PowerFlex 7000 Series Safe Torque Off

Bulletin Numbers 7000A, 7000, 7000L

Allen-Bradley
by ROCKWELL AUTOMATION

User Manual

Original Instructions

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

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.

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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.

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 a hazard, and recognize the consequence.

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

These labels may also be on or inside the equipment to provide specific precautions.

SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.

BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

The following icon may appear in the text of this document.

Identifies information that is useful and can help to make a process easier to do or easier to understand.

Table of Contents

About This Publication

This manual explains how PowerFlex® 7000 drives with Safe Torque Off option can be used in Safety Integrity Level (SIL) CL3, Performance Level [PLe], or Category 3 (Cat. 3) applications. It describes the safety requirements, including PFD and PFH values and application verification information, and provides information on installing, configuring, and preventative maintenance of the Safe Torque Off option.

Use this manual if you are responsible for designing, installing, configuring, or troubleshooting safety applications that use the PowerFlex 7000 drive with Safe Torque Off option.

We recommend that you have a basic understanding of the electrical circuitry and familiarity with these products. You must also be trained and experienced in the creation, operation, and maintenance of safety systems.

Download Firmware, AOP, EDS, and Other Files

Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes from the Product Compatibility and Download Center at rok.auto/pcdc.

Summary of Changes

This publication contains the following new or updated information. This list includes substantive updates only and is not intended to reflect all changes.

Topic	Page
Updated links to certification webpage	32
Added UKCA section to certification table	32
Updated certification 2004/108/EC to 2014/30/EU	32
Added UKCA conformity section	33
Removed EU Declaration of Conformity	–

Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
HMI Interface Board Software Updater and Firmware Download Procedure, publication 7000-QS002	Provides the procedure to update the HMI board software.
PowerFlex 7000 Medium Voltage AC Drive (Firmware Version 11.xxx) - ForGe Control, publication 7000-TD002	Provides complete parameter listing for all PowerFlex 7000 medium voltage drives.
PowerFlex 7000 Medium Voltage AC Drive (ForGe Control) - Troubleshooting Guide, publication 7000-TG002	Provides fault and warning messages, spare parts, and fault and warning codes for all PowerFlex 7000 medium voltage drives.
PowerFlex 7000 Medium Voltage AC Drive (A Frame) - ForGe Control, publication 7000A-UM200	Provides detailed information on hardware replacement, overview, control and power component definition, maintenance and specifications for air-cooled medium voltage variable frequency drives.
PowerFlex 7000 HMI Offering with Enhanced Functionality, publication 7000-UM201	Provides detailed information to configure, set up, operate, update and troubleshoot the PowerFlex 7000 HMI Interface Board.
PowerFlex 7000 Medium Voltage AC Drive (B Frame) - ForGe Control, publication 7000-UM202	Provides detailed information on hardware replacement, overview, control and power component definition, maintenance and specifications for air-cooled medium voltage variable frequency drives.
PowerFlex 7000 Medium Voltage AC Drive (C Frame) - ForGe Control, publication 7000L-UM301	Provides detailed information on hardware replacement, overview, control and power component definition, maintenance and specifications for liquid-cooled medium voltage variable frequency drives.
EtherNet/IP Network Devices User Manual, ENET-UM006	Describes how to configure and use EtherNet/IP devices to communicate on the EtherNet/IP network.
Ethernet Reference Manual, ENET-RM002	Describes basic Ethernet concepts, infrastructure components, and infrastructure features.
System Security Design Guidelines Reference Manual, SECURE-RM001	Provides guidance on how to conduct security assessments, implement Rockwell Automation products in a secure system, harden the control system, manage user access, and dispose of equipment.
Industrial Components Preventive Maintenance, Enclosures, and Contact Ratings Specifications, publication IC-TD002	Provides a quick reference tool for Allen-Bradley industrial automation controls and assemblies.
Safety Guidelines for the Application, Installation, and Maintenance of Solid-state Control, publication SGI-1.1	Designed to harmonize with NEMA Standards Publication No. ICS 1.1-1987 and provides general guidelines for the application, installation, and maintenance of solid-state control in the form of individual devices or packaged assemblies incorporating solid-state components.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, rok.auto/certifications.	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at rok.auto/literature.

Abbreviations

Abbreviation	Description
DC_{avg}	Diagnostic Coverage (Average)
DIC	Drive Input Contactor
DPM	Drive Processor Module
ForGe	Fourth Generation Control
$MTTF_d$	Mean Time to Dangerous Failure
OIB2	Optical Interface Board (Rev. 2)
OIBBS	Optical Interface Base Board Safety
PFD	Probability of Failure on Demand
PFH	Probability of a Dangerous Failure occurring per Hour
PSD	Power Structure Diagnostic
PWM	Pulse Width Modulation
SCR	Silicon Controlled Rectifier
SGCT	Symmetrical Gate Commutated Thyristor
SPS	Self-powered SGCT (Power Supply)
STO	Safe Torque Off
STORK	Safe Torque Off Retrofit

General Description

The Safe Torque Off option is intended to be applied as a component in a safety control system. Components in the system must be chosen and applied appropriately to achieve the desired level of operational safety.

What Is the PowerFlex 7000 Drive Safe Torque Off Option?

The PowerFlex™ 7000 Drive Safe Torque Off option:

- Is designed to help safely remove power from the gate firing circuits of the drive's power devices (SGCTs). This helps prevent the drive's power devices from switching in the pattern necessary to generate AC power to the motor.
- Satisfies the STO definition in IEC 61800-5-2:2016.
- Can be used in combination with other safety devices to satisfy the requirements of IEC 61508, IEC 61800-5-2 SIL 3, ISO 13849-1 PLe, and Cat. 3 for Safe Torque Off (STO).

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 de-energized and locked out or tagged out in accordance with the requirements of ANSI/NFPA 70E, Part II.

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: There is a residual risk associated with four or more failures of SCGTs within the drive that would cause torque to be developed even when the PowerFlex 7000 Drive Safe Torque Option has controlled the drive outputs to the off state. In this case, the drive may provide energy until the published response time of 1000 ms has expired.

ATTENTION: Removal of power generation from the drive to the motor does not ensure the motor will not rotate. Mechanical braking may be necessary in order to prevent motor rotation. In the absence of motor braking, the motor may continue to rotate or may start to rotate based on the inertia of the load, stored energy in the load, or external forces.

Safety Standards Applied To Safe Torque Off Option

The Safe Torque Off option satisfies applicable requirements in the following standards related to functional and machinery safety.

- IEC 61508-1 to 7: 2010
- IEC 61800-5-2:2016
- IEC 61800-3:2017
- IEC 61800-5-1:2007 + A1:2016
- IEC 62061:2005 + A1:2012 + A2:2015
- ISO 13849-1:2015
- IEC 60204-1:2016
- EN 60204-11: 2000

Safety Concept

Introduction

This section describes the safety performance level concept and how the PowerFlex™ 7000 drives can meet the requirements for SIL CL3, Cat. 3, or PLe applications.

Safety Certification

The PowerFlex 7000 drive safety option is certified for use in safety applications up to and including SIL 3 according to IEC 61800-5-2, IEC 61508, and IEC 62061, PLe, and Cat. 3 according to ISO 13849-1. Safety requirements are based on the standards current at the time of certification.

The TÜV Rheinland group has approved the PowerFlex 7000 drive safety option for use in safety-related applications where the de-energized state is considered to be the safe state. All of the examples in this manual are based on achieving de-energization as the safe state for typical Machine Safety and Emergency Shutdown (ESD) systems.

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.
- 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.

IMPORTANT This safety function may be used where power removal is required to prevent unexpected start-up.

ATTENTION: The drive should never be considered in a safe state unless the safety function is active.

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.

Safety Cat. 3 Performance Definition

To achieve Safety Cat. 3 according to ISO 13849-1:2015, 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.
- basic safety principles shall be applied.
- a single fault in any of its parts does not lead to a loss of safety function.
- the average diagnostic coverage of the safety-related parts of the control system shall be medium.
- the mean time to dangerous failure of each of the redundant channels shall be high.
- measures against common cause failure shall be applied.

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. Safe Torque Off accomplishes a Stop Category 0 stop.
- 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.

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 IEC 60204-1.

Performance Level and Safety Integrity Level (SIL) CL3

For safety-related control systems, Performance Level (PL), according to ISO 13849-1, and SIL levels, according to IEC 61508 and 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 ISO 13849-1, IEC 61508, and IEC 62061 standards for complete information on requirements for PL and SIL determination.

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 the Probability of Failure on Demand (PFD) and Probability of a Dangerous Failure occurring per Hour (PFH) values.

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

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 PFD. The SIL value for a High Demand/continuous mode safety-related system is directly related to the PFH.

Safety Parameter Data

PFH calculations are based on the equations from Part 6 of IEC 61508. $MTTF_d$ and DC_{avg} values are based on ISO 13849-1.

This table provides data for a 12-year mission time only if the safety function is demanded at least once every 6 months, and demonstrates the worst-case effect of various drive configuration changes on the data.

Table 1 - Reliability Data for 12-year Mission Time Test

Attribute	Value(1)
PFH	2.26 E-8 1/hour
SIL CL	3
PL	e
Category	3
$MTTF_d$	803 years
DC_{avg}	90%
HFT	1
PTI (Proof Test Interval)	12

(1) STO data for all medium voltage drive frames.

Safe State

The Safe State encompasses all operation that occurs outside of the other monitoring and stopping behavior of the drive as defined as part of the normal operation without the Safe Torque Off Option.

If a Functional Safety System Fault is detected, the safety option goes to the Safe State. This includes faults related to integrity of hardware or firmware.

Safety Reaction Time

The safety reaction time is the amount of time from a safety-related event as input to the system until the system is in the Safe State.

The safety reaction time from an input signal condition that triggers a safe torque off to safe state reached is 1000 ms (maximum).

IMPORTANT An input signal condition that is present for less than the reaction time may not result in the safety function being performed. A request of the safety function for less than the reaction time may result in the detection of a fault.

Considerations for Safety Ratings

The achievable safety rating of an application using the safety option installed in PowerFlex 7000 drives is dependent upon many external factors.

For applications that rely on the immediate removal of power to the actuator, resulting in an uncontrolled coast to stop, a safety rating up to and including SIL CL3, PLe, and Cat. 3 can be achieved.

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 components 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.

Operation, Installation, and Wiring

PowerFlex 7000 Drive Safe Torque Off Operation

The PowerFlex™ 7000 Drive Safe Torque Off option disables the rectifier and inverter SGCTs by removing the power supply to the fiber optic transmitters that command the devices to turn on, and disabling the gating signals to those fiber optic transmitters. The system satisfies the requirements of SIL3 for safe turn off of torque. Figure 1 shows the block diagram of the STO option in the PowerFlex 7000 drive.

The 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 Safe Torque 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.

The STO option is available in two types. The 24STO option is installed during manufacturing of the drive and is intended for new drives. The 24STORK retrofit option is intended for existing drives and is located on the LV Door (see STO System Components Location on page 23) and must be installed by Rockwell Automation.

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.

IMPORTANT The Safe Torque 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: There is a residual risk associated with four or more failures of SCGTs within the drive that would cause torque to be developed even when the PowerFlex 7000 Drive Safe Torque Option has controlled the drive outputs to the off state. In this case, the drive may provide energy until the published response time of 1000 ms has expired.

ATTENTION: By itself, the PowerFlex 7000 Drives Safe Torque Off option initiates a coast-to-stop action. Additional protective measures will need to be applied when an application requires a different stopping action.

IMPORTANT The status of the MV drive input device must be configured and connected correctly to the safety system to prevent faults being generated. For the system test function to work correctly on an SPS drive, follow the recommended circuit as shown in Drive Input Isolation Device Interlock on page 16.

Figure 1 - Drive Safe Torque Off Block Diagram

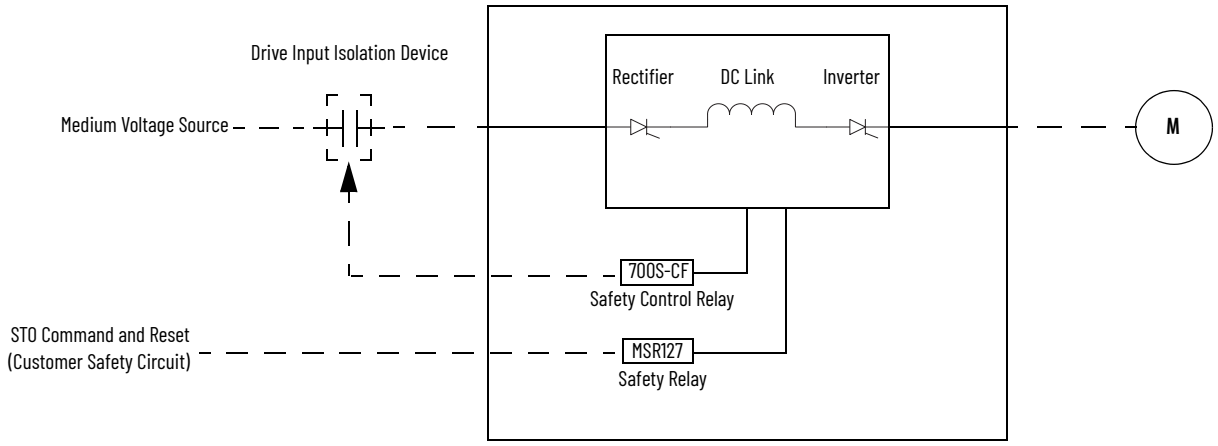
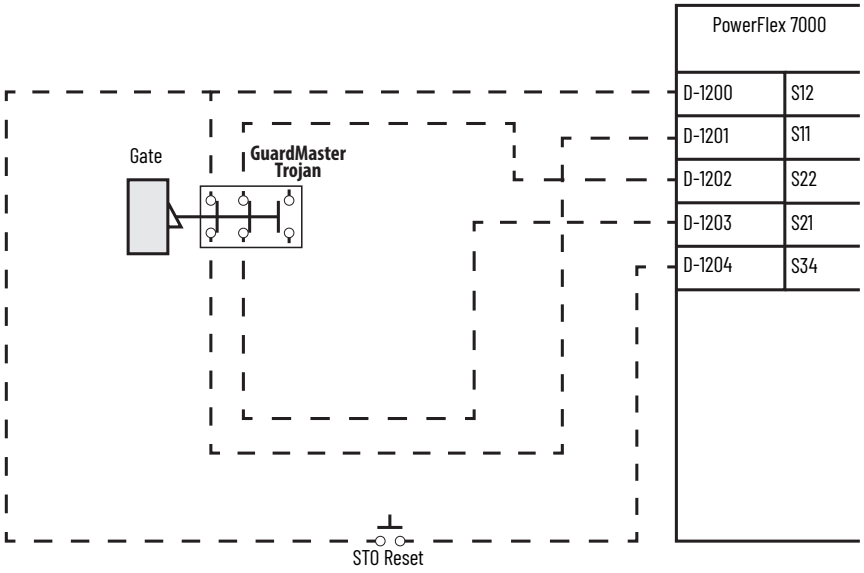


Figure 2 - Example of PowerFlex 7000 Drive, Safe Torque Off Connection, Dual Channel

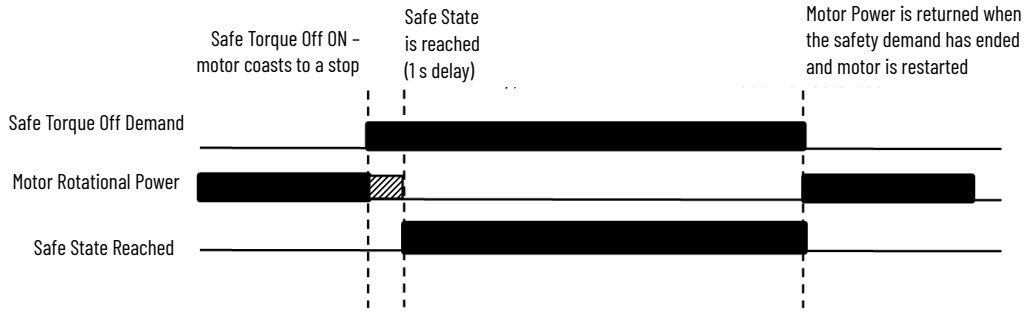


Circuit Status

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

Operating Principle

The drive implements a dual channel system interface using an Allen-Bradley™ Minotaur™ MSR127 safety relay unit. Opening the gate door will switch the input circuits to the safety relay (Figure 2). The output circuits of the safety relay will signal each OIBBS (one for the rectifier bridge and one for the inverter bridge) to go to the safe state. Each OIBBS will signal the drive control to immediately initiate a shutdown causing the power devices to quench the current in the DC link. After the requested demand for the safety function, the gating signals are inhibited and the fiber transmitters power is removed. 1000 ms after the requested demand for the safety function, the STO active light on the door illuminates, indicating the system is in the safe state. The drive status on the PanelView™ 1000 will show 'not ready' and parameter P699 'Drive Not Ready 2' bit 3 will be asserted. To restart the drive, close the gate door, and press the STO reset button followed by a valid start command to the drive (Figure 2).



ATTENTION: It is possible to configure the MSR127 for an automatic reset. This must only be done if a system level risk analysis has been done to deem this method acceptable for the application.

IMPORTANT The outputs that switch the STO active light On (on the drive door) are only for indication and are not safety related outputs.

Fault Detection

A single fault detected on the Allen-Bradley Minotaur MSR127 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.

Single faults detected on the other system components (for example, OIBBS, power structure) will result in the demand for the safety function and a lock-out of the system until the faults are corrected and a drive reset is executed.

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.

Wiring

Wiring to the safety components in the drive must be in accordance with the following steps and must be carried out by competent personnel.

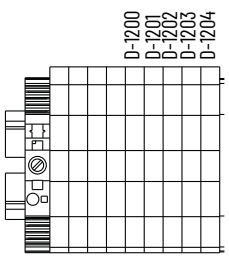
Important points to remember about control wiring:

- 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).
- Safety input wiring must be protected against external damage by cable ducting, conduit, armored cable, or other means.
- Shielded cable is required.
- Refer to the Power and Control Wiring section of the applicable PowerFlex 7000 User Manual

Table 2 - Safe Torque Off Option Terminal Block Specifications

Wire Size Range		Wire Type	Strip Length
Maximum	Minimum		
5.2 mm^2 (10 AWG)	0.3 mm^2 (22 AWG)	Single or Multi-conductor cable	10 mm (0.39 in.)

Table 3 - VFD6 Terminal Description



Terminal	Name	Description
D-1200	S12	Safety Input N.C. (Ch 1)
D-1201	S11 (via OIBBS)	
D-1202	S22 (via OIBBS)	Safety Input N.C. (Ch 2)
D-1203	S21	
D-1204	S34	Reset

Drive Input Isolation Device Interlock

IMPORTANT The term "Drive Input Isolation Device" refers to an electrically held contactor or a circuit breaker with an undervoltage trip circuit used as the drive input device.

The STO option requires both an interlock to open the drive input isolation device and a feedback monitoring status to indicate the drive input isolation device status.

Refer to the electrical drawings to show the proper interlocking based on the type of input device used in the application. In all cases, the interlock connects to the emergency stop input of the input device.

ATTENTION: Interlocking to a drive input isolation device must be done in accordance with the recommendations in this manual and the system's electrical drawings.

ATTENTION: Do not use mechanically held input contactors as a drive input isolation device. The safety system must be able to open the drive input isolation device if a failure of the drive's power structure is detected.

Based on the type of input device that is upstream of the PowerFlex 7000, there are requirements that must be met to insure proper operation of the STO option. Table 4 shows the required feedback contacts from the drive input isolation device based on the input device option. For more details, see publication7000-AT002 and 7000-AT003.

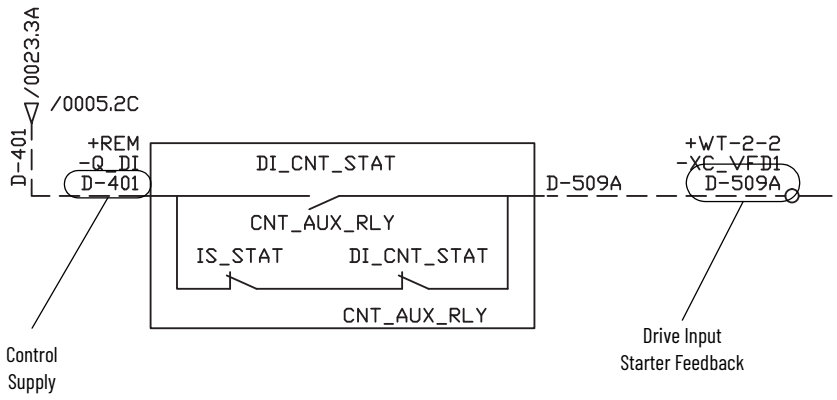
Table 4 - Feedback Contacts Based on Input Device

Input Option	Auxiliary Contacts Required by Drive without STO Option		Auxiliary Contacts Required by Drive with STO Option		Notes
	Starter/Circuit Breaker	Isolation Switch	Starter/Circuit Breaker	Isolation Switch	
Internal/External Starter (Allen-Bradley 1512 with IntelliVAC™)(1)	1 NO, 1 NC	3 NO, 1 NC	1 NO, 2 NC	3 NO, 2 NC	Remaining spare contacts on contactor are 1 NO and 1 NC for light or aux relay options
External Starter (Customer Supplied)	1 NO	1 NO	2 NO, 1 NC	1 NO, 1 NC	
Circuit Breaker (Allen-Bradley or Customer Supplied)	1 pretrip, 1 NO	N/A	1 pretrip, 1 NO, 1 NC	N/A	STO requires UV relay to trip circuit breaker in addition to existing control method from DIC relay

(1) Additional relay for STO is mounted in the LV starter cabinet.

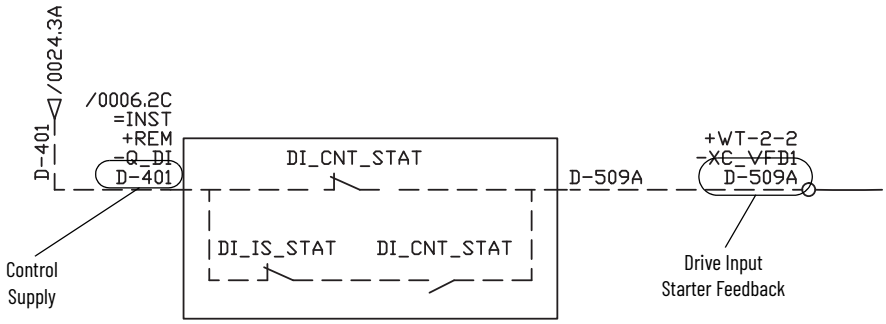
When using an Allen-Bradley Bulletin 1512 starter or if the starter is built into the drive, a relay is added (CNT_AUX_RLY) and wired for the STO option to generate the proper logic required to meet the feedback requirements. The following shows the circuit used when the Allen-Bradley starter is external (see Electrical Drawings).

Figure 3 - Allen-Bradley Drive Input Starter Circuitry Requirements for Safe Torque Off



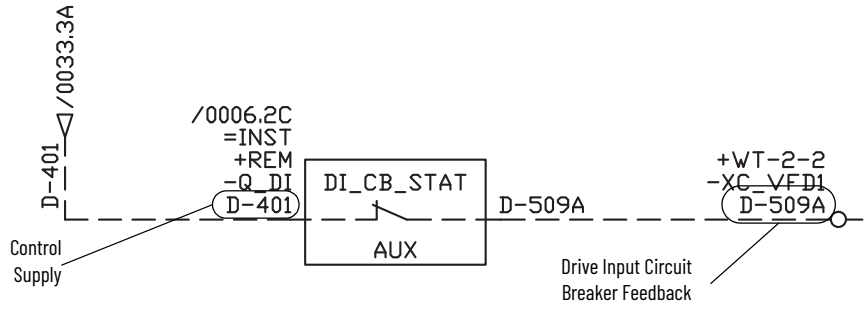
When a customer's drive input starter/disconnect is used, the circuit shown in Figure 4 for the feedback to the STO system is used. This is in addition to the interlocking already needed for the drive.

Figure 4 - Customer-supplied Drive Input Starter Circuitry Requirements for Safe Torque Off



When a drive input circuit breaker is used as the drive input isolation device, only a NC contact is needed for the STO option (Table 4). Figure 5 shows the connection requirements of this contact.

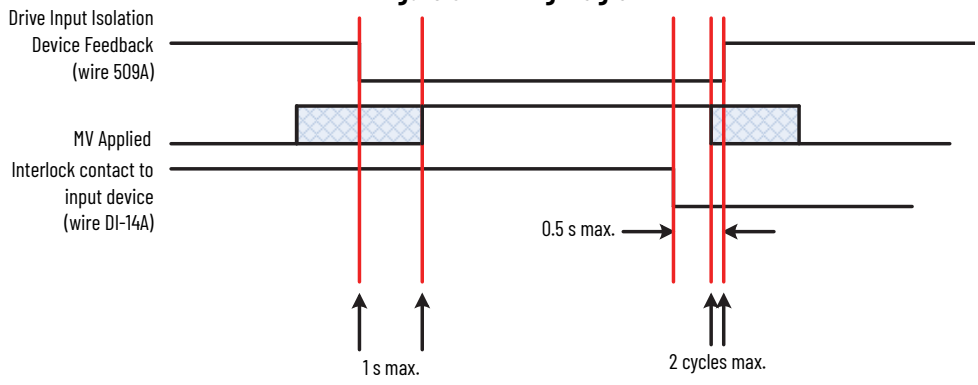
Figure 5 - Drive Input Circuit Breaker Circuitry Requirements for Safe Torque Off



A dry contact is supplied that must be inserted to either the emergency stop input of the starter (in the case of an internal/external Allen-Bradley or customer-supplied starter) or the undervoltage dropout circuit if the drive input isolation device is a circuit breaker. The terminal points are DI-14A and DI-1.

In all cases, Figure 6 shows the dependency of the feedback status with medium voltage applied and the requirements when the interlock contact trips the drive input isolation device.

Figure 6 - Timing Diagram



Product Compatibility

The STO option is not compatible with these PowerFlex 7000 configurations:

- 18 Pulse SCR rectifiers
- SGCT redundant devices (for example, N+1, N-1 configurations)
- Parallel drives
- Use of bypass contactor (for example, synchronous transfer, separately controlled bypass contactor)
- Mechanically-held drive input contactors (for example, option 3950_)
- Versions of the drive firmware prior to 10.002
- Versions of the drive hardware prior to ForGe control

The STO option does not allow for:

- Automatic restart if medium voltage is interrupted for long enough to discharge the gate driver power supplies on an SPS rectifier.
- More than a 200 ms ride through capability of the input starter control with an IntelliVAC contactor control module (see 1503-UM053).

Parameter Setup

All PowerFlex drive parameters related to the STO option are in the functional safety group. Functional Safety Mode is the only writable parameter, and must match the hardware installed (for other drive configuration parameters, see Table 5). If this parameter is enabled, there must be OIBBS and OIB2s installed to run the drive. The access mode must be at least advanced to change this parameter (see publication 7000-UM201).

Figure 7 - Functional Safety Mode

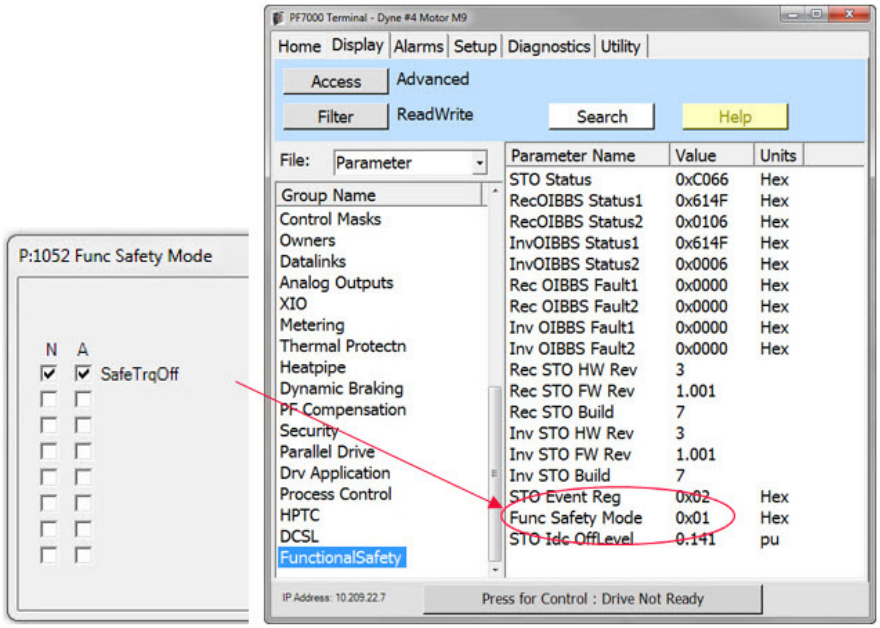


Table 5 - Parameter Settings

Group	Parameter Name	Status
Drive Hardware Group	Number of Devices (P145/P146)	Number of installed OIB2s
	Rectifier Type (P153)	6 PWM
	Bypass Contactor (Hardware Options 1 – P141)	Unchecked
	Redundant Devices (Hardware Options 1 – P141)	Unchecked
	SPS Drive (Hardware Options 2– P274)	Must match SPS jumper on rectifier OIBBS
Parallel Drive Group	Drives in System (P745)	Set to 1
	Powerup Config (P717)	Single
Feature Select Group	Synchronous Transfer (Special Features – P99)	Unchecked

SPS Jumper Settings

See Figure 12 for SPS jumper location on the OIBBS.

1. Ensure the SPS jumper on the rectifier OIBBS is installed if the drive is installed with an SPS rectifier.
2. Ensure the SPS jumper on the inverter OIBBS is not installed.

Commissioning

Follow the commissioning procedure in the user manual pertaining to the drive frame size (see Additional Resources on page 6).

IMPORTANT	When using the System Test mode with the STO option and an SPS rectifier, follow input device interlock requirements.

Verify Operation

Test the safety function for proper operation after initial installation of the drive or STO retrofit kit. Retest the safety function at the intervals determined by the safety analysis described on page 13. Perform these procedures after the drive commissioning procedure is complete.

IMPORTANT	The input component of the STO system in the drive is an Allen-Bradley Minotaur MSR127 Safety Relay. Perform an STO functional test at least once every six months to maintain the safety rating.

Verify the interlocking of the drive input isolation device and the ability of the STO system to open this device.

Table 6 - Power Up

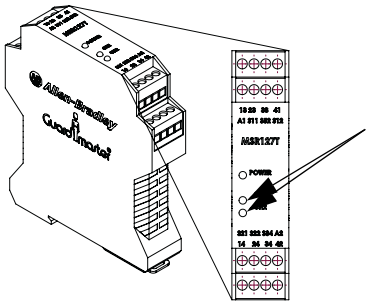
Complete?	Description
	Upon power up of the drive, ensure there is no fault code 657 or code 689 (i.e., Rec InpCtrctrClsd or Inv InpCtctrClsd).
	Reset any faults in the drive, and put the system in the normal running state (i.e., reset the STO active state).

Table 6 - Power Up

Complete?	Description
	Run the drive above 5 Hz and ensure Rec General Flt (code 639) and Inv General Flt (code 671) are not generated because the input device feedback for the STO system is not the correct status.
	Stop the drive and set the input contactor to critical faults. This parameter is in the feature select group, P1 Input Ctctr Cfg. a. Reset any faults that exist and reset the STO feature. The input device should be on and supplying MV to the drive. Ensure the drive is NOT running. b. Remove any one of the fiber optic cables on the inverter OIB2s. c. Verify that relays KG_STO and KG_DIC open, and that the drive input device opens. The only fault generated should be an Inverter PSD fault 690. d. Reinstall the fiber optic cable, ensuring it is seated properly.
	e. Reset any faults that exist and reset the STO feature. The input device should be on and supplying MV to the drive. Ensure the drive is NOT running. f. Using a screwdriver, force the white indicator in on relay KG_DIC so it does not open for steps g. and h. g. Remove any one of the fiber optic cables on the inverter OIB2s. h. Verify that relay KG_STO opens and the drive input device opens. The only fault generated should be an Inverter PSD fault 690. Reinstall the fiber optic cable, ensuring it is seated properly. Reset the faults and STO feature. Ensure any changed parameters are set back to the correct state.

This procedure involves causing a demand for the safety function. Verify that 1 second after the demand for the safety function, the following is true:

Table 7 - STO Activation

Complete?	Description
	Both channels on the MSR127 safety relay switch off. 
	There are no STO related faults on the drive and parameters Rec Safe Supply and Inv Safe Supply (P1062 and 1074) show <0.2V. Note that service level access is required to view these parameters.
	The STO active indicator light illuminates on the door.
	The drive status on the PV1000 shows not ready and parameter P699 'Drive Not Ready 2' bit 3 is checked.
	Parameters Rec OIBBS Status 1 and Inv OIBBS Status 1 (P1057 and P1069) have their 'STO Active' bits checked.
	The motor coasts if it was running and the drive will not start.

Verify the STO system can be reset.

Table 8 - STO Deactivation

Complete?	Description
	Reset the STO safety device that caused the demand for the safety function. – Verify the drive cannot be started.
	Reset the STO function via the hardwire STO reset. – Verify the drive can now be started.

IMPORTANT Submit a copy of Table 6, Table 7, and Table 8 (signed off by the Field Service Engineer) to MV Tech Support to indicate the drive component of the functional safety system has been commissioned and functions correctly.

Notes:

System Components

STO System Components Location

The location of the 24STO option components is the same for all PowerFlex™ 7000 drive frame sizes and configurations (Figure 8). The STO system components are mounted on a DIN rail in the Low Voltage cabinet above the Control Board Panel and shown in detail in Figure 9. The OIB2 and OIBBS boards are located behind the Hinged Panel above the DC to DC Power Supply.

The 24STORK retrofit option has the system components mounted on the Low Voltage Cabinet door (Figure 10) or in the Low Voltage Cabinet depending on the available space.

Both 24STO and 24STORK options have an indicator light on the LV cabinet door.

Figure 8 - Safe Torque Off Option Location for 24STO

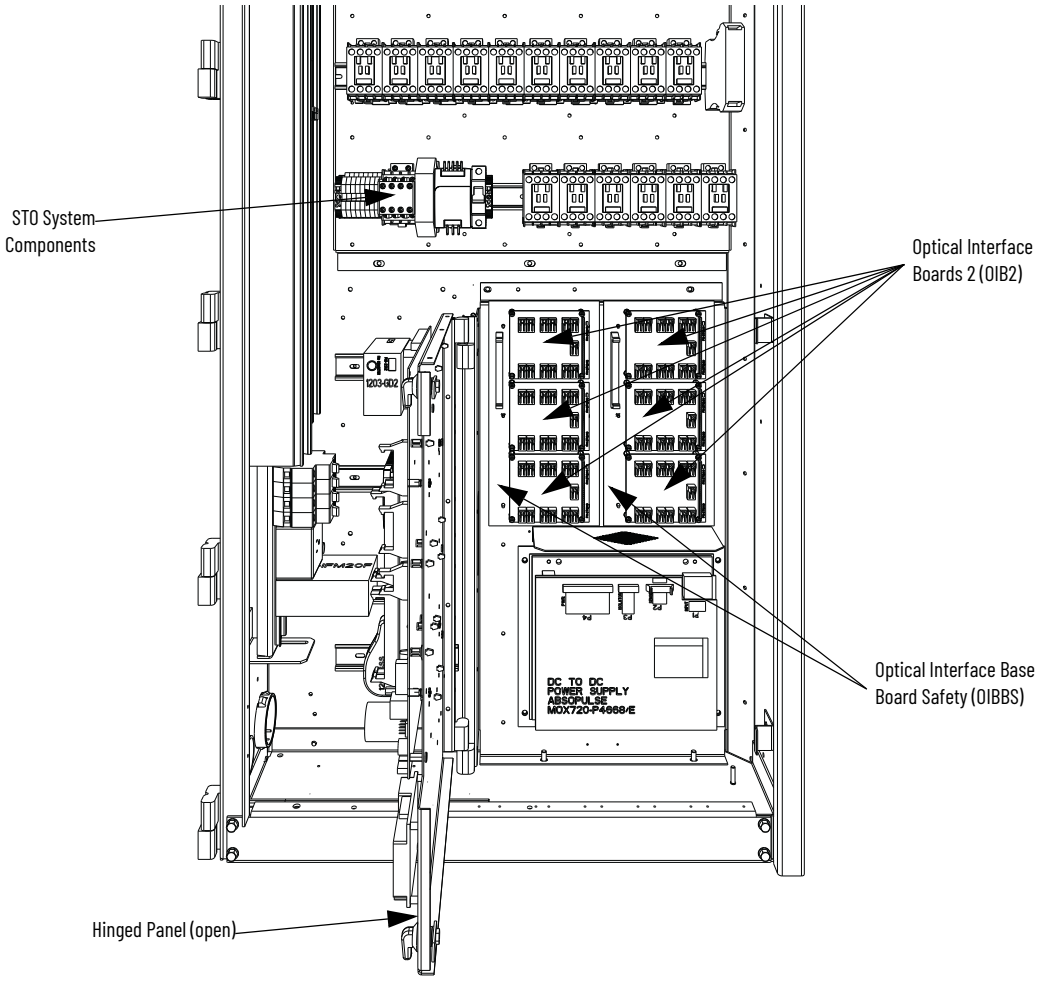


Figure 9 - STO System Components Detail

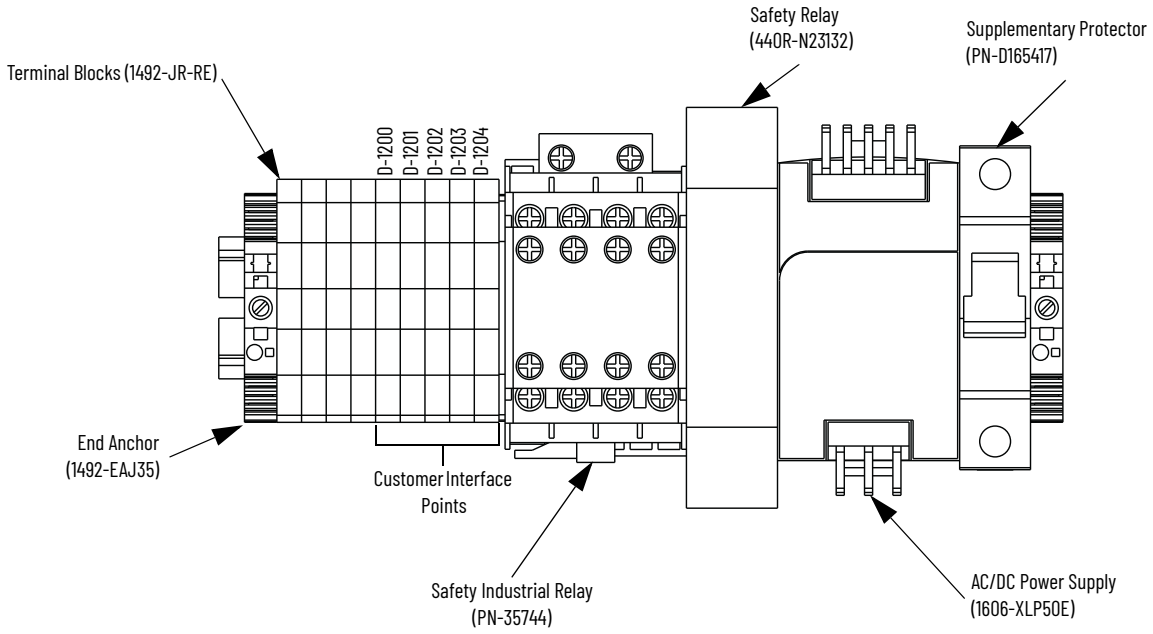
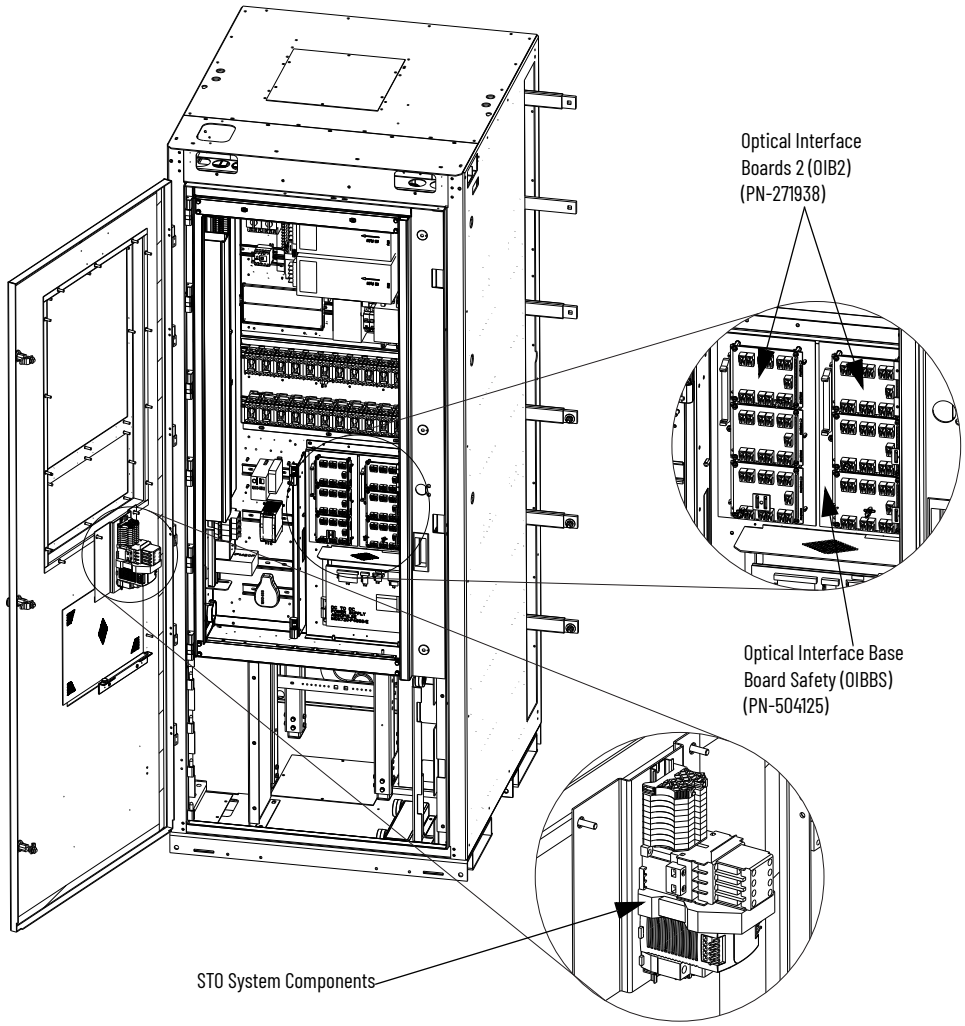


Figure 10 - Safe Torque Off Option Location for 24STORK

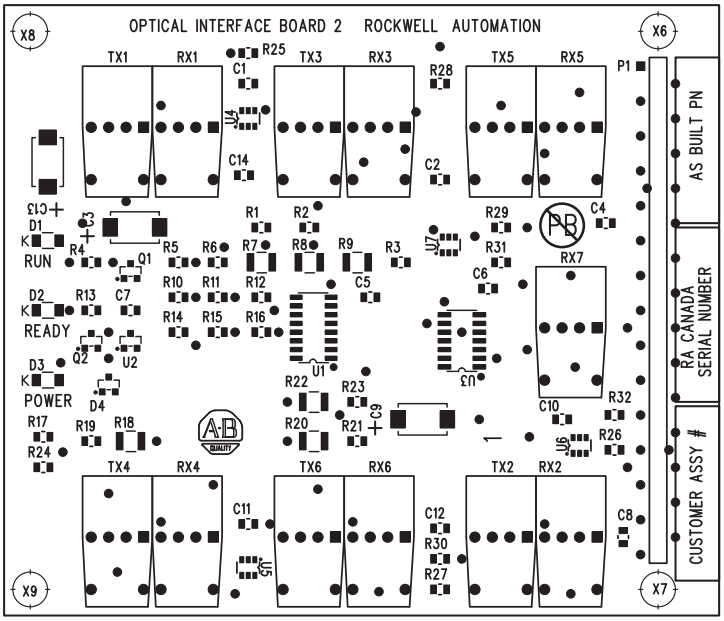


Optical Interface Boards 2

The Optical Interface (OIB2) Boards are the interface between the DPM/OIBBS and the Gate Driver circuitry. The drive control decides which device to fire, and sends an electrical signal to the OIB2 boards via the OIBBS boards. The OIB2 board converts that electrical signal to an optical signal, which is transmitted via fiber optics to the gate driver cards. Typically, the Transmit ports are Grey and the Receive ports are Blue. The gate driver accepts that signal and turns the device on and off accordingly. The diagnostic fiber optic signals work the same way, but the source is the gate driver boards and the destination is the drive control boards. Each OIB2 contains one extra fiber optic receiver (RX7), which is used for temperature measurement.

The OIB2 boards differ from the OIB boards in that the transmitter power can be turned off while the receiver power stays on. This allows for diagnostic feedback of the power devices while the drive is in a safe state.

Figure 11 - Optical Interface Board



The OIB2 boards are mounted directly on the Optical Interface Base Board Safety (OIBBS) using two parallel 14-pin connectors for the electrical connection, and metal standoffs to provide the mechanical support. There is one OIBBS for the inverter, and one OIBBS for the rectifier devices. The OIBBSs are interfaced to the DPM using two ribbon cables to connect to J11 and J12. The OIBBS has four Phoenix connectors which connect the board to the safety system.

Each OIB2 board can handle the Firing and Diagnostic duplex fiber optic connector for six devices. Physically, on the OIBBS, there is provision for 18 devices for the inverter and the rectifier. This is enough capacity to handle the highest rated drive that we currently produce. The top OIB2 board on the OIBBS is for the ‘A’ devices, the middle OIB2 board on the OIBBS is for the ‘B’ devices, and the bottom OIB2 board on the OIBBS is for the ‘C’ devices. Test points for the OIB2 gating diagnostics and temperature feedback signal are on the OIBBS.

Each OIB2 also has input RX7 for a signal from a Temperature Feedback Board. The quantity and location of thermistor connections is dependent on

the drive configuration. Typically there is one temperature sensor from the Line Converter and one temperature sensor from the Machine Converter, each going into the respective OIB2 in the 'A' position. However some drive configurations only require one thermistor feedback connection. The temperature feedback connection on OIB2C is not implemented on the OIBBS and is never used. For more information, see the drawings supplied with your drive. The alarm and trip set points for each of these signals is programmable in software.

There are three status indicators on the OIB2. The following table illustrates the status and description for the status indicator states:

Status Indicator	Status	Description
D1	Red – On	Run – The OIB2 has received an Enable signal. The drive control software is in control of all gating.
D2	Yellow – On	Ready –The OIB2 power supply is sufficient for proper operation.
D3	Green – On	Power – The OIB2 has received a voltage signal greater than 2V.
	D3 –On D1 and D2 – Off	Drive is powered and is in the safe state.

Replace Optical Interface Board 2

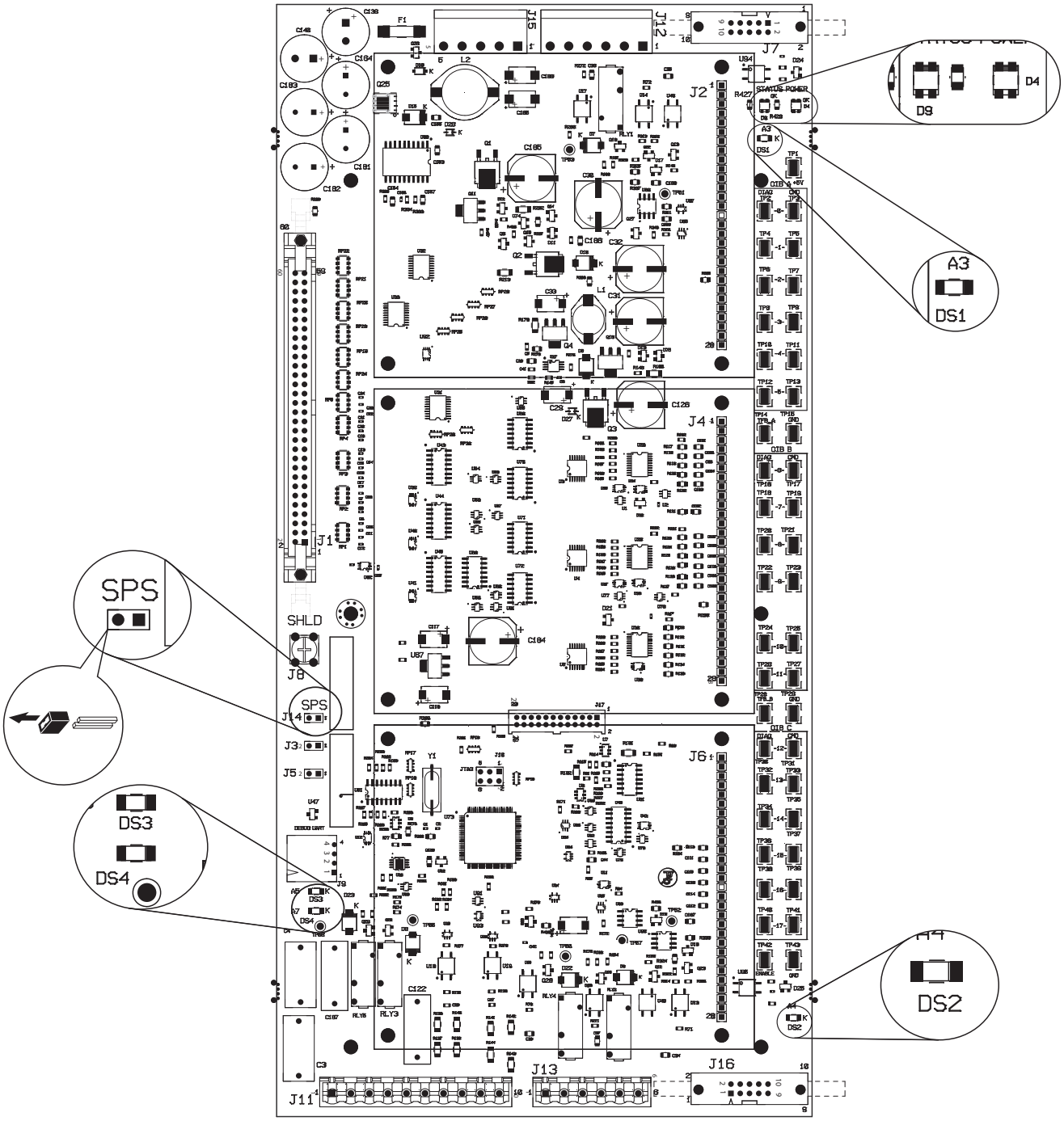
ATTENTION: Ensure that all medium voltage and control voltage power to the drive is isolated and locked out.

1. Note and mark the location and orientation of all the fiber optic cables. Use the electrical drawing for reference.
2. Using your static strap, disconnect all of the connections. It may be necessary to remove the 60 core cable connectors on the Optical interface base and the ground connection for access to the standoffs.
3. Remove the OIB2 board from the OIBBS. There are four standoffs that are secured in place on the OIB2. There is also the 28-pin connection between the boards, and this connection must be handled carefully to avoid bending the pins.
4. Install the new OIB2 on the OIBBS. Ensure all four screws for the standoffs are replaced.
5. Reconnect all fiber optic connections and verify the locations.
6. Apply Low Voltage power and complete a Gating Test, System Test, and Medium Voltage tests to ensure the new board functions properly.
7. Perform procedures as described in Verify Operation on page 20.

Optical Interface Base Board Safety

This board provides the mechanical and electrical interconnections between the OIB2s and the DPM as well as providing the required circuitry to implement Safe Torque Off. It connects to either J11 or J12 on the DPM via a 60 conductor shielded ribbon cable. Attach the cable's drain wire to the screw terminal J8. The remaining connectors on the board complete the electrical connection of the installed OIB2s to the DPM. Each OIBBS can support from one to three OIB2s.

Figure 12 - Optical Interface Base Board Safety (OIBBS)



There are six status indicators on the OIBBS.

Table 9 - Status Indicators

Status Indicator	Status	Description
D4	Off	Board has no power.
	Green	Normal operating condition
	Red	Diagnostic processor watchdog timeout or power supply faults
D9	Flashing Green	Normal operation
	Red	Diagnostic processor faulted
DS1	Yellow – On	There are no diagnostic faults detected on the OIBBS. This represents the status of the A3 relay used for the STO system interlock back to the MSR127
DS2	Yellow – On	There are no diagnostic faults detected on the OIBBS. This represents the status of the A4 relay used for the STO system interlock back to the MSR127
DS3	Yellow – On	There is no power structure fault detected by the OIBBS. This represents the status of the A5 relay used for the permissive control of the drive input device
DS4	Yellow – On	The OIBBS is in the safe state. This represents the status of the A7 relay that is used to illuminate the STO active light on the door

Replace Optical Interface Base Board Safety

ATTENTION: Ensure that all medium voltage and control voltage power to the drive is isolated and locked out.

1. If the OIB2 is also being replaced, note and mark the location and orientation of all fiber optic cables. Use the electrical drawing for reference.
2. Using your static strap, remove the OIB2 board from the OIBBS. There are four standoffs that are secured in place on the OIB2. There is also the 28-pin connection between the boards, and this connection should be handled carefully. Do not bend the pins.
3. Unplug the four Phoenix connectors J11, J12, J13, and J15.
4. Remove the 60-pin cable connectors on the OIBBS and the ground connection.
5. Remove the ground nut holding in the OIBBS. There are five standoffs that snap into place on the OIBBS and they need to be carefully handled when removing the boards.
6. Install the new OIBBS and reinstall the ground nut.
7. Plug in the OIB2s and reconnect all the cables.
8. Ensure the SPS jumper on the OIBBS is set correctly (see Figure 12).
9. Apply Low Voltage power and complete a Gating Test, System Test, and Medium Voltage tests to ensure the new board functions properly.
10. Perform procedures as described in Verify Operation on page 20.

Optical Interface Base Board Safety Test Points

In addition to the command and diagnostic test points, there are three ground reference test points. These reference points are electrically identical, but their locations facilitate oscilloscope or chart recorder test leads connections.

Table 10 - OIBBS Test Points

Test Point	Signal Name	Description
TP1	+5V	Positive 5V Power Supply
TP2	DIAG_0	OIB2 A, RX1 Diagnostic Feedback
TP3	CMD_0	OIB2 A, TX1 Firing Command Signal
TP4	DIAG_1	OIB2 A, RX2 Diagnostic Feedback
TP5	CMD_1	OIB2 A, TX2 Firing Command Signal
TP6	DIAG_2	OIB2 A, RX3 Diagnostic Feedback
TP7	CMD_2	OIB2 A, TX3 Firing Command Signal
TP8	DIAG_3	OIB2 A, RX4 Diagnostic Feedback
TP9	CMD_3	OIB2 A, TX4 Firing Command Signal
TP10	DIAG_4	OIB2 A, RX5 Diagnostic Feedback
TP11	CMD_4	OIB2 A, TX5 Firing Command Signal
TP12	DIAG_5	OIB2 A, RX6 Diagnostic Feedback
TP13	CMD_5	OIB2 A, TX6 Firing Command Signal
TP14	TFB_A	OIB2 A Temperature Feedback Signal
TP15	GND	Ground Reference for TP1 – TP14
TP16	DIAG_6	OIB2 B, RX1 Diagnostic Feedback
TP17	CMD_6	OIB2 B, TX1 Firing Command Signal
TP18	DIAG_7	OIB2 B, RX2 Diagnostic Feedback
TP19	CMD_7	OIB2 B, TX2 Firing Command Signal
TP20	DIAG_10	OIB2 B, RX5 Diagnostic Feedback
TP21	CMD_8	OIB2 B, TX3 Firing Command Signal
TP22	DIAG_9	OIB2 B, RX4 Diagnostic Feedback
TP23	CMD_9	OIB2 B, TX4 Firing Command Signal
TP24	DIAG_8	OIB2 B, RX3 Diagnostic Feedback
TP25	CMD_10	OIB2 B, TX5 Firing Command Signal
TP26	DIAG_11	OIB2 B, RX6 Diagnostic Feedback
TP27	CMD_11	OIB2 B, TX6 Firing Command Signal
TP28	TFB_B	OIB2 B Temperature Feedback Signal
TP29	GND	Ground Reference for TP16 – TP28
TP30	DIAG_12	OIB2 C, RX1 Diagnostic Feedback
TP31	CMD_12	OIB2 C, TX1 Firing Command Signal
TP32	DIAG_13	OIB2 C, RX2 Diagnostic Feedback
TP33	CMD_13	OIB2 C, TX2 Firing Command Signal
TP34	DIAG_14	OIB2 C, RX3 Diagnostic Feedback
TP35	CMD_14	OIB2 C, TX3 Firing Command Signal
TP36	DIAG_15	OIB2 C, RX4 Diagnostic Feedback
TP37	CMD_15	OIB2 C, TX4 Firing Command Signal
TP38	DIAG_16	OIB2 C, RX5 Diagnostic Feedback
TP39	CMD_16	OIB2 C, TX5 Firing Command Signal
TP40	DIAG_17	OIB2 C, RX6 Diagnostic Feedback
TP41	CMD_17	OIB2 C, TX6 Firing Command Signal
TP42	TFB_C	OIB2 C Temperature Feedback Signal – There is no provision in the drive for the use of this signal, it is only provided for Rockwell internal testing.
TP43	GND	Ground Reference for TP30 – TP42

Notes:

Specifications

Introduction

This appendix provides general specifications for the PowerFlex™ 7000 drive Safe Torque Off Option module.

General Specifications

Table 1 - General Specifications

Attribute	Value
Standards	IEC 60204-1, IEC 61508, IEC 61800-3, IEC 61800-5-1, IEC 61800-5-2, IEC 62061, ISO 13489
Safety category	Cat. 3 and PLe per IEC 13849-1; SIL CL3 per IEC 61508 and IEC 62061
Safety inputs	2 N.C.
Maximum allowable input resistance	110 Ω
Conductor type	Multi-conductor cable
Conductor size(1)	0.3…5.2 mm^2 (22…10 AWG)
Strip length	10 mm (0.39 in.)

(1) Refer to Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

Environmental Specifications

IMPORTANT The following are environmental specifications for the OIBBS and OIB2 boards only. For detailed drive environmental specifications, see the user manual pertaining to your drive frame size (see Additional Resources on page 6).

Table 2 - Environmental Specifications

Category	Specification
Storage Temperature (all const.):	-40…+70 °C (-40…+158 °F)
Shock - Packaged for Shipment	381 mm (15 in.) drop height
Vibration - Packaged for Shipment Sinusoidal Loose Load: Random Secured:	20.0 mm (0.8 in.) peak to peak, 2…5.186 Hz; 1.1 g peak from 5.186…20 Hz Frequency (Hz)PSD (g^2/Hz) 10.004 20.1008 50.0008 90.012 200.012 1000.00008

Certifications

See the Product Certification link at rok.auto/certifications for Declarations of Conformity, Certificates, and other certifications details.

Certification[1]	Value
c-UL-us [2]	UL Listed, certified for US and Canada.
CE	European Union 2014/30/EU EMC Directive, compliant with: IEC 61800-3; PowerFlex 7000 AC Drive, Emissions and Immunity IEC 62061; Safety Function, Immunity European Union 2006/42/EC Machinery Directive: ISO 13849-1; Safety Function IEC 60204-1; Safety Function IEC 62061; Safety Function IEC 61800-5-2; Safety Function
UKCA	UK EMC Regulations 2016 No. 1091, compliant with: IEC 61800-3; PowerFlex 7000 AC Drive, Emissions and Immunity IEC 62061; Safety Function, Immunity UK Machinery (Safety) Regulations 2008 No. 1597, compliant with: ISO 13849-1; Safety Function IEC 60204-1; Safety Function IEC 62061; Safety Function IEC 61800-5-2; Safety Function
TÜV Rheinland	Certified by TÜV Rheinland for Functional Safety: up to SIL CL3, according to IEC 61800-5-2, and IEC 62061; up to Performance Level PLe and Cat. 3, according to ISO 13849-1; when used as described in this PowerFlex 7000 Drive Safe Torque Off User Manual, publication 7000-UM203.

(1) When product is marked, refer to rok.auto/certifications for Declarations of Conformity Certificates.
(2) Underwriters Laboratories Inc. has not evaluated the safe torque-off option for functional safety.

CE Conformity

CE Declarations of Conformity are available online at: rok.auto/certifications.

The 24STO and 24STORK Safe Torque Off option is in conformity with the essential requirements of the 2006/42/EC Machinery Directive and the 2014/108/EC EMC Directive when installed and maintained in accordance with the instructions contained in this document. The following standards have been applied to demonstrate conformity:

Machinery Directive (2006/42/EC)

- ISO 13849-1:2015 Safety of machinery - Safety related parts of control systems - Part 1: General principles for design
- IEC 60204-1:2016 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- IEC 62061:2005 + A1:2012 + A2:2015 Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
- IEC 61800-5-2:2016 Adjustable speed electrical power drive systems - Part 5-2: Safety requirement - Functional

EMC Directive (2014/30/EC)

- IEC 61800-3:2017 - Adjustable speed electric power drive systems - Part 3: EMC requirements and specific test methods

UKCA Conformity

UK Declarations of Conformity are available online at: rok.auto/certifications.

The 24STO and 24STORK Safe Torque Off option is in conformity with the essential requirements of the UK Machinery (Safety) Regulations 2008 No. 1597 and the UK EMC Regulations 2016 No. 1091 when installed and maintained in accordance with the instructions contained in this document. The following standards have been applied to demonstrate conformity:

UK Machinery (Safety) Regulations 2008 No. 1597

- ISO 13849-1:2015 Safety of machinery - Safety related parts of control systems - Part 1: General principles for design
- IEC 60204-1:2016 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- IEC 62061:2005 + A1:2012 + A2:2015 Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
- IEC 61800-5-2:2016 Adjustable speed electrical power drive systems - Part 5-2: Safety requirement - Functional

UK EMC Regulations 2016 No. 1091

- IEC 61800-3:2017 - Adjustable speed electric power drive systems - Part 3: EMC requirements and specific test methods

Notes:

Spare Parts and Preventative Maintenance

Spare Parts

Table 3 -

Part No.	Description	Quantity
PN-504125	Optical Interface Base Board Safety (OIBBS)	1
PN-271938	Optical Interface Board (OIB2)	1
PN-35744	Safety Industrial Relay	1
440R-N23132	Safety Relay	1
1606-XLP50E	XLP 50 W Power Supply	1

ATTENTION: In addition to the restart procedure in the user manual, perform the Verify Operation procedures on page 20 after replacing any of these components.

The estimated time required to verify if the functional safety system in the drive is functioning is less than 0.5 hours.

Preventative Maintenance

IMPORTANT See the PowerFlex™ 7000 user manual for detailed preventative maintenance schedule and procedure for other non-safety related parts.

Replace the following parts at 12 year intervals to maintain the SIL rating of the drive.

Table 4 -

Part	Quantity
OIBBS	2
OIB2	2/4/6 (based on voltage class)
SGCTs	12/24/36 (based on voltage class)
MSR127	1

Notes:

History of Changes

This appendix contains the new or updated information for each revision of this publication. These lists include substantive updates only and are not intended to reflect all changes. Translated versions are not always available for each revision.

7000-UM203D-EN-P, August 2020

Topic
Updated standard number that STO satisfies
Updated all safety standards applied to STO
Updated safety standard number
Updated machinery directive standards
Updated EMC directive number and standard
Updated EU Declaration of Conformity
Added History of Changes appendix

7000-UM203C-EN-P, September 2018

Topic
Updated Firmware revision to 11.xxx
Added PowerFlex 7000A User Manual to Additional Resources table
Updated OIBBS part number to PN-504125
Updated Safety Industrial Relay to PN-35744

Notes:

Rockwell Automation Support

Use these resources to access support information.

Technical Support Center	Find help with how-to videos, FAQs, chat, user forums, Knowledgebase, and product notification updates.	rok.auto/support
Local Technical Support Phone Numbers	Locate the telephone number for your country.	rok.auto/phonesupport
Technical Documentation Center	Quickly access and download technical specifications, installation instructions, and user manuals.	rok.auto/techdocs
Literature Library	Find installation instructions, manuals, brochures, and technical data publications.	rok.auto/literature
Product Compatibility and Download Center (PCDC)	Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes.	rok.auto/pcdc

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Waste Electrical and Electronic Equipment (WEEE)

At the end of life, this equipment should be collected separately from any unsorted municipal waste.

Rockwell Automation maintains current product environmental compliance information on its website at rok.auto/pec.

Rockwell Otomasyon Ticaret A.Ş. Kar Plaza İş Merkezi E Blok Kat:6 34752, İçerenköy, İstanbul, Tel: +90 (216) 5698400 EEE Yönetmeliğine Uygundur

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AMERICAS: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
EUROPE/MIDDLE EAST/AFRICA: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
ASIA PACIFIC: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846
UNITED KINGDOM: Rockwell Automation Ltd. Pitfield, Kiln Farm Milton Keynes, MK11 3DR, United Kingdom, Tel: (44)(1908) 838-800, Fax: (44)(1908) 261-917

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