Allen-Bradley

DriveGuard®

Safe-Off Option for PowerFlex® 700S Phase II AC Drives and PowerFlex 700L Liquid-Cooled AC Drives

User Manual

Rockwell Automation

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. *Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls* (Publication SGI-1.1 available from your local Rockwell Automation sales office or online at **http://www.rockwellautomation.com/literature**) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

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Throughout this manual, when necessary we use notes to make you aware of safety considerations.

WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

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

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid the hazard, and recognize the consequences.

Shock Hazard labels may be located on or inside the equipment (e.g., drive or motor) to alert people that dangerous voltage may be present.

Burn Hazard labels may be located on or inside the equipment (e.g., drive or motor) to alert people that surfaces may be at dangerous temperatures.

Manual Updates

The following changes apply to revision “D” (December 2006) of this manual.

Change	See Page...
Added a new wiring diagram for “Safe-Off Connection with Coast-to-Stop Action, Dual Channel” for PowerFlex 700S High Horse Power AC Drives, Frames 9 - 13 and PowerFlex 700L Liquid Cooled AC Drives, Frames 3A and 3B.	20

The following changes apply to revision “C” (October 2006) of this manual.

Change	See Page...
Added PowerFlex 700L Liquid-Cooled AC Drive Frame 3A and 3B information.	Throughout manual
Added Attention message to advise that the drive may provide energy for up to 180° of rotation in a 2-pole motor in the event two output IGBTs in the drive fail and the DriveGuard Safe-Off option has controlled the drive outputs to a safe state.	3 and 17
Added an Important message to advise that the DriveGuard Safe-Off option does not eliminate dangerous voltages at the drive output.	17

The following changes apply to revision “B” (August 2005) of this manual.

Change	See Page...
Added 400/500V and 600/690V Frame 9 - 13 drives to EN 954-1, Category 3 approval.	3
Updated the option board installation instructions to include frames 9 - 13.	6 and 12

Table of Contents

General Description

The DriveGuard Safe-Off option, when used with other safety components, helps provide protection according to EN 954-1:1997; Category 3 for safe-off and protection against restart. The DriveGuard Safe-Off option is just one component in a safety control system. Components in the system must be chosen and applied appropriately to achieve the desired level of operator safeguarding.

What Is the DriveGuard Safe-Off Option?

The DriveGuard Safe-Off option:

- Is designed to help safely remove power from the gate firing circuits of the drive's output power devices (IGBT's). This helps prevent the drive's output power devices from switching in the pattern necessary to generate AC power to the motor.
- Can be used in combination with other safety devices to satisfy the requirements of EN 954-1, Category 3 for safe-off and help protect against restart.

Important: This option is suitable for performing mechanical work on the drive system or affected area of a machine only. It does not provide electrical safety.

This option should not be used as a control for starting and/or stopping the drive.

ATTENTION: Electrical Shock Hazard. Verify that all sources of AC and DC power are deenergized and locked out or tagged out in accordance with the requirements of ANSI/NFPA 70E, Part II.

ATTENTION: To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Measure the DC bus voltage at the +DC and -DC terminals or test points (refer to your drive's *User Manual* for locations). The voltage must be zero.

ATTENTION: In safe-off mode, hazardous voltages may still be present at the motor. To avoid an electric shock hazard, disconnect power to the motor and verify that the voltage is zero before performing any work on the motor.

ATTENTION: In the event of the failure of two output IGBTs in the drive, when the DriveGuard Safe-Off option has controlled the drive outputs to the off state, the drive may provide energy for up to 180° of rotation in a 2-pole motor before torque production in the motor ceases.

Safety of Machinery Standards

The DriveGuard Safe-Off option satisfies requirements in the following machine safety standards:

- EN 954-1:1996; Safety of Machinery – Safety-related parts of control systems – Part 1: General Principles for design
- EN ISO 13849-2:2003 Safety of Machinery – Safety-related parts of control systems – Part 2: Validation

Evaluation/Certification by TUV Rheinland Group

Drive	Rating	TUV Report on Safety Function	TUV fs Certification
PowerFlex 700S Phase II	208/240V Frames 1-6	(1)	(4)
	400/480V Frames 1-6	(1)	(4)
	400/480V Frames 9-13	(2)	None
	600V Frames 1-4	(2)	None
	600/690V Frames 5 and 6	(1)	(4)
	600/690V Frames 9-13	(2)	None
PowerFlex 700L Liquid-Cooled	400/480V Frames 3A and 3B	(3)	(5)
	600/690V Frames 3A and 3B	(3)	(5)

(1) TUV Report No. 968/EZ 189.00/05
(2) TUV Report No. 968/EL 328.00/05
(3) TUV Report No. 968/EZ 230.00/06
(4) TUV Certificate No: 968EZ 189.00/05
(5) TUV Certificate No: 968/EZ 230.00/06

Installation and Wiring

Installation must be in accordance with the following steps and must be carried out by competent personnel. The DriveGuard Safe-Off option is intended to be part of the safety related control system of a machine. Before installation, a risk assessment should be performed that compares the DriveGuard Safe-Off option specifications and all foreseeable operational and environmental characteristics of the machine to which it is to be fitted.

A safety analysis of the machine section controlled by the drive is required to determine how often the safety function should be tested for proper operation during the life of the machine.

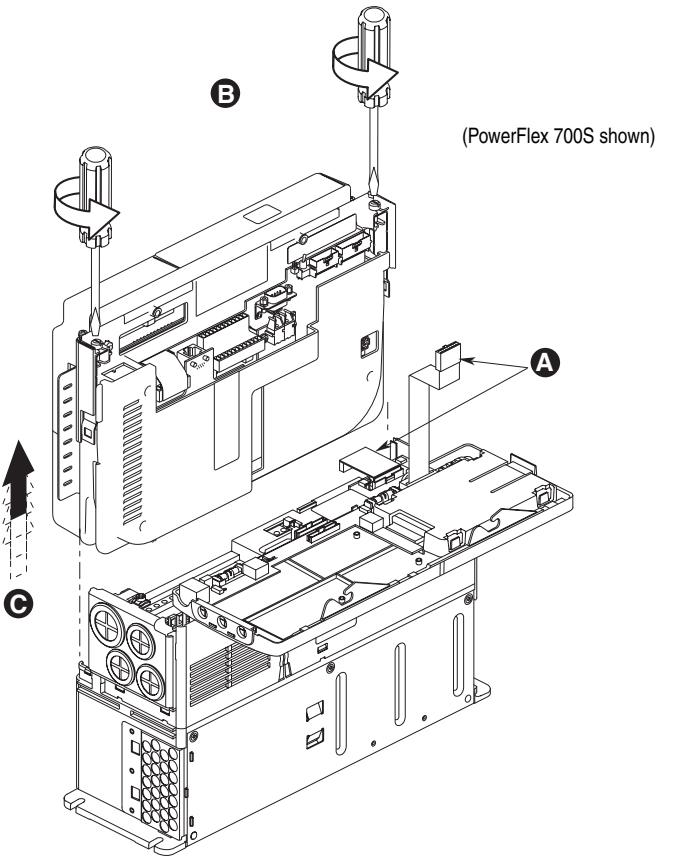
ATTENTION: The following information is merely a guide for proper installation. Rockwell Automation, Inc. cannot assume responsibility for the compliance or the noncompliance to any code, national, local or otherwise for the proper installation of this equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

Option Board Installation

PowerFlex 700S Frames 1 - 6 and PowerFlex 700L Frames 3A and 3B

1. Remove the I/O Control Cassette from the drive.

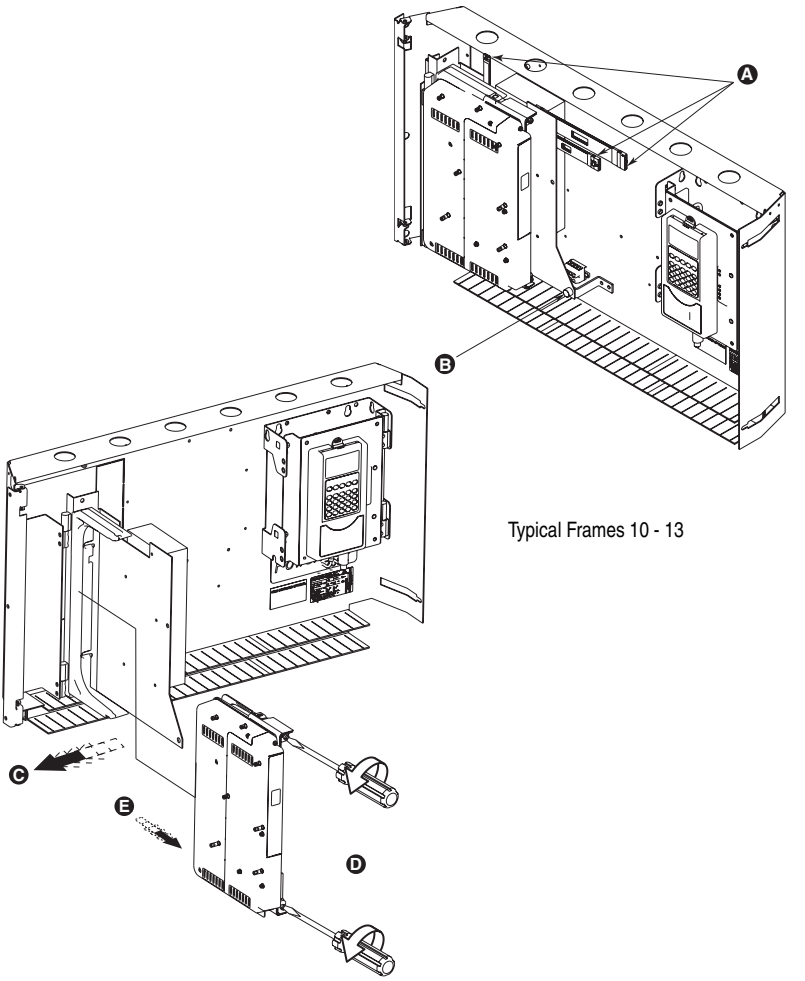
Task	Description
A	Open the door of the power structure and disconnect the cables that connect to the main board.
B	Loosen the screws on the face of the cassette.
C	Remove the cassette.



PowerFlex 700S Frames 9 - 13

1. Remove the I/O Control Cassette from the drive.

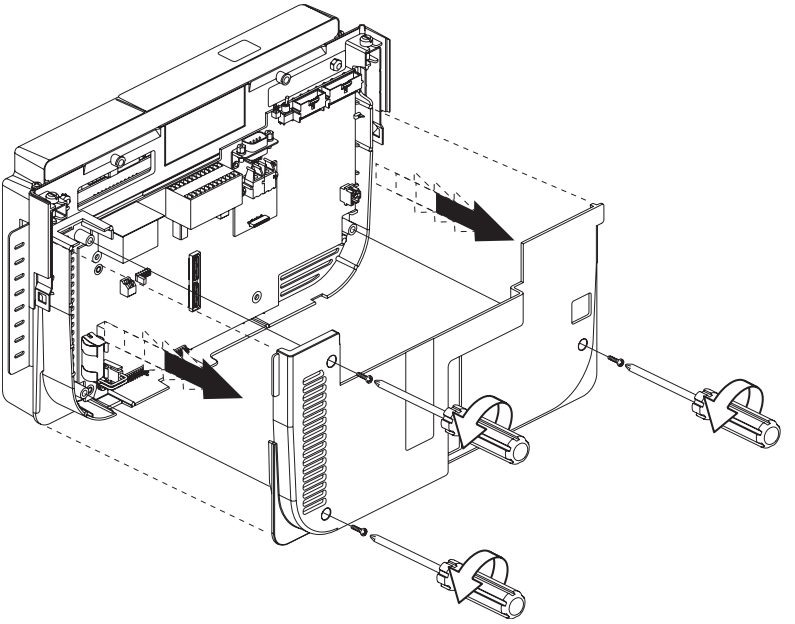
Task	Description
A	Open the door of the power structure and carefully disconnect the three (3) cables that connect to the main board.
B	Loosen the thumb screw that holds the metal flange in place.
C	Swing the flange and cassette away from the control frame.
D	Loosen the screws on the face of the cassette.
E	Remove the cassette.



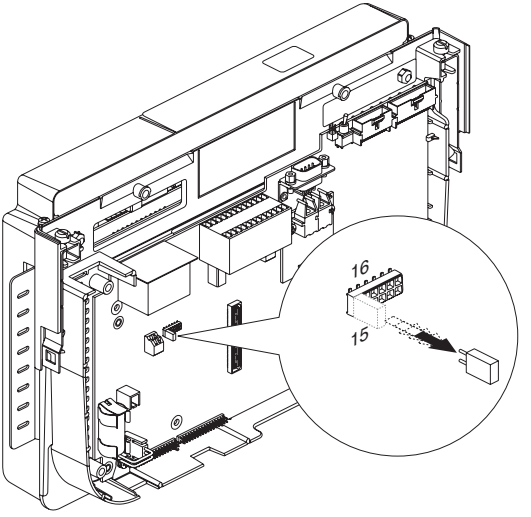
Typical Frames 10 - 13

PowerFlex 700S and PowerFlex 700L – All Frames

2. Remove the screws securing the interior cassette cover to gain access to the Main board.

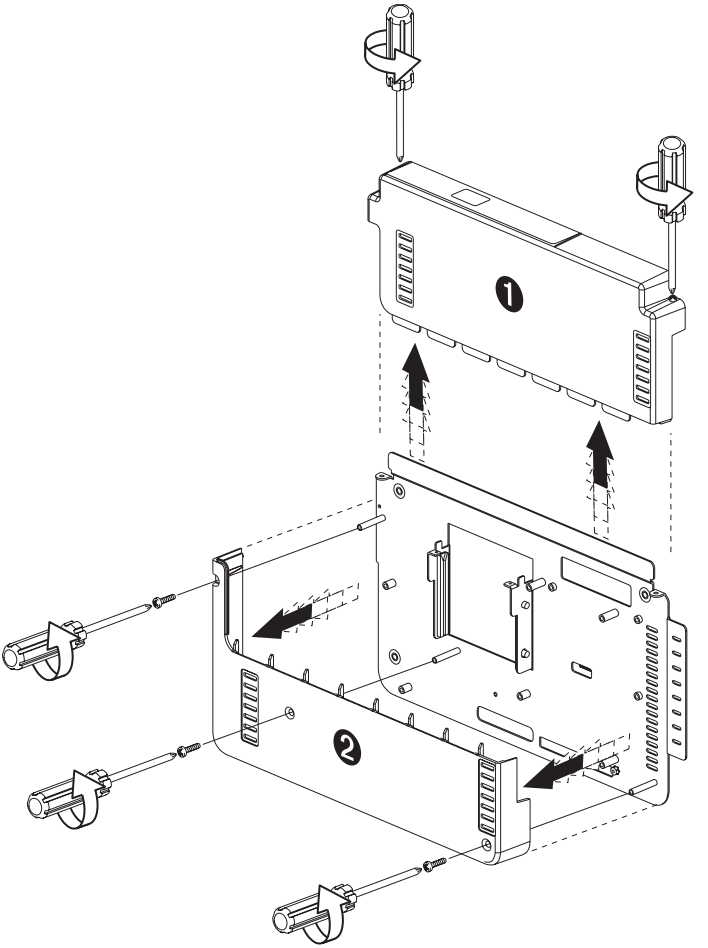


3. Remove the 2-pin shunt jumper from the 16-15 pin position.

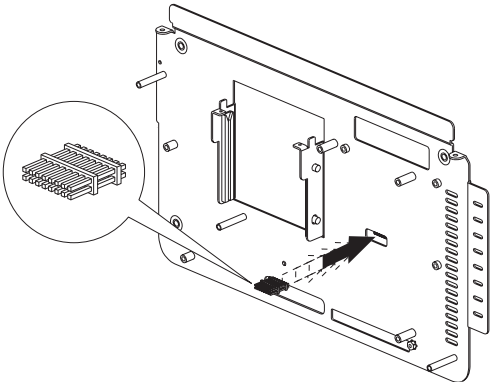


Important: If the DriveGuard Safe-Off option is removed from the drive, this jumper must be reinstalled or the drive will not run.

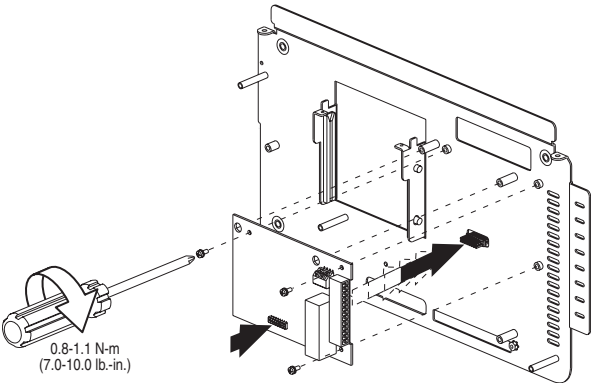
4. Remove the exterior cassette covers to access the grounding plate.



5. Install the 16-pin stacker connector.

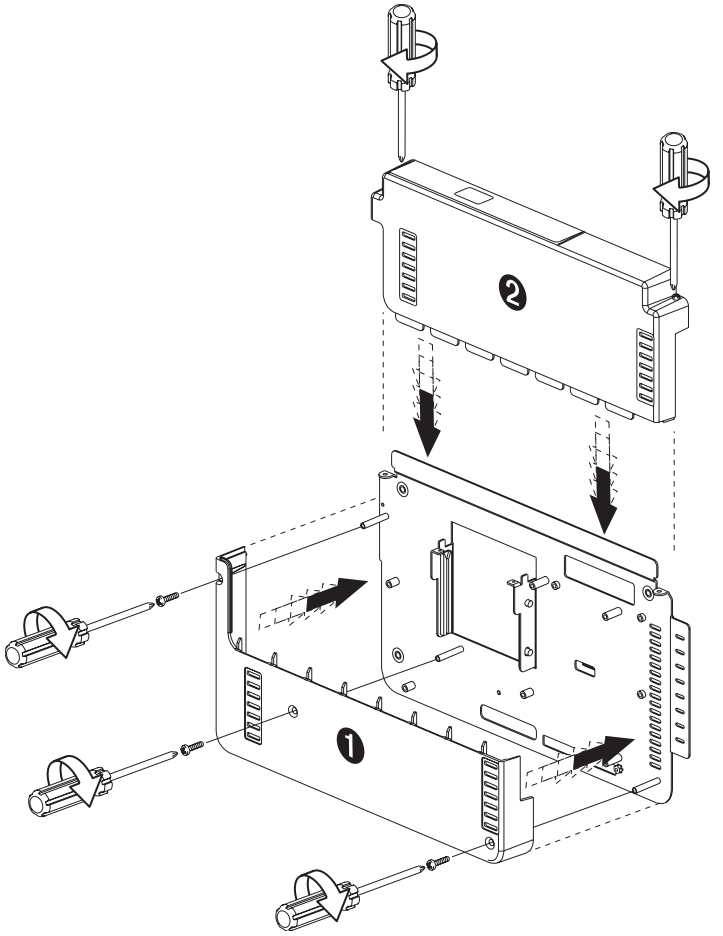


6. Plug the DriveGuard Safe-Off option into the 16-pin connector.

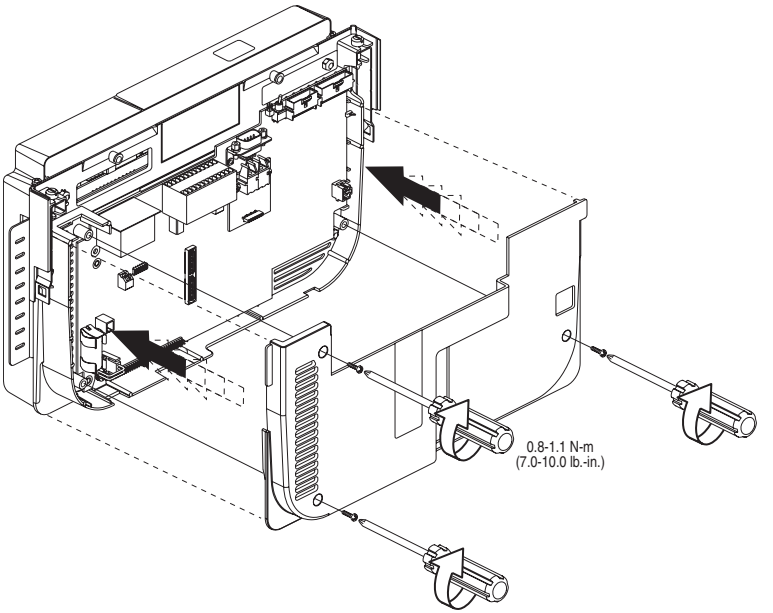


7. Install and tighten mounting screws.

8. Install the exterior cassette covers.



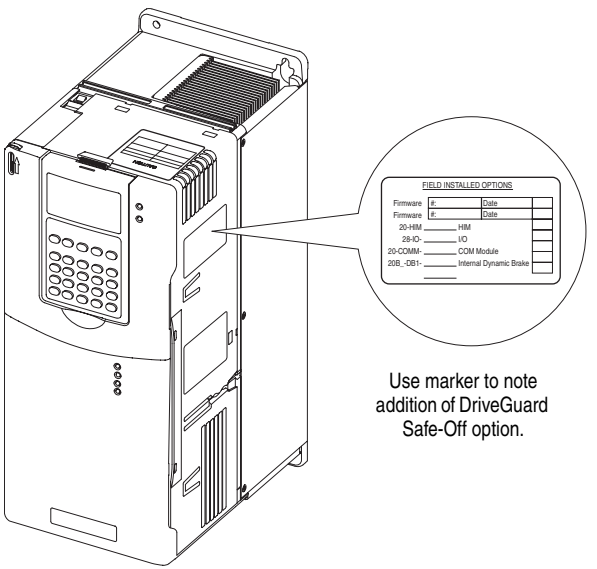
9. Install the inside front cover.



10. Reinstall the cassette in the drive.

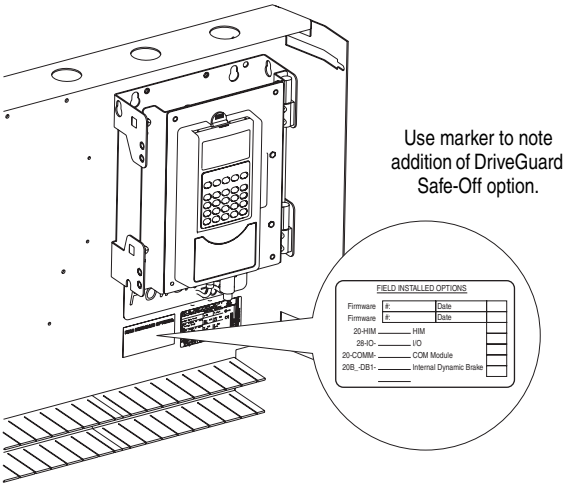
11. Record the modification on the Field Installed Option label.

PowerFlex 700S Frames 1 - 6



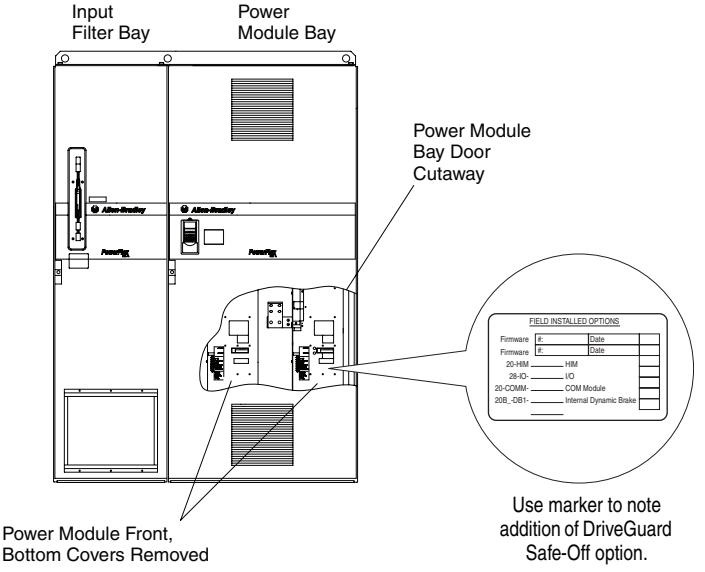
Use marker to note addition of DriveGuard Safe-Off option.

PowerFlex 700S Frames 9 - 13



Frame 10 shown

PowerFlex 700L Frames 3A and 3B



Wiring

Important points to remember about wiring:

- Always use tinned copper wire.
- Wire with an insulation rating of 600V or greater is recommended.
- Control wires should be separated from power wires by at least 0.3 meters (1 foot).

Table 1 DriveGuard Safe-Off Option Terminal Block Specifications

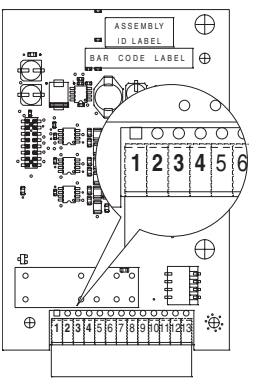
Wire Size Range[1]		Torque	
Maximum	Minimum	Maximum	Recommended
1.5 mm^2 (16 AWG)	0.14 mm^2 (26 AWG)	0.25 N-m (2.2 lb.-in.)	0.22 N-m (1.9 lb.-in.)

(1) Maximum / minimum that the terminal block will accept - these are not recommendations.

Table 2 Wire Types

	Wire Type(s)	Description	Minimum Insulation Rating
Unshielded	Per US NEC or applicable national or local code	—	300V, 60 degrees C (140 degrees F)
Shielded	Multi-conductor shielded cable such as Belden 8770 (or equiv.)	0.750 mm^2 (18 AWG), 3 conductor, shielded.	

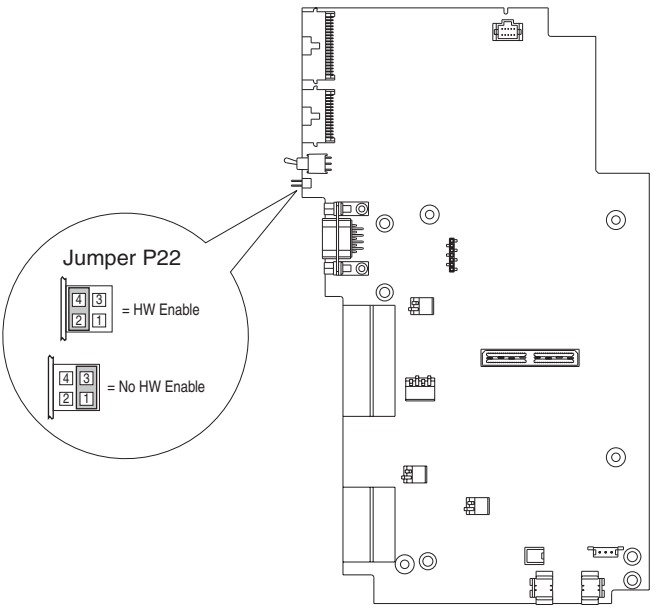
Table 3 DriveGuard Safe-Off Option Terminals Description



No.	Signal	Description
1	+24V DC	Connections for user-supplied power to energize coil. 33.3 mA typical, 55 mA maximum.
2	24V Common	
3	Monitor - N.C.	Normally closed contacts for monitoring relay status. Maximum Resistive Load: 250V AC / 30V DC / 50 VA / 60 Watts Maximum Inductive Load: 250V AC / 30V DC / 25 VA / 30 Watts
4	Common - N.C.	

Configure Hardware Enable

Ensure that Jumper P22 on the Main Control Board is set to HW Enable (Pins 2 and 4).



Important: In addition to the correct jumper setting, enable circuitry must be connected to I/O Terminals 13 and 16. Refer to the PowerFlex 700S Phase II Control *User Manual*, publication 20D-UM006…, for wiring examples.

Configure Digital Outputs

Digital Output 1 and 2 (TB2 Terminals 3, 4, and 5) and Relay Output 3 (TB2 Terminals 6, 7, and 8) can be configured to activate external logic in the event the safety enable diagnostic routine results in an F45 “Enable Health” fault.

1. Set Par 147 [FW Functions En], Bit 14 “Digital Outs” to 1 (True).
2. Set Par 845 [Dig Out1 Sel], Par 850 [Dig Out2 Sel] or Par 855 [Rly Out3 Sel] to option 0 “User Select”.
3. Link Par 846 [Dig Out1 Data], Par 851 [Dig Out2 Data] or Par 856 [Rly Out3 Data] to Par 324 [Fault Status 2]. See “Linking Parameters” below.
4. Set Par 847 [Dig Out1 Bit], Par 852 [Dig Out2 Bit] or Par 857 [Rly Out3 Bit] to 12. Par 324 Bit 12 = EnableHealth status.

Linking Parameters

Use the following procedure to establish a link between Par 846 [Dig Out1 Data], Par 851 [Dig Out2 Data] or Par 856 [Rly Out3 Data] and Par 324 [Fault Status 2].

1. Using the drive’s Human Interface Module (HIM), select Parameter from the Main Menu and press the Enter key.
2. Using the HIM keypad, enter 846, 850, or 856 and press the Enter key. The parameter value screen will appear.
3. Press ALT and then View (Sel). Next, press the Up or Down Arrow to change “Present Value” to “Defined Link.” Press the Enter key.
4. Press the Enter key to select the “Link” field. Using the HIM keypad, enter 324 as the Source Parameter Number and press the Enter key.

   The linked parameter can now be viewed two different ways by repeating the steps above and selecting “Preset Value” or “Define Link.” If an attempt is made to edit the value of a linked parameter, “Parameter is Linked!” will be displayed, indicating that the value is coming from a source parameter and cannot be edited.

5. To remove a link, repeat the steps above and change the source parameter to zero (0).

Verify Operation

Test the safety function for proper operation after initial installation of the DriveGuard Safe-Off option. Retest the safety function at the intervals determined by the safety analysis described on page 4.

Verify that both safety channels are functioning according to Table 4.

Table 4 Channel Operation and Verification

Safety Function Status	Drive In Safe State	Drive In Stopped State	Drive In Stopped State	Drive Able To Run
Safety Channel Operation				
Safe-Off Option Terminals 1 & 2	No Power Applied	Power Applied	No Power Applied	Power Applied
PowerFlex 700S/700L Enable Input	No Power Applied	No Power Applied	Power Applied	Power Applied
Description For Verification				
Safe-Off Option Monitor Contact Terminals 3 & 4	Closed	Open	Closed	Open
PowerFlex 700S/700L Drive Inhibits Param. 156, Bits 1 & 16	Bit 16 = 0 Bit 1 = 1	Bit 16 = 0 Bit 1 = 1	Bit 16 = 1 Bit 1 = 0	Bit 16 = 0 Bit 1 = 0

Description of Operation

The DriveGuard Safe-Off option (see Figure 1) disables the drive's output IGBT's by disconnecting the gate control power supply. When used in combination with a second safety channel (the Enable input), the system satisfies the requirements of EN 954-1, Category 3 for safe turn off of torque-producing energy at the output of the drive.

Important: The DriveGuard Safe-Off option does not eliminate dangerous voltages at the drive output. Input power to the drive must be turned off and safety procedures followed before performing any electrical work on the drive or motor.

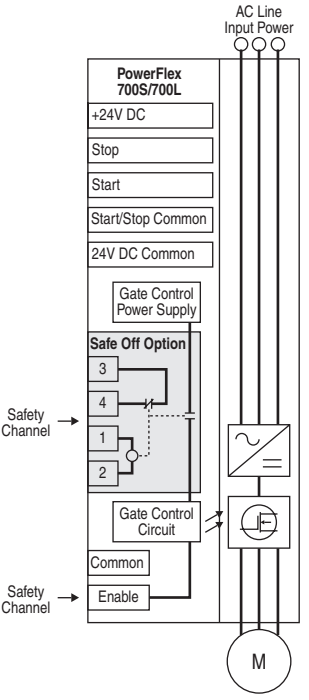
ATTENTION: In the event of the failure of two output IGBTs in the drive, when the DriveGuard Safe-Off option has controlled the drive outputs to the off state, the drive may provide energy for up to 180° of rotation in a 2-pole motor before torque production in the motor ceases.

Under normal drive operation, the Safe-Off relay is energized, the enable input is energized, and gate control power is available to the gate control circuit. If either of these inputs is de-energized, the gate control circuit is disabled and the STS (Status) indicator on the drive will change to a yellow flashing light. When the enable input is de-energized, parameter 156 [Start Inhibits], bit 1 "No Enable" is set to "1." When the Safe-Off relay is de-energized, parameter 156 [Start Inhibits] bit 16 "GateShutDown" is set to "1." If both inputs are de-energized, only bit 1 "No Enable" will be set to "1" because it takes precedence.

To meet EN 954-1, Category 3 operation, both safety channel inputs to the drive must be de-energized to safely turn off output to the motor. Refer to the following examples for details.

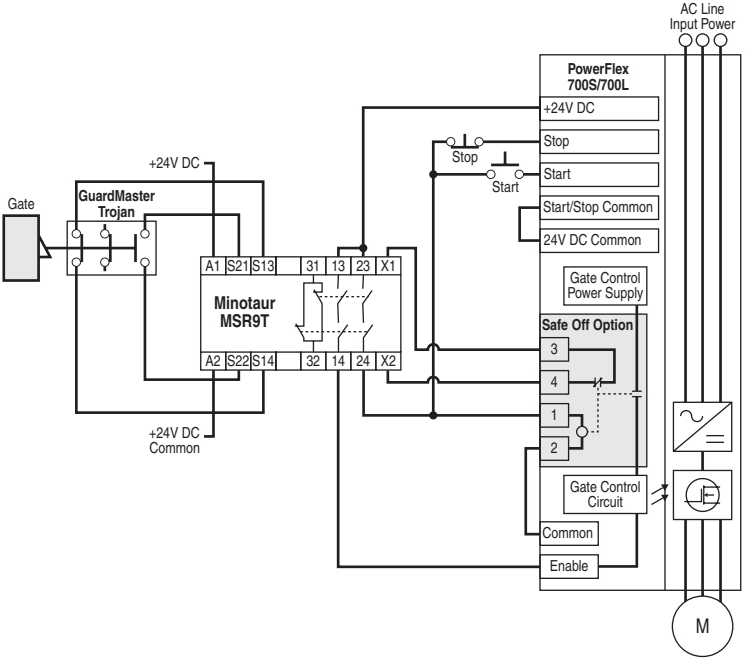
ATTENTION: By itself, the DriveGuard Safe-Off option initiates a coast-to-stop action. Additional protective measures will need to be applied when an application requires a different stopping action.

Figure 1 Drive Safe-Off Circuitry



Example 1 - PowerFlex 700S Drives, Frames 1-6 Safe-Off Connection with Coast-to-Stop Action, Dual Channel

Figure 2 Stop Category 0 – Coast



Circuit Status

Circuit shown with guard door closed and system ready for normal drive operation.

Operating Principle

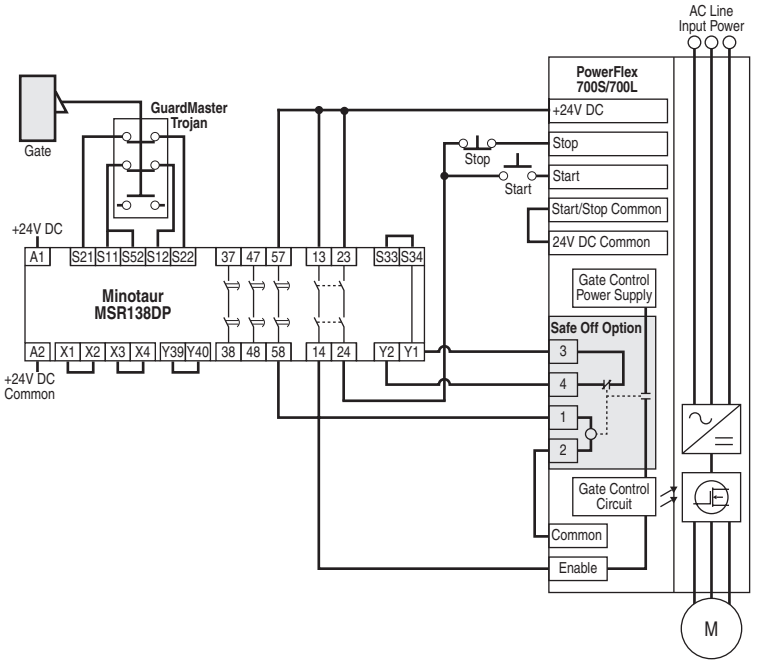
This is a dual channel system with monitoring of the safe-off circuit and drive. Opening the guard door will switch the input circuits (S13-S14 & S21-S22) to the Minotaur monitoring safety relay unit. The output circuits (13-14 & 23-24) will cause the Safe-Off option and drive Enable circuit to trip and the motor will coast to stop. To restart the drive, the Minotaur safety relay must first be reset followed by a valid start command to the drive.

Fault Detection

A single fault detected on the Minotaur safety input circuits will result in the lock-out of the system at the next operation and will not cause loss of the safety function.

Example 2 - PowerFlex 700S Drives, Frames 9-13 and PowerFlex 700L Drives, Frames 3A and 3B
Safe-Off Connection with Coast-to-Stop Action, Dual Channel

Figure 3 Stop Category 0 – Coast



Circuit Status

Circuit shown with guard door closed and system ready for normal drive operation.

Operating Principle

This is a dual channel system with monitoring of the safe-off circuit and drive. Opening the guard door will switch the input circuits (S11-S12 & S21-S22) to the Minotaur monitoring safety relay unit. The output circuits (13-14 & 23-24) cause the drive Enable circuit to trip and the motor will coast to stop. After the programmed delay, the timed output circuits (57-58) will cause the Safe-Off option circuit to trip. To restart the drive, the Minotaur safety relay must first be reset followed by a valid start command to the drive.

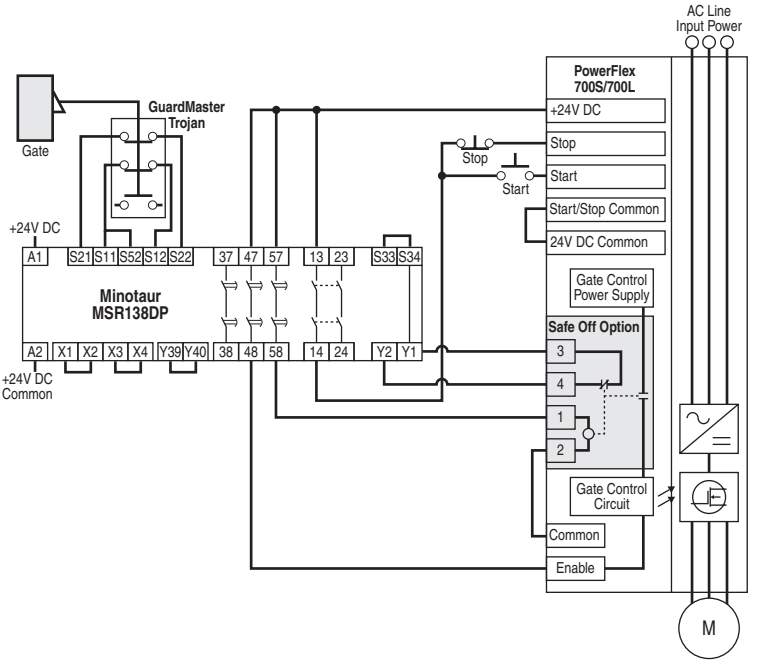
Application Considerations

When the hazard analysis for the overall machine determines the need for external mechanical brakes or other stopping means, the external means shall be activated after the removal of power for Stop Category 0.

If the Safe-Off option sticks ON, the motor will stop on command due to the enable input. The system cannot be reset when this fault condition exists.

Example 3 - All Drives
Safe-Off Connection with Controlled Stop Action, Dual Channel

Figure 4 Stop Category 1 – Controlled



Circuit Status

Circuit shown with guard door closed and system ready for normal operation.

Operating Principle

This is a dual channel system with monitoring of the safe-off circuit and drive. Opening the guard door will switch the input circuits (S11-S12 & S21-S22) to the Minotaur monitoring safety relay unit. The output circuits (13-14) will issue a Stop command to the drive and cause a

controlled deceleration. After the programmed delay, the timed output circuits (47-48 & 57-58) will cause the Safe-Off option and the drive Enable circuit to trip. If the motor is rotating when the trip occurs, it will coast to stop. To restart the drive, the Minotaur safety relay must first be reset followed by a valid start command to the drive.

Fault Detection

A single fault detected on the Minotaur safety input circuits will result in the lock-out of the system at the next operation and will not cause loss of the safety function.

If the Safe-Off option sticks ON, the motor will stop on command due to the enable input. The system cannot be reset when this fault condition exists.

Supplemental Information

PowerFlex 700S Certification

TÜV Rheinland Group

TÜV Industrie Service GmbH
Automation, Software und Informationstechnologie

ZERTIFIKAT
CERTIFICATE

Nr./No. 968/EZ 189.00/05

Prüfgegenstand/ Product tested	Adjustable Frequency AC Drive	**Zertifikatsinhaber/ License holder Hersteller/ Manufacture**	Rockwell Automation 6400 West Enterprise Drive USA-Mequon, WI 53092 United States of America
Typbezeichnung/ Type designation Allen Bradley PowerFlex 700S AC Drive Frame 1/2/3/4/5/6 240 V, 400 V, 480 V and corresponding DC input voltage ratings Frame 5/6 600 V, 690 V and corresponding DC input voltage ratings		**Verwendungszweck/ Intended application** category	Safety relevant applications; Safety Function "Safe stand-still" according to EN 954-1 3
Prüfgrundlagen/ Codes and standards forming the basis of testing	EN 954-1:1996 EN ISO 13849-2:2003 EN 60204-1:1997 EN 50178:1997 EN 61800-3:1996 & A11:2000		
Prüfungsergebnis/ Test results	The safety function "Safe standstill" meets the requirements for category 3 according EN 954-1.		
Besondere Bedingungen/ Specific requirements	Fault exclusion for the external wiring has to be made according to EN ISO 13849-2. The user manual "Safe Off Option for PowerFlex 700S AC Drive" has to be considered.		

Der Prüfbericht-Nr. 968/EZ 189.00/05 vom 2005-02-25 ist Bestandteil dieses Zertifikates.
Der Inhaber eines für den Prüfgegenstand gültigen Genehmigungs-Ausweises ist berechtigt, die mit dem Prüfgegenstand übereinstimmenden Erzeugnisse mit dem abgebildeten Prüfzeichen zu versehen.

The test report-no. 968/EZ 189.00/05 dated 2005-02-25 is an integral part of this certificate.
The holder of a valid licence certificate for the product tested is authorized to affix the test mark shown opposite to products, which are identical with the product tested.

TÜV Industrie Service GmbH
Geschäftsfeld ASI
Automation, Software und Informationstechnologie
Am Grauen Stein, 51105 Köln
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2005-02-25

Datum/Date | Firmenstempel/Company seal | Unterschrift/Signature

PowerFlex 700L Certification

TÜV Rheinland Group

TÜV Rheinland Industrie Service GmbH
Automation, Software und Informationstechnologie

ZERTIFIKAT
CERTIFICATE

Nr./No. 968/EZ 230.00/06

Prüfgegenstand/ Product tested	Safety function "Safe standstill" within the Adjustable Frequency AC Drive	**Zertifikatsinhaber/ License holder Hersteller / Manufacture**	Rockwell Automation 6400 West Enterprise Drive USA-Mequon, WI 53092 United States of America
Typbezeichnung/ Type designation Allen-Bradley PowerFlex 700L AC Drive Frames 3A and 3B - 400 V, 480 V, 600 V, 690 V		**Verwendungszweck/ Intended application**	Safety relevant applications; Safety Function "Safe standstill" according to EN 954-1 category 3
Prüfgrundlagen/ Codes and standards forming the basis of testing	EN 954-1:1996 EN ISO 13849-2:2003 EN 60204-1:1997 EN 50178:1997 EN 61800-3:2004		
Prüfungsergebnis/ Test results	The safety function "Safe standstill" fulfils the requirements for category 3 according EN 954-1.		
Besondere Bedingungen/ Specific requirements	The possibility of the small movement of the motor resulting from simultaneous IGBT failures must be taken into account during the hazard analysis of the system. The external wiring has to meet the requirements for fault exclusions according to Annex D.5.2 (Table D.4) of EN ISO 13849-2. The user manual "Safe Off Option for PowerFlex 700L AC Drive" has to be considered.		

Functional Safety FS Type Approved

Der Prüfbericht-Nr. 968/EZ 230.00/06 vom 2006-06-27 ist Bestandteil dieses Zertifikates.
Der Inhaber eines für den Prüfgegenstand gültigen Genehmigungs-Ausweises ist berechtigt, die mit dem Prüfgegenstand übereinstimmenden Erzeugnisse mit dem abgebildeten Prüfzeichen zu versehen.

The test report-no. 968/EZ 230.00/06 dated 2006-06-27 is an integral part of this certificate.
The holder of a valid licence certificate for the product tested is authorized to affix the test mark shown opposite to products, which are identical with the product tested.

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2006-06-27
Date

Company seal

Signature

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