TB1 at the bottom of the heat sink. The Fan Transformer and Fan Capacitor are located in the bottom left corner of the chassis.

Figure 5.12
Fan and Transformer



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 the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus 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 Main Chassis:

1. Remove power from the drive.
2. Check for zero volts at:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Remove the High Voltage Guard from the drive. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the High Voltage Guard.
5. Remove the Circuit Board Platform. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
6. Remove the nine bolts fastening the Output Bus Bars to the Power Module Assembly and TB1.
7. Pull the Output Bus Bars away from the drive.
8. Remove the Input Fuses. Refer to the removal instructions for Input Fuses in this chapter.

9. Remove the three bolts fastening the Input Bus Bars to the Input Rectifier and remove the six screws on the Input Bus Bars.

10. Remove the Input Bus Bars, with the Ground Fault CT encircling the bars, from the drive.

11. Remove the MOV Surge Suppressor. Refer to the removal instructions for the MOV Surge Suppressor in this chapter.

Remove TB1:

- 1.** Remove the nut located on the lowest stud on Terminal PE.
- 2.** Remove the four screws fastening the TB1 Assembly to the drive.
- 3.** Pull the complete TB1 Assembly, with the shield and LEMS attached, away from the drive.

Access the Fan:

- 1.** Disconnect the Fan Wiring Harness.
- 2.** Remove the screws fastening the Fan Cover to the chassis.
- 3.** Pull the Fan Cover assembly away from the drive.
- 4.** Remove the screws fastening the fan to the Fan Cover to remove the fan.
- 5.** Disconnect the Fan Capacitor from the Fan Wiring Harness.
- 6.** Unscrew the Fan Capacitor from the chassis by hand.
- 7.** Disconnect the Fan Transformer from the Fan Wiring Harness.
- 8.** Remove the screws fastening the Fan Transformer to the chassis.

Installation

Install the Fan Assembly in reverse order of removal, with the following exceptions:

- Thread the fan wiring connector through the hole in the Fan Cover.
- Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.
- Install the Fan Capacitor to the chassis with M8 split washer and hand tighten.
- Connect the Fan Transformer red wire to TB1 terminal S-L2 and the black wire to TB1 terminal R-L1.

Important: Install washers on TB1 terminals with the serrated side up.

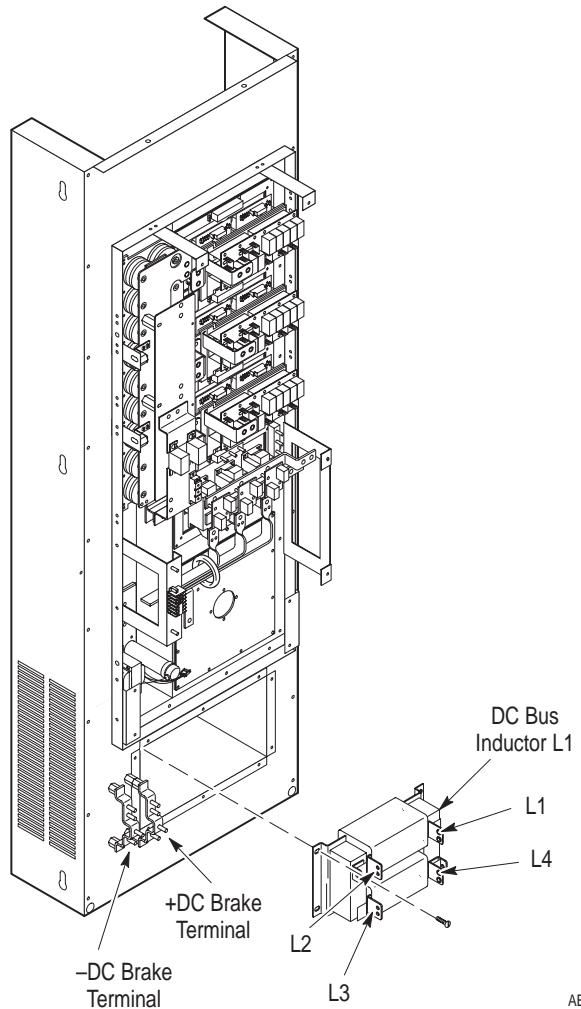


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

DC Bus Inductor L1

DC Bus Inductor L1 is located at the bottom of the drive.

Figure 5.13
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 the +DC/-DC Brake Terminals. 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:
 - +DC/-DC Brake Terminals
 - terminals R-L1, S-L2, and T-L3 on TB1
3. Check for absence of control voltage at:
 - terminals V+ and V- on TB11 on the Main Control Board
 - TB20 and TB21 on drives using a PLC Comm Adapter Board
 - TB5, TB6, and TB7 on drives using a Standard Adapter Board
 - TB3 on drives using a Control Interface L-Option Board
4. Disconnect AC input and motor output wiring from TB1 to provide easy access to the DC Bus Inductor enclosure.



ATTENTION: The DC Bus Inductor weighs 100 lbs. Failure to use extreme caution in handling this part may result in serious injury.

5. Remove the eight bolts fastening the Bus Bar Cables to the DC Bus Inductor terminals.
6. Remove the four bolts fastening the DC Bus Inductor to the back panel of the chassis.
7. Remove the Bus Inductor from the drive.

Installation

Install DC Bus Inductor L1 in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Fastener Torque Specifications.



ATTENTION: If you mount the inductor remotely, verify the connections between the Bus Inductor, the Input Rectifier Bus Bars and the DC Brake Terminals. L1 of inductor should connect to the (+) Input Rectifier Bus Bar, L2 to the +DC Brake Terminal, L3 to the –DC Brake Terminal, and L4 to the (–) Input Rectifier Bus Bar. Refer to Chapter 3 – Component Test Procedures, Test 5 – Testing the Input Rectifiers.



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

Replacement Parts List

Chapter Objectives

This chapter illustrates and lists replacement parts for the 1336 FORCE Drives rated BP300 – BP450, 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 Rockwell Automation Drives Division and the Rockwell Automation 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 Rockwell Automation 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:

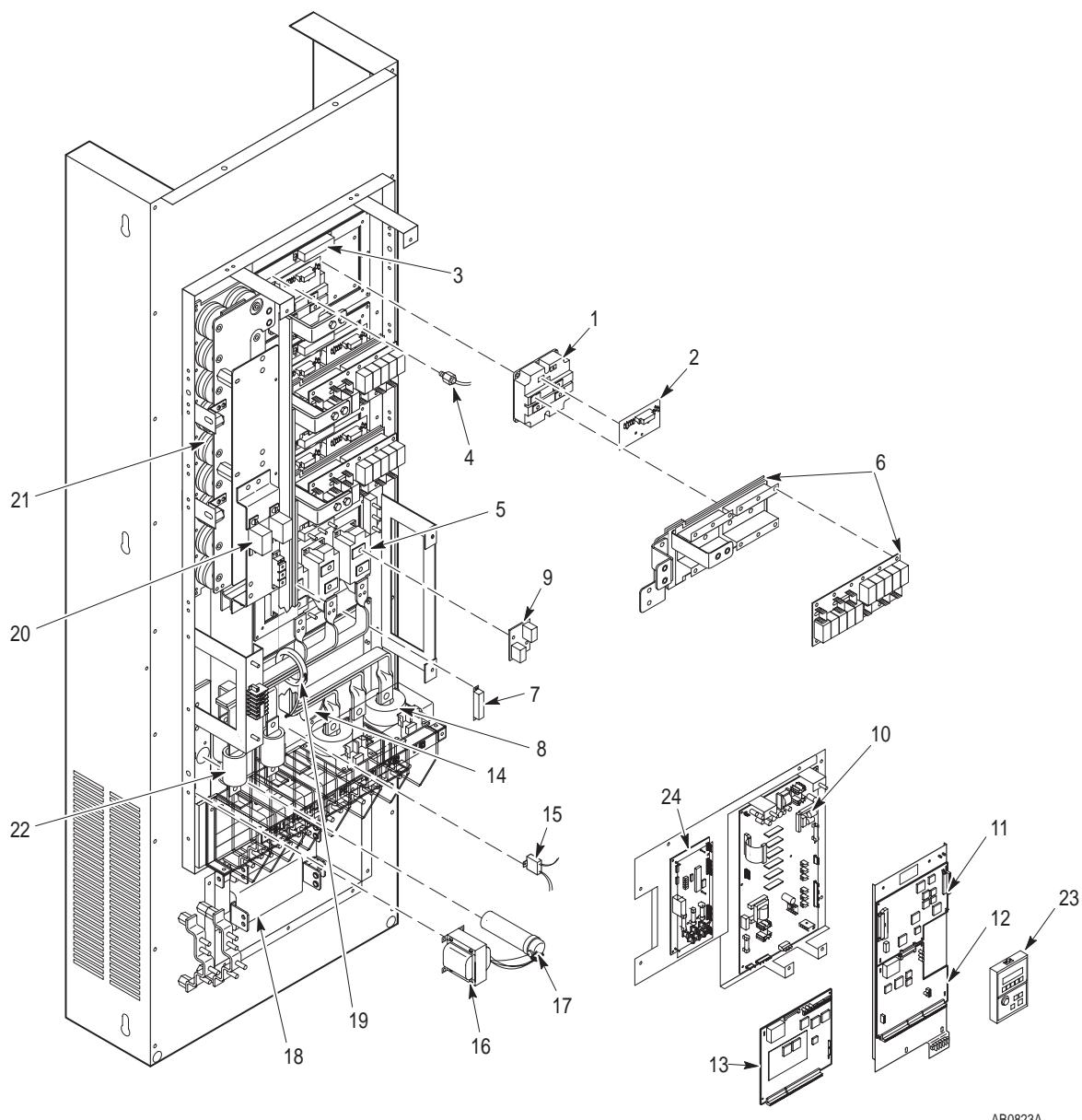
- Your company name
- Your company address
- The repair purchase order number
- A brief description of the problem

Contact your local Rockwell Automation 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 6.1
Parts for BP300 – BP450 Drives



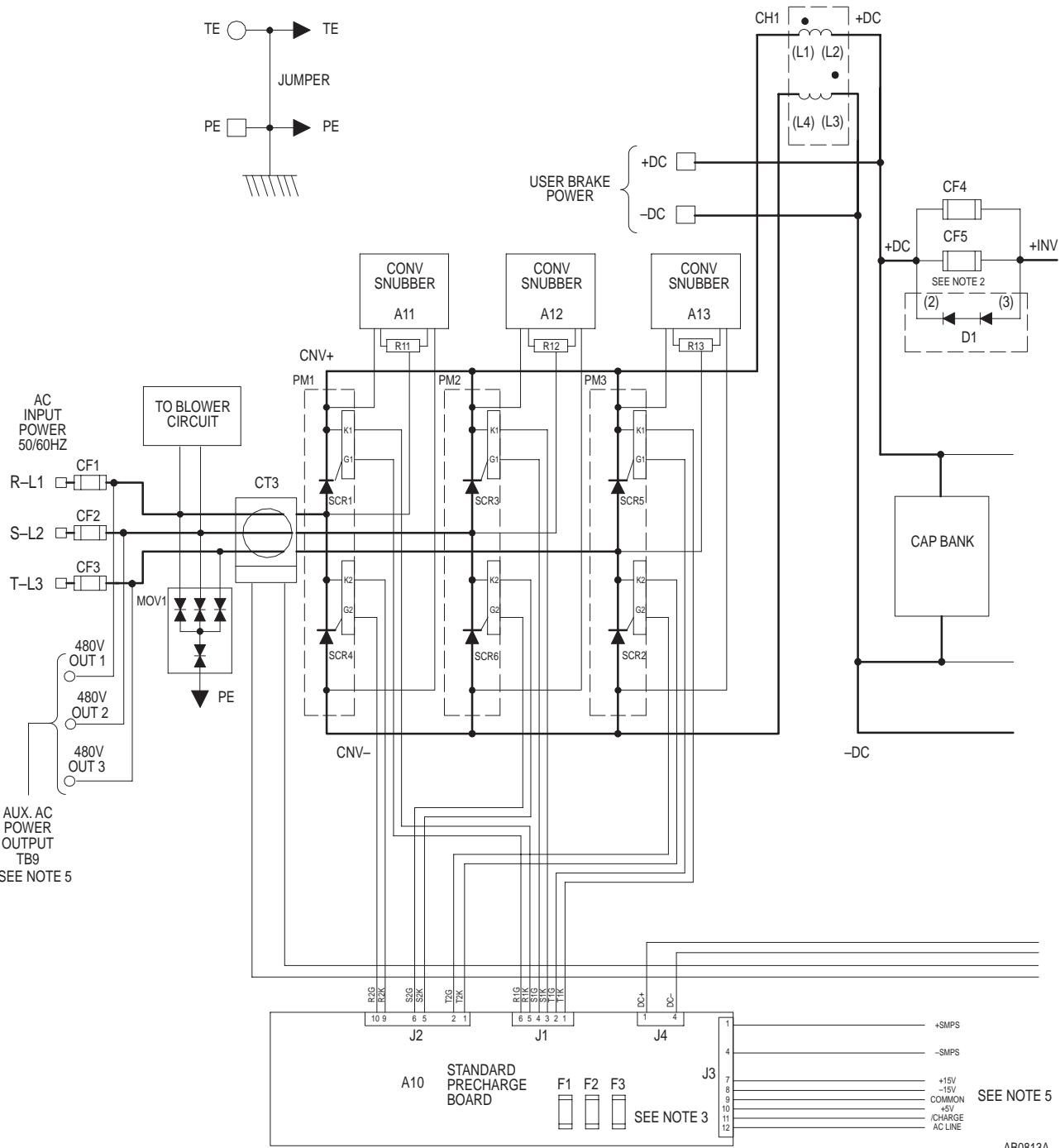
AB0823A

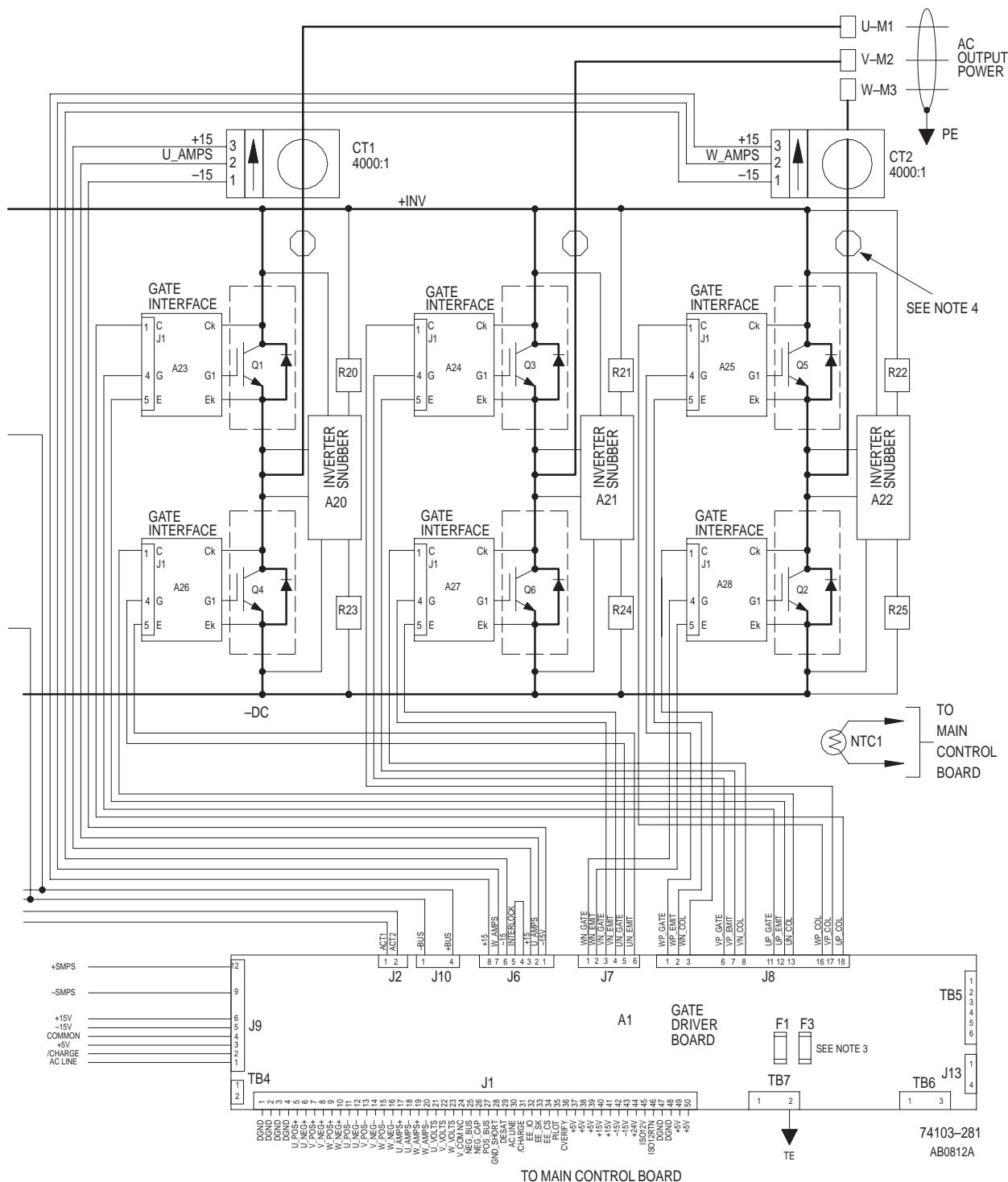
Table 6.A
Replacement Parts for BP300 – BP450 Drives

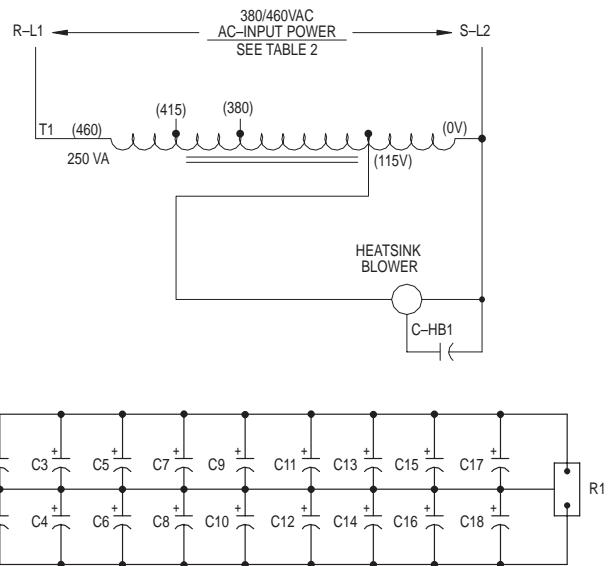
Callout	Symbol	Description	Location	Replacement Procedures
1	Q1 – Q6	Transistor (Power Module)	Heat Sink	Chapter 4, Power Modules
2	A23 – A28	Power Module Gate Interface Board	Power Module	Chapter 4, Power Modules
3	R20 – R22	Power Module Snubber Resistor	Heat Sink	Chapter 2, Removing a Power Module Snubber Board
4	NTC1	Thermistor	Heat Sink	Chapter 4, Thermistor
5	SCR1 – SCR3	Input Rectifier	Heat Sink	Chapter 4, Input Rectifiers
6	A20 – A22	Power Module Bus Bar and Snubber Board	Power Module	Chapter 2, Removing a Power Module Snubber Board
7	R1 – R3	Load-Sharing Resistor	Heat Sink	Chapter 4, Bus Capacitor Bank
8	CT1, CT2	LEM	TB1	Chapter 4, LEMs
9	A11 – A13	Input Rectifier Snubber Board	Input Rectifier	Chapter 2, Removing the Input Rectifier Snubber Board
10	A1	Gate Driver Board	Circuit Board Platform	Chapter 2, Removing the Gate Driver Board from the Mounting Plate
11	MAIN CONTROL BOARD	Main Control Board	Main Control Board Mounting Plate	Chapter 2, Removing the Main Control Board
12	GT2	Standard Adapter Board	Control Board/Adapter Mounting Plate	Chapter 2, Removing the Standard Adapter Board
13	GT1	PLC Comm Adapter Board	Control Board/Adapter Mounting Plate	Chapter 2, Removing the PLC Comm Adapter Board
14	FAN	Fan	Main Chassis	Chapter 4, Fan and Transformer
15	MOV1	MOV Surge Suppressor	Fan Cover Plate	Chapter 4, MOV Surge Suppressor
16	T1	Fan Transformer	Main Chassis	Chapter 4, Fan and Transformer
17	C-HB1	Fan Capacitor	Main Chassis	Chapter 4, Fan and Transformer
18	L1	DC Bus Inductor	Main Chassis	Chapter 4, DC Bus Inductor L1
19	CT3	Ground Sense CT	Input Bus Bar	Chapter 4, Ground Fault CT
20	CF4 – CF5	Bus Fuses	Capacitor Bus Bank	Chapter 4, Bus Fuses F1
21	C1 – C10	Bus Capacitors	Main Chassis	Chapter 4, Bus Capacitor Bank
22	CF1 – CF3	Input Fuses	Input Bus Bars	Chapter 4, Input Fuses
23	HIM	Human Interface Module	Enclosure Cover	Chapter 1, Module Removal
24	A10	Precharge Board	Circuit Board Platform	Chapter 2, Removing the Precharge Board from the Mounting Plate

This Page Intentionally Left Blank.

**Schematics — 250 – 450 HP 1336
FORCE Drives**



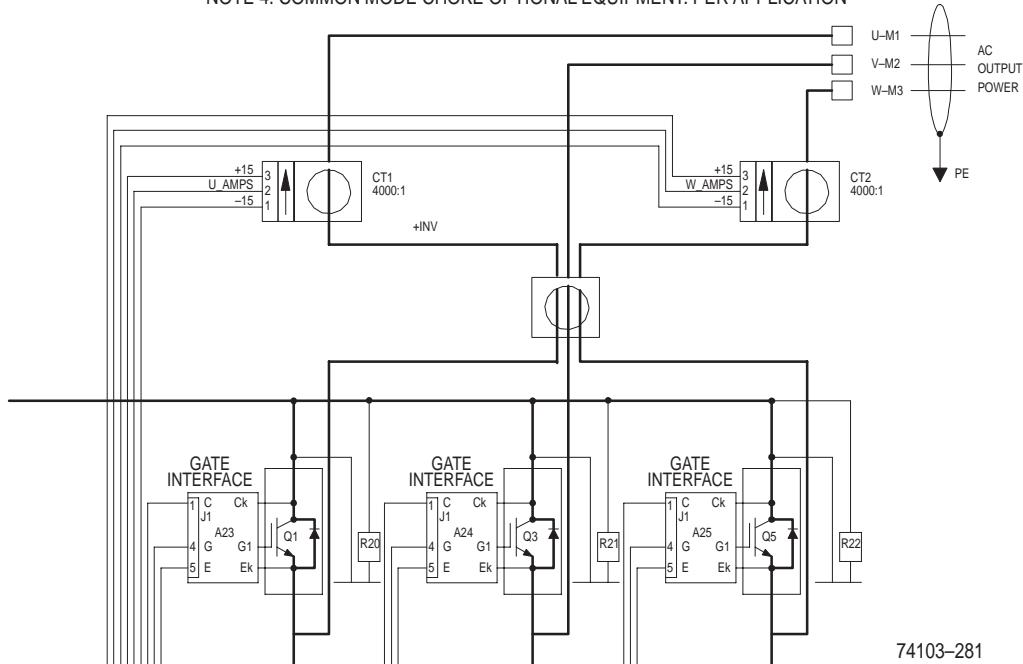




DETAIL 1 – 380/460 VAC

NOTES: – DETAIL 1:
1. C1 THRU C18 ARE 400 VDC CAPACITORS.

NOTE 4. COMMON MODE CHOKE OPTIONAL EQUIPMENT. PER APPLICATION



AB0814A

Note 1: The Input Line Fuses for this product are supplied in the unit as follows:

HORSEPOWER	380/460VAC FUSE CURRENT/TYPE		
	FUSE INFORMATION		
	RATING	TYPE	P/N
250	450A	A70QS	25178-315-18
300	500A	A70QS	25178-315-19
350	600A	A70QS	25178-315-20
400	600A	A70QS	25178-315-20
450	700A	A70QS	25178-315-21

Note 2: The Inverter Bus Fuse for this product is as follows:

HORSEPOWER	380/460VAC FUSE CURRENT/TYPE		
	FUSE INFORMATION		
	RATING	CATALOG	P/N
ALL	2 x 450A	A65C450-4AB	25178-254-01

Note 3: The following is a listing of all printed circuit assemblies versus fuse and documentation information.

ITEM	B/M	SCHEMATIC DIAGRAM	FUSE INFORMATION			
			DESIGNATOR	RATING	TYPE	P/N
A1	74101-399-XX	74101-167	F1	1.0A/600V	KTK-R-1	25172-260-08
			F3	1.5A/600V	KTK-R-1.5	25172-260-09
A10	74101-181-51	74101-179	F1-F3	1.5A/600V	KTK-R-1.5	25172-260-09
A11-13	74103-867-51	74103-866	NONE			
A20-22	74103-784-51	74103-783	NONE			
A23-28	74103-845-51	74103-844	NONE			

Note 5: The Output Terminal Block (TB9) is only available on F Frame drives. This terminal block provides a three-phase, high voltage connection from the load side of the AC Input Line Fuses. Normally this connection is used to power an external control transformer (user supplied) or other auxiliary circuit. Refer to Figure 1.1 for location.

Important: Depending on the circuitry connected, additional fusing may be required.

Attention: The installation of auxiliary circuits must comply with the national codes and standards (NEC, VDE, BSA, etc.) and local codes regarding wire type, conductor size, branch circuit protection and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

The auxiliary circuit can be utilized to a maximum current capacity of 8 amperes RMS.

The maximum and minimum wire size accepted by TB9 is 4.0 and 0.8 mm (12 and 18 AWG). Use copper wire only with a minimum temperature rating of 75°C. Maximum Torque is 0.90 – 1.81 N·m (8 – 16 lb-in.).

AB0815A

This Page Intentionally Left Blank.

A

Adapter Locations, 1–12
Audience for this Manual, P–1
Auxiliary Input, Definition, P–6
Auxiliary Interlock, Definition, P–6

B

Bit, Definition, P–6
Bus Capacitor Bank
 Illustration, 4–4
 Installation, 4–7
 Removal, 4–5
 Test, 3–12
Bus Fuse
 Illustration, 4–13
 Installation, 4–14
 Removal, 4–13
Bus Inductor. *See* DC Bus Inductor L1

C

Check, Definition, P–6
Circuit Board Platform
 Illustration, 2–9
 Installation, 2–11
 Removal, 2–9
Component Test Procedures, 3–1
Connector, Definition, P–6
Control Board/Adapter Mounting Plate
 Illustration, 2–19
 Installation, 2–20
 Removal, 2–19
Control Interface L-Option Board
 Available Inputs, 1–5
 Definition, P–7
 Illustration, 2–7
 Installation, 2–8
 Jumper Locations, 1–4
 Options, 1–3
 Removal, 2–7
Control Interface Option, 1–3
Control Logic Wiring and Adapters, 1–1
Conventions in this Manual, P–6

D

DC (+/–) Brake Terminals, 3–8, 3–12, 4–3
DC Bus Inductor L1
 Illustration, 4–32
 Installation, 4–34
 Removal, 4–32
Default, Definition, P–7
Disassembly and Access Procedures, 2–1
Drive
 Enclosure Type, P–5
 Identification, P–4
 Illustration, 4–3
 Nameplate Location, P–3
 Rating, P–5
Drive Tools, 1–16

E

Electrostatic Discharge, P–2
Enable Input, Definition, P–7
Enclosure Type, P–5
ESD, P–2

F

False, Definition, P–7
Fan and Transformer
 Illustration, 4–28
 Installation, 4–30
 Removal, 4–28
Fastener Torque Specifications, 2–2
Firmware, Function, 1–16
Four-Point Mounting, 2–3

G

Gate Driver Board
 Illustration, 2–21
 Installation, 2–23
 Removal, 2–21
 Test, 3–3
Graphic Programming Terminal (GPT),
 Description, 1–15

- Ground Fault CT
Illustration, 4-17
Installation, 4-19
H
High Voltage Guard
Illustration, 2-5
Installation, 2-6
Removal, 2-6
HIM. *See* Human Interface Module
Human Interface Module (HIM)
Adapter Locations, 1-12
Description, 1-11
Illustration, 1-11
Operation, 1-14
Removal, 1-13
I
Identification, Product, P-3
Input Fuses
Illustration, 4-15
Installation, 4-16
Input Mode
Programming, 1-5
Selection, 1-6
Three-Wire, Multi-Source, 1-7
Two-Wire, Single-Source, 1-7
Input Rectifier
Illustration, 4-20
Installation, 4-22
Removal, 4-20
Test, 3-15
Input Rectifier Snubber Board
Illustration, 2-29
Installation, 2-30
Removal, 2-29
Inputs, Available, 1-5
Installation Procedures. *See* Procedures
J
Jumper, Locations, 1-4
Jumper, Definition, P-7
L
LEMs
Illustration, 4-23
Installation, 4-25
Removal, 4-23
M
Main Control Board
Illustration, 2-12
Installation, 2-14
Removal, 2-13
Major Component Replacement. *See* Procedures
Manual
Audience, P-1
Conventions, P-6
Objective, P-1
Related Publications, P-8
Mounting
Four-Point, 2-3
Six-Point, 2-3
Two-Point, 2-3
MOV Surge Suppressor
Illustration, 4-26
Installation, 4-27
Removal, 4-26
N
Nameplate Location, P-3
O
Objective of this Manual, P-1
Operation, Human Interface Module, 1-14
Option
Control Interface, 1-3
Identification, P-4
P
Parameter, Definition, P-7
PLC Comm Adapter Board
Illustration, 2-17
Installation, 2-18
Reference Signal Connections, 1-9
Removal, 2-17
Terminal Block Locations, 1-2
Power Module
Illustration, 4-10
Installation, 4-12

- Removal, 4–10
Test, 3–8
- Power Module Snubber Board
Illustration, 2–26
Installation, 2–28
Removal, 2–26
- Precautions
Electrostatic Discharge, P–2
Safety, P–1
- Precharge Board
Illustration, 2–24
Installation, 2–25
Removal, 2–24
Test, 3–6
- Press, Definition, P–7
- Procedures
Accessing Internal Drive Components, 2–1
Bus Capacitor Bank Installation, 4–7
Bus Capacitor Bank Removal, 4–5
Bus Capacitor Bank Test, 3–12
Bus Fuse Installation, 4–14
Bus Fuse Removal, 4–13
Circuit Board Platform Installation, 2–11
Circuit Board Platform Removal, 2–9
Component Test, 3–1
Control Board/Adapter Mounting Plate
Installation, 2–20
Control Board/Adapter Mounting Plate
Removal, 2–19
Control Interface L-Option Board
Installation, 2–8
Control Interface L-Option Board
Removal, 2–7
DC Bus Inductor L1 Installation, 4–34
DC Bus Inductor L1 Removal, 4–32
Fan Installation, 4–30
Fan Removal, 4–28
Gate Driver Board Installation, 2–23
Gate Driver Board Removal, 2–21
Gate Driver Board Test, 3–3
Ground Fault CT Installation, 4–19
Ground Fault CT Removal, 4–17
High Voltage Guard Installation, 2–6
High Voltage Guard Removal, 2–6
Input Fuse Installation, 4–16
Input Fuse Removal, 4–15
Input Rectifier Installation, 4–22
Input Rectifier Removal, 4–20
Input Rectifier Snubber Board Installation, 2–30
Input Rectifier Snubber Board Removal, 2–29
Input Rectifier Test, 3–15
LEM Installation, 4–25
LEM Removal, 4–23
- Main Control Board Installation, 2–14
Main Control Board Removal, 2–13
Major Component Replacement, 4–2
MOV Surge Suppressor Installation, 4–27
MOV Surge Suppressor Removal, 4–26
PLC Comm Adapter Board Installation, 2–18
PLC Comm Adapter Board Removal, 2–17
Power Module Installation, 4–12
Power Module Removal, 4–10
Power Module Snubber Board Installation, 2–28
Power Module Snubber Board Removal, 2–26
Power Module Test, 3–8
Precharge Board Installation, 2–25
Precharge Board Removal, 2–24
Precharge Board Test, 3–6
Replacement Part, 4–1
Standard Adapter Board Installation, 2–16
Standard Adapter Board Removal, 2–15
Thermistor Installation, 4–9
Thermistor Removal, 4–8
- Product Identification, P–3, 4–3
- Programming
Input Mode, 1–5
Local, 1–5
- R**
- Rating, Drive, P–5
Related Publications, P–8
Removal Procedures. *See* Procedures
Removal, HIM, 1–13
Replacement Part Procedures, 4–1
Replacement Parts List, 5–1
- S**
- Safety Precautions, P–1
Schematics, 6–1
Six-Point Mounting, 2–3
Snubber Board, Input Rectifier
Illustration, 2–29
Installation, 2–30
Removal, 2–29
Snubber Board, Power Module
Illustration, 2–26
Installation, 2–28
Removal, 2–26

- Speed Select, Input State, 1–9
Standard Adapter Board
 Illustration, 2–15
 Installation, 2–16
 Removal, 2–15
 Terminal Block Locations, 1–2
- T**
- TB3 Terminal Designations, 1–6
Terminal Block Locations, 1–2
Terminal Designations, TB3, 1–6
- Thermistor
 Illustration, 4–8
 Installation, 4–9
 Removal, 4–8
- W**
- Tools, Required for Service, 2–2, 3–2, 4–2
Torque
 Four-Point Mounting Sequence, 2–3
 Maximum for TB Terminals, 1–6
 Six-Point Mounting Sequence, 2–3
 Specifications, 2–3
 Two-Point Mounting Sequence, 2–3
- Troubleshooting, Component Test
 Procedures, 3–1
- True, Definition, P–8
- Two-Point Mounting, 2–3
- Wire Sizes, 1–6

Notes



We Want Our Manuals to be the Best!

You can help! Our manuals must meet the needs of you, the user. This is your opportunity to make sure they do just that. By filling out this form you can help us provide the most useful, thorough, and accurate manuals available. Please take a few minutes to tell us what you think. Then mail or FAX this form.

FAX: to your local Rockwell Automation/Allen-Bradley Sales Office or 414/512-8579

PUBLICATION NAME _____

PUBLICATION NUMBER, DATE AND PART NUMBER (IF PRESENT) _____

✓ **CHECK THE FUNCTION THAT MOST CLEARLY DESCRIBES YOUR JOB.**

- | | |
|--|--|
| <input type="checkbox"/> SUGGEST / RESPONSIBLE FOR THE PURCHASE OF EQUIPMENT | <input type="checkbox"/> MAINTAIN / OPERATE PROGRAMMABLE MACHINERY |
| <input type="checkbox"/> DESIGN / IMPLEMENT ELECTRICAL SYSTEMS | <input type="checkbox"/> TRAIN/EDUCATE MACHINE USERS |
| <input type="checkbox"/> SUPERVISE FLOOR OPERATIONS | |

✓ **WHAT LEVEL OF EXPERIENCE DO YOU HAVE WITH EACH OF THE FOLLOWING PRODUCTS?**

	NONE	LITTLE	MODERATE	EXTENSIVE
PROGRAMMABLE CONTROL	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
AC / DC DRIVES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PERSONAL COMPUTERS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NC / CNC CONTROLS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
DATA COMMUNICATIONS / LAN	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

✓ **RATE THE OVERALL QUALITY OF THIS MANUAL BY CIRCLING YOUR RESPONSE BELOW. (1) = POOR (5) = EXCELLENT**

HELPFULNESS OF INDEX / TABLE OF CONTENTS	1	2	3	4	5
CLARITY	1	2	3	4	5
EASE OF USE	1	2	3	4	5
ACCURACY AND COMPLETENESS	1	2	3	4	5
QUALITY COMPARED TO OTHER COMPANIES' MANUALS	1	2	3	4	5
QUALITY COMPARED TO OTHER ALLEN-BRADLEY MANUALS	1	2	3	4	5

✓ **WHAT DID YOU LIKE MOST ABOUT THIS MANUAL?**

✓ **WHAT DID YOU LIKE LEAST ABOUT THIS MANUAL?**

✓ **PLEASE LIST ANY ERRORS YOU FOUND IN THIS MANUAL (REFERENCE PAGE, TABLE, OR FIGURE NUMBERS).**

✓ **DO YOU HAVE ANY ADDITIONAL COMMENTS?**

✓ **COMPLETE THE FOLLOWING.**

NAME _____ COMPANY _____

TITLE _____ DEPARTMENT _____

STREET _____ CITY _____ STATE _____ ZIP _____

TELEPHONE _____ DATE _____

FOLD HERE

FOLD HERE



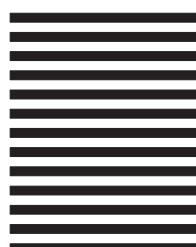
NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 413 MEQUON, WI

POSTAGE WILL BE PAID BY ADDRESSEE

ALLEN-BRADLEY
Attn: Marketing Communications
P.O. Box 760
Mequon, WI 53092-9907



SCANport is a trademark of Rockwell Automation Company, Inc.

PLC is a registered trademark of Rockwell Automation Company, Inc.



Allen-Bradley, a Rockwell Automation Business, has been helping its customers improve productivity and quality for more than 90 years. We design, manufacture and support a broad range of automation products worldwide. They include logic processors, power and motion control devices, operator interfaces, sensors and a variety of software. Rockwell is one of the world's leading technology companies.

Worldwide representation.

Argentina • Australia • Austria • Bahrain • Belgium • Brazil • Bulgaria • Canada • Chile • China, PRC • Colombia • Costa Rica • Croatia • Cyprus • Czech Republic • Denmark • Ecuador • Egypt • El Salvador • Finland • France • Germany • Greece • Guatemala • Honduras • Hong Kong • Hungary • Iceland • India • Indonesia • Ireland • Israel • Italy • Jamaica • Japan • Jordan • Korea • Kuwait • Lebanon • Malaysia • Mexico • Netherlands • New Zealand • Norway • Pakistan • Peru • Philippines • Poland • Portugal • Puerto Rico • Qatar • Romania • Russia-CIS • Saudi Arabia • Singapore • Slovakia • Slovenia • South Africa, Republic • Spain • Sweden • Switzerland • Taiwan • Thailand • Turkey • United Arab Emirates • United Kingdom • United States • Uruguay • Venezuela • Yugoslavia

Allen-Bradley Headquarters, 1201 South Second Street, Milwaukee, WI 53204 USA, Tel: (1) 414 382-2000 Fax: (1) 414 382-4444

