



# Safe Torque Off Option (Series B) for PowerFlex 40P and PowerFlex 70 Enhanced Control AC Drives

Catalog Number 20A-DG01

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Original Instructions

## General Description

The DriveGuard Safe Torque Off option, when used with PowerFlex 40P or PowerFlex 70 drives together with other safety components, provides a safety function which inhibits torque generation in the motor(s) powered by the drive. When used with PowerFlex 40P or PowerFlex 70 drive, the DriveGuard Safe Torque Off option has been certified to meet the requirements for SIL 2 according to EN/IEC 61800-5-2 and IEC 61508, and PL d and Category 3 according to EN ISO 13849-1. The DriveGuard Safe Torque 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 safeguarding.

### What Is the DriveGuard Safe Torque Off Option?

The DriveGuard Safe Torque Off option:

- Provides the “Safe torque off (STO)” function defined in EN/IEC 61800-5-2.
- Blocks gate firing signals from reaching the IGBT output power devices of the drive. This prevents the IGBT’s from switching in the sequence necessary to generate torque in the connected motor.
- Can be used in combination with other safety devices to fulfill the requirements of a system “safe torque off” function which satisfies Category 3 / PL (d) according to EN ISO 13849-1 and SIL CL 2 according to EN/IEC 62061, IEC 61508, and EN/IEC 61800-5-2.

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**IMPORTANT**

This option is suitable for performing only mechanical work on the drive system or affected area of a machine. It does NOT disconnect or isolate the drive power output to the motor.

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

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**ATTENTION:** Electrical Shock Hazard. Verify that all sources of AC and DC power are de-energized 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 Torque 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 IGBT's in the drive, when the DriveGuard Safe Torque 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.

## Certifications and Compliance

### TUV Rheinland EC Type Examination Certification

TUV Rheinland has certified the DriveGuard Safe Torque Off option, when used in a PF70 or PF40P drive, is compliant with the requirements for machines defined in Annex I of the EC Directive 2006/42/EC, and that it complies with the requirements of the relevant standards listed below.

- EN ISO 13849-1:2008 Safety of machinery - Safety related parts of control systems - Part 1: General principles for design  
(**DriveGuard Safe Torque Off option + drive achieves Category 3 / PL (d)**)
- EN/IEC 61800-5-2:2007 Adjustable speed electrical power drive systems - Part 5-2 Safety requirements - Functional  
(**DriveGuard Safe Torque Off option + drive achieves SIL CL 2**)
- EN/IEC 62061:2005 Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
- IEC 61508 Part 1-7:1998 and 2000 Functional safety of electrical/electronic/programmable electronic safety-related systems - Parts 1-7

TUV also certifies that the DriveGuard Safe Torque Off option may be used in applications up to Category 3 / PL (d) according to EN ISO 13849-1 and SIL 2 according to EN/IEC 62061 / IEC 61508 / EN/IEC 61800-5-2.

TUV Rheinland certificate 01/205/0665/09 may be found at:

[www.rockwellautomation.com/products/certification/](http://www.rockwellautomation.com/products/certification/)

## **CE Certification**

### **LV Directive 2006/95/EC**

Rockwell Automation declares the PF40P and PF70 drives compliant with the CE LV Directive as demonstrated by compliance with the requirements of EN 50178 Electronic equipment for use in power installations. The DriveGuard Safe Torque Off Option Kit is not within the scope of the Low Voltage Directive.

### **EMC Directive 2004/108/EC**

Rockwell Automation declares the PF40P (240V, 480V), PF70 (240V, 400V, 480V), and DriveGuard Safe Torque Off option compliant with the CE EMC Directive as demonstrated by compliance with the requirements of EN 61800-3 Adjustable speed electrical power drive systems Part 3: EMC requirements and specific test methods.

### **Machinery Directive 2006/42/EC**

TUV Rheinland, Notified Body Identification Number 0035, certifies the DriveGuard Safe Torque Off option compliant with the CE Machinery Directive as demonstrated by compliance with the requirements of EN ISO 13849-1, EN ISO 13849-2, EN/IEC 61800-5-2, and EN/IEC 62061.

### **UL Certification**

The PF40P, PF70, and DriveGuard Safe Torque Off option have been listed with UL as compliant with UL 508C.

### **Canadian Certification**

The PF40P, PF70, and DriveGuard Safe Torque Off option have been listed (CuL) as compliant with C22.2 No 14.

### **Australian C-tick Certification**

Rockwell Automation declares the PF40P (240V, 480V), PF70 (240V, 400V, 480V), and DriveGuard Safe Torque Off option compliant with the Australian Radiocommunications Act of 1992, the Radiocommunications (Electromagnetic Compatibility) Standard of 2008, and the Radiocommunications Labelling (Electromagnetic Compatibility) Notice of 2008 as demonstrated by compliance with IEC 61800-3 Adjustable speed electrical power drive systems Part 3: EMC requirements and specific test methods.

## Certified Equipment

Drive	Rating	TUV Certified	DriveGuard Safe Torque Off Function
PowerFlex 40P	240V	✓	Series B or greater
	480V	✓	Series B or greater
PowerFlex 70 Enhanced Control	240V	✓	Series A or greater
	400V	✓	Series A or greater
	480V	✓	Series A or greater



**ATTENTION:** Hazard of injury exists due to electric shock. Only install a Series B or greater DriveGuard Safe Torque Off option in a PowerFlex 40P Drive.

## Certifications Online

See the Product Certifications link at <http://ab.com> for Declarations of Conformity, Certificates, and other certifications details.

## Important Safety Considerations

The system user is responsible for:

- the set-up, safety rating, and validation of any sensors or actuators connected to the system.
- completing a system-level risk assessment and reassessing the system any time a change is made.
- certification of the system to the desired safety performance level.
- project management and proof testing.
- programming the application software and the safety option configurations in accordance with the information in this manual.
- access control to the system, including password handling.
- analyzing all configuration settings and choosing the proper setting to achieve the required safety rating.

### IMPORTANT

When applying Functional Safety, restrict access to qualified, authorized personnel who are trained and experienced.



**ATTENTION:** When designing your system, consider how personnel will exit the machine if the door locks while they are in the machine. Additional safeguarding devices may be required for your specific application.

## Safe State

The DriveGuard Safe Torque Off option is intended for use in safety-related applications where the de-energized state is the safe state. All of the examples in the Description of Operation section are based on achieving the de-energization as the safe state.

## Safety Category 3 / PL (d) Performance Definition

To achieve Safety Category 3 / PL (d) according to EN ISO 13849-1, the safety-related parts have to be designed such that:

- the safety-related parts of machine control systems and/or their protective equipment, as well as their components, shall be designed, constructed, selected, assembled, and combined in accordance with relevant standards so that they can withstand expected conditions.
- well tried safety principles shall be applied.
- a single fault in any of its parts does not lead to a loss of safety function.
- some but not all faults will be detected.
- the accumulation of undetected faults can lead to loss of safety function.
- short circuits in the external wiring of the safety inputs is not one of the faults that can be detected by the system, therefore, according to EN ISO 13849-2, these cables must be installed so as to be protected against external damage by cable ducting or armor.
- whenever reasonably practical a single fault shall be detected at or before the next demand of the safety function.
- the average diagnostic coverage of the safety-related parts of the control system shall be low.
- the mean time to dangerous failure of each of the redundant channels shall be low to high.

## Stop Category Definitions

The selection of a stop category for each stop function must be determined by a risk assessment.

- Stop Category 0 is achieved with immediate removal of power to the actuator, resulting in an uncontrolled coast to stop. See “Description of Operation” Example 1 on [page 20](#).
- Stop Category 1 is achieved with power available to the machine actuators to achieve the stop. Power is removed from the actuators when the stop is achieved. See “Description of Operation” Example 2 on [page 21](#).

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**IMPORTANT**

When designing the machine application, timing and distance should be considered for a coast to stop (Stop Category 0 or Safe Torque Off). For more information regarding stop categories, refer to EN/IEC 60204-1.

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## Performance Level and Safety Integrity Level (SIL) CL2

For safety-related control systems, Performance Level (PL), according to EN ISO 13849-1, and SIL levels, according to IEC 61508 and EN/IEC 62061, include a rating of the system’s ability to perform its safety functions. All of the safety-related components of the control system must be included in both a risk assessment and the determination of the achieved levels.

Refer to the EN ISO 13849-1, IEC 61508, and EN/IEC 62061 standards for complete information on requirements for PL and SIL determination.

## PFD and PFH Definitions

Safety-related systems can be classified as operating in either a Low Demand mode, or in a High Demand/Continuous mode.

- Low Demand mode: where the frequency of demands for operation made on a safety-related system is no greater than one per year or no greater than twice the proof-test frequency.
- High Demand/Continuous mode: where the frequency of demands for operation made on a safety-related system is greater than once per year or greater than twice the proof test interval.

The SIL value for a low demand safety-related system is directly related to order-of-magnitude ranges of its average probability of failure to satisfactorily perform its safety function on demand or, simply, average probability of failure on demand (PFD). The SIL value for a High Demand/Continuous mode safety-related system is directly related to the probability of a dangerous failure occurring per hour (PFH).

## PFD and PFH Data

These PFD and PFH calculations are based on the equations from Part 6 of IEC 61508 and show worst-case values.

This table provides data for a 20-year proof test interval and demonstrates the worst-case effect of various configuration changes on the data.

### PowerFlex 40P PFD and PFH for 20-year Proof Test Interval

Attribute	Test Result
PFD	1.74E-05
PFH	2.0E-10
SFF	81%

### PowerFlex 70 PFD and PFH for 20-year Proof Test Interval

Attribute	Test Result
PFD	3.4E-05
PFH	3.9E-10
SFF	81%

## Terminology

Abbreviation	Full Term	Definition
PFD	Probability of Failure on Demand	The average probability of a system to fail to perform its design function on demand.
PFH	Probability of Failure per Hour	The probability of a system to have a dangerous failure occur per hour.
SFF	Safe Failure Fraction	The sum of safe failures plus the sum of dangerous detected failures divided by the sum of all failures.



## Functional Proof Tests

The functional safety standards require that functional proof tests be performed on the equipment used in the system. Proof tests are performed at user-defined intervals and are dependent upon PFD and PFH values.

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**IMPORTANT** Your specific application determines the time frame for the proof test interval.

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## Contact Information if Safety Option Failure Occurs

If you experience a failure with any safety-certified device, contact your local Rockwell Automation distributor. With this contact, you can:

- return the device to Rockwell Automation so the failure is appropriately logged for the catalog number affected and a record is made of the failure.
- request a failure analysis (if necessary) to determine the probable cause of the failure.

# Installation and Wiring

## Pre-Installation Instructions

Installation must be in accordance with the following steps and must be carried out by competent personnel. The DriveGuard Safe Torque 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 Torque Off option specifications and all foreseeable operational and environmental characteristics of the machine to which it is to be fitted.

In no case should be DriveGuard Safe Torque Off option be used in a PowerFlex 40P or PowerFlex 70 drive where the maximum surrounding air temperature, shock, or vibration specifications of the drive are exceeded.

PowerFlex 70	Maximum Surrounding Air Temperature without derating: IP20, NEMA/UL Type 1: Flange Mount: IP66, NEMA/UL Type 4X/12:	0...50 °C (32...122 °F) 0...50 °C (32...122 °F) 0...40 °C (32...104 °F)
PowerFlex 40P	Maximum Surrounding Air Temperature without derating: IP20, Open Type: IP30, NEMA 1, UL Type 1: Flange and Plate Mount:	-10...50 °C (14...122 °F) -10...40 °C (14...104 °F) Heatsink: -10...40 °C (14...104 °F) Drive: -10...50 °C (14...122 °F)
Both Drives	Shock:	15 g peak for 11 ms duration (±1.0 ms)
	Vibration:	0.152 mm (0.006 in.) displacement, 1 g peak

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.

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## EMC Considerations

The DriveGuard Safe Torque Off option and PF40P and PF70 drives may be installed in an industrial electromagnetic environment which is consistent with the “Second Environment” described in IEC 61800-3 and where the EMC requirements documented in the PF40P and PF70 Installation manuals have been satisfied. Important installation requirements include:

- All motor output, control (I/O) and signal wiring for the drive and DriveGuard Safe Torque Off option must be shielded cable
- Grounding (earthing) must conform to the requirements described in the drive user manuals

## DriveGuard Safe Torque Off Option Installation

### PowerFlex 40P Drives

1. Remove all power to the drive.

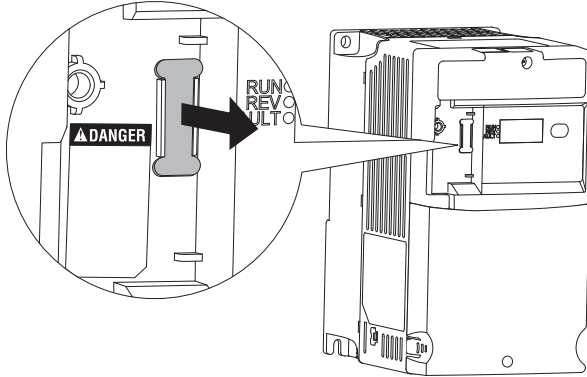


**ATTENTION:** To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Measure the DC bus voltage at the +DC and -DC terminals or test points (refer to your drive's User Manual for locations). The voltage must be zero.

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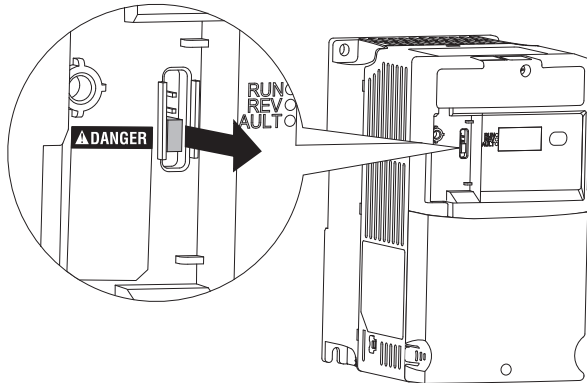
2. Remove the protective plug covering the PowerFlex 40P Safe Torque Off connector shown in Figure 1.

**Figure 1 - PowerFlex 40P Protective Plug**



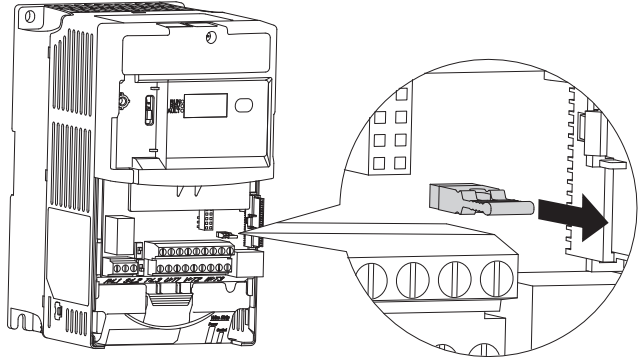
3. Remove the PowerFlex 40P Safe Torque Off connection jumper shown in Figure 2.

**Figure 2 - PowerFlex 40P Safe Torque Off Connection Jumper Location**



- Remove the PowerFlex 40P Hardware Enable jumper shown in Figure 3.

**Figure 3 - PowerFlex 40P Hardware Enable Jumper Location**

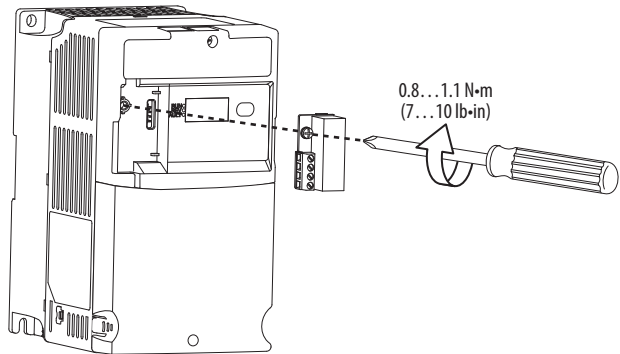


**IMPORTANT**

The PowerFlex 40P hardware enable jumper must be removed when using the DriveGuard Safe Torque Off option. Failure to remove the jumper will cause the drive to fault when a start command is issued.

- Plug the DriveGuard Safe Torque Off option (Series B or greater) into the PowerFlex 40P four pin Safe Torque Off connector as shown in Figure 4.

**Figure 4 - PowerFlex 40P Safe Torque Off Connector**

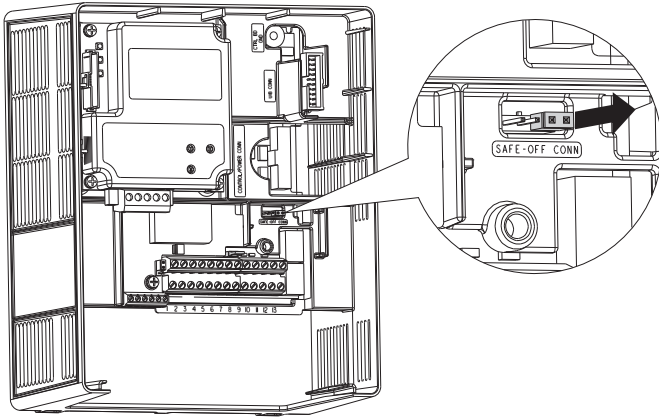


- Tighten screw to 0.8...1.1 N•m (7...10 lb•in).

## PowerFlex 70 Enhanced Control Drives

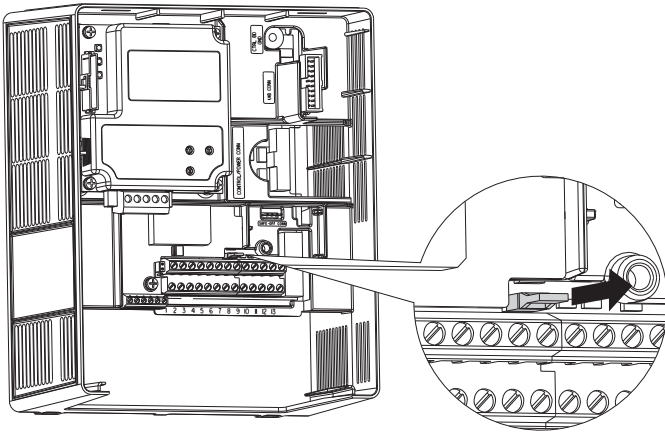
- Remove the PowerFlex 70 Safe Torque Off Connection jumper as shown in Figure 5.

**Figure 5 - PowerFlex 70 Safe Torque Off Connection Jumper Location (Typical)**



2. Remove the PowerFlex 70 Hardware Enable jumper as shown in Figure 6.

**Figure 6 - PowerFlex 70 Hardware Enable Jumper Location (Typical)**

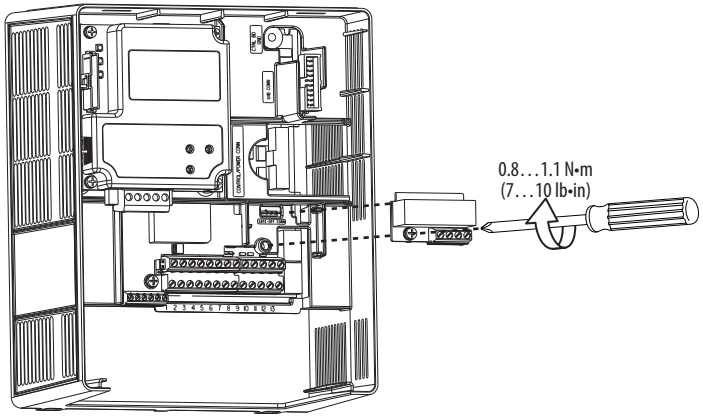


**IMPORTANT**

The PowerFlex 70 hardware enable jumper must be removed when using the DriveGuard Safe Torque Off option. Failure to remove the jumper will cause the drive to fault when a start command is issued.

3. Plug the DriveGuard Safe Torque Off option (Series A or greater) into the PowerFlex 70 four pin connector as shown in Figure 7.

**Figure 7 - PowerFlex 70 Safe Torque Off Connector**



4. Tighten screw to 0.8...1.1 N•m (7...10 lb•in).

## Wiring

Important points to remember about wiring:

- Always use 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).

### DriveGuard Safe Torque Off Option Terminal Block Specifications

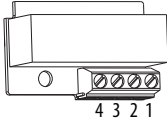
Wire Size Range <sup>(1)</sup>		Torque	
Maximum	Minimum	Maximum	Recommended
1.5 mm <sup>2</sup> (16 AWG)	0.14 mm <sup>2</sup> (26 AWG)	0.25 N•m (2.2 lb•in)	0.22 N•m (1.9 lb•in)

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

### 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 <sup>2</sup> (18 AWG), 3 conductor, shielded.	

**DriveGuard Safe Torque Off Option Terminal Description**



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

**Verify Operation**

Test the safety function for proper operation after the initial installation of the DriveGuard Safe Torque Off option. Retest the safety function at the intervals determined by the safety analysis described on [page 10](#).

Verify that both safety channels are functioning according to the Table 4 or Table 5.



### PowerFlex 40P Channel Operation and Verification

Safety Function Status	Drive In Safe State	Drive In Stopped State	Drive In Stopped State	Drive Able To Run
<b>Safety Channel Operation</b>				
<b>Safe Torque Off Option</b> Terminals 3 & 4	No Power Applied	Power Applied	No Power Applied	Power Applied
<b>PowerFlex 40P</b> Enable Input	No Power Applied	No Power Applied	Power Applied	Power Applied
<b>Description For Verification</b>				
<b>Safe Torque Off Option</b> Monitor Contact Terminals 1 & 2	Closed	Open	Closed	Open
<b>PowerFlex 40P</b> [Control In Status] Param. 13, Bit 2	Value = 0	Value = 0	Value = 1	Value = 1
<b>PowerFlex 40P</b> Comms Status Word 8448, Bit 0	Value = 0	Value = 0	Value = 0	Value = 1
<b>Safe Torque Off</b> <b>Output<sup>(1)</sup></b> Relay N.O. Dig Output States	Closed	Open	Open	Open

(1) Must set A055 [Relay Out Sel], A058 or A061 [Opto Outx Sel] to option 25 "Safe-Off".

### PowerFlex 70 Channel Operation and Verification

Safety Function Status	Drive In Safe State	Drive In Stopped State	Drive In <sup>(1)</sup> Stopped State	Drive Able To Run
<b>Safety Channel Operation</b>				
<b>Safe Torque Off Option</b> Terminals 3 & 4	No Power Applied	Power Applied	No Power Applied	Power Applied
<b>PowerFlex 70</b> Enable Input	No Power Applied	No Power Applied	Power Applied	Power Applied
<b>Description For Verification</b>				
<b>Safe Torque Off Option</b> Monitor Contact Terminals 1 & 2	Closed	Open	Closed	Open
<b>PowerFlex 70</b> Drive Inhibits Param. 214, Bit 2	Value = 1	Value = 1	Value = 0	Value = 0

(1) A Start/Run command will cause an F111 "Enable Hardware" fault.

# Description of Operation

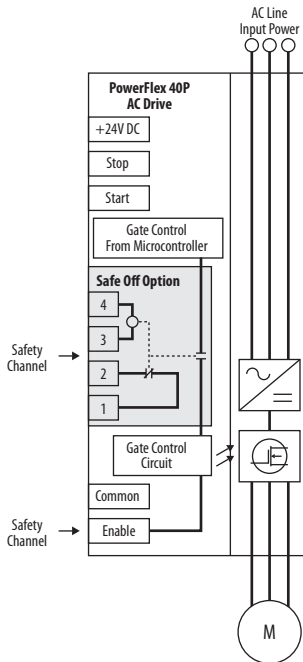
## PowerFlex 40P Safe Torque Off Operation

The DriveGuard Safe Torque Off option for PowerFlex 40P (see [Figure 8](#)) disables the drive's output IGBT's by breaking the link with the drive microcontroller. When used in combination with a second safety channel (the Enable input), the system satisfies the requirements of EN ISO 13849-1, Category 3 / PL (d) for Safe Torque Off and helps protect against restart.

Under normal drive operation, the Safe Torque Off relay is energized, the enable input is energized, and the drive is able to run. If either inputs is de-energized, the gate control circuit is disabled. To meet EN ISO 13849-1, Category 3 / PL (d) operation, both safety channels must be de-energized. Refer to the following examples for details.

**IMPORTANT** By itself, the Safe Torque Off option initiates a coast-to-stop action. Additional protective measures will need to be applied when an application requires a change to the stop action.

**Figure 8 - PowerFlex 40P Drive Safe Torque Off Circuitry**



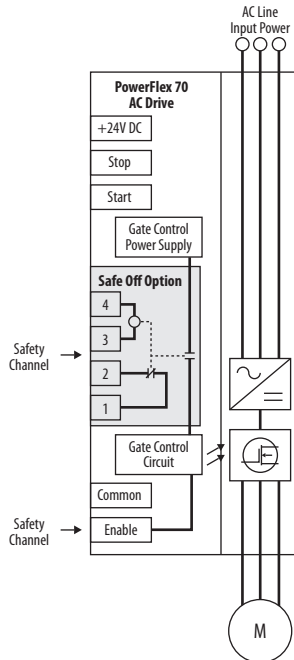
## PowerFlex 70 Safe Torque Off Operation

The PowerFlex 70 DriveGuard Safe Torque Off option (see [Figure 9](#)) 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 ISO 13849-1, Category 3 / PL (d) for Safe Torque Off and helps protect against restart.

Under normal drive operation, the Safe Torque 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. To meet EN ISO 13849-1, Category 3 / PL (d) operation, both safety channels must be de-energized. Refer to the following examples for details.

**IMPORTANT** By itself, the Safe Torque Off option initiates a coast-to-stop action. Additional protective measures will need to be applied when an application requires a change to the stop action.

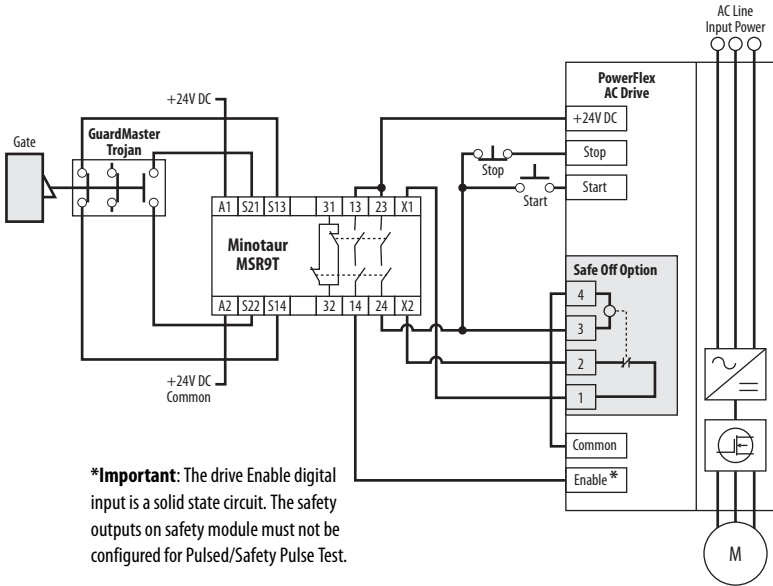
**Figure 9 - PowerFlex 70 Drive Safe Torque Off Circuitry**



## Connection Examples

### Example 1 - Safe Torque Off Connection with Coast-to-Stop Action, Dual Channel

Figure 10 - Stop Category 0 – Coast



**\*Important:** The drive Enable digital input is a solid state circuit. The safety outputs on safety module must not be configured for Pulsed/Safety Pulse Test.

#### 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 Torque 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 Torque 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.

If the Safe Torque 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.



**Notes:**

**Notes:**



PN-163523

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