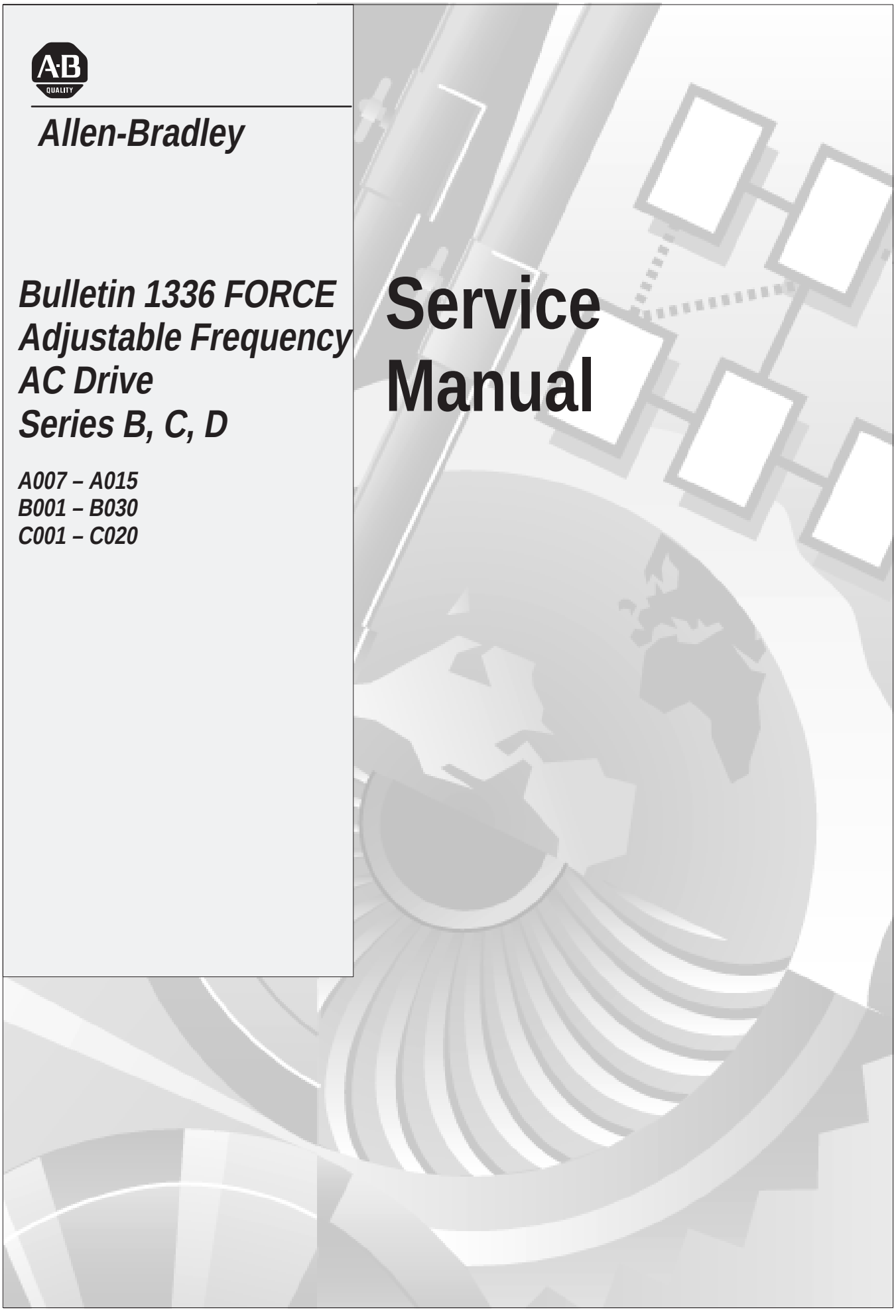

Allen-Bradley

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

A007 – A015
B001 – B030
C001 – C020

Service Manual

Important User Information

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

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

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

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

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

Attention statements help you to:

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

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

Summary of Changes

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

Updated Information

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

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Table of Contents

Preface

Control Logic Wiring and Adapters

Chapter 1

Disassembly and Access Procedures

Chapter 2

Component Test Procedures

Chapter 3

Part Replacement Procedures

Chapter 4

Preface

Manual Objective

The information in this manual is designed to help troubleshoot or repair an Allen-Bradley Bulletin 1336 FORCE Adjustable Frequency AC Drive with ratings A007 – A015, B007 – B030, and C007 – C020.

Who Should Use This Manual

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

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

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

Safety Precautions

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

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

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

Electrostatic Discharge Precautions

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

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

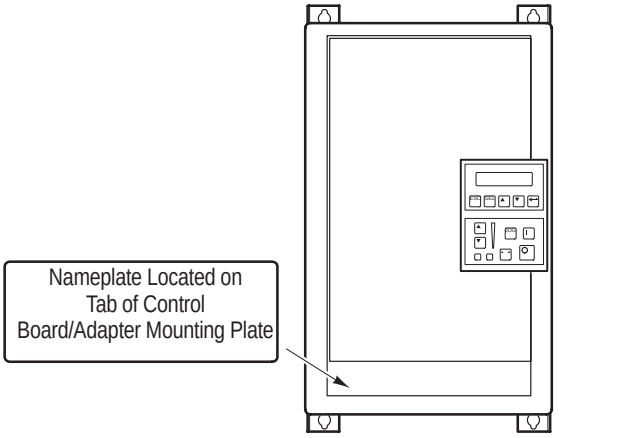
- Wear a wrist-type grounding strap that is grounded to the drive chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

1336 FORCE Product Identification

Drive Nameplate Location

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

Figure P.1
Drive Nameplate Location



Software Compatibility

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

Three-Phase Drive Rating[1]				
200 – 240V	**380 – 480V**	**500 – 600V**	**Compatible with Version**	**Frame Reference**
5.5 – 11 kW 7.5 – 15 HP	5.5 – 22 kW 7.5 – 30 HP	5.5 – 15 kW 7.5 – 20 HP	1.05 & Up or 1.06 w/std. Jog	B

[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	– A007-AN	– GT2EN	– L6	– HA1	– GM1
BULLETIN NO.	RATING-ENCLOSURE (MUST BE SPECIFIED)	LANGUAGE MODULE[1] (MUST BE SPECIFIED)	CONTROL INTERFACE[1] (OPTIONAL)	HUMAN INTERFACE[1] (OPTIONAL)	COMMUNICATION CARD[1] (OPTIONAL)

200 – 240V AC Input, Constant Torque Drive

Drive Rating[2]			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	**Output Amps**	**Nominal HP**	**Code**	**Code[3]**	**Code**	**Code**
B	27	7.5	A007-AN	A007-AA, -AE	A007-AF	A007-AJ
	34	10	A010-AN	A010-AA, -AE	A010-AF	A010-AJ
	48	15	A015-AN	A015-AA, -AE	A015-AF	A015-AJ

Table P.B

1336T	– B007-AA	– GT2EN	– L6	– HA1	– GM1
BULLETIN NO.	RATING-ENCLOSURE (MUST BE SPECIFIED)	LANGUAGE MODULE [1] (MUST BE SPECIFIED)	CONTROL INTERFACE [1] (OPTIONAL)	HUMAN INTERFACE [1] (OPTIONAL)	COMMUNICATION CARD [1] (OPTIONAL)

380 – 480V AC Input, Constant Torque Drive

Drive Rating [2]			Enclosures			
			Open IP00 No Enclosure	NEMA Type 1 IP20 General Purpose	NEMA Type 4 IP56 Resist Water, Dust	NEMA Type 12 IP54 Industrial Use
Frame Designation	Constant Torque [4] Output Amps	Constant Torque [4] Nominal HP	Code	Code [3]	Code	Code
B	14	7.5	B007-AN	B007-AA, -AE	B007-AF	B007-AJ
	21	10	B010-AN	B010-AA, -AE	B010-AF	B010-AJ
	27	15	B015-AN	B015-AA, -AE	B015-AF	B015-AJ
	34	20	B020-AN	B020-AA, -AE	B020-AF	B020-AJ
	42	25	B025-AN	B025-AA, -AE	B025-AF	B025-AJ
	48	30	B030-AN	B030-AA, -AE	B030-AF	B030-AJ

Table P.C

1336T	– C007-AA	– GT2EN	– L6	– HA1	– GM1
BULLETIN NO.	RATING-ENCLOSURE (MUST BE SPECIFIED)	LANGUAGE MODULE [1] (MUST BE SPECIFIED)	CONTROL INTERFACE [1] (OPTIONAL)	HUMAN INTERFACE [1] (OPTIONAL)	COMMUNICATION CARD [1] (OPTIONAL)

500 – 600V AC Input, Constant Torque Drive

Drive Rating [2]			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	Output Amps	Nominal HP	Code	Code [3]	Code	Code
B	10	7.5	C007-AN	C007-AA, -AE	C007-AF	C007-AJ
	12	10	C010-AN	C010-AA, -AE	C010-AF	C010-AJ
	19	15	C015-AN	C015-AA, -AE	C015-AF	C015-AJ
	24	20	C020-AN	C020-AA, -AE	C020-AF	C020-AJ

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

[2] 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°. Refer to1336 FORCE User Manual.

[3] Refer to Table 1.I for explanation of “E” rating.

Table P.D

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

Table P.E

Options

Code[1]	Description[2]
Human Interface Modules, NEMA Type 1 (IP20)	
HAB	Blank – No Functionality
HAP	Programmer Only
HA1	Programmer/Controller with Analog Pot
HA2	Programmer/Controller with Digital Pot
Human Interface Modules, NEMA Type 4 (IP56)	
HFP	Programmer Only
HF2	Programmer/Controller with Digital Pot
Human Interface Modules, NEMA Type 12 (IP54)	
HJP	Programmer Only
HA2	Programmer/Conroller with Digital Pot

Code	Description[2]
Communication Options	
GT1EN	PLC Communication Adapter, English
	Standard Adapter, English
GT2EN	No Adapter
GT0	
Control Interface Options	
L4	Contact Closure
L5	+24V AC/DC
L6	115V AC

[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.F
Enclosure Type Code Descriptions

Enclosure Type Code	Description
N	Open style (IP 00)
A	NEMA Type 1 (IP 20)
E	NEMA Type 1 (IP 20) "CE" Metal Cover
F	NEMA Type 4 (IP 56)
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.

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.

Control Interface L-Option Board

A Control Interface Board plugs into connectors J7 and J9, located on the lower portion of the Standard Adapter Board. This board is identified as L4, L5 or L6 and provides optional control wiring configurations for a drive.

Parameter

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

Press

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

True

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

Related Publications

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

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

Control Logic Wiring and Adapters

Chapter Objectives

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

Chapter Overview

This chapter also 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 +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

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

Figure 1.1
Terminal Block Locations, Standard Adapter

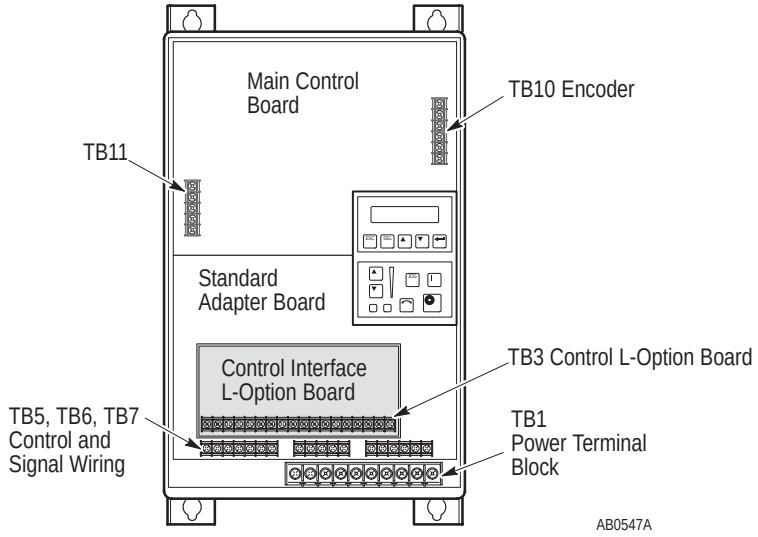
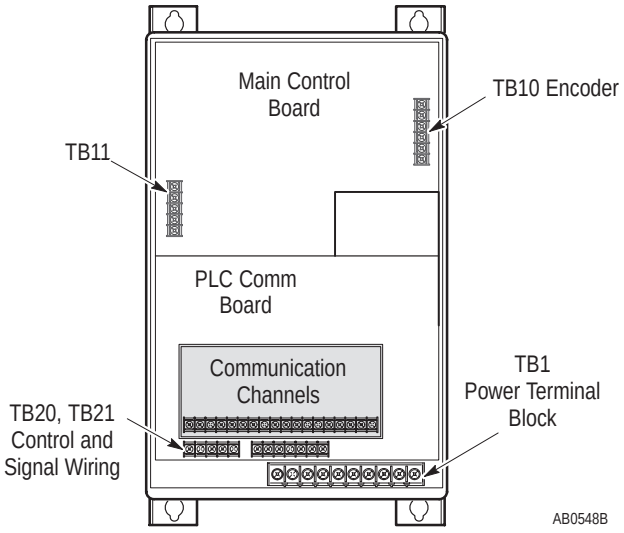


Figure 1.2
Terminal Block Locations, PLC Comm Adapter



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.

Three different versions of the option are available:

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

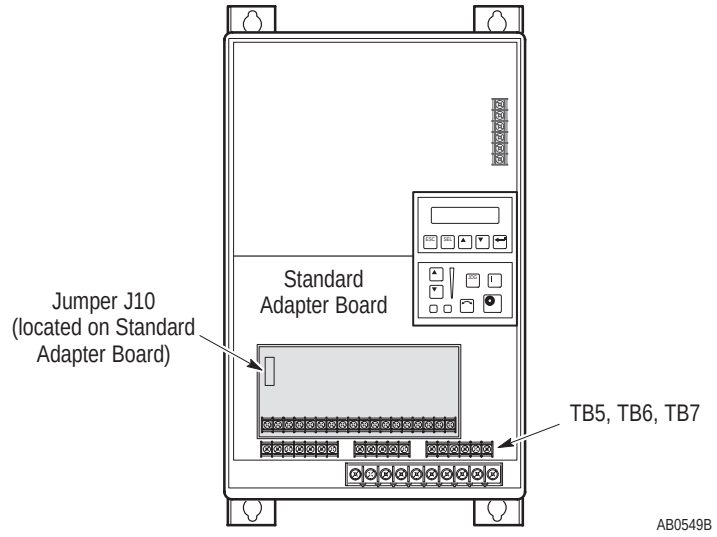
[1] Uses internal +5V DC supply.

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

Control Interface L-Option 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 1.3
Jumper Locations, Standard Adapter Board



Available Inputs

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

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

The available combinations are shown in Figure 1.5. 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 effect until power has been cycled to the drive. When changing an input mode, it is important to note that the corresponding inputs to TB3 may also change.

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

Selected Mode Number:_____

Standard Adapter Local Programming

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

Table 1.A
Input Mode Selection

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

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

Figure 1.4
TB3 Terminal Designations

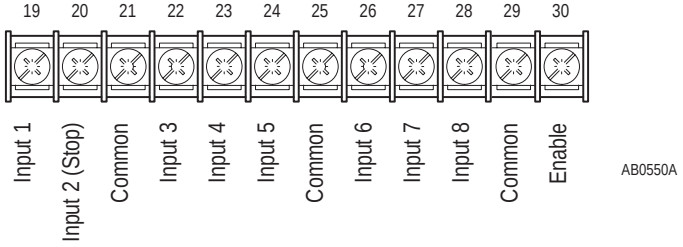
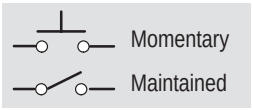
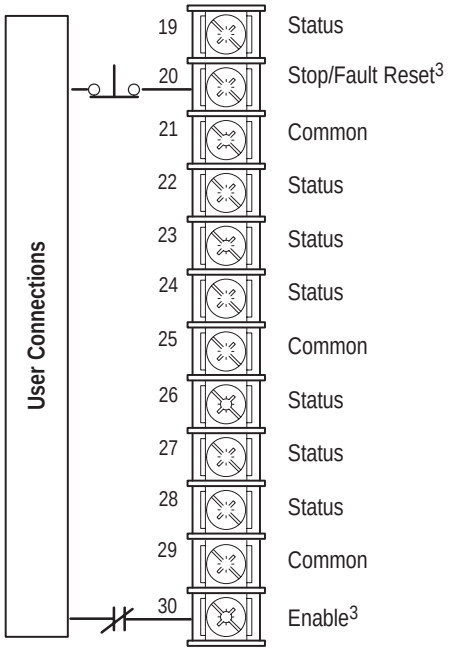


Figure 1.5
Input Mode Selection and Typical TB3 Connections



[Input Mode] 1
Factory Default

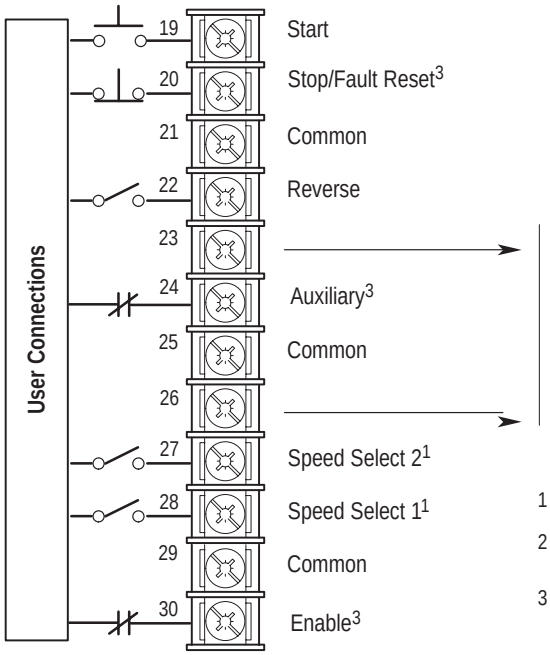


Note: If this mode is selected, the status of all inputs can be read at the [Input Status] parameter. However, only "Stop/Fault Reset" and "Enable" will have control function.

[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-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.



Mode	2	3	4	5	6
	Jog	Stop Type	2nd Accel	Digital Pot Up	Jog
	Speed Select 31	Speed Select 31	2nd Decel	Digital Pot Dn	Local Control2

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.

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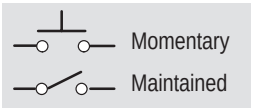
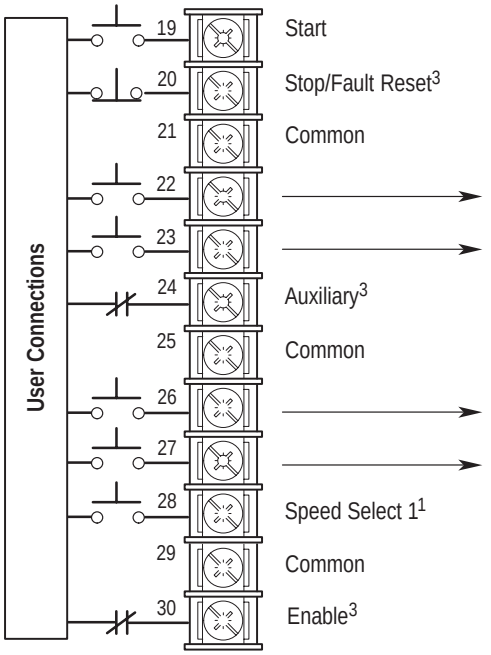


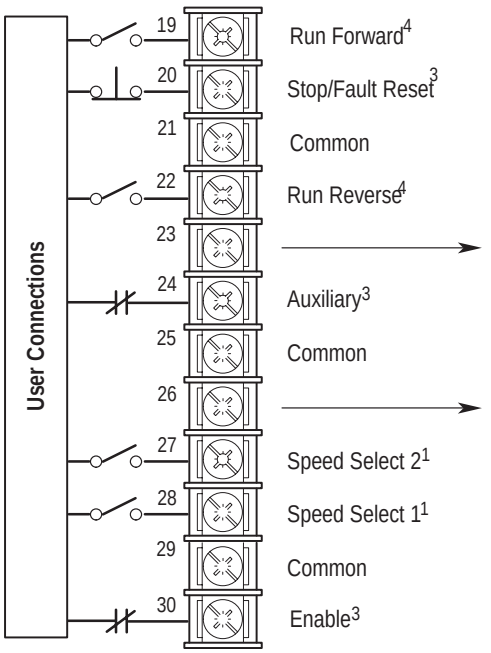
ATTENTION: The JOG function will not operate properly unless a SCANport option is connected to the drive. To assure proper JOG function, install at least one of the following:
1201-HAP, 1201-HA1, 1201-HA2, 1336-GM1. Applies to 1305 with firmware FRN 2.01 or earlier and 1336 PLUS with Language Module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

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



	Mode				
	7	8	9	10	11
Start	Reverse	Reverse	Digital Pot Up	Reverse	1st Accel
Stop/Fault Reset[3]	Forward	Forward	Digital Pot Dn	Forward	2nd Accel
Common					
Auxiliary[3]	Jog	Speed Select 3[1]	Speed Select 3[1]	Digital Pot Up	1st Decel
Common					
Speed Select 1[1]	Speed Select 2[1]	Speed Select 2[1]	Speed Select 2[1]	Digital Pot Dn	2nd Decel
Common					
Enable[3]					

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



	Mode				
	12	13	14	15	16
Run Forward[4]	Local Control[2]	Stop Type	2nd Accel	Digital Pot Up	Local Control[2]
Stop/Fault Reset[3]					
Common					
Run Reverse[4]					
Auxiliary[3]					
Common					
Speed Select 2[1]	Speed Select 3[1]	Speed Select 3[1]	2nd Decel	Digital Pot Dn	Stop Type
Speed Select 1[1]					
Common					
Enable[3]					

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 to allow operation.

AB0291B

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

Table 1.B
Speed Select Input State vs. Velocity Reference Source

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

O = Open — Input Removed

X = Closed — Input Present

The DIP switches and jumpers on the PLC Communications Board have been preset at the factory. Communication is received through Channels A and B. This communication protocol is defined through SW U2 – U5. If switches or jumpers require reconfiguration, refer to the 1336 FORCE PLC Communications Adapter User Manual.

Figure 1.6
PLC Comm Adapter Reference Signal Connections

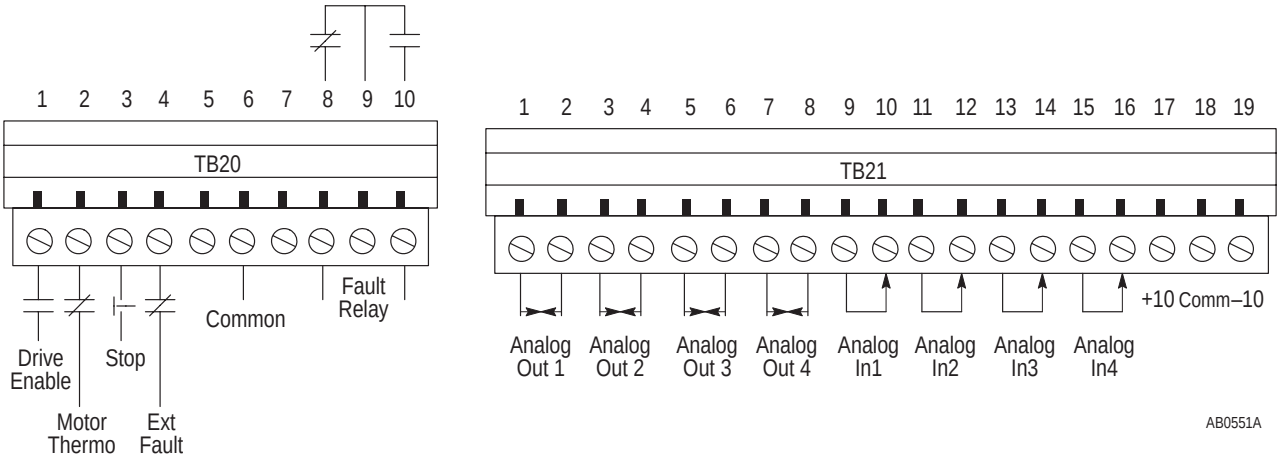


Table 1.C
PLC Comm Adapter Reference Signal Connections

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

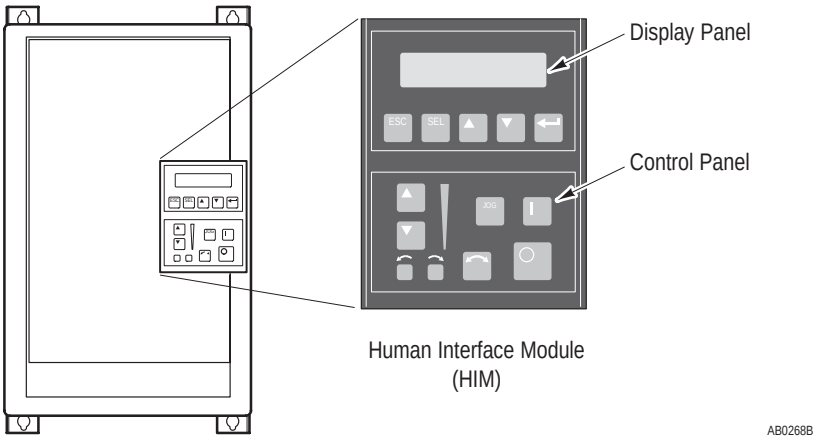
Adapters and Communication Ports

Human Interface Module

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

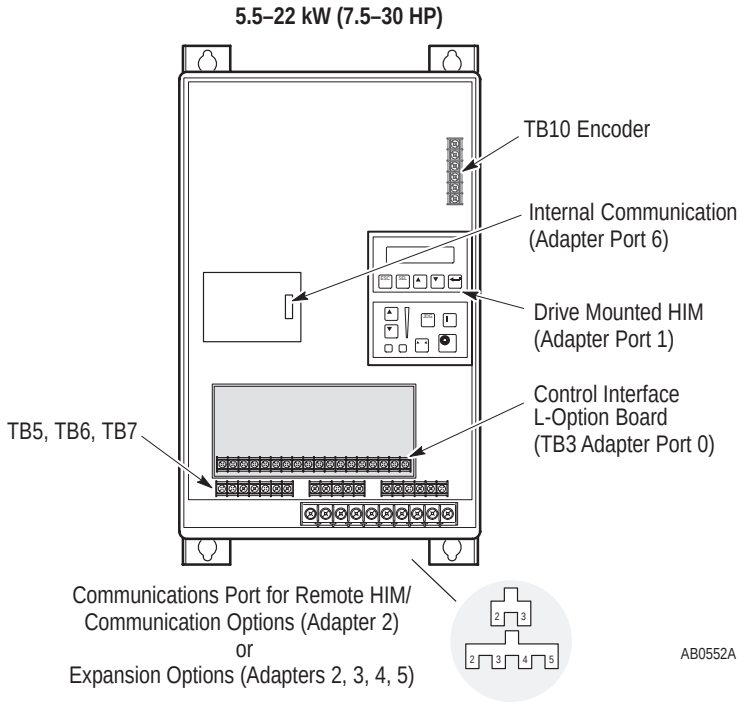
Important: The operation of HIM functions depends upon drive parameter settings. Default parameter values allow full HIM functionality.

Figure 1.7
Human Interface Module, Standard Adapter Only



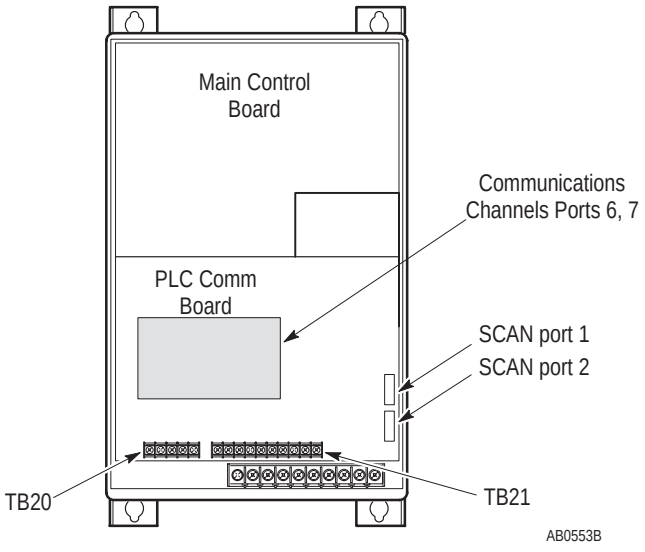
Standard Adapter Ports

Figure 1.8
Standard Adapter Board Port Locations



PLC Comm Adapter Ports

Figure 1.9
PLC COMM Adapter Board Port Locations



HIM Removal

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

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

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

To remove the module:

1. Assure that power has been removed or [Logic Mask] 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 [Logic Mask] parameter to "1" to enable HIM control.

HIM Operation

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

For HIM operation, refer to the 1336 FORCE Field Oriented Control User Manual.

Figure 1.10
Status Display

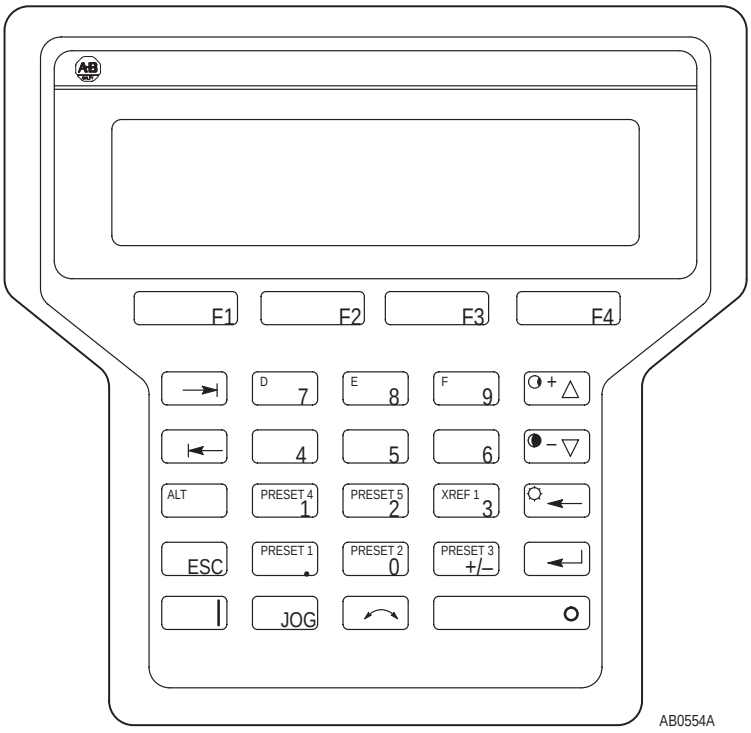
Graphic Programming Terminal

GPT Description

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

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

Figure 1.11
Graphic Programming Terminal



Drive Tools

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

Control Firmware Function

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

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

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

Disassembly and Access Procedures

Chapter Objectives

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

Disassembly and Access Overview

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

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

Electrostatic Discharge Precautions

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

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

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

Tools

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

- Pliers
- #2 Phillips screwdriver
- 5/16-inch or 8mm socket
- Torque wrench, metered in lb-in. or N-m

Fastener Torque Specifications

Torque Sequence

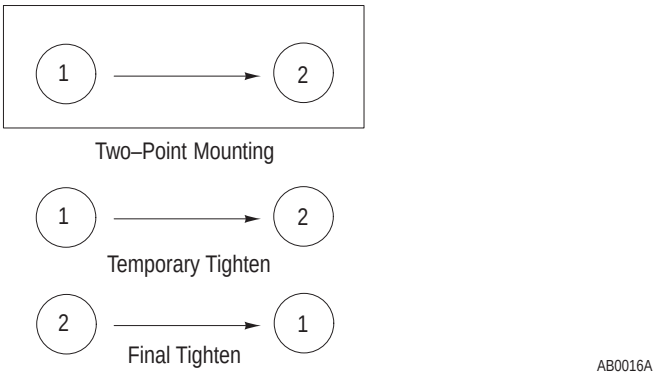
When mounting components to a drive's heat sink, component-fastener torque sequences and tolerances are crucial to component-to-heat sink heat dissipation.

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

Two-Point Mounting

The following illustrates temporary and final tightening sequences for components fastened to a heat sink using two screws. Temporary torque is 1/3 (33%) of final torque. The numeric illustration labels are for your assistance. Drive components do not carry these labels.

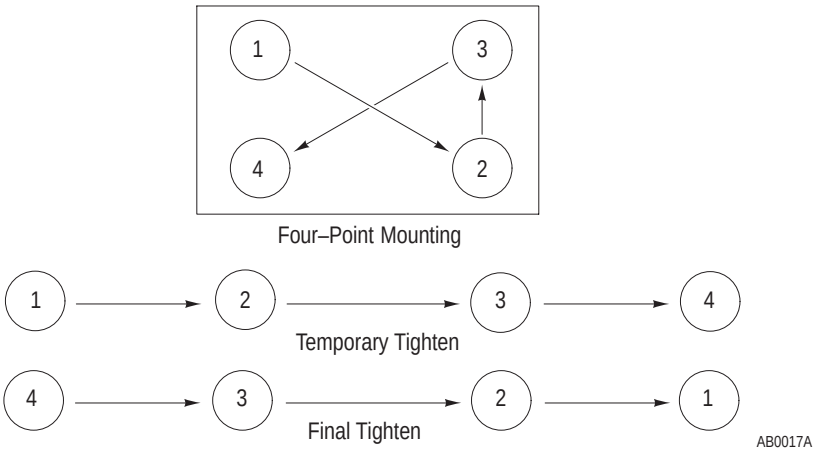
Figure 2.1
Two-Point Mounting



Four-Point Mounting

The following illustrates temporary and final tightening sequences for components fastened to a heat sink using four screws. Temporary torque is 1/3 (33%) of final torque. The numeric illustration labels are for your assistance. Drive components do not carry these labels.

Figure 2.2
Four-Point Mounting



Torque Specifications

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

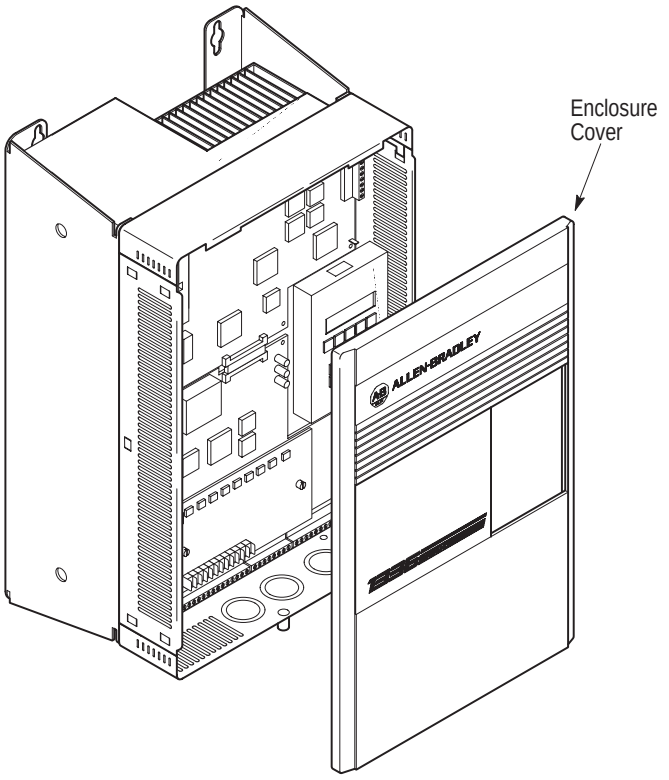
Table 2.A
Fastener Torque Specifications

Component	Fastener Application	Torque, lb-in.	Torque, N-m
Bus Capacitor Ass'y	Ass'y to chassis	22 – 30	2.5 – 3.4
Gate Driver Board	Driver board to capacitors	22 – 30	2.5 – 3.4
Gate Driver Board	Driver board to inductor	22 – 30	2.5 – 3.4
Gate Driver Board	Module (M5 screw)	22 – 30	2.5 – 3.4
Gate Driver Board	Module (M6 screw)	30 – 39	3.4 – 4.4
Bridge Rectifier BR1	BR1 to Driver board	22 – 30	2.5 – 3.4
Bridge Rectifier BR1	BR1 to heat sink	25 – 31	2.8 – 3.5
Precharge Module	M1 to heat sink	22 – 30	2.5 – 3.4
Precharge Module	M1 to Driver board	22 – 30	2.5 – 3.4
Transistor Modules Q1 – Q3	Module to heat sink	25 – 31	2.8 – 3.5
Inductor	Inductor to chassis	22 – 30	2.5 – 3.4
TB1	Wires to TB1	16	1.8
TB3	Wires to TB3	8 – 10	0.9 – 1.1
Standard Adapter Board	Board to Mounting Plate	12 – 16	1.4 – 1.8
PLC Comm Adapter Board	Board to Mounting Plate	12 – 16	1.4 – 1.8
Main Control Board	Board to Mounting Plate	12 – 16	1.4 – 1.8
TB5, 6, 7, 10, 11, 20, 21	Wires to terminals	8 – 10	0.9 – 1.1

Disassembly and Access Procedures

Opening the Drive Enclosure

Figure 2.3
Opening the Drive Enclosure



Removal

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

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

1. Remove power from the drive.
2. Remove the screws fastening the Enclosure cover to the bottom of the Enclosure frame.
3. Pull the bottom of the cover outward to clear the Enclosure frame, then lift the cover upward to remove the cover.
4. Check for zero volts at TB1 terminals +DC and –DC.
5. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
6. Remove the customer-supplied wiring from the drive.
7. Remove the screws from the Enclosure frame top and bottom panels to remove the panels.

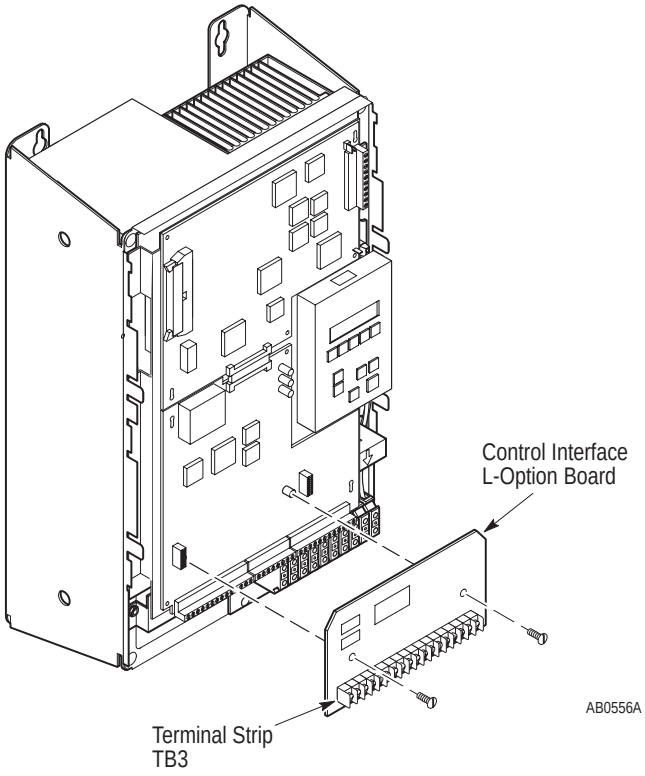
Installation

Install the Enclosure in reverse order of removal.

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

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

Figure 2.4
Control Interface L-Option Board



Removal

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

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

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

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

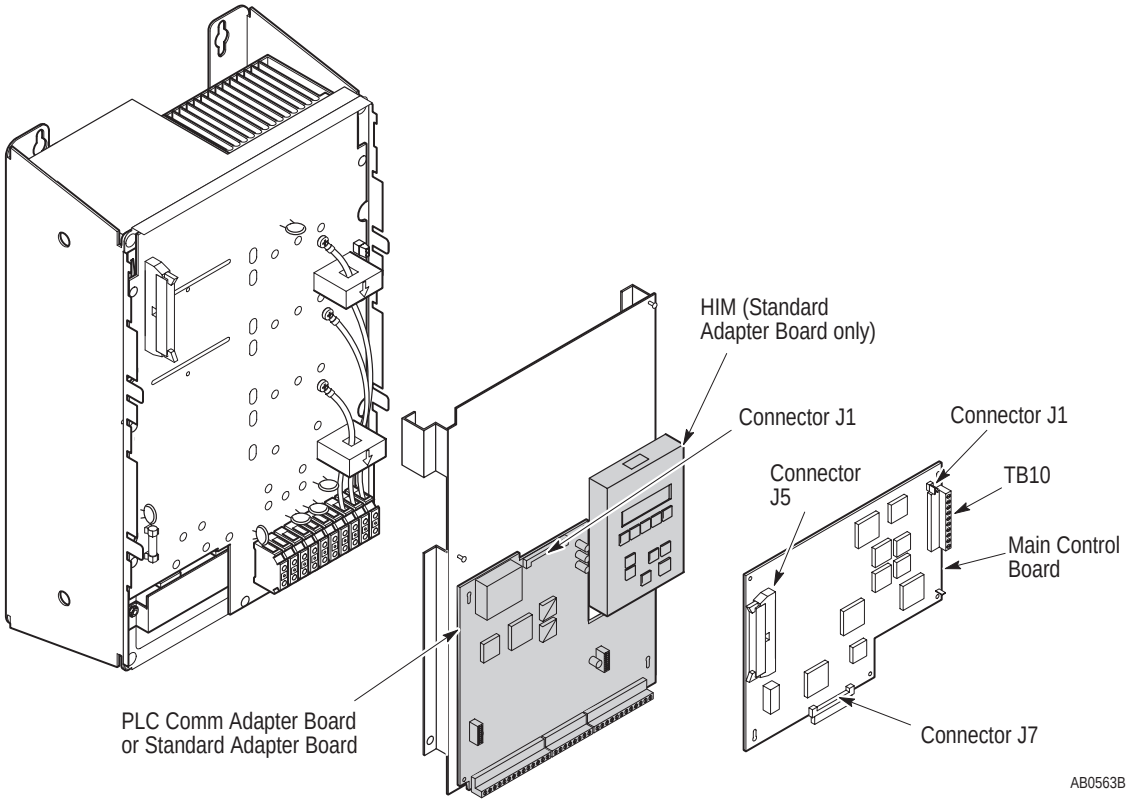
Installation

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

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

Removing the Main Control Board

Figure 2.5
Main Control Board and Mounting Plate



Removal

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

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

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

1. Remove power from the Drive.
2. Open the Enclosure cover. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 Terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Disconnect the following from the Main Control Board:
   - J5 ribbon cable connector
   - Stake-on ground wire connector
   - All wires from TB10
   - J1 connector
6. Remove the screws fastening the Main Control Board to the Mounting Plate.
7. Lift the Main Control Board upward to release it from the slide-mount stand-offs and connector J7.
8. Pull the Main Control Board away from the Mounting Plate.

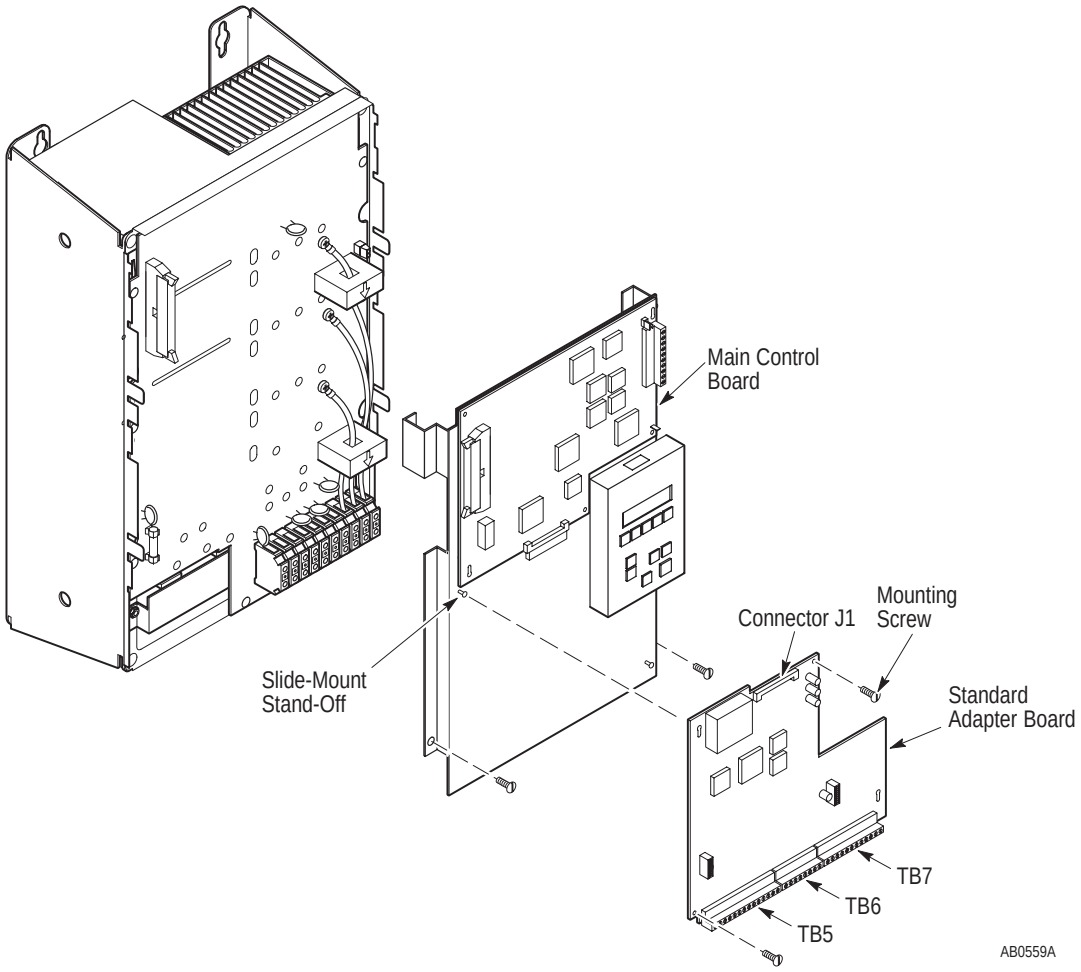
Installation

Install the Main Control Board in reverse order of removal.

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

Removing the Standard Adapter Board

Figure 2.6
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 +DC and –DC on Terminal Block TB1. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

1. Remove power from the drive.
2. Open the Enclosure cover. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at TB5, TB6, and TB7 on the Standard Adapter Board.
5. Disconnect the following from the Standard Adapter Board:
   - Stake-on ground wire connector
   - All wires from TB5, TB6, and TB7.
6. Remove the Control Interface L-Option Board. Refer to Removing the Control Interface L-Option Board in this chapter.
7. Remove the two screws fastening the Standard Adapter Board to the mounting plate.
8. Pull the Standard Adapter Board down to release it from the slide mount stand-offs and connector J1.

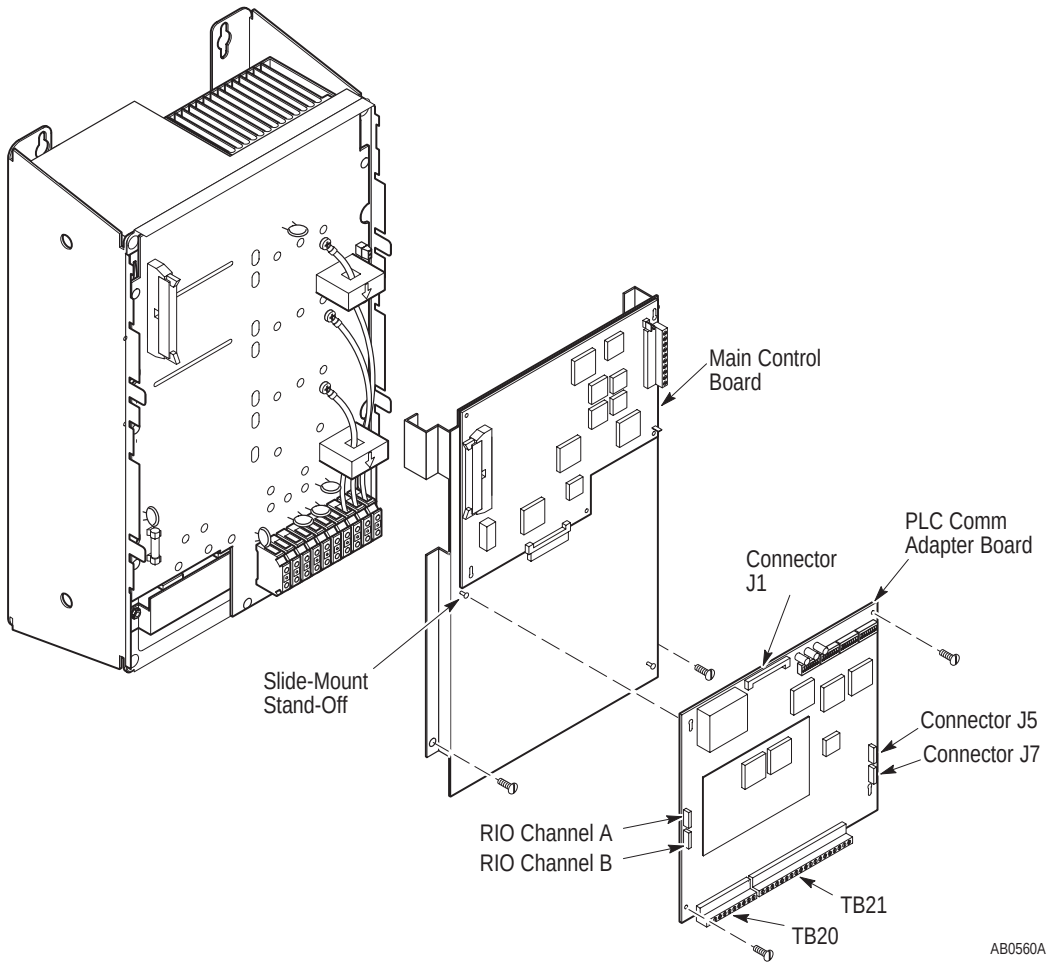
Installation

Install the Standard Adapter Board in reverse order of removal.

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

Removing the PLC Comm Adapter Board

Figure 2.7
Main Control Board and PLC Comm Adapter Board



Removal

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

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

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

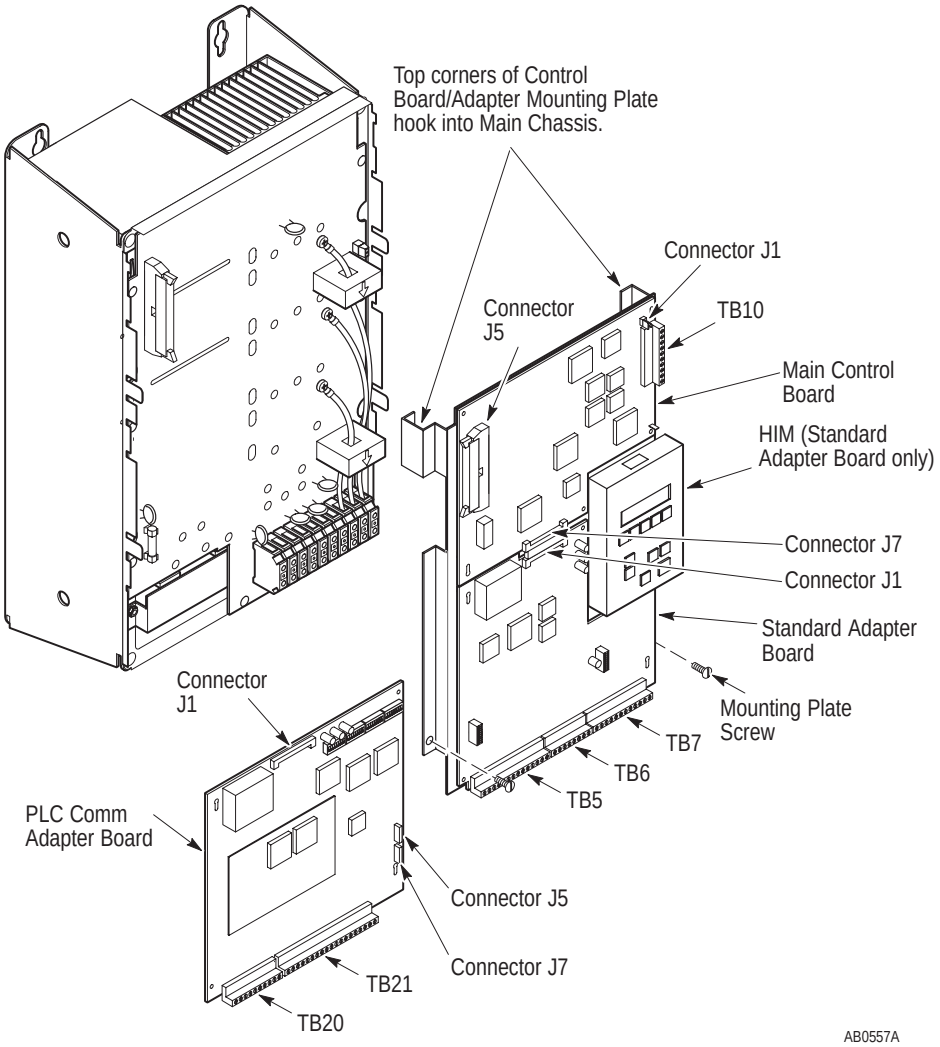
Installation

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

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

Removing the Control Board/Adapter Mounting Plate

Figure 2.8
Control Board Mounting Plate



Removal

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

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

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

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

   This drive may have either a Standard Adapter Board or a PLC Comm Adapter Board. Refer to Removing the Standard Adapter Board or Removing the PLC Comm Adapter Board in this chapter.

6. Remove the wires and connectors from the Main Control Baord.
7. Loosen the two captive screws near the bottom of the Control Board/Adapter Mounting Plate.
8. Pull the Control Board/Adapter Mounting Plate out about two inches, then slide it downward.

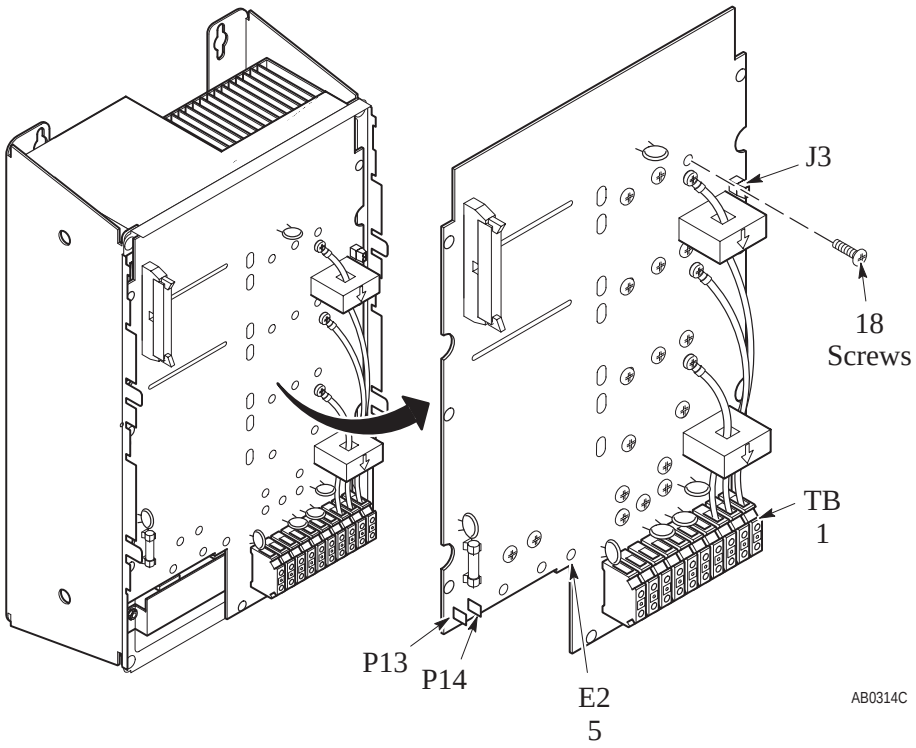
Installation

Install the Control Board/Adapter Mounting Plate in reverse order of removal.

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

Removing the Gate Driver/Power Supply Board (Series A and B)

Figure 2.9
Gate Driver/Power Supply Board



Removal

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

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

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

1. Remove power from the drive.
2. Open the Enclosure cover. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Remove the Control Board/Adapter Mounting Plate. Refer to Removing the Control Board/Adapter Mounting Plate in this chapter.
6. Disconnect the following from the Gate Driver/Power Supply Board:
   - P13 Stake-on connector
   - P14 Stake-on connector
   - IGBT gate connections (14)
   - E1 inductor wire
   - E26 inductor wire
   - E25 ground wire
   - J3 fan wires
   - All incoming power wires at TB1
7. Remove all screws connecting the Gate Driver/Power Supply Board to the power components.

Installation

Install the Gate Driver/Power Supply Board in reverse order of removal. Refer to Table 2.A – Fastener Torque Specifications.

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

Removing the Gate Driver/Power Supply Board (Series C and D)

Figure 2.10
Gate Driver/Power Supply Board A010, A015, B020 – B030, and C020 Drives

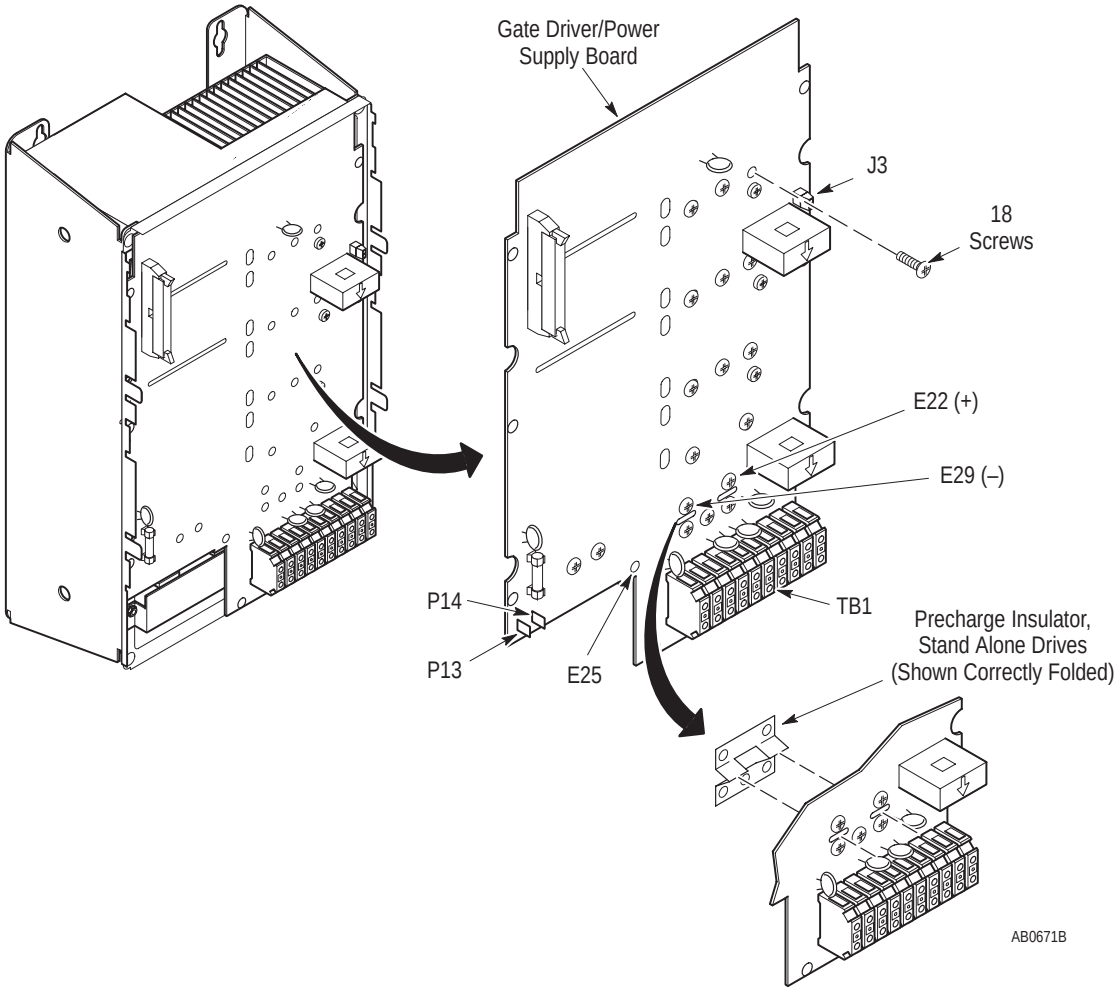
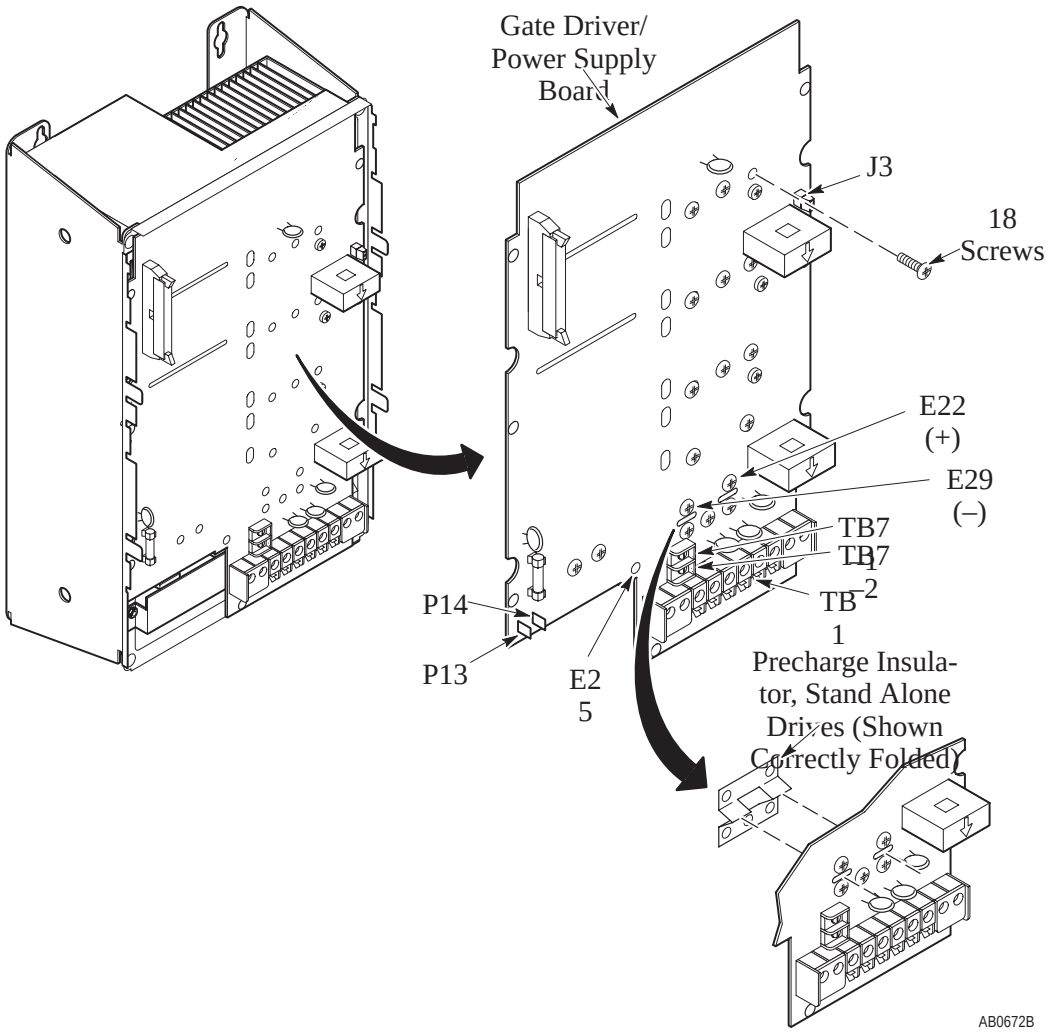


Figure 2.11
Gate Driver/Power Supply Board A007, B007 – B015, and C007 – C015 Drives



Removal

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

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

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

1. Remove power from the drive.
2. Open the Enclosure cover. Refer to Opening the Drive Enclosure in this chapter.
3. Check for zero volts at TB1 terminals +DC and –DC.
4. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
5. Remove the Control Board/Adapter Mounting Plate. Refer to Removing the Control Board/Adapter Mounting Plate in this chapter.
6. Disconnect the following from the Gate Driver/Power Supply Board:
   - P13 stake-on connector
   - P14 stake-on connector
   - DC Bus Inductor wires, on Series A and B Drives, from:
     - E29 – DC Bus Inductor wire
     - E22 + DC Bus Inductor wire
   - DC Bus Inductor wires, on Series C and D Drives, from:
     - TB1 –DC and TB1 +DC (A010, A015, and B020 – B030 Drive ratings only)
     - TB7-1 and TB7-2 (A007, B007 – B015, and C007 – C015 Drive ratings only)
   - E25 ground wire
   - J3 connector fan wires
   - IGBT gate connections (12)
   - Precharge Module gate connections (2)
   - All incoming power wires at Terminal Block TB1

7. Remove all screws connecting the Gate Driver/Power Supply Board to the power components.

Installation

Install the Gate Driver/Power Supply Board in reverse order of removal. Refer to Table 2.A – Fastener Torque Specifications.

Important: Before positioning the Gate Driver/Power Supply Board in the drive, fold and install the Precharge Insulator through the back of the Gate Driver/Power Supply Board. Refer to Figures 2.10 and 2.11.

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

Accessing Chassis Power Components

To access the power components located on the chassis, refer to Removing the Gate Driver/Power Supply Board in this chapter.

Component Test Procedures

Chapter Objectives

The following tests help you troubleshoot A007 – A015, B007 – B030, and C007 – C020 drives.

Component Test Overview

In some cases, different tests troubleshoot components of the same name. These similar tests vary according to the rating of the drive being tested. Verify that the rating on the drive matches the rating for the test you are performing.

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

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

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

Electrostatic Discharge Precautions

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

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

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

Tools

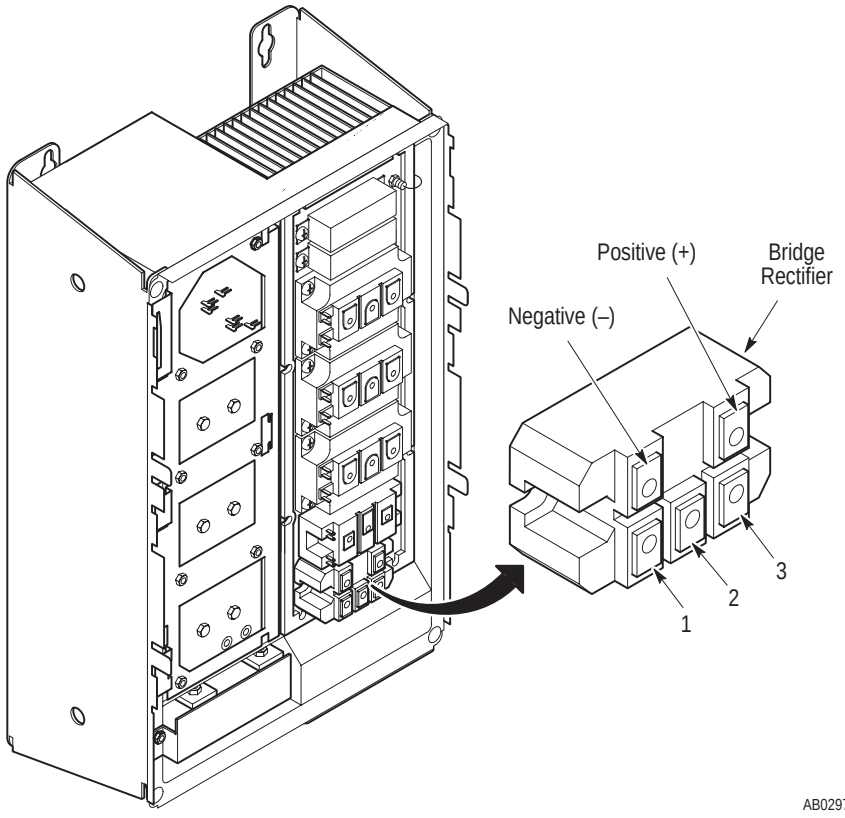
You need the following tools to disassemble and assemble the drive:

- Pliers
- #2 Phillips screwdriver
- 5/16-inch or 8mm socket
- Torque wrench, metered in lb-in. or N-m

Test 1 Testing Bridge Rectifier BR1

Bridge Rectifier BR1 is located on the bottom right of the heat sink.

Figure 3.1
Bridge Rectifier Test



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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board

4. Remove the Gate Driver/Power Supply Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver/Power Supply Board.
5. Set your meter to test diodes.
6. The following table shows meter connections and ideal meter readings for those connections. Refer to the previous illustration for meter connection locations.

Table 3.A
Bridge Rectifier BR1 Test

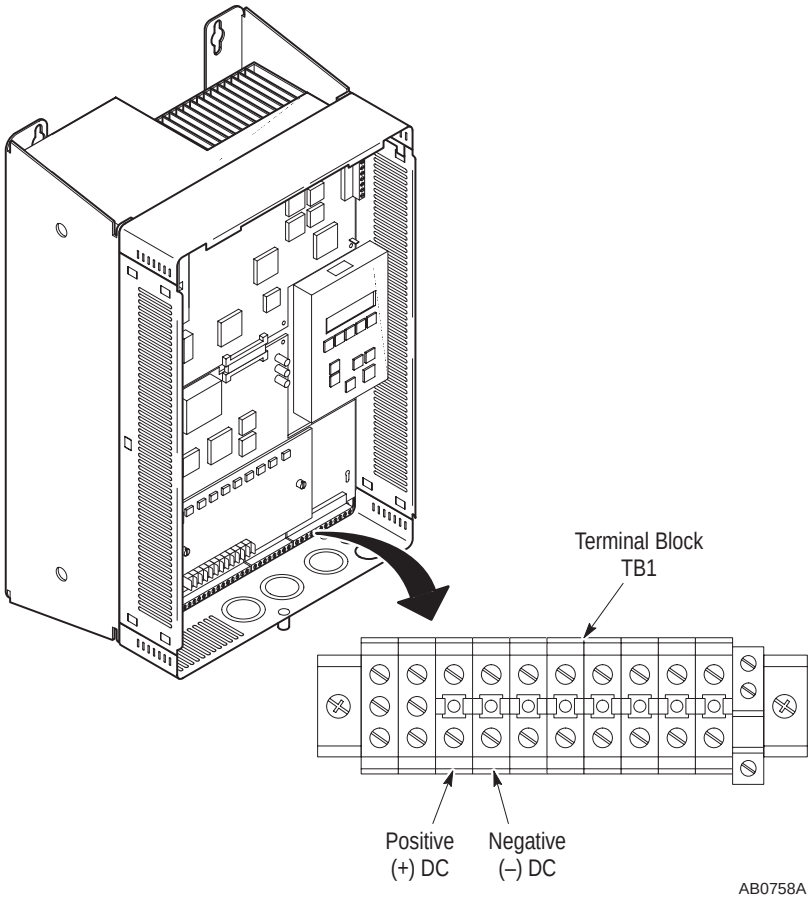
Meter (+) Lead	Meter (–) Lead	Nominal Meter Reading
1	+	0.43
2	+	0.43
3	+	0.43
+	1	Infinite
+	2	Infinite
+	3	Infinite
–	1	0.43
–	2	0.43
–	3	0.43
1	–	Infinite
2	–	Infinite
3	–	Infinite

7. Replace BR1 if any readings are not as shown above.
   - Clean all surfaces between the rectifier and the heat sink using a soft, clean cloth.
   - Replace the Preform between the rectifier and the chassis.
   - Apply 25 – 31 lb-in. or 2.8 – 3.5 N-m torque to the mounting screws.
8. If the rectifier shorted, check:
   - Transistor Modules for possible damage.
   - MOV1 for an open/shorted condition.
9. Replace and secure the Gate Driver/Power Supply Board and Control Board/Adapter Mounting Plate.

Test 2 Testing the Bus Capacitors

The Bus Capacitors are located on the left side of the Main Chassis.

Figure 3.2
Bus Capacitor Test



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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC.

3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Inspect the capacitors for deformation, discoloration, or other indications of high temperature, and replace if damaged. Otherwise, go to Step 5.
5. Set your meter to test voltage.
6. Connect the negative lead of your meter to the (–) DC Bus terminal on TB1 and the positive lead to the (+) DC Bus terminal. Refer to the previous illustration for TB1 terminal locations.

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

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

Table 3.B
Bus Capacitor Group Test

Drive Rating	Input Volts	Meter Reading
A	200	282V DC +/–5%
	230	325V DC +/–5%
	240	339V DC +/–5%
B	380	537V DC +/–5%
	415	586V DC +/–5%
	480	478V DC +/–5%
C	500	707V DC +/–5%
	575	813V DC +/–5%
	600	850V DC+/–5%

8. If the voltage is out of tolerance, check the following:
   - An open condition at Bridge Rectifier BR1.
   - A voltage drop due to Inductor L1 resistance.
   - A voltage drop between Bridge Rectifier BR1 and the bus capacitors due to loose or resistive wires or connections.
   - Precharge Circuit problems.

9. If the above check did not reveal a problem, replace the capacitors and balancing resistors. The balancing resistors are located on the top-right of the heat sink.

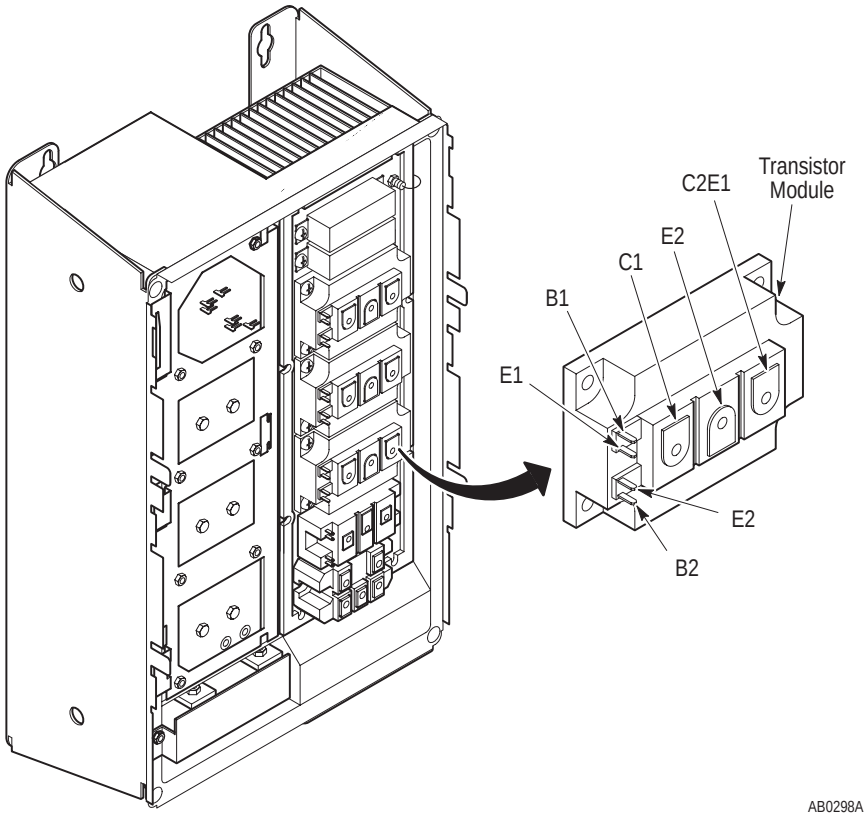
10. Install the nuts fastening the capacitor assembly. Refer to Chapter 2 – Disassembly and Access Procedures, Table 2.A – Fastener Torque Specifications.

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

Test 3 Testing Transistor Modules Q1, Q2, and Q3

Transistor Modules Q1, Q2, and Q3 are located near the center of the heat sink.

Figure 3.3
Transistor Module Test



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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC before proceeding.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver/Power Supply Board.
5. Set your meter to test diodes.
6. The following tables show meter connections and ideal meter readings for those connections. Refer to the previous illustration for meter connection locations.

Table 3.C
A007 – A005, B007 – B015, and C007 – C015 Q1, Q2, and Q3 Test

Meter (+) Lead	Meter (–) Lead	Nominal Meter Reading
C2E1	E2	Infinite
E2	C2E1	0.36
C1	C2E1	Infinite
C2E1	C1	0.36
B1	E1	Infinite/capacitive
B2	E2	Infinite/capacitive

Table 3.D
B020 – B030 and C020 Q1, Q2, and Q3 Test

Meter (+) Lead	Meter (–) Lead	Nominal Meter Reading	Maximum Meter Reading
C2E1	E2	Infinite	–
E2	C2E1	0.34	0.6
C1	C2E1	Infinite	–
C2E1	C1	0.34	0.6
B1	E1	Infinite	Infinite/capacitive
B2	E2	Infinite	Infinite/capacitive

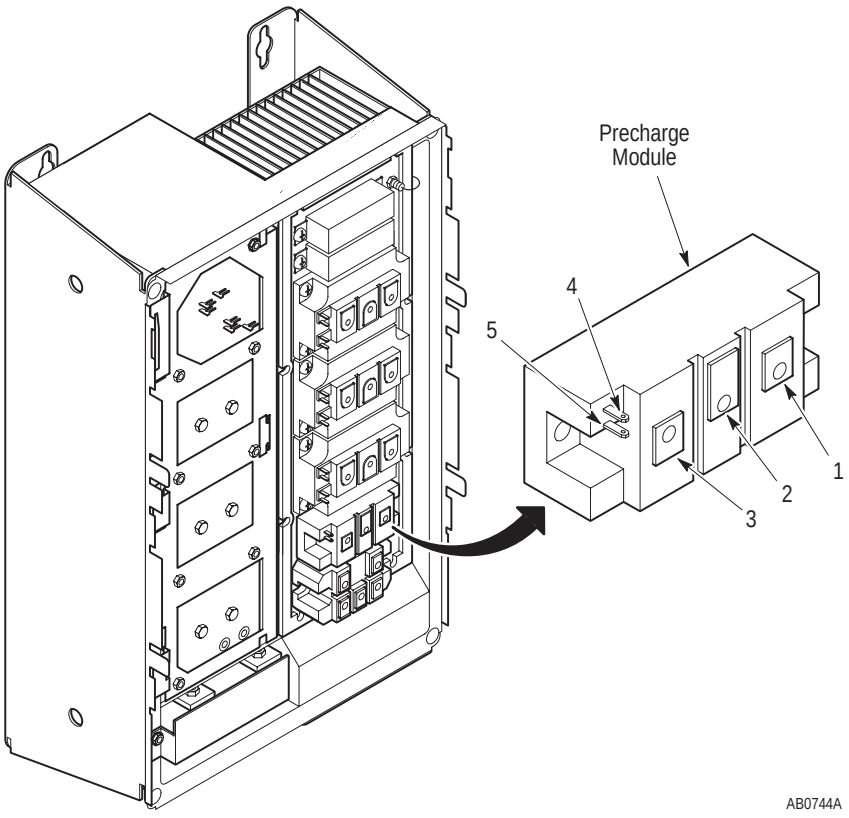
NOTE: Check the Transistor Module casings and replace if deformed.

7. If your readings do not match the table readings, replace Transistor Module Q1, Q2, or Q3.
   - Clean all surfaces between the transistor and the heat sink using a soft, clean cloth.
   - Replace the Preform between the transistor and the heat sink.
   - Install the screws fastening the Transistor Module to the heat sink. Refer to Chapter 2 – Disassembly and Access Procedures, Table 2.A – Fastener Torque Specifications.
8. If a Transistor Module is replaced, replace the Precharge Module. Refer to Test 4 – Testing the Precharge Module. You must also test the Gate Driver/Power Supply Board. Refer to Test 5 – Testing the Gate Driver/Power Supply Board.
9. Replace and secure the Gate Driver/Power Supply Board and Control Board/Adapter Mounting Plate.

Test 4
Testing the Precharge Module (Series A and B)

The Precharge Module is located near the bottom of the heat sink. If one or more Transistor Modules has been replaced, you must replace the Precharge Module.

Figure 3.4
Precharge Module Test (Series A and B)



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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC before proceeding.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver/Power Supply Board (Series A and B).
5. Set your meter to test diodes.
6. Test the module. The following table shows meter connections at the module and ideal meter readings for those connections. Refer to the previous illustration for meter connection locations.

Table 3.E
Precharge Module Test

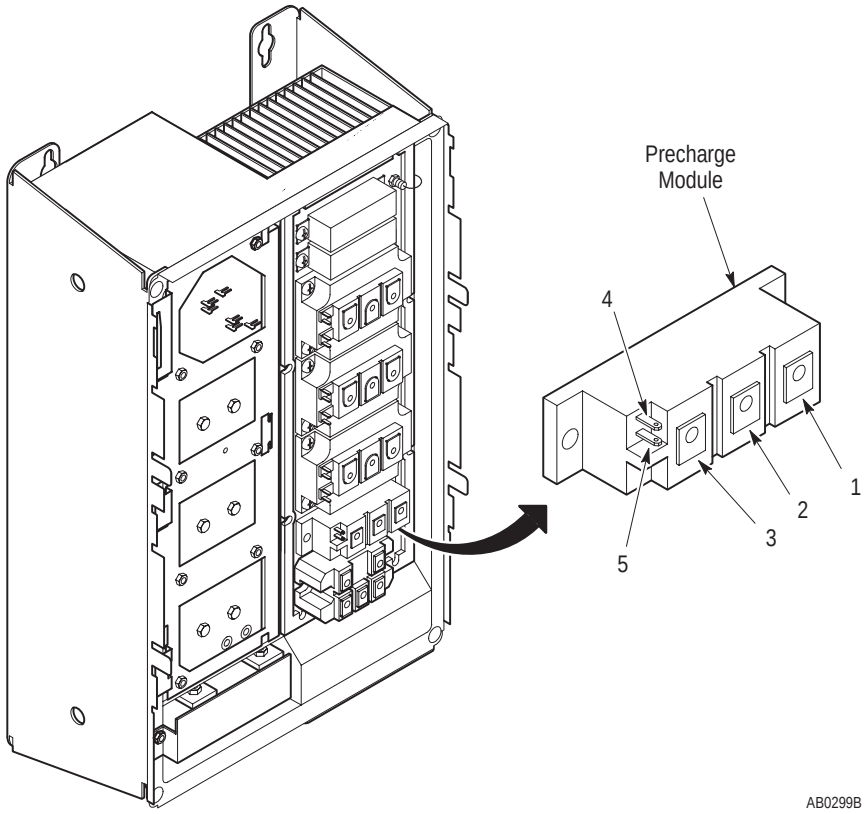
Meter (+) Lead	Meter (–) Lead	Nominal Meter Reading
1	3	0.35
3	1	Infinite
4	5	Infinite/capacitive
5	4	Infinite/capacitive

7. If your readings do not match the table readings, replace the Precharge Module.
   - Clean all surfaces between Precharge Module and the heat sink using a soft, clean cloth.
   - Replace the Preform between the module and the Main Chassis.
   - Install the screws. Refer to Chapter 2 – Disassembly and Access Procedures, Table 2.A – Fastener Torque Specifications.
8. Replace and secure the Gate Driver/Power Supply Board and Control Board/Adapter Mounting Plate.

Test 5
Testing the Precharge Module (Series C and D)

The Precharge Module is located near the bottom of the heat sink.

Figure 3.5
Precharge Module Test (Series C and D)



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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 Terminals +DC and –DC before proceeding.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver/Power Supply Board (Series C and D).
5. Set your meter to test diodes.
6. Test the module. The following table shows meter connections at the module and ideal meter readings for those connections. Refer to the previous illustration for meter connection locations.

Table 3.F
Precharge Module Diode Test

Meter (+) Lead	Meter (–) Lead	Nominal Meter Reading
1	3	Infinite
3	1	0.42
1	2	Infinite
2	1	Infinite
2	3	Infinite
3	2	Infinite

7. Set your meter to test resistance.

8. Test the module. The following table shows meter connections at the module and ideal meter readings for those connections. Refer to the previous illustration for meter connection locations.

Table 3.G
Precharge Module Resistance Test

Meter (+) Lead	Meter (–) Lead	Nominal Meter Reading
5	4	20
4	5	20
5	3	>500K
5	2	0.00
2	5	0.00
4	2	15
5	1	Infinite
4	3	Infinite
4	1	>500K

9. If your readings do not match the table readings, replace the Precharge Module.

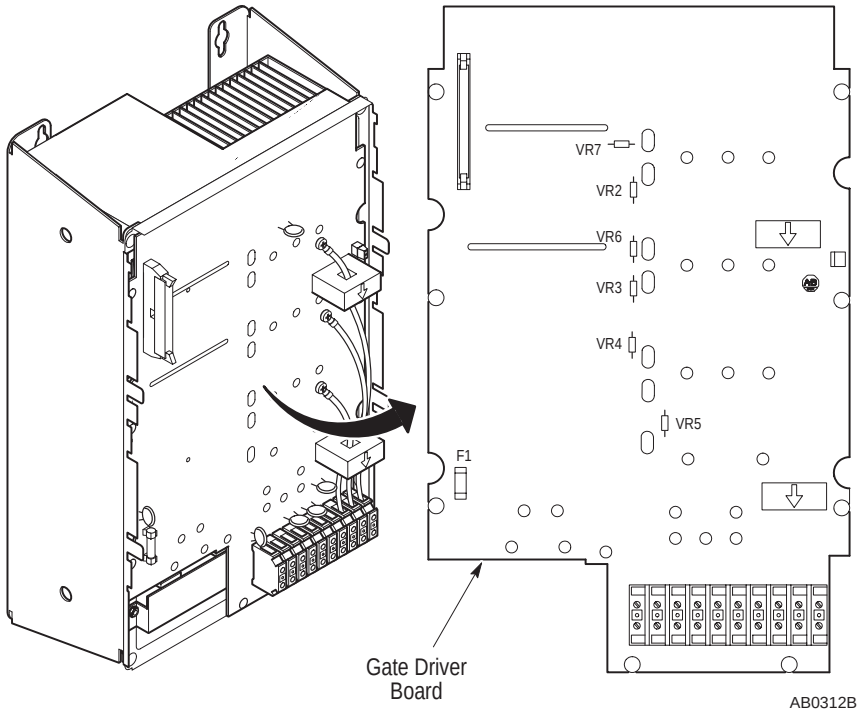
- Clean the surfaces between the Precharge Module and the heat sink using a soft, clean cloth.
- Replace the Preform between the Precharge Module and the heat sink.
- Fasten the Precharge Module to the heat sink using two screws. Refer to Chapter 2 – Disassembly and Access Procedures, Table 2.A – Fastener Torque Specifications.

10. Replace and secure the Gate Driver/Power Supply Board and Control Board/Adapter Mounting Plate.

Test 6 Testing the Gate Driver/Power Supply Board

The Gate Driver/Power Supply Board is located between the Main Control Board and the Main Chassis. If one or more Transistor Modules Q1, Q2, or Q3 has been replaced, you must test the Gate Driver/Power Supply Board.

Figure 3.6
Gate Driver/Power Supply Board Test



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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 terminals +DC and –DC before proceeding.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Control Board/Adapter Mounting Plate. Refer to Chapter 2 –Disassembly and Access Procedures, Removing the Control Board/Adapter Mounting Plate.
5. Unplug the connectors from the Gate Driver/Power Supply Board.
6. Set your meter to test resistance.
7. Check Fuse F1, located on the lower left side of the Gate Driver/Power Supply Board, for continuity. Replace the fuse if it shows an open condition.
8. Set your meter to test diodes.
9. Test VR2 through VR7. The following table shows meter connections at the components and ideal meter readings for those connections. Refer to the previous illustration for meter connection locations.

Table 3.H
Gate Driver Board Test

Component	Meter (+) Lead	Meter (–) Lead	Nominal Meter Reading
VR2 – VR7	+	–	1.2
	–	+	2.5

NOTE: Typical malfunction is shorted in both directions.

10. If your readings do not match the table readings, replace the Gate Driver/Power Supply Board.
11. Install the Control Board/Adapter Mounting Plate in reverse order of removal.

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Part Replacement Procedures

Chapter Objective

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

Part Replacement Overview

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

Safety Precautions

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

Electrostatic Discharge Precautions

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

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

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

Tools

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

- Pliers
- #2 Phillips screwdriver
- 5/16-inch or 8mm socket
- Torque wrench, metered in lb-in. or N-m

Major Component Replacement

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

- Precharge Module
- Thermistor
- Transistor Modules
- Bridge Rectifier BR1
- Fan
- DC Bus Inductor L1
- Bus Capacitors

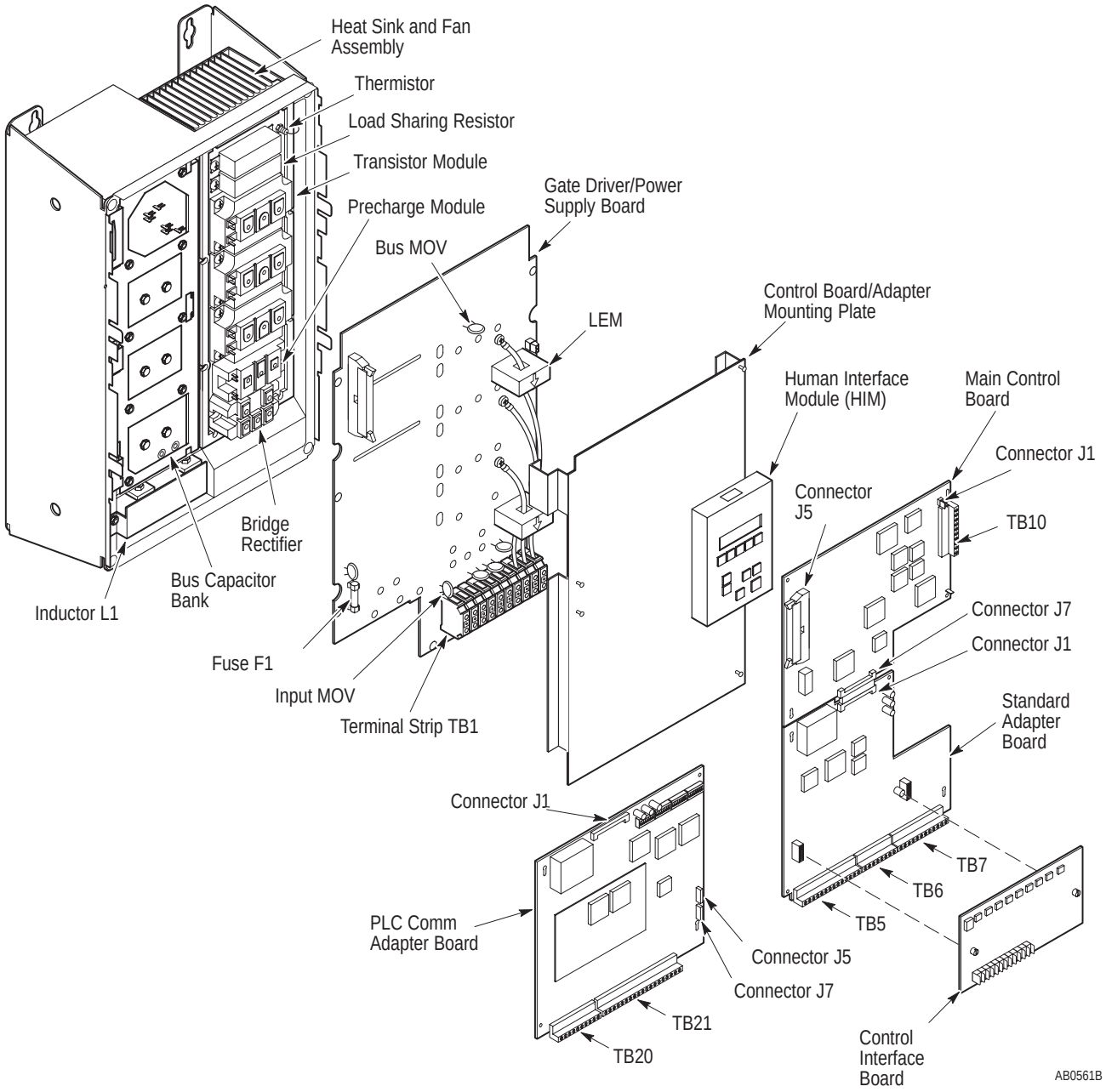
For Gate Driver/Power Supply Board, Main Control Board, Standard Adapter Board, PLC Comm Adapter Board, and Control Interface L-Option Board installation and removal procedures, refer to Chapter 2.

Detailed Product Identification

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

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

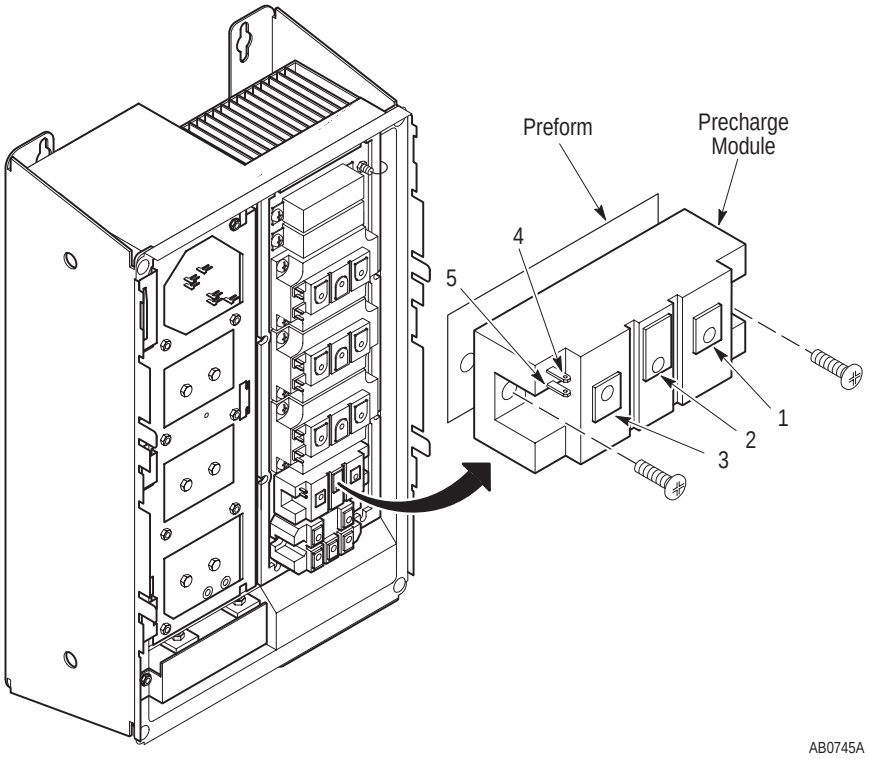
Figure 4.1
Main Drive Components



Precharge Module (Series A and B)

The Precharge Module is located behind the Gate Driver/Power Supply Board, to the right of the Bus Capacitor assembly.

Figure 4.2
Precharge Module (Series A and B)



Removal

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

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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 Terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board from the drive. Refer to Chapter 2 – Removing the Gate Driver/Power Supply Board.
5. Remove the two round-head screws fastening the Precharge Module to the heat sink.
6. Remove the Precharge Module from the drive.

Installation

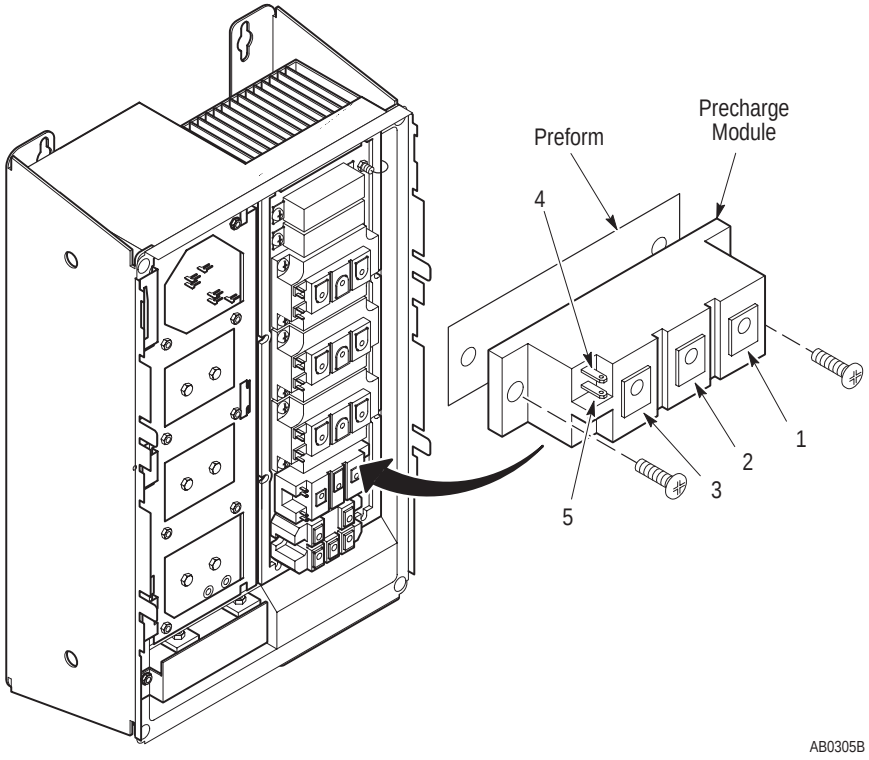
1. Clean the surfaces between the Precharge Module and the heat sink using a soft, clean cloth.
2. Replace the Preform between the Precharge Module and the heat sink.
3. Install the Precharge Module in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Table 2.A – Fastener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

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

Precharge Module (Series C and D)

The Precharge Module is located near the bottom of the heat sink. If one or more Transistor Modules has been replaced, you must replace the Precharge Module.

Figure 4.3
Precharge Module (Series C and D)



Removal

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

ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. For Electrostatic Discharge Precautions, refer to Chapter 2 – Disassembly and Access Procedures.

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

1. Remove power from the drive.
2. Check for zero volts at TB1 Terminals +DC and –DC before proceeding.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver/Power Supply Board.
5. Remove the two round-head screws fastening the Precharge Module to the heat sink.
6. Remove the Precharge Module from the drive.

Installation

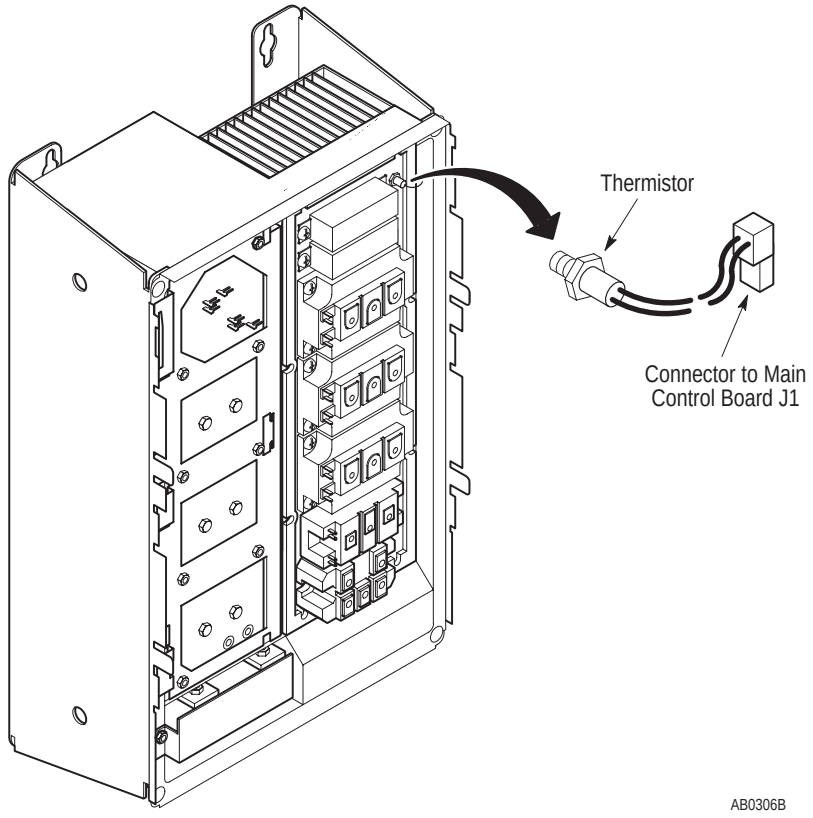
1. Clean surfaces between the Precharge Module and the heat sink.
2. Replace the Preform between the Precharge Module and the heat sink.
3. Install the Precharge Module in reverse order of removal. Refer to Chapter 2 – Disassembly and Access Procedures, Table 2.A – Fastener Torque Specifications.

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

Thermistor

The Thermistor is fastened to the upper right corner of the heat sink.

Figure 4.4
Thermistor



Removal

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

ATTENTION: 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 TB1 Terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver/Power Supply Board.
5. Unscrew the Thermistor from the heat sink.

Installation

Install the Thermistor in reverse order of removal.

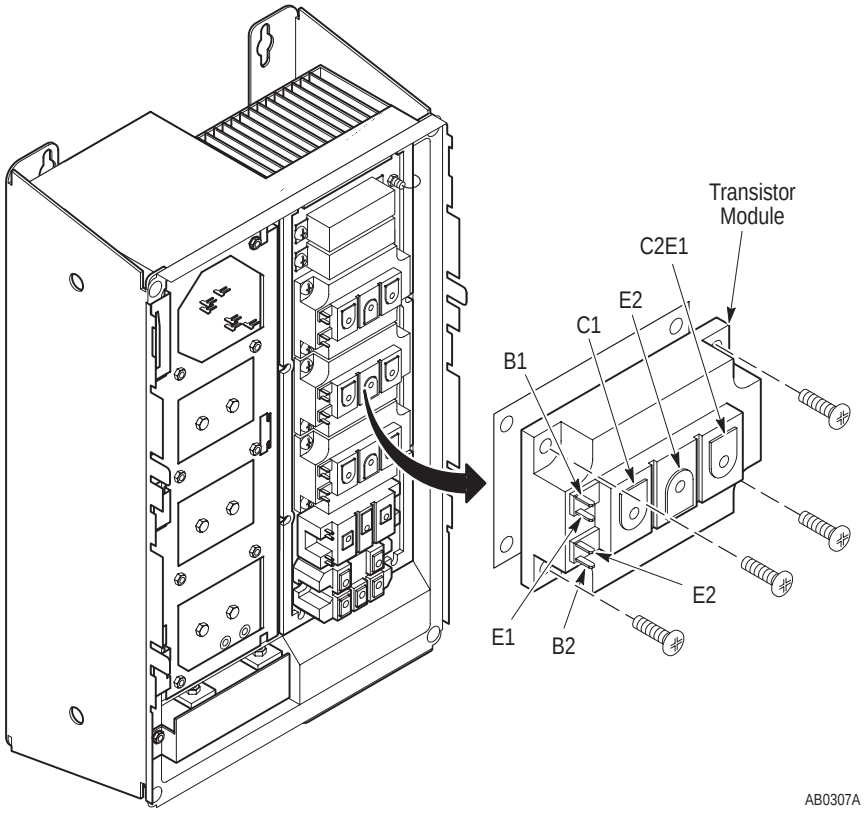
Important: When fastening the Thermistor to the heat sink, hand-tighten the Thermistor to avoid damaging the porcelain Thermistor body.

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

Transistor Modules

Transistor Modules Q1, Q2, and Q3 are located on the center of the heat sink.

Figure 4.5
Transistor Modules



Removal

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

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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 Terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board from the drive. Refer to Chapter 2 – Removing the Gate Driver/Power Supply Board.
5. Remove all wires connected to the transistor module terminals.
6. Remove the screws fastening the transistor to the heat sink.

Installation

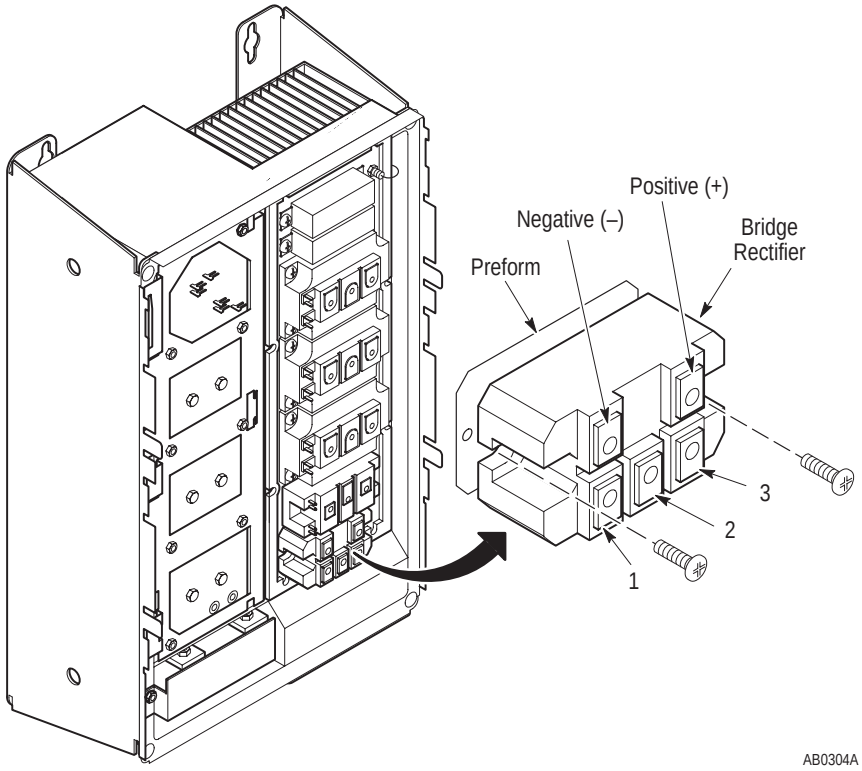
1. Clean all surfaces between the transistor and the heat sink using a soft, clean cloth.
2. Replace the Preform between the transistor and the heat sink.
3. Install the transistor modules in reverse order of removal.
4. Fasten the mounting screws. Refer to Chapter 2 – Disassembly and Access procedures, Table 2.A – Fastener Torque Specifications.
5. Fasten the terminal screws. Refer to Chapter 2 – Disassembly and Access procedures, Table 2.A – Fastener Torque Specifications.

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

Bridge Rectifier BR1

Bridge Rectifier BR1 is located at the bottom of the heat sink.

Figure 4.6
Bridge Rectifier BR1



Removal

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

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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 Terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board from the drive. Refer to Chapter 2 – Removing the Gate Driver/Power Supply Board.
5. Remove the two screws fastening the bridge rectifier to the heat sink.
6. Remove the rectifier from the heat sink.

Installation

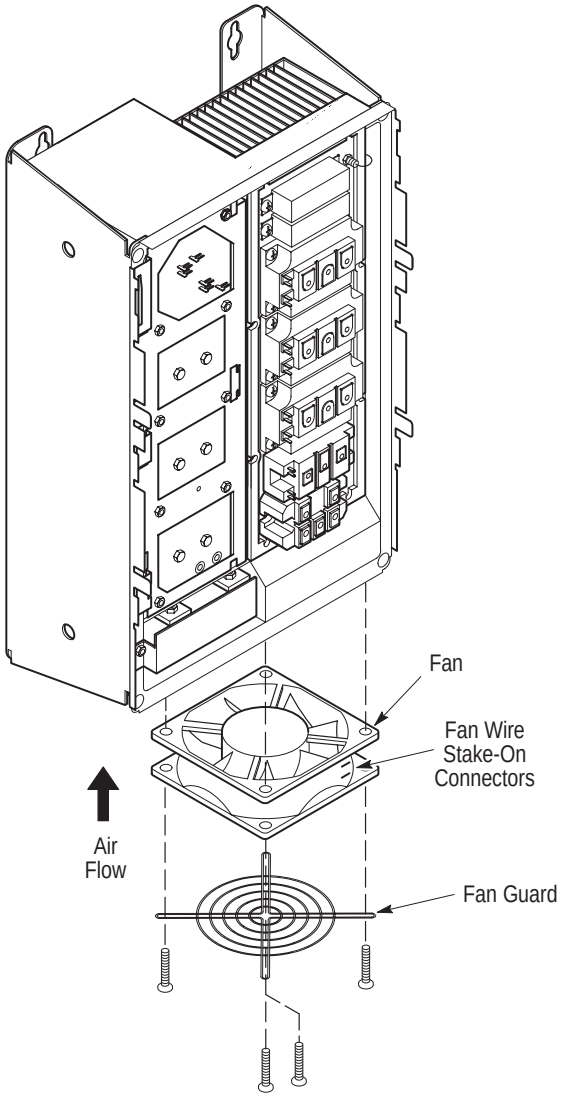
1. Clean all surfaces between Bridge Rectifier BR1 and the heat sink using a soft, clean cloth.
2. Replace the Preform between the rectifier and the heat sink.
3. Install the rectifier in reverse order of removal.
4. Fasten the mounting screws. Refer to Chapter 2 – Disassembly and Access Procedrues, Table 2.A – Fastener Torque Specifications.
5. Fasten the terminal screws. Refer to Chapter 2 – Disassembly and Access Procedrues, Table 2.A – Fastener Torque Specifications.

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

Fan

The Fan is located behind and to the bottom of the heat sink.

Figure 4.7
Fan



Removal

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

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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 Terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the wire connectors from the terminals on the Fan.
5. Remove the four round-head screws fastening the top and bottom of the Fan guard to the heat sink.
6. Pull the Fan guard and Fan away from the heat sink.

Installation

Install the Fan in reverse order of removal.

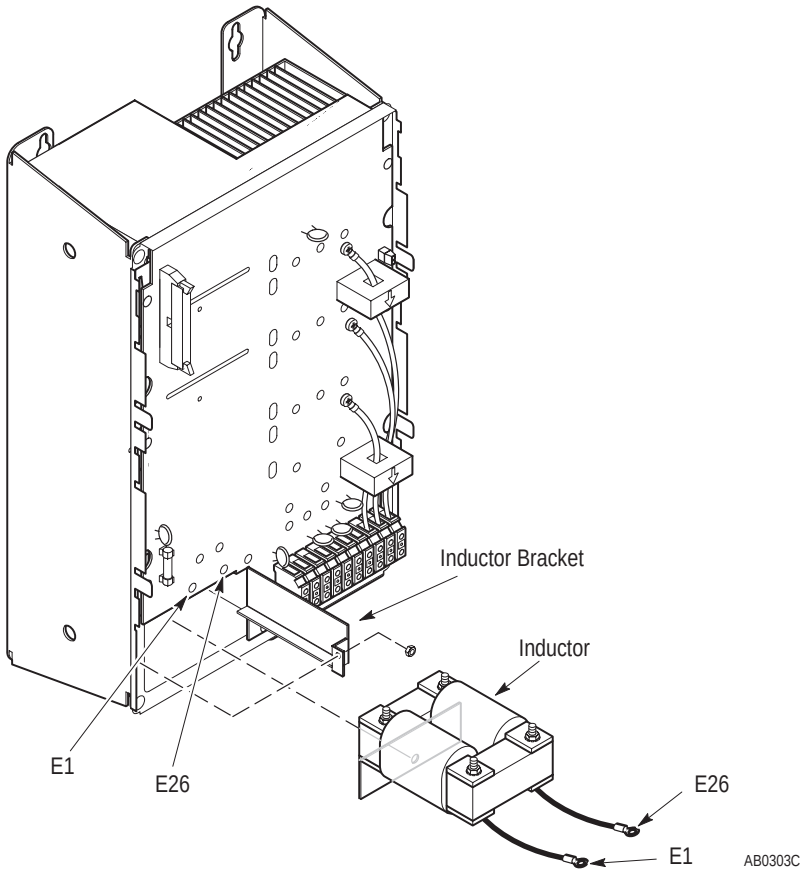
Important: When fastening the Fan to the cover plate, position the air flow arrow, located on the top of the fan near the connectors, so it points to the top of the drive. Position the Fan connectors to the front, away from DC Bus Inductor L1. Connect the red wire to the positive fan terminal and the black wire to the negative terminal.

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

DC Bus Inductor (Series A and B)

DC Bus Inductor is located on the lower left-hand corner of the Main Chassis.

Figure 4.8
DC Bus Inductor



Removal

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

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

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

1. Remove power from the drive.
2. Check for zero volts at TB1 Terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Control Board/Adapter Mounting Plate. Refer to Chapter 2 – Removing the Control Board/Adapter Mounting Plate.
5. Remove the inductor wires from Gate Driver/Power Supply Board terminals E1 and E26.
6. Remove the nut fastening the inductor bracket to the chassis.
7. Remove the inductor bracket by swinging it to the side.
8. Remove the inductor from the drive.

Installation

1. Lower the inductor into the Main Chassis, aligning the hole in the bottom inductor bracket with the peg on the chassis.
2. Install DC Bus Inductor L1 in reverse order of removal.

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

DC Bus Inductor (Series C and D)

DC Bus Inductor is located on the lower left-hand corner of the Main Chassis.

Figure 4.9
DC Bus Inductor and Gate Driver/Power Supply Board, A010, A015, B020 – B030, and C020 Drives

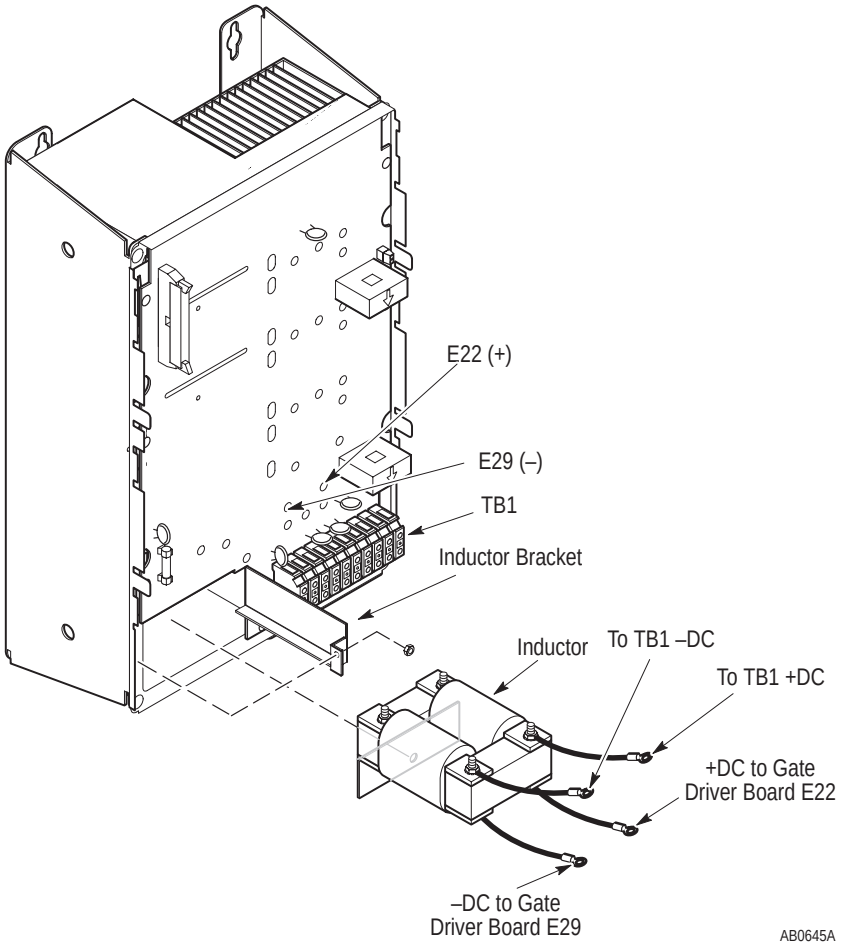
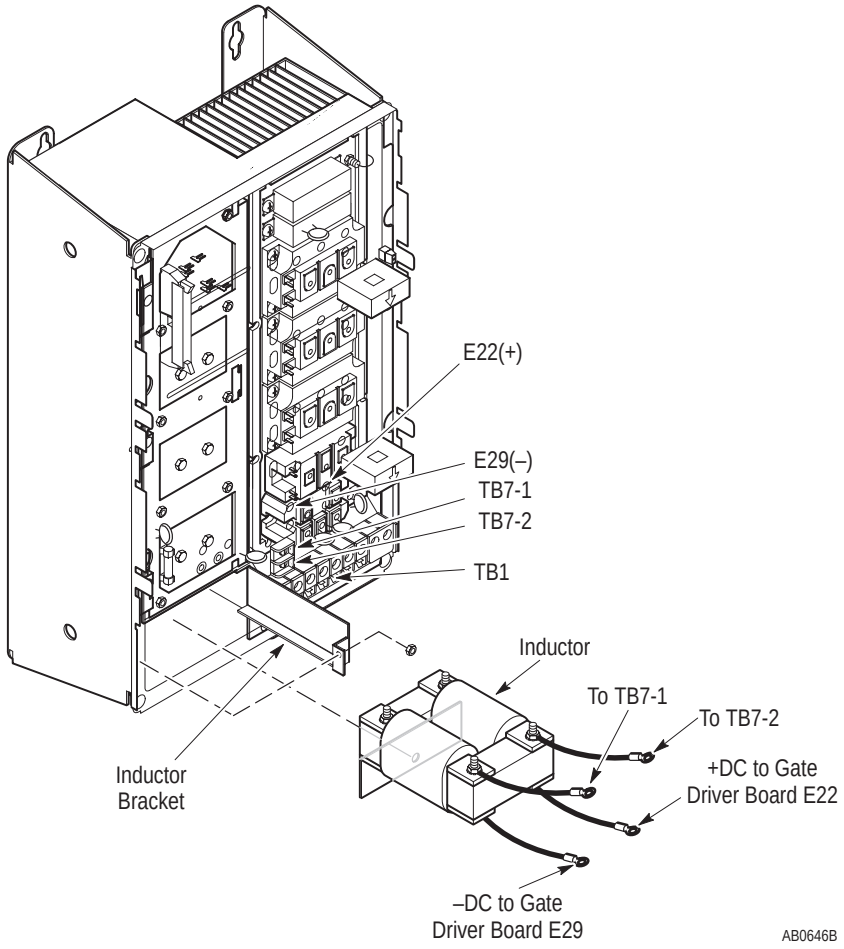


Figure 4.10
DC Bus Inductor and Gate Driver/Power Supply Board, A007, B007 – B015, and C007 – C015 Drives



Removal

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

ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS 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 TB1 Terminals +DC and –DC before proceeding.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Control Board/Adapter Mounting Plate. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Control Board/Adapter Mounting Plate.
5. Remove the DC Bus Inductor wires from TB1 –DC and TB1 +DC. (TB7-1 and TB7-2 on A007, B007 – B015, and C007 – C015 drives).
6. Remove the nut fastening the inductor bracket to the chassis.
7. Remove the bracket from the DC Bus Inductor to remove the inductor.

Installation

1. Lower the DC Bus Inductor into the Main Chassis. Align the hole in the bottom inductor bracket with the peg on the chassis.

   Important: The DC Bus Inductor insulator may shift when the inductor is removed. Before installing the inductor, check the insulator position.

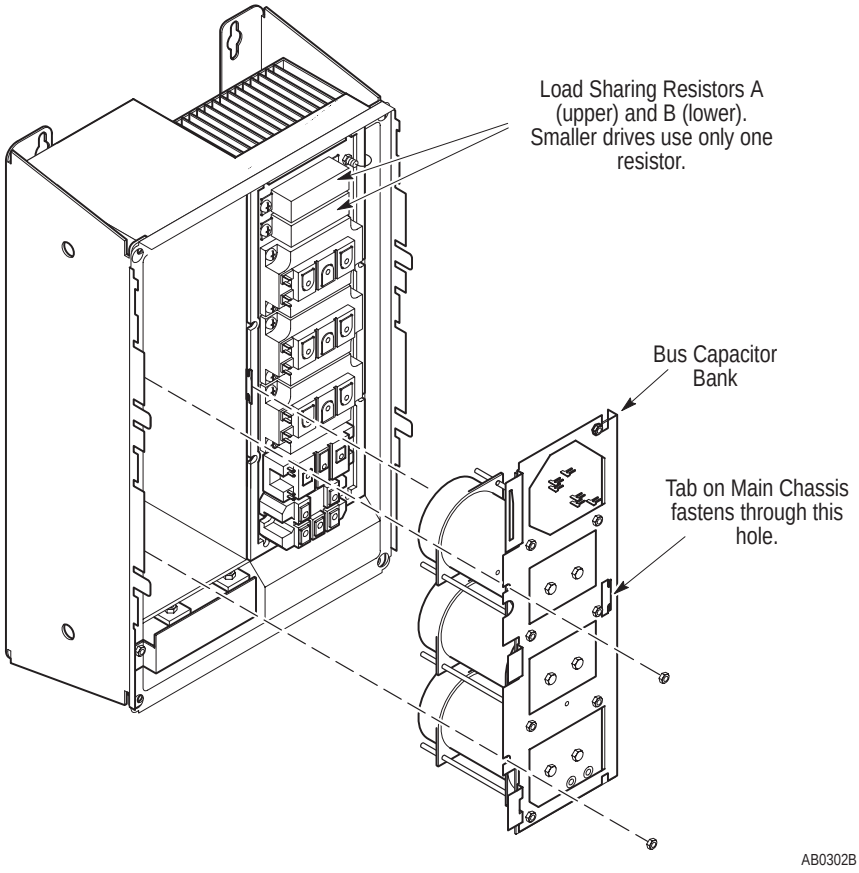
2. Install the DC Bus Inductor in reverse order of removal.

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

Bus Capacitors

The Bus Capacitors are located on the left side of the Main Chassis. Bus Capacitor sizes and quantities vary according to drive ratings.

Figure 4.11
Bus Capacitors



Removal

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

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

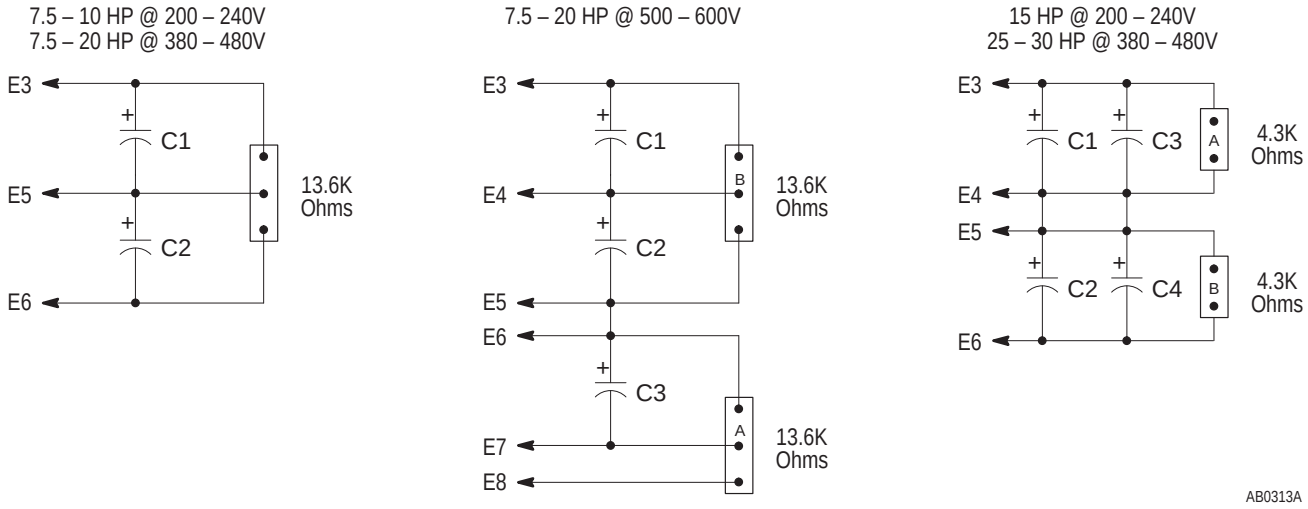
Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at TB1 Terminals +DC and –DC.
3. Check for the absence of control voltage at:
   - TB20 and TB21 on drives using a PLC Comm Adapter Board
   - TB5, TB6, and TB7 on drives using a Standard Adapter Board
4. Remove the Gate Driver/Power Supply Board. Refer to Chapter 2 – Disassembly and Access Procedures, Removing the Gate Driver/Power Supply Board.
5. Remove the Load Sharing Resistor wires from the connectors on the Bus Capacitor Bank.
6. Remove the two nuts fastening the Bus Capacitor assembly to the chassis.
7. Remove the Bus Capacitor assembly from the Main Chassis.

Installation

1. Fasten the capacitor assembly to the Main Chassis using the two nuts on the left side. Refer to Chapter 2 – Disassembly and Access Procedures, Table 2.A – Fastener Torque Specifications.
2. Connect the Load Sharing Resistors to the Bus Capacitors according to the following diagrams.

Figure 4.12
Load Sharing Resistor Connections to Bus Capacitors



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

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Replacement Parts List

Chapter Objectives

This chapter illustrates and lists replacement parts for the 1336 FORCE Drives rated A007 – A015, B007 – B030, and C007 – C020 and describes replacement parts ordering procedures.

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

Ordering Replacement Parts

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

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

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

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

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

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

Replacement Parts Listing

Figure 5.1
Parts for A007 – A015, B007 – B030, and C007 – C020 Drives

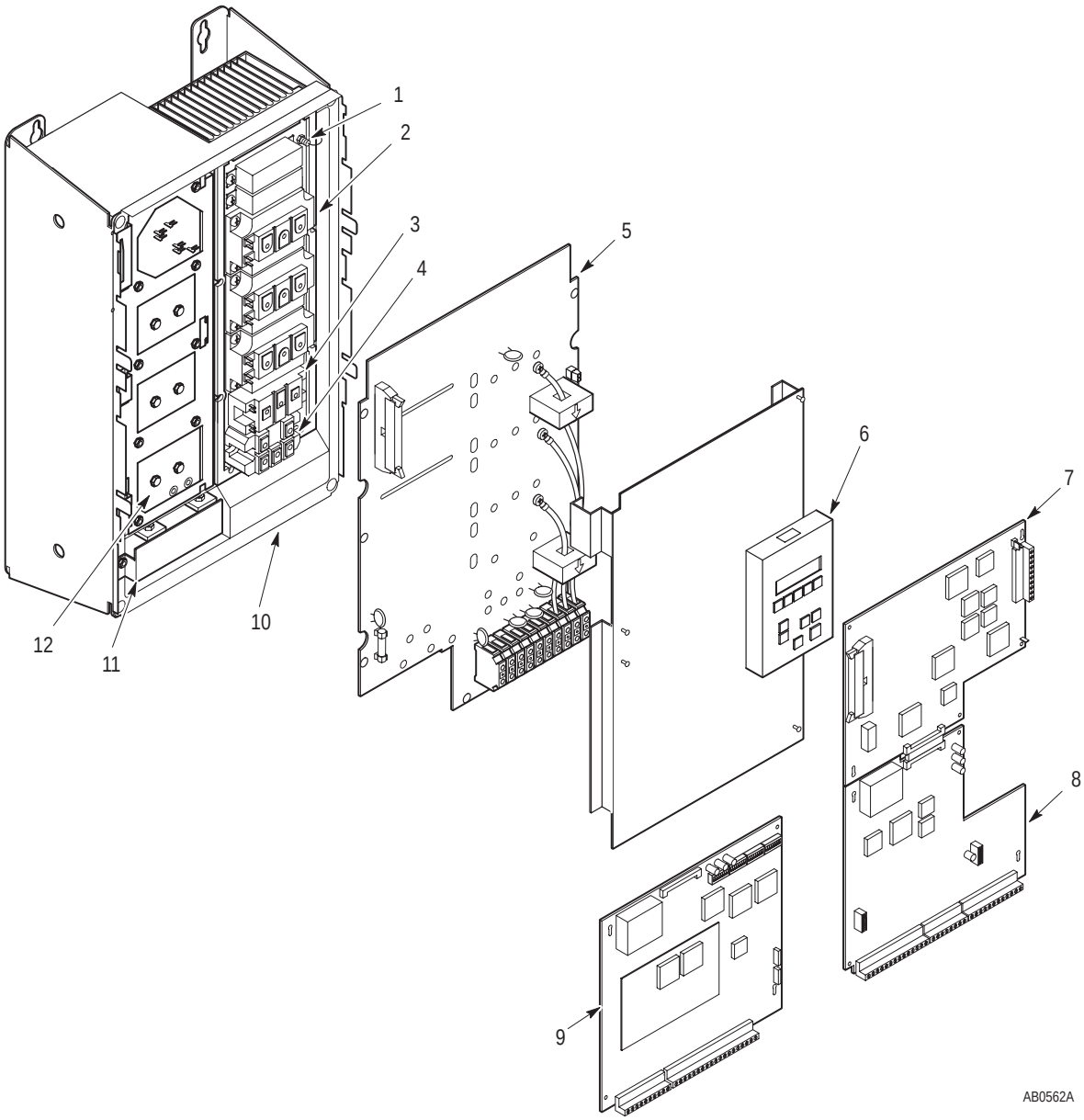

Table 5.A
Replacement Parts for A007 – A015, B007 – B030, and C007 – C020 Drives

Callout	Symbol	Description	Location	Replacement Procedures
1	ST	Thermistor	Main Chassis	Chapter 4, Thermistor
2	Q1 – 3	Transistor	Main Chassis	Chapter 4, Transistor Modules
3	M1	Precharge Module	Main Chassis	Chapter 4, Precharge Module
4	BR1	Bridge Rectifier	Main Chassis	Chapter 4, Bridge Rectifier BR1
5	BASEDR/ PWRSPLY	Gate Driver/Power Supply PCB	–	Chapter 2, Removing the Gate Driver/Power Supply Board
6	LOCAL DIS	Human Interface Module	Control Board/Adapter Mounting Plate	Chapter 2, Module Removal
7	MAIN CTL	Main Control PCB	Control Board/Adapter Mounting Plate	Chapter 2, Removing the Main Control Board
8	GT2	Standard Adapter Board	Control Board/Adapter Mounting Plate	Chapter 2, Removing the Standard Adapter Board
9	GT1	PLC Comm Adapter Board	Control Board/Adapter Mounting Plate	Chapter 2, Removing the PLC Comm Adapter Board
10	FAN	Fan	Main Chassis	Chapter 4, Bus Capacitors
11	L1	DC Bus Inductor	Main Chassis	Chapter 4, DC Bus Inductor L1
12	C1 – C4	Bus Capacitors	Main Chassis	Chapter 4, Bus Capacitors

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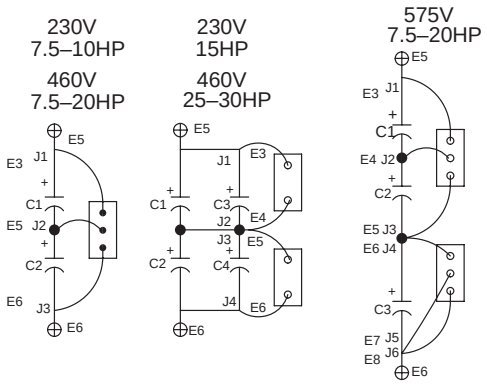
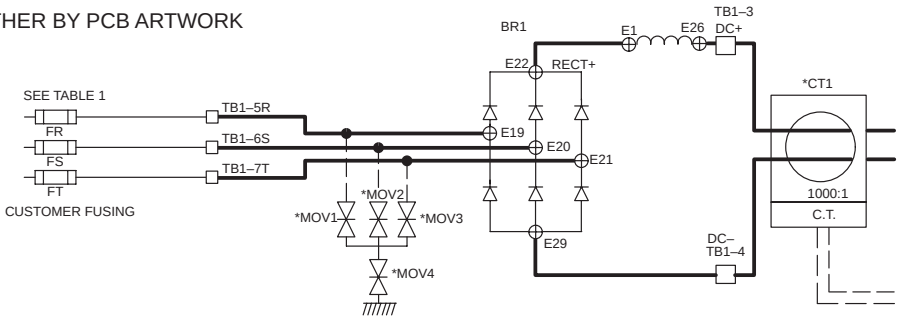
Schematics — 7 – 30 HP 1336 FORCE Drives

CAP BANK DETAILS



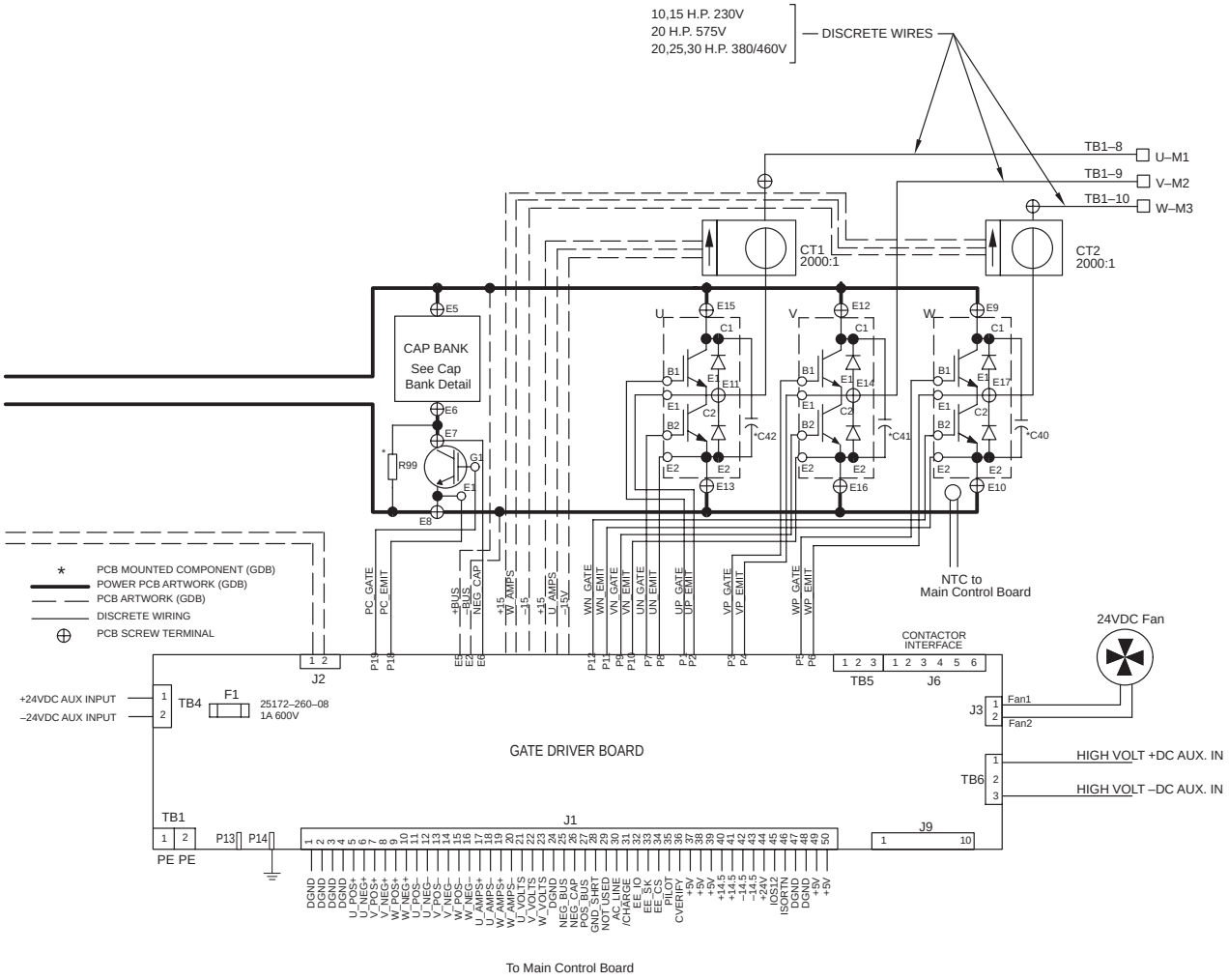
ALL CAPS ARE CONNECTED TOGETHER BY PCB ARTWORK



HP	VOLTAGE	FUSE (AC)
		FR,FS,FT TYPE JJ
7.5	230	35
10	230	45
15	230	70
7.5CT 10VT	380/460	20
10CT 15VT	380/460	30
15CT 20VT	380/460	35
20CT 25VT	380/460	45
25CT 30VT	380/460	60
30CT 30IEC	380/460	70
7.5	575	15
10	575	20
15	575	25
20	575	35

Series A and B
STAND ALONE UNIT
BULLETIN 1336 FORCE
200–240 Volt: 5.5–11 kW (7.5–15 HP)
380–480 Volt: 5.5–22 kW (7.5–30 HP)
500–600 Volt: 5.5–15 kW (7.5–20 HP)

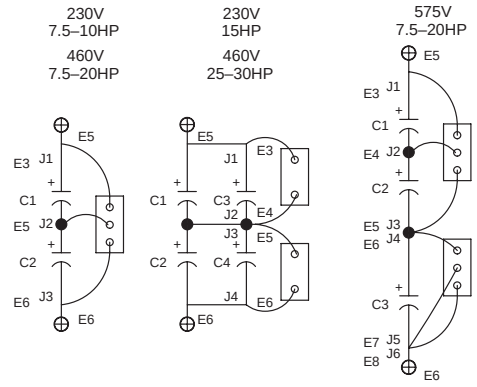
AB0755A



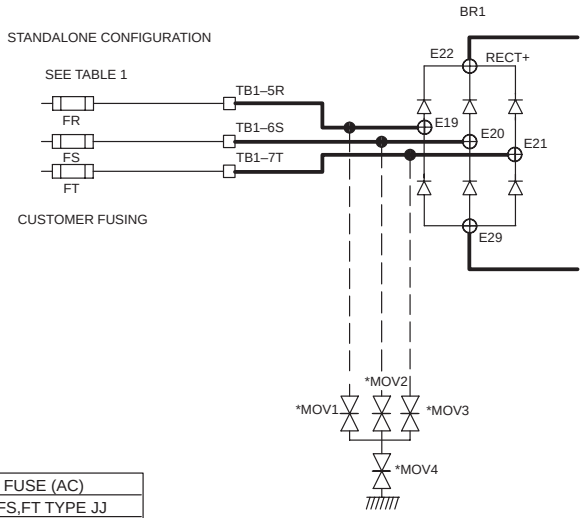
Series A and B
STAND ALONE UNIT
BULLETIN 1336 FORCE
200–240 Volt: 5.5–11 kW (7.5–15 HP)
380–480 Volt: 5.5–22 kW (7.5–30 HP)
500–600 Volt: 5.5–15 kW (7.5–20 HP)

AB0756A

CAP BANK DETAILS



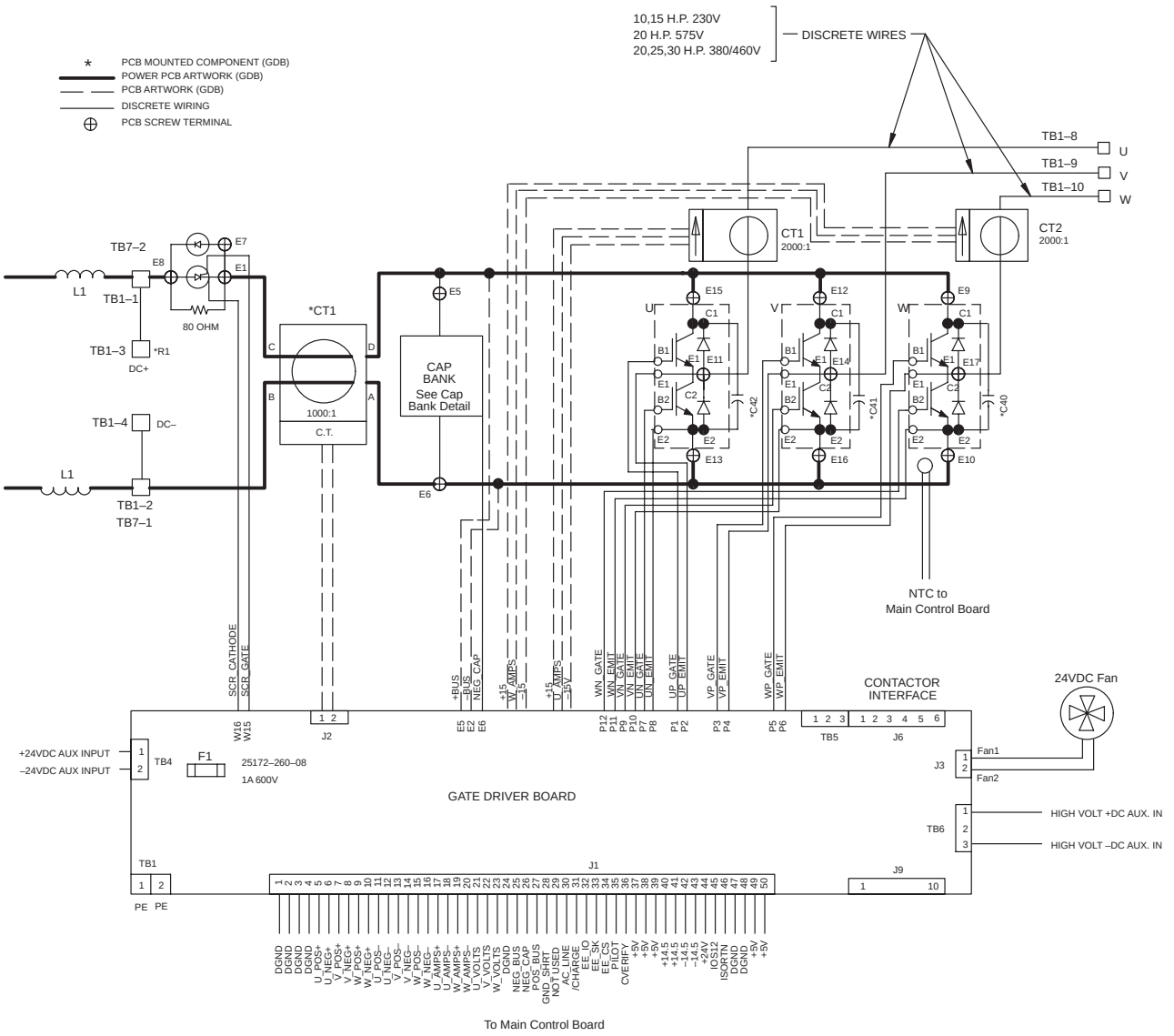
ALL CAPS ARE CONNECTED TOGETHER BY PCB ARTWORK



HP	VOLTAGE	FUSE (AC)
		FR,FS,FT TYPE JJ
7.5	230	35
10	230	45
15	230	70
7.5CT 10VT	380/460	20
10CT 15VT	380/460	30
15CT 20VT	380/460	35
20CT 25VT	380/460	45
25CT 30VT	380/460	60
30CT 30IEC	380/460	70
7.5	575	15
10	575	20
15	575	25
20	575	35

Series C and D
STAND ALONE UNIT
BULLETIN 1336 FORCE
200–240 Volt: 5.5–11 kW (7.5–15 HP)
380–480 Volt: 5.5–22 kW (7.5–30 HP)
500–600 Volt: 5.5–15 kW (7.5–20 HP)

AB0753A



Series C and D
STAND ALONE UNIT
BULLETIN 1336 FORCE
200–240 Volt: 5.5–11 kW (7.5–15 HP)
380–480 Volt: 5.5–22 kW (7.5–30 HP)
500–600 Volt: 5.5–15 kW (7.5–20 HP)

AB0754A

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Glossary

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

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

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

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

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

BR: Refer to *Bridge Rectifier.*

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

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

3. Regenerative braking — A method which produces electromagnetic braking forces in the motor by electronically controlling the return of generated power to the AC supply. The result is a controllable linear braking characteristic (ramp) that does not diminish with motor speed.

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

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

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

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

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

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

BTU: Refer to *British Thermal Unit*.

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

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

CEMF: Refer to *Counter Electromotive Force*.

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

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

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

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

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

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

Converter:

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

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

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

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

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

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

Diode: A solid-state uni-directional conductor.

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

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

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

Duty Cycle:

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

Dynamic Braking: Refer to *Braking*.

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

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

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

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

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

ESD: Refer to *Electrostatic Discharge*.

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

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

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

Gate:

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

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

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

IEC: International Electrotechnical Commission.

IGBT: Refer to *Insulated Gate Bipolar Transistor.*

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

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

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

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

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

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

Inverter:

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

ISO: Refer to *International Organization for Standards*.

Isolation Transformer:

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

Jogging:

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

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

LAD: Refer to *Linear Acceleration/Deceleration*.

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

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

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

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

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

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

MOV: Refer to *Surge Protection*.

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

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

NEC: Refer to *National Electrical Code*.

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

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

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

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

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

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

PC:

1. Personal Computer.

2. Programmable Controller.

3. Printed Circuit.

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

Pot: A potentiometer, or variable resistor.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Set Speed: The desired operating speed.

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

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

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

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

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

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

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

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

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

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

Transistor: An active solid-state semiconductor device.

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

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AC / DC DRIVES	❑	❑	❑	❑
PERSONAL COMPUTERS	❑	❑	❑	❑
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