This manual links to Armor PowerFlex AC Drive Fault Codes Reference Data, publication [35-RD002](35-RD002) and to Armor PowerFlex AC Drive CIP Objects and Attributes Reference Data, publication [35-RD001](35-RD001); download the spreadsheet now for offline access.

# Armor PowerFlex AC Drives

Bulletins 35E, 35S

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.

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

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

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.

Rockwell Automation recognizes that some of the terms that are currently used in our industry and in this publication are not in alignment with the movement toward inclusive language in technology. We are proactively collaborating with industry peers to find alternatives to such terms and making changes to our products and content. Please excuse the use of such terms in our content while we implement these changes.

## Chapter 2

## Install the Armor PowerFlex Drive

## EtherNet/IP Operation

### Chapter 3



## Keypad Operation

### Chapter 4



## Standard and Configurable I/O Operation

### Chapter 5



## Safety Functions

### Chapter 6

## Chapter 7

## Configure the Armor PowerFlex Drive

## Chapter 8

## Develop Secure Applications



## Chapter 9

## Diagnostics, Status, and Troubleshooting



## Chapter 10

## Maintenance and Repair



## Appendix A

## Integrated Safety Instruction Validation Checklist

## Appendix B

## Configure a Message Instruction

## About This Publication

This manual describes Armor™ PowerFlex® AC drives with EtherNet/IP® and Armor PowerFlex drives with Integrated Safety via EtherNet/IP. It includes information on installation, configuration, programming, and use.

This manual is intended for engineers or technicians that are directly involved in the installation, wiring, programming, operation, and maintenance of the Armor PowerFlex drive.

Rockwell Automation recognizes that some of the terms that are currently used in our industry and in this publication are not in alignment with the movement toward inclusive language in technology. We are proactively collaborating with industry peers to find alternatives to such terms and making changes to our products and content. Please excuse the use of such terms in our content while we implement these changes.

## Conventions

In this manual, we use the term GuardLogix® controller to collectively refer to all of the following safety programmable controllers: GuardLogix, Compact GuardLogix, Armor GuardLogix, and Armor Compact GuardLogix controllers. We use the term Logix controller to collectively refer to all compatible programmable controllers. See Integrated Safety Functions and Compatible Controllers on page 81 for more information.

## Access Fault Code and CIP Object and Attribute Data

This manual links to Armor PowerFlex AC Drive Fault Codes Reference Data, publication 35-RD002 and to Armor PowerFlex AC Drive CIP Objects and Attributes Reference Data, publication 35-RD001. Download the spreadsheets from Literature Library.

## 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 |
|---|---|
| Added footnote explaining when to choose a 4-pin or 7-pin motor cable | 18 |
| Added IP66, UL Type 1/12 rating for 5-pin auxiliary power cables and receptacles | 18, 45, 57 |
| Changed minimum firmware version to 32.0 | 18, 114, 190 |
| Added IMPORTANT note about using Rockwell Automation dynamic brake resistors | 26 |
| Updated steps for checking if hazardous voltage is still present after removing power | 34, 206 |
| Changed power supply fault trigger value from 19V to 20.4V | 46 |
| Added table describing the power terminal connections | 49, 50 |
| Updated encoder wiring diagrams | 54 |
| Changed “manual” and “hand” mode to “local” mode | 76 |
| Removed overload curves | 154 |

| Topic | Page |
|---|---|
| Corrected EM brake default release mode to "always engaged" | 167 |
| Updated Safety Input tags | 184 |
| Added Syslog event logging | 191 |

## Terminology

This table defines the abbreviations that are used in this manual.

**Abbreviations and Definitions**

| Abbreviation | Full Term | Definition |
|---|---|---|
| 1oo2 | One out of Two | Refers to the behavioral design of a dual-channel safety system. |
| CAT | Category | Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection, and/or by their reliability (source ISO 13849). |
| CL | Claim Limit | The maximum Safety Integrity Level (SIL) rating that can be claimed for a safety-related electrical control system subsystem in relation to architectural constraints and systematic safety integrity (source IEC 62061). |
| DC | Diagnostic Coverage | The ratio of the detected failure rate to the total failure rate. |
| DeviceID | Device ID | A unique identifier, which is comprised of the module number and Safety Network Number (SNN), to make sure that duplicate module numbers do not compromise communication between the correct safety devices. |
| EN | European Norm | The official European Standard. |
| ESD | Emergency Shutdown Systems | A system, usually independent of the main control system, which is designed to safely shut down an operating system. |
| ESPE | Electro-sensitive Protective Equipment | An assembly of devices and/or components working together for protective tripping or presence-sensing purposes and includes as a minimum:<br>• A sensing device.<br>• Controlling/monitoring devices.<br>• Output signal-switching devices (OSSD). |
| HFT | Hardware Fault Tolerance | The Hardware Fault Tolerance (HFT) equals *n*, where *n*+1 faults could cause the loss of the safety function. An HFT of one means that two faults are required before safety is lost. |
| IEC | International Electrotechnical Commission | The International Electrotechnical Commission (IEC) is the organization that prepares and publishes international standards for all electrical, electronic, and related technologies. |
| IGBT | Insulated Gate Bipolar Transistors | Typical power switch that is used to control main current. |
| ISO | International Organization for Standardization | The International Organization for Standardization (ISO)is an international standard-setting body that is composed of representatives from various national standards organizations. |
| MTTF | Mean Time to Failure | The length of time that a device or other product is expected to remain reliable in operation. |
| PELV | Protective Extra Low Voltage | An electrical system where the voltage cannot exceed ELV under normal conditions, and under single-fault conditions, except earth faults in other circuits. |
| PFD | Average Probability of a Dangerous Failure on Demand | The average probability of a system to fail to perform its design function on demand. |
| PFH | Average Frequency of a Dangerous Failure per hour | The average frequency of a system to have a dangerous failure per hour. |
| PL | Performance Level | EN ISO 13849-1 safety rating |
| PM | Permanent Magnet | In permanent magnet (PM) motors, magnets mounted on or embedded in the rotor, couple with the current-induced internal magnetic fields of the motor generated by electrical input to the stator. |
| SELV | Safety Extra Low Voltage Circuit | A secondary circuit that is designed and protected so that, under normal and single fault conditions, its voltages do not exceed a safe value. |
| SIL | Safety Integrity Level | A measure of a products ability to lower the risk that a dangerous failure could occur. |
| SSN | Safety Network Number | A unique number that identifies a section of a safety network. |
| STR | Spurious Trip Rate | That part of the overall failure rate that does not lead to a dangerous undetected failure. |
| STO | Safe Torque Off | The Safe Torque Off (STO) function is used to help prevent unexpected motor rotation during an emergency while the drive remains connected to the power supply. When STO is activated, the torque power cannot reach the drive, which stops and helps prevent any motor shaft rotation. |

## Additional Resources

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

| Resource | Description |
|---|---|
| Armor PowerFlex AC Drives Fault Codes Reference Data, publication 35-RD002 | Provides a list of Armor PowerFlex drive fault codes. |
| Armor PowerFlex AC Drives CIP Objects and Attributes Reference Data, publication 35-RD001 | Provides a list of Armor PowerFlex drive CIP® objects and attributes. |
| Armor PowerFlex Drives Specifications Technical Data, publication 35-TD001 | Provides information on product specifications, ratings, certifications, system interface, and wiring diagrams to aid in product selection. |
| Armor PowerFlex Motor Controller Product Information, publication 35-PC001 | Provides basic information on how to install, configure, and program the Armor PowerFlex controllers. |
| On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect Products Selection Guide, publication 280PWR-SG001 | Provides information on product specifications, ratings, certifications, system interface, wiring diagrams, and dimensions to aid in On-Machine™ media product selection. |
| EtherNet/IP Device Level Ring Application Technique, publication ENET-AT007 | Describes Device Level Ring (DLR) topologies, configuration considerations, and diagnostic methods. |
| EtherNet/IP Network Devices User Manual, publication ENET-UM006 | Describes how to configure and use EtherNet/IP devices with a Logix 5000® controller and communicate with various devices on the Ethernet network. |
| Group Installation Listing Requirements for Drives and Contactor-based Motor Controllers White Paper, publication 280-WP001 | Describes the importance of drives and motor controllers being Listed for group installations and how to verify if they have been Listed for group installations. |
| Armor PowerFlex Fan Replacement Kit Installation Instructions, publication 35-IN008 | Provides instructions on how to replace the Armor PowerFlex fan. |
| Logix5000 Controllers Common Procedures Programming Manual, publication 1756-PM001 | Provides access to the Logix 5000 Controllers set of programming manuals. The manuals cover such topics as how to manage project files, organize tags, program logic, test routines, handle faults, and more. |
| Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003 | Provides information on the programming instructions available to use in Logix Designer application projects. |
| GuardLogix Safety Application Instruction Set Reference Manual, publication 1756-RM095 | Provides information on the GuardLogix Safety application instruction set. |
| GuardLogix 5570 and Compact GuardLogix 5370 Controller Systems Safety Reference Manual, publication 1756-RM099 | Provides information on safety application requirements for GuardLogix 5570 and Compact GuardLogix 5370 controllers in Studio 5000 Logix Designer® applications. |
| GuardLogix 5580 and Compact GuardLogix 5380 Controller Systems Safety Reference, publication 1756-RM012 | Provides information on safety application requirements for GuardLogix 5580 and Compact GuardLogix 5380 controllers in Studio 5000 Logix Designer applications. |
| GuardLogix 5570 Controllers User Manual, publication 1756-UM022 | Provides information on how to use standard Guard Logix 5570 controllers. |
| ControlLogix 5580 and GuardLogix 5580 Controllers User Manual, publication 1756-UM543 | Provides information on how to use standard ControlLogix® 5580 controllers. |
| Compact GuardLogix 5370 Controllers User Manual, publication 1769-UM022 | Provides information on how to use Compact GuardLogix 5370 controllers. |
| CompactLogix 5380 and Compact GuardLogix 5380 Controllers User Manual, publication 5069-UM001 | Provides information on how to use CompactLogix™ 5380 and Compact GuardLogix 5380 controllers. |
| Wiring and Grounding Guidelines for Pulse-width Modulated (PWM) AC Drives, publication DRIVES-IN001 | Provides information to install, protect, wire, and ground pulse-width modulated (PWM) AC drives. |
| System Design for Control of Electrical Noise Reference Manual, publication GMC-RM001 | Information, examples, and techniques that are designed to minimize system failures caused by electrical noise. |
| Safety Automation Builder and SISTEMA Library | Download Safety Automation Builder® software to help simplify machine safety design and validation, and reduce time and costs.<br>The SISTEMA tool, also available for download from the Safety Automation Builder page, automates calculation of the attained Performance Level from the safety-related parts of a machine's control system to (EN) ISO 13849-1. |
| Ethernet Reference Manual publication, ENET-RM002 | Describes basic Ethernet concepts, infrastructure components, and infrastructure features. |
| CIP Security with Rockwell Automation Products Application Technique, publication SECURE-AT001 | Provides information on CIP Security™, including which Rockwell Automation products support CIP Security. |
| System Security Design Guidelines Reference Manual publication, 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. |
| American Standards, Configurations, and Ratings: Introduction to Motor Circuit Design, publication IC-AT001 | Provides an overview of American motor circuit design based on methods that are outlined in the NEC®. |
| 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. |

| Resource | Description |
|---|---|
| Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1 | Provides general guidelines for installing a Rockwell Automation industrial system. |
| 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. |
| 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.

## CE Conformity

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

The Armor PowerFlex drive when installed and maintained in accordance with the instructions in this document, is in conformity with the essential requirements of these directives:

- 2006/42/EC Machinery Directive
- 2014/30/EU EMC Directive
- 2014/35/EU Low Voltage Directive
- 2011/65/EU RoHS Directive
- 2009/125/EC Ecodesign Directive

The following standards have been applied to demonstrate conformity.

### Machinery Directive (2006/42/EC)

- EN ISO 13849-1 Safety of machinery - Safety related parts of control systems - Part 1: General principles for design
- EN 60204-1 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- EN 62061 Safety of machinery - Functional safety of safety-related electrical, electronic, and programmable electronic control systems
- EN 61800-5-2 Adjustable speed electrical power drive systems - Part 5- 2: Safety requirement - Functional
- IEC 61508 Part 1…7 Functional safety of electrical/electronic/ programmable electronic safety-related systems

### EMC Directive (2014/30/EU)

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

### LVD Directive (2014/35/EU)

- EN 61800-5 -1 Adjustable speed electrical power drive systems - Part 5-1: Safety requirements – Electrical, thermal and energy (LVD)

### RoHS Directive (2011/65/EU)

- EN 63000 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

### Ecodesign Directive (2019/1781)

# Armor PowerFlex Variable Frequency Drives Overview

## Description

The Armor™ PowerFlex® unit is a variable frequency drive (VFD) and is suited for variable frequency applications where more precise motor control is needed. The Armor PowerFlex drives are available in integrated safety (Bulletin 35S) and standard (Bulletin 35E) versions.

All Armor PowerFlex drives feature an embedded dual-port EtherNet/IP™ switch, which supports star, linear, and DLR topologies.

The Armor PowerFlex drive provides an IP54/66, UL Type 4/12, and NEMA 4/12 enclosure design, which is suitable for water wash down environments, when appropriate cables are attached or sealing caps are in place.

| | |
|---|---|
| **IMPORTANT** | The Armor PowerFlex drive ships with a rubber sealing boot which is required to be installed when the power OUT connection is not in use. (This scenario could apply when daisy chaining is not in use or when the drive is the last unit in the daisy chain).<br>When installed, this rubber sealing boot provides an IP54 rating to the power OUT connection. If a greater IP rating is required, for example IP66, appropriately rated sealing caps are required to be installed. For selection information, see Accessories in the On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect Products Selection Guide, publication 280PWR-SG001. |

Fault diagnostic capabilities, including status indicators, are built in to the Armor PowerFlex drive to help you pinpoint a problem for easy troubleshooting and quick restarting.

### Input and Outputs

All Armor PowerFlex drives include four standard inputs and two standard configurable I/Os.

The Armor PowerFlex safety drive includes: two test outputs, four safety inputs, and one bipolar safety output.

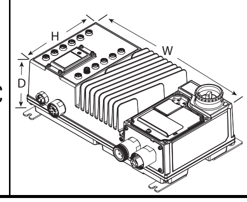
**Table 1 - Product Overview**

| Type | Bulletin | Inputs and Outputs | On-board Safety Inputs and Outputs |
|---|---|---|---|
| Armor PowerFlex with integrated safety on EtherNet/IP network | 35S | 4 inputs<br>2 configurable I/Os | 1 bipolar safety output<br>4 safety inputs |
| Armor PowerFlex on EtherNet/IP network | 35E | | — |

## Frame Size

The Armor PowerFlex drive is available in Frame size A.

**Table 2 - Frame Sizes**

| Frame | | Output Current | Input Voltage | Approximate Dimensions | | | |
|---|---|---|---|---|---|---|---|
| Size | Rating | | | Diagram | Width (W), max. | Depth (D), max. | Height (H), max. |
| A | 1 Hp (0.75 kW) | 2.3 A | 380…480V AC |  | 16.0 in. (40.6 cm) | 5.67 in. (14.4 cm) | 8.0 in. (20.3 cm) |
| | 2 Hp (1.5 kW) | 4.0 A | | | | | |
| | 3 Hp (2.2 kW) | 6.0 A | | | | | |

For additional specifications see Armor PowerFlex AC Drives Specifications Technical Data, publication 35-TD001.

We recommend that the drive rating should be no more than two times the motor rating. Example: For a 1 Hp drive, the motor should be 0.5 Hp or larger.

## Safety Functions

The Armor PowerFlex safety version (35S) is capable of hard-wired and integrated safety. In hardwired mode, Safe Torque Off (STO) can be used. Integrated safety supports STO, integrated drive-based Safe Stop functions and integrated controller-based Safe Monitor functions. See Chapter 6, for details.

## Location of Features

Figure 1 - Bulletin 35E Armor PowerFlex Standard VFD

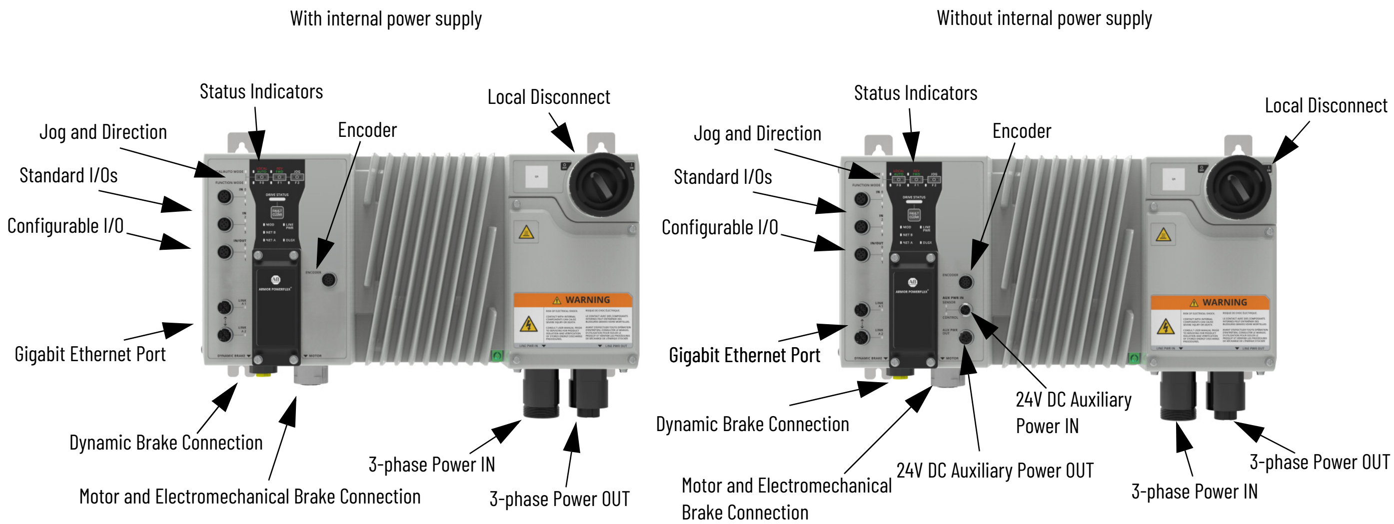
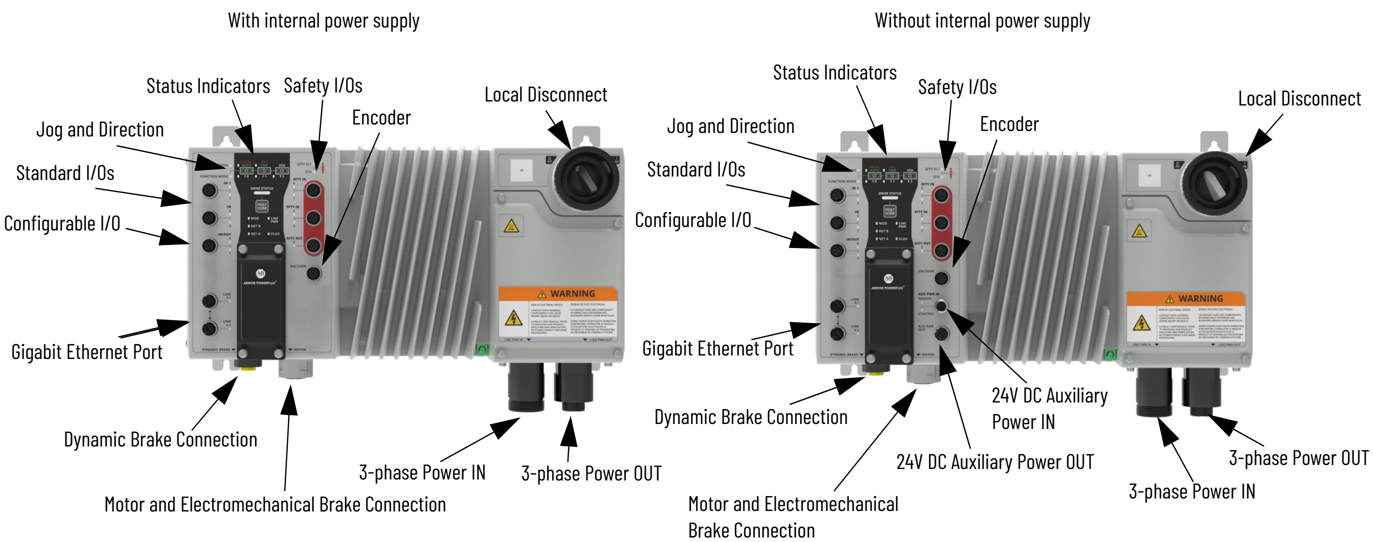



Figure 2 - Bulletin 35S Armor PowerFlex with Integrated Safety VFD



## Catalog Number Explanation

Examples that are given in this section are not intended to be used for product selection. Not all combinations produce a valid catalog number. Use ProposalWorks™ software to configure the Armor PowerFlex Drive. ProposalWorks software is available from rok.auto/systemtools.

*Catalog Number Explanation for Bulletin 35 Armor PowerFlex VFDs*

| 35 | S | - | 6 | D | 1 | - | L | 2 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|
| a | b | | c | d | e | | f | g | h | i |

| a | |
|---|---|
| **Bulletin Number** | |
| **Code** | **Description** |
| 35 | Armor PowerFlex Drive |

| b | |
|---|---|
| **Type** | |
| **Code** | **Description** |
| S | Integrated Safety version |
| E | EtherNet/IP |

| c | |
|---|---|
| **Enclosure Type** | |
| **Code** | **Description** |
| 6 | IP54/66, Type 1/4/12, NEMA Type 1/4/12 |

| d | |
|---|---|
| **Line Voltage** | |
| **Code** | **Description** |
| D | 480Y/277V AC, 50/60 Hz |

| e | |
|---|---|
| **Motor Power Output Rating** | |
| **Code** | **Description** |
| 1 | 1 Hp, 0.75 kW, 2.3 A |
| 2 | 2 Hp, 1.5 kW, 4.0 A |
| 3 | 3 Hp, 2.2 kW, 6.0 A |

| f | |
|---|---|
| **24V DC Auxiliary Power Source** | |
| **Code** | **Description** |
| L | External(1) |
| P | Internal |

| g | |
|---|---|
| **Power-in Gland** | |
| **Code** | **Description** |
| 0 | Cord/conduit |
| 1 | Round Quick Connect |
| 2 | Square Quick Connect |

| h | |
|---|---|
| **EM Brake(2)** | |
| **Code** | **Description** |
| 0 | None |
| 1 | Included |

| i | |
|---|---|
| **EMI Filter** | |
| **Code** | **Description** |
| 1 | Included |

(1) Our current offering of 5-pin, auxiliary power cables and receptacles have an IP66, UL Type 1/12 rating. You must confirm that this rating is acceptable for the intended application.
(2) If you choose a drive without an EM brake (Code 0), then a 4-pin motor cable is required. If you choose a drive with an EM brake (Code 1), then a 7-pin motor cable is required. Example: Cat. No. 35S-6D3-P1**0**1 requires a 4-pin cable (Cat. No. 280-PWRM29-Mxx or 284-PWRM29-Mxx). Cat. No. 35S-6D3-P1**1**1 requires a 7-pin cable (Cat. No. 357-PWRM29-Mxx). For details, see the On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect Products Selection Guide, publication 280PWR-SG001.

## Required Software

Table 3 lists the software that is required to operate Armor PowerFlex drives.

**Table 3 - Armor PowerFlex Drives Required Software**

| **Network** | **Software** | **Version** |
|---|---|---|
| EtherNet/IP | FactoryTalk® Linx | 6.20 or later |
| | Studio 5000® | 32.0 or later |
| | Add-on Profile | Download the most current version from the Product Compatibility and Download Center at rok.auto/pcdc |
| | BOOTP/DHCP Utility | Version 2.3 or later (BOOTP is not supported.) |
| **Programmable Controller** | | **Firmware Version** |
| 35S and 35E Armor PowerFlex versions | GuardLogix and Compact GuardLogix controllers (see page 81 for the listing of compatible controllers) | 32.0 or later |
| 35E Armor PowerFlex version | ControlLogix and CompactLogix controllers (see page 81 for the listing of compatible controllers) | 32.0 or later |

Studio 5000 Logix Designer® application is the single software that is used for setup and commissioning. It's accomplished through the installation and use of an Add-on Profile (AOP) downloaded from Product Compatibility and Download Center (PCDC). See page 11 for more information.

# Motor Control

Armor PowerFlex drives provide you with selectable choices for accurate motor control.

For induction motors, the Control Axis leverages the IEEE recommended phase-neutral equivalent circuit motor model based on "Wye" configuration. Reactance values, X, are related to their corresponding Inductance values, L, by $X = \omega L$, where $\omega$ is the rated frequency of the motor. The prime notation, for example, $X_2'$, $R_2'$, indicates that the actual rotor component values $X_2$, and $R_2$ are referenced to the stator side of the stator-to-rotor winding ratio.

**Figure 3 - IEEE per Phase Motor Model**

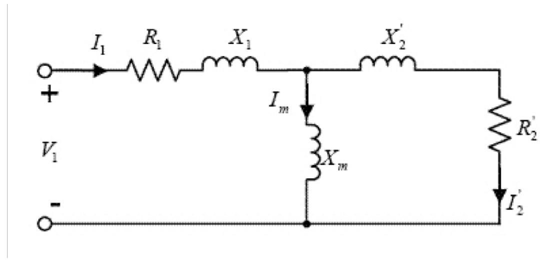



**Table 4 - IEEE Phase Motor Model Diagram Designations**

| | |
|---|---|
| $I_1$ | Stator current [Amps] |
| $I_2$ | Rotor current [Amps] |
| $R_1$ | Stator circuit resistance [Ohms] |
| $R_2$ | Stator circuit resistance [Ohms] |
| $X_1$ | Stator leakage reactance [Ohms] |
| $X_2$ | Rotor circuit reactance [Ohms] |
| $I_\omega$ | Magnetizing current [Amps] |
| $X_\omega$ | Magnetizing reactance [Ohms] |
| $V_1$ | Applied stator voltage [Volts] |

## Control Modes

Velocity control is accomplished via three options for control mode:

- Volts/Hertz (V/Hz)
- Sensorless Vector
- Velocity Vector

### *Volts/Hertz*

Volts/Hz control is a simple, low-cost method for controlling variable frequency drives (VFD), and is generally regarded as the most common VFD control scheme. It's suitable for both constant torque and variable torque applications and can provide up to 150% of the rated torque at zero speed for startup and peak loads. The magnetic field strength is proportional to the ratio of voltage (V) to frequency (Hz), or V/Hz. The VFD controls the motor speed by varying the frequency of the applied voltage, according to the synchronous speed equation.

Operation in this mode, creates a fixed relationship between output voltage and output frequency. Voltage is applied to the motor, which is based on the operating frequency command at a fixed volts/Hertz ratio. The ratio is calculated from the motor nameplate data.

*Sensorless Vector*

Sensorless vector control (SVC) provides better torque production and a wider speed range than V/Hz. However, it may not be appropriate when more than one motor is connected to the same drive.

SVC does not have an external sensor to obtain feedback from a motor. SVC mode monitors the voltage and current of the motor via the already-connected power leads, and then mathematically determines the motor speed with optimum accuracy. This is a simpler and less costly solution than installing and connecting an encoder. While not as good as a dedicated sensor, SVC provides sufficient feedback in most applications to enable pseudo closed-loop operation.

SVC uses a V/Hz core that is enhanced by current resolution, a slip estimator, a high-performance current limiter, and the vector algorithms. The algorithms operate on the knowledge that motor current is the vector sum of the torque and flux producing components.

Values can be entered to identify the motor values or an autotune routine can be run to identify the motor values (see Configure Autotune on page 156).

*Velocity Vector*

In Velocity Vector Control (VVC), a high bandwidth regulator that separates and controls the components of stator current, replaces the volts/hertz core used in V/Hz and SVC control modes. The high bandwidth characteristics of this control help eliminate nuisance trips due to shock-loads and will continuously adapt to changes in the motor and load characteristics.

A separate adaptive controller uses information gained during auto tuning; actual reference information and motor feedback information, to give independent torque and flux control. This allows continuous regulation of the motor speed and improved overall control. For the Armor PowerFlex drive, this mode should be operated with feedback to provide the fastest response to load changes.

A rotate tune must be done in order to provide the optimal motor velocity control using vector mode (see Configure Autotune on page 156).

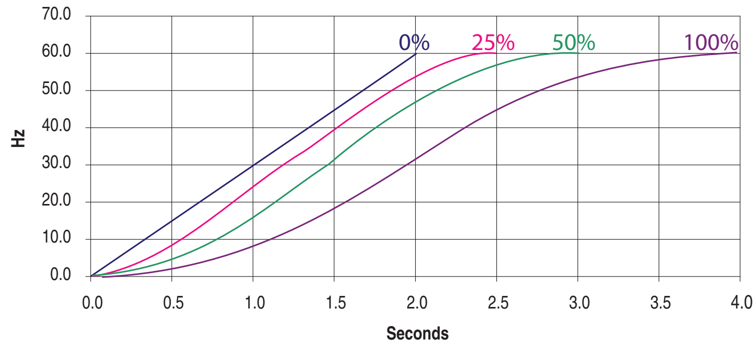
## Velocity Control

Velocity control refers to controlling the speed of a connected motor. Acceleration and deceleration times can be specified, which indicate the time it should take the velocity to go from zero to the rated speed of the motor (or vice versa). From these times, actual acceleration/deceleration values (rates) can be calculated and the motor output controlled to meet these desired values.

Velocity control also allows the rate of change of acceleration and deceleration (also known as "jerk") to be adjusted. This control function is known as S-Curve. By enabling/configuring the S-Curve function, the transition between velocities can be made smoother by not immediately applying or removing the desired acceleration/deceleration rate.

When S Curve is enabled, it adds time to the overall acceleration by a percentage of the programmed acceleration time. This is shown in the curve in Figure 4 which represents 0%, 25%, 50%, and 100% S Curve. Note that half of the “S” is added to the beginning and half is added to the end of the ramp.

**Figure 4 - S Curve Example**




## Flying Start

The flying start feature lets you start a motor that is already in motion. Flying start is used to start a rotating motor, as quick as possible, and resume normal operation with a minimal impact on load or speed. When a drive is started in its normal mode, it initially applies a frequency of 0 Hz and ramps to the desired frequency. If the drive is started in this mode with the motor already spinning, large currents will be generated. An overcurrent trip may result if the current limiter cannot react quickly enough. The likelihood of an overcurrent trip is further increased if there is a residual electro-magnetic flux (back EMF) on the spinning motor when the drive starts. In addition, larger mechanical stress is placed on the application.

In Flying Start mode, the drive's response to a start command is to synchronize with the motors speed (frequency and phase) and voltage. The motor will then accelerate to the desired frequency. This process helps prevent an overcurrent trip and significantly reduces the time for the motor to reach its desired frequency. Since the drive synchronizes with the motor at its rotating speed and ramps to the proper speed, little or no mechanical stress is present.

When flying start is disabled and the drive receives a start command while the motor is in motion, the drive performs a ramp from zero speed (no output frequency) to the commanded speed. Performing this ramp from zero on a running motor can cause an overcurrent condition which may result in damage to the motor or load.

## Load Monitor

This feature monitors the drive for conditions where more or less power than expected is being provided to or provided by the motor to drive a particular load. Two types of monitoring can be performed: shear pin and load loss.

Shear pin monitors for power greater than the configured level, which may indicate a stuck load. This feature can cause a fault and stop the motor to help prevent damage to the motor or load device.

Load loss monitors for power less than the configured level, which may indicate that the load is no longer connected to the motor. This feature can stop the motor or trigger an alarm.

You can configure the power level as an absolute amount of output current being supplied to the motor.

You can also configure a monitor time, which delays the reporting of a load monitoring condition when the power is above or below the level.

## Motor Thermal Overload

Motor thermal overload protection helps to prevent overheating and possible damage to the connected motor. When the drive detects that the motor is too hot, a thermal overload condition is declared. Power to the motor is removed to allow the motor to cool and the overload condition to clear. When the overload condition is cleared, the motor can be restarted. You can define the behavior of the motor thermal overload feature (erase thermal memory or allow cool down) when the device powers up. See Configure Advanced Motor Protection on page 155.

A motor thermal model calculates thermal capacity utilization to estimate the actual heating of the connected motor based on:

- Configured motor overload current, which is the level at which the motor is considered to be in an overload condition
- Actual product output current (all three phases are measured)
- Time over which the output current is delivered

The protection feature lets the motor operate at a power level above its overload rating for short periods of time while starting or accelerating to help prevent faults from occurring.

When excessive current flows through the motor circuit, there is increased motor temperature sensed which will result in a Drive fault after a specified delay, defined as Class 10. This overheating generally occurs when the motor is overloaded, when a bearing seizes up, when something locks the motor shaft and prevents it from turning, or when the motor simply fails to start properly. A failure to start may be caused by faulty start windings in the motor.

See Armor PowerFlex AC Drives Specifications, publication 35-TD001, for overload trip curves specifications.

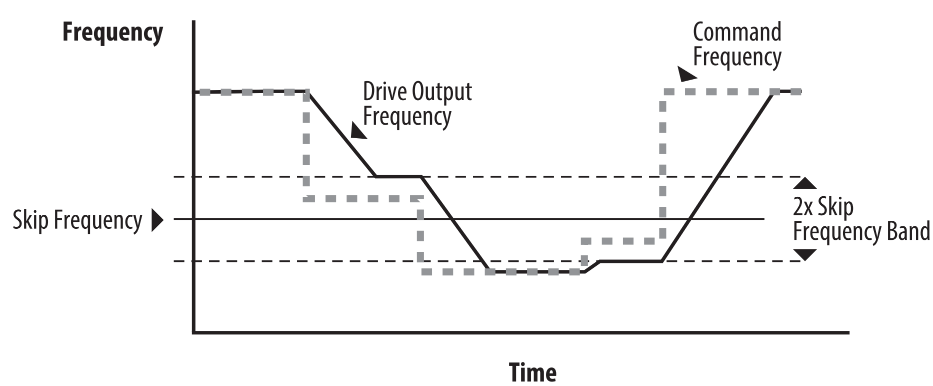
## Velocity Skip Band

Velocity skip band is a velocity band in which a motor will not run constantly (the commanded velocity is forced outside the band).

Velocity skip bands are used to keep the motor / machine from running at a resonant frequency that could cause damage.

Velocity skip bands can also be used to keep a machine from operating at a speed where operation is unstable or untested.

**Figure 5 - Velocity Skip Bands**



### Fault Auto Reset

The fault auto reset and run (auto restart) feature lets certain faults be cleared and the product be commanded back into the running state.

The Auto Restart feature provides the ability for the drive to automatically perform a fault reset followed by a start attempt without user or application intervention. This allows remote or "unattended" operation. Only certain faults are allowed to be reset. Certain faults that indicate possible drive component malfunction are not resettable. Caution should be used when enabling this feature, since the drive will attempt to issue its own start command based on user selected programming.

List of resettable faults:

- Inverter - Ground Fault (event code 0x04250002)
- Motor Thermal Overload - Overload, Hard (event code 0x04320001)
- Load Monitor - Above Level (Shear Pin) (event code 0x04340001)
- Load Monitor - Below Level (Load Loss) (event code 0x04340002)
- Temperature Sensor - Overtemperature, Hard (event code 0x04230002)

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| **IMPORTANT** | Multiple simultaneous faults of any type will prevent a restart. |

## Safe Torque Off and Safe Monitor Functions

The hardwired and integrated safety features are available on the Armor PowerFlex safety drive (35S).

*Hardwired Safe Torque Off*

When the Armor PowerFlex safety drive is in its out-of-box state, it operates in hardwired Safe Torque Off (STO) mode. The STO function is controlled by either dual channel safety input; either safety input 0 (S0) and safety input 1 (S1), or safety input 2 (S2) and safety input 3 (S3).

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| **IMPORTANT** | The Armor PowerFlex safety drive (35S) includes functional safety. If during the initial out-of-box setup a local jog is required, install the red (M12) safety bypass plug onto one of the two safety inputs. This plug is used to enable torque in the out-of-box hardwired mode, during setup. After a safety connection is made with the safety drive, a reset ownership must be performed to enter the out-of-box, hardwired state again. For details, see STO Bypass Operation on page 90. |

Use only the S0 and S1 connector when the hardwired safety device that controls when safety is demanded, requires pulse testing per the risk assessment. If pulse testing is not required, then either the S2 and S3 connector or the S0 and S1 connector can be used, but not both.

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| **IMPORTANT** | In hardwired safety mode, only one of the two safety input connectors can be used. Connecting a cable and safety device to both safety inputs' connectors, in hardwired safety mode, will cause an STO Both Pairs Used fault. See section *Hardwired STO Operation* For information on resetting this fault, see Hardwired STO Operation on page 91. |

Torque is permitted when one input pair on one of the two safety input connectors is energized and disabled when either input is de-energized. Choose the desired safety input connector for hardwired STO mode. See Hardwired Safe Torque Off Function on page 91 for details.

*Integrated Safety Functions*

When the Armor PowerFlex is applied with a suitable safety programmable controller, additional functionality is available. This functionality includes network safety functions such as STO, timed SS1, SBC, and Safety I/O. When adding a suitable safety encoder to the Armor PowerFlex drive, it can support additional safe speed monitoring functions, such as SLS, SLP, SDI, and SS1 ramp.

In addition to safety I/O features, the drive supports these functions: integrated STO, timed SS1, Safe Brake control (SBC), and ramped SS1 when a safety encoder is used.

See Chapter 6 for details on integrated safety I/O and safety functions.

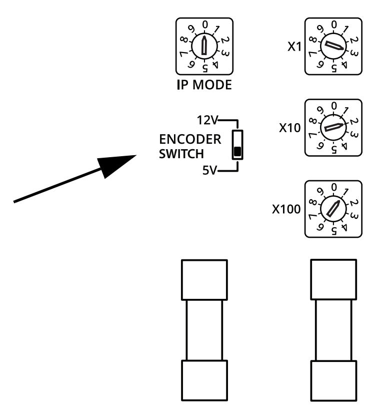
## Standard Encoder Operation and Diagnostics

The Armor PowerFlex drive has a feedback interface that allows an external feedback device (encoder) to be connected to the product. An encoder can provide more accurate velocity control by providing an indication of the actual speed of the motor/load.

Supported standard encoder types:
- Digital Incremental, Single Channel, Single Ended
- Digital Incremental, Single Channel, Differential
- Digital Incremental, Dual Channel, Single Ended
- Digital Incremental, Dual Channel, Differential

The encoder signals are connected in parallel for both safety and standard drive control. Standard control can use single-ended encoder signals, but differential signals are required for safety functions. The standard and safety feedback must be configured separately. If the feedback device uses safe speed monitor functions, additional diagnostics and configuration values must be considered. See Safety Feedback Interface Instruction Operation on page 115 for more information on the controller-based safety encoder support and diagnostics. See Configure Encoder Feedback on page 160 for information on how to configure the standard and safety encoder.

The Armor PowerFlex can supply either 5V or 12V to the encoder, through the encoder output. The encoder voltage supply switch, next to the IP address switches, must be set to the proper supply voltage (5V or 12V) for the connected encoder. See Remove Front Logic Cover on page 62 for information on how to gain access to the encoder voltage supply switch.




The safety feedback configuration allows for the voltage supply to be monitored, see Encoder Voltage Monitoring on page 111 for more details.

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| **IMPORTANT** | For fault-free operation of the encoder, the cable shield of the connecting cable must be grounded on both sides (encoder and control) using large area connections. On the encoder side, this is typically done in the plug connector or via the connecting cable. |

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| **IMPORTANT** | For proper operation of the Armor PowerFlex drive, the maximum total encoder cable length is 20 m (65.6 ft). |

Supported Standard Encoder Diagnostics:

- Wire Error Detection
- Velocity Comparison

The standard encoder diagnostics support basic wire error checking and velocity comparison. The standard encoder diagnostics check for wiring errors and reports them to the user. The diagnostics detect when 1 of the 4 encoder signals is open, shorted to ground, or shorted to encoder power. The velocity comparison diagnostic detects when the measured velocity from the encoder is outside of the expected velocity value.

For more information, see Configure Encoder Feedback on page 160.

## Group Motor Application

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| **IMPORTANT** | The Armor PowerFlex drives and their mating cable assemblies can be applied using NFPA 70 (NEC), NFPA 79, and specific local electrical code as required. |

The Armor PowerFlex drive integrates the motor branch short circuit and ground fault protection devices and is considered self-protected. Therefore, no additional motor control branch circuit protection is required. Multiple Armor PowerFlex drives can be applied in a group application, as each Armor PowerFlex is self-protected. The installer must follow the local electrical codes for the protection of the feeder conductors using recommended Branch Circuit Protection device.

## Local Disconnect

The Armor PowerFlex drive has a local, at-motor disconnect switch which is positioned on the front of the unit. The local disconnect removes power from the motor terminals and outputs when in the Off position. The local disconnect does not remove safety output power. A lock can be applied to the local disconnect when in the Off position. For additional information, see Local Disconnect Behavior on page 58.

If a motor over-current fault should occur, the integrated branch protection may trip. This may cause the drive to fault if the bus voltage falls below minimum threshold. If a fault occurs, the disconnect switch (On/Off) position will not change state. For diagnostic help and trouble shooting, see System Status Indicator on page 197.

## EMI Filter

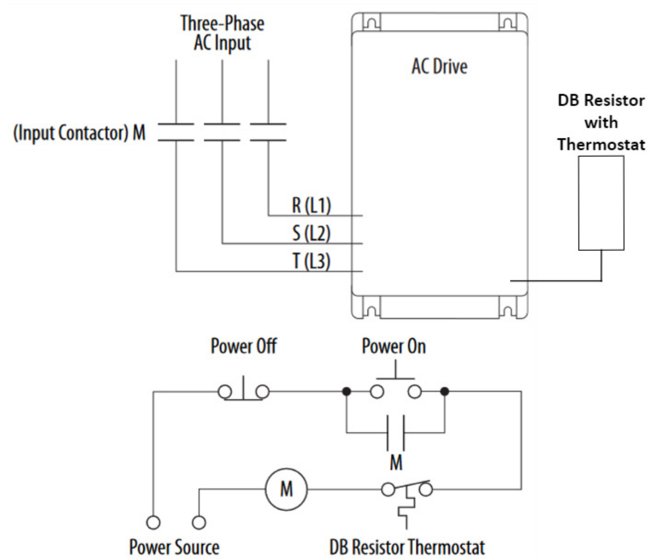
The EMI filter is required to be CE compliant. The filter must only be used in installations with solidly grounded Wye AC supply distribution and must be bonded to the power distribution ground. The shielded motor cable is ordered separately. Use the Rockwell Automation® power media and cable assemblies that are specified by the selection guide or instructions for the controller, to comply with the UL Listing of the controller. See the Armor PowerFlex AC Drives Specifications Technical Data, publication 35-TD001 and the On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect

Products Selection Guide, publication, 280PWR-SG001, for available catalog numbers.

## Dynamic Brake Resistor

Dynamic braking (DB) allows excess electrical energy to be dissipated as thermal energy by directing it through a large resistor. When the dynamic braking feature is enabled, the brake resistor is activated (current is allowed to flow through it) when the bus voltage exceeds a user-defined threshold. This is primarily useful when stopping, allowing a faster stop without causing a DC bus overvoltage.

Typically, AC drives do not offer protection for externally mounted dynamic brake resistors. A risk of fire exists if external braking resistors are not protected from drive component failure, for example, failure of the brake IGBT. In this case, external resistor packages must be protected from over-temperature condition using a protective circuit, or equivalent, as the example shown.




The Armor PowerFlex drive has the internal ability to detect a thermal event on the dynamic brake resistor and shut down the Electronic Motor Disconnect which eliminates the need for the upstream control devices. See Electronic Motor Disconnect on page 59, for more information.

The dynamic brake resistor kit is available for light-duty applications (mountable, does not take extra space) or standard duty applications (larger footprint, with more capability). The dynamic brake resistor kit can be factory-ordered separately. See the Armor PowerFlex AC Drive Specifications Technical Data, publication 35-TD001, for available catalog numbers.

| | |
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| **IMPORTANT** | We recommend that you apply only light-duty or standard-duty dynamic braking resistors, based on your application needs. If you require a deviation from the Rockwell Automation recommended resistors, it is your responsibility to ensure it is suitable to be used with the Armor PowerFlex drive and will meet the application's needs. As a precaution, you should review these changes with your UL representative or Authority Having Jurisdiction (AHJ). |

The dynamic brake connector is provided standard with the Armor PowerFlex drive.

## Power Input Gland

The Armor PowerFlex drive offers several methods to connect 3-phase power to the unit. You can select one of the three offered connectivity options via the catalog number configuration.

Conduit/cord allows you to apply conduit or cord to manually terminate each conductor.

Factory-installed receptacles can be selected to provide connectivity to three-phase quick-connections. You can select the round M35 ArmorConnect® quick-connect power media, or you can select the square quick-connect that offers connectivity to DESINA Q4/2 connectors, such as HARTING® power cable assembly solutions. For selection information, see the On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect Products Selection Guide, publication, 280PWR-SG001.

## Factory-installed Options

You must select factory-installed options and add them to the catalog number selection before ordering. Options are not modular and you cannot install them onsite.

### Internal Power Supply

When you select your Armor PowerFlex drive catalog number, you can choose for it to be configured with an internal 24V DC auxiliary power supply (50 W) or you can choose to have an external power supply. Your power supply choice is made by catalog number selection and cannot be changed in the field. The internal power supply provides all control and I/O power and is sourced from the incoming three-phase power. This eliminates the need to run separate control power to each unit, reducing installation time and cost.

The internal power supply (IPS) connects to the line side of the local disconnect. This means that when the local disconnect is Off, the IPS will continue to provide 24V DC to the Armor PowerFlex. Only when the machine level (main) disconnect is Off, removing all three-phase power, does the IPS shutdown and the Armor PowerFlex drive turns Off.

### Electromechanical Brake

The Armor PowerFlex Drive supports an optional electromechanical brake (EMB or EM brake) function. Internally controlled (On/Off) mechanical contacts apply source (line) voltage to the external motor mechanical brake solenoid when it is demanded. This releases the motor brake to allow motion.

The EMB can be configured for automatic drive control or manual control using a programmable controller logic output bit. A brake status bit is accessible for diagnostic purposes over the network. A customer-accessible, 3 A fuse is provided to help protect the brake cable from over-current. The brake and motor conductors are integrated into a single cable assembly and ordered separately. Use the Rockwell Automation power media and cable assemblies that are specified in the selection guide or instructions for the drive, to comply with the UL Listing of the drive. See the On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect Products Selection Guide, publication, 280PWR-SG001.

| | |
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| **IMPORTANT** | For proper operation, the minimum EM brake current required is 100 mA. Current draw less than 70 mA rms will cause EM brake not connected/broken wire or undercurrent fault. |

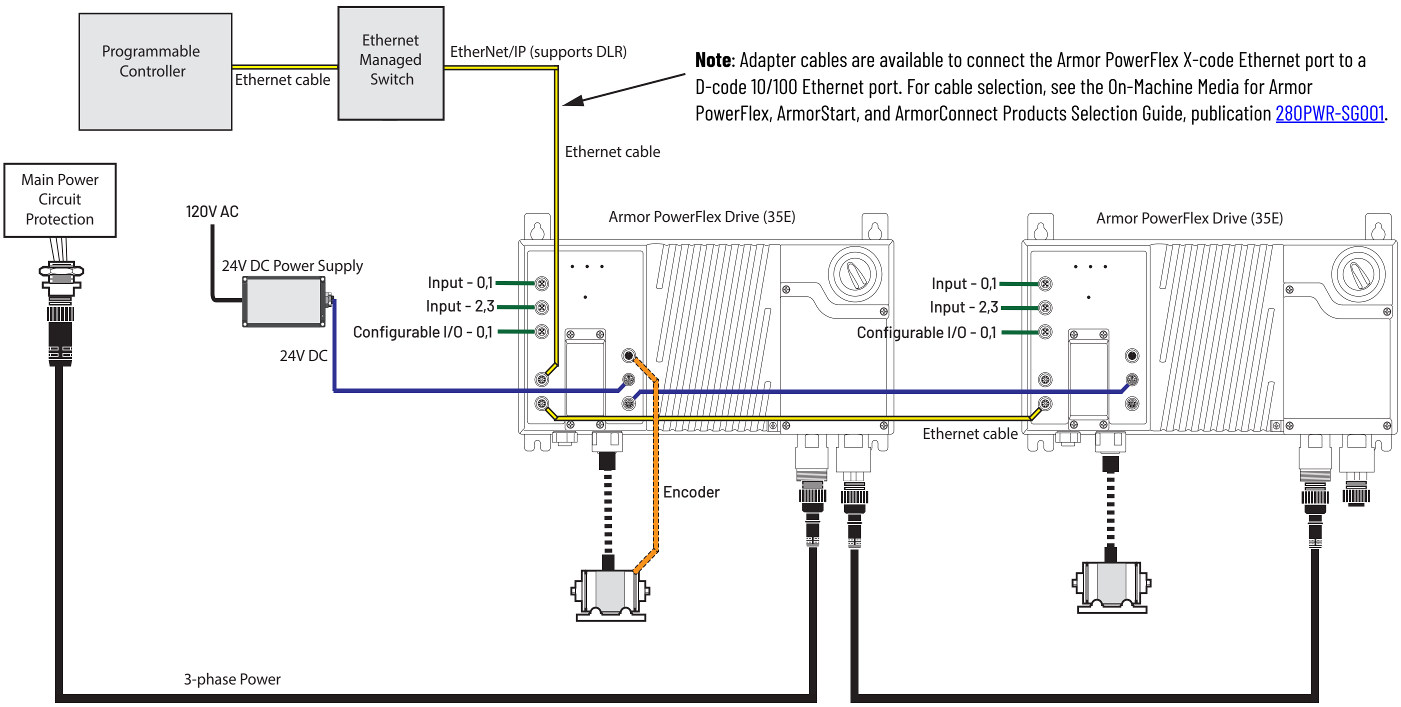
# Typical Configurations

Armor PowerFlex drives can be configured for standard or safety applications.

## Standard Configuration

The Armor PowerFlex standard drive (35E) is normally applied in systems where integrated safety functions **are not** required (see Figure 6). For more complex systems or systems with higher-end safety requirements, you should consider using the Armor PowerFlex safety drive (35S).

**Figure 6 - Standard Drives Configuration**



## Safety Drives Configuration

Armor PowerFlex safety drives (35S) are capable of Safe Torque Off (STO) via hardwired STO connections and integrated drive-based STO and SS1, and integrated controller-based safety functions like Safely Limited Speed (SLS). These examples illustrate some of the functional safety configuration options.

*Hardwired STO*

Armor PowerFlex safety drives use the STO connector for wiring external safety-devices and cascading hardwired safety-connections from one drive to another.

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| **IMPORTANT** | Safety inputs 0 and 1 support safety pulse test in hardwired safety operation. Safety inputs 2 and 3 do NOT support pulse test in hardwired mode. |

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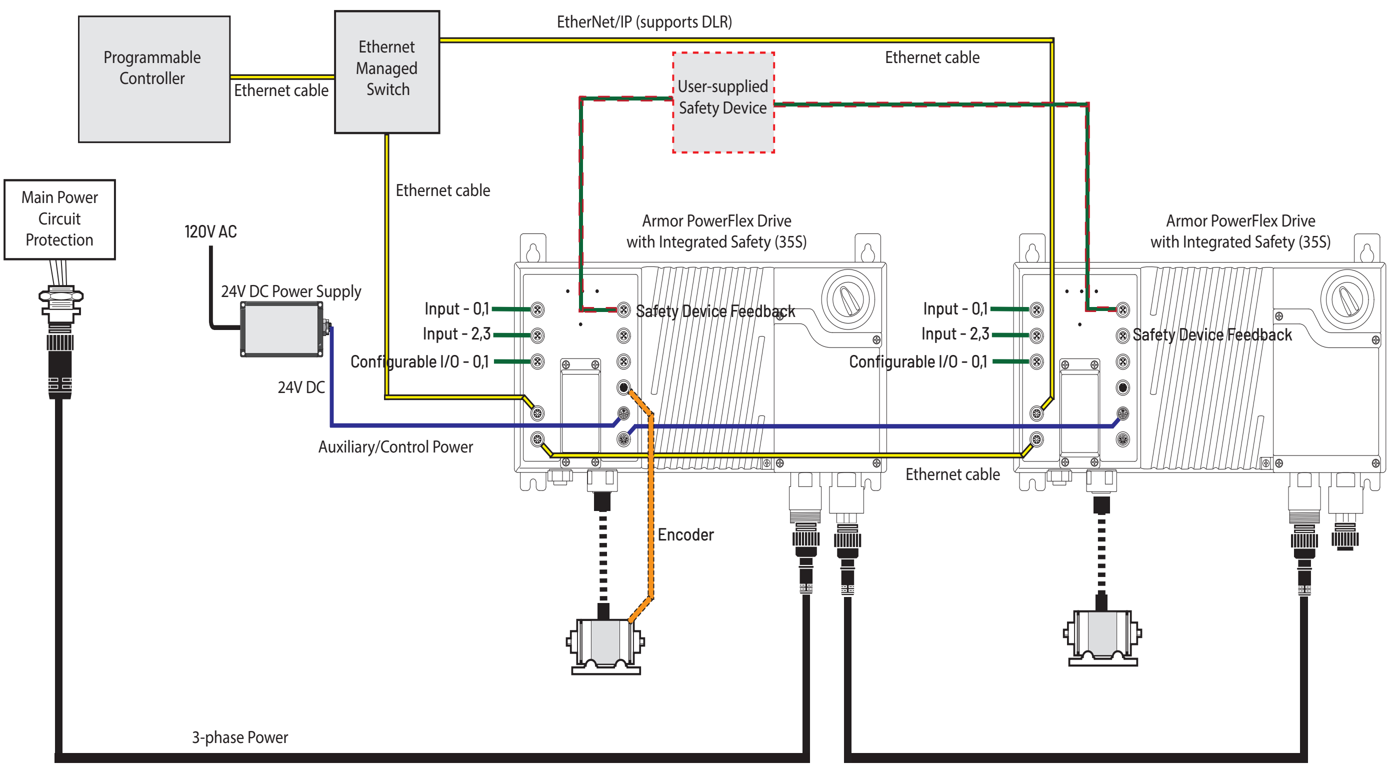
| **IMPORTANT** | In hardwired safety mode only, one of the two safety input connectors can be used (either safety input 0 and 1 or safety input 2 and 3). Connecting a cable and safety device to both safety inputs connectors, in hardwired safety mode, will cause a safety fault that cannot be reset. |

**Figure 7 - Hardwired Safe Torque Off**

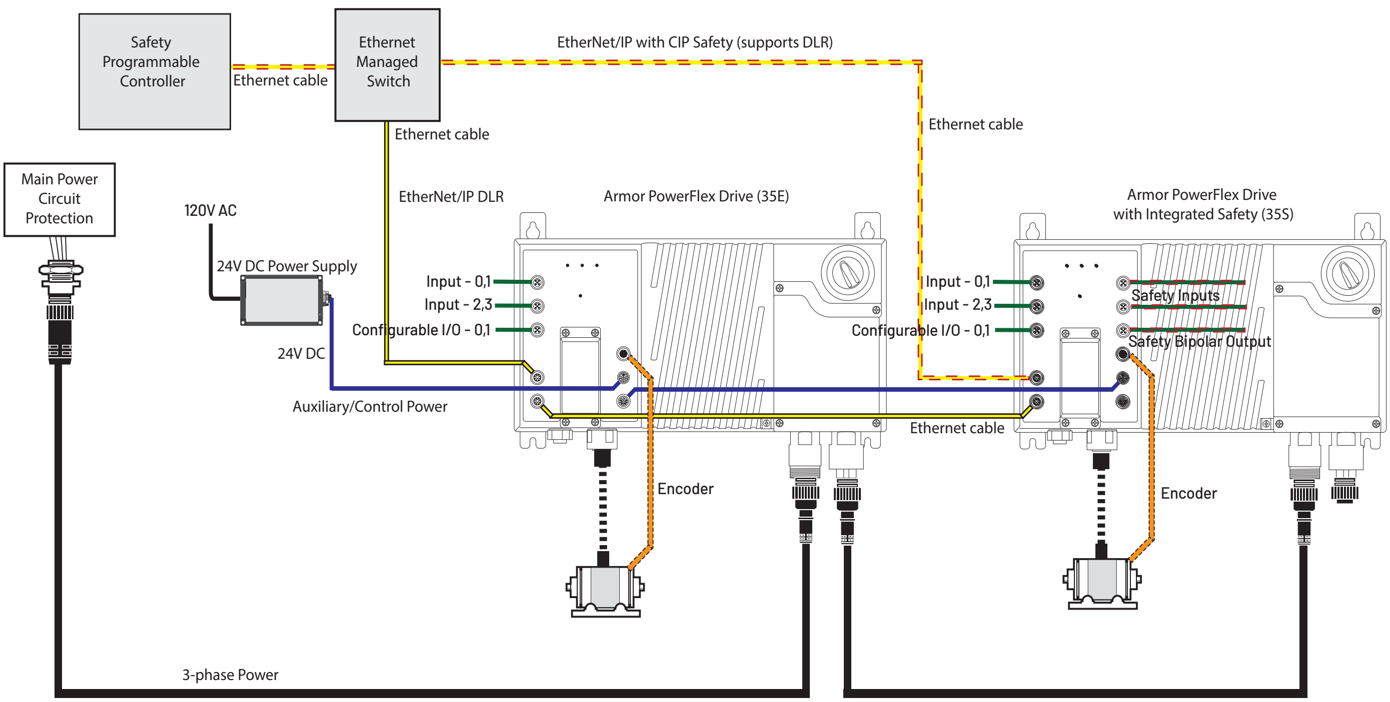


### *Integrated STO*

The GuardLogix or Compact GuardLogix safety controller issues the STO or SS1 command over the EtherNet/IP network and the Armor PowerFlex drive executes the command.

In this example, a drive without the safety configuration (35E) makes the standard I/O connection and a separate Armor PowerFlex safety drive (35S) makes the safety-only I/O connection.

**Figure 8 - Integrated Safe Torque Off (STO) or Timed Safe Stop (SS1)**

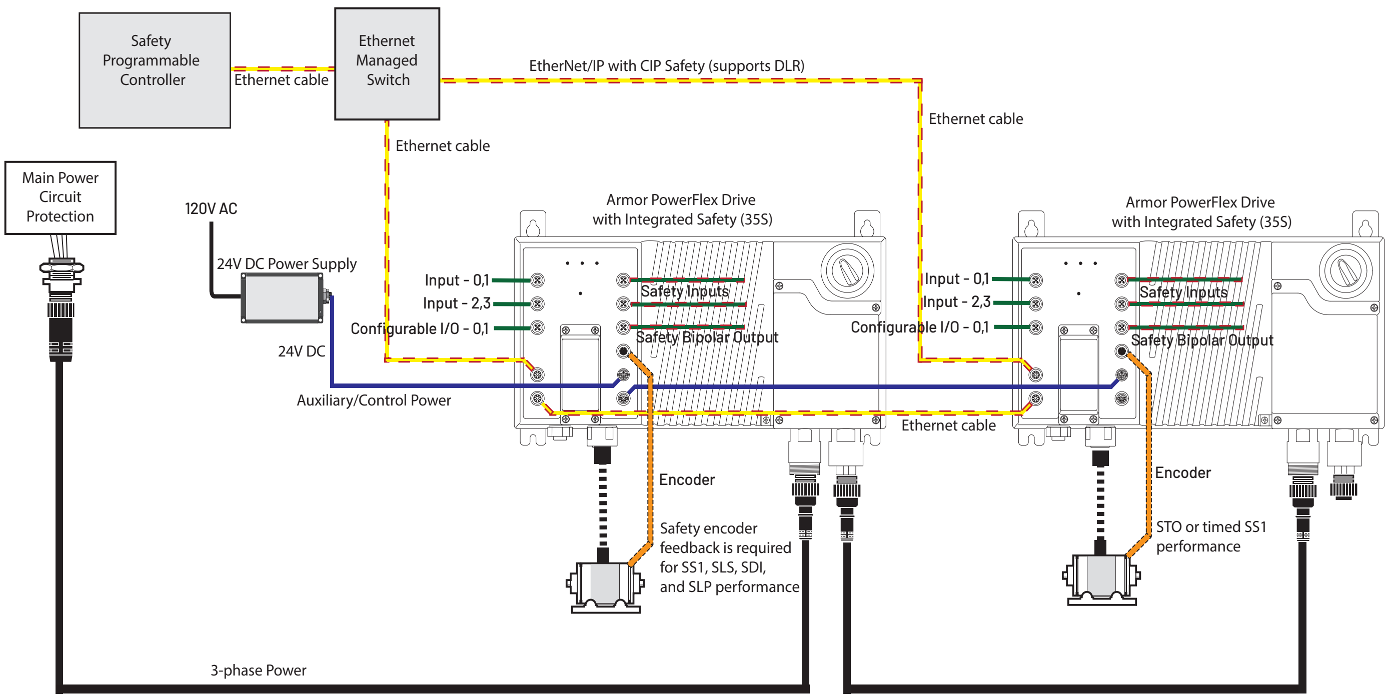


### Integrated Safe Speed Monitoring

Armor PowerFlex drives are capable of safe stop and safe speed monitor functions via drive-based and controller-based integrated safety over the EtherNet/IP network.

In this example, the SS1 stopping function is used in a standard and safety drive-based configuration with dual-feedback monitoring.

**Figure 9 - Integrated Safe Speed Monitored**



# Notes:

# Install the Armor PowerFlex Drive

This chapter provides installation information.

## Unpack and Inspect

The installer/customer is responsible for thoroughly inspecting the equipment before accepting the shipment from the freight company. Check the items that are received against the purchase order. If any items are damaged, it is your responsibility not to accept delivery until the freight agent has noted the damage on the freight bill. If any concealed damage is found during unpacking, it is again your responsibility to notify the freight agent. Leave the shipping container intact and request the freight agent to make a visual inspection of the equipment.

Follow these steps to unpack and inspect the unit:

- Remove all packing material, wedges, or braces from within and around the Armor PowerFlex controller.
- Remove all packing material from the device or devices.
- Check the items nameplate numbers against the purchase order. See Catalog Number Explanation on page 18 and for an explanation of the catalog number system that aids in nameplate interpretation.
- Contact your local Allen-Bradley distributor if any items are missing.

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| **IMPORTANT** | Before the installation and startup of the drive, you must perform a general inspection of mechanical integrity (for example: loose parts, wires, connections, packing materials, and so on). |

| | |
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| **IMPORTANT** | Locate and retain the red STO bypass plug that ships with the product. It can be used for product commissioning. See STO Bypass Operation on page 90. |

## Storage

The drive must remain in its shipping container before installation. If the equipment will not be used for some time, it must be stored according to the following instructions to maintain warranty coverage.

- Store in a clean, dry location.
- Store within an ambient temperature range of –25…+70 °C (–13…+158 °F).
- Store within a relative humidity range of 5…95%, noncondensing.
- Do not store equipment where it can be exposed to a corrosive atmosphere.
- Do not store equipment in a construction area.

## Personal and Electrical Safety Precautions

In addition to the precautions listed throughout this manual, the following statements, which are general to the system, must be read and understood.

**ATTENTION:** Only trained and qualified personnel familiar with the controller and associated machinery can plan or implement the installation, startup, adjustment, and subsequent maintenance or repair of the system. You must have previous experience with and a basic understanding of electrical terminology, configuration procedures, required equipment, and safety precautions.

**ATTENTION:** An incorrectly applied or installed drive can damage components or reduce product life. Wiring or application errors, such as undersizing the motor, incorrect or inadequate AC supply, or excessive ambient temperatures, can result in malfunction of the system.

**ATTENTION:** If this equipment is used in a manner not specified by the manufacturer, the protection that is provided by the equipment, could be impaired.

**ATTENTION:** If a malfunction or damage occurs, make no attempt to repair. Return the module to the manufacturer for repair. Do not dismantle the module.

**ATTENTION:** The National Electrical Code® (NEC®), NFPA®79, and any other governing regional or local code overrules the information in this manual. Rockwell Automation cannot assume responsibility for the compliance or proper installation of the Armor PowerFlex drive or associated equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

**ATTENTION:** This unit has remote sources of power. Disconnect all power sources before the cover is removed. Failure to comply could result in death or serious injury.
**ATTENTION:** Do not attempt to service internal components when the unit is energized. Complete lock out / tag out procedures for all input power sources.

**ATTENTION:** The drive contains high-voltage capacitors. After removal of the main power supply, the capacitor discharge process can take 30 seconds to several minutes before a safe voltage is reached. Before working on the drive, or before servicing any device on the motor side, follow the procedure Test for Hazardous Voltage, starting on page 206, to verify that power is isolated and to verify that there are no hazardous voltages present. Use the test points under the power section door to confirm there are no hazardous AC line voltages (Test points: D1, D2, D3), and to confirm that the DC Bus capacitor bank voltage is at a safe level (Test points: DC+, DC-).
After confirming no hazardous voltages are present at the test points under the power section door, open the power section cover to access the terminal block. Measure the input power on the L1, L2, and L3 of the exposed terminal block to verify that the power has been removed and that no hazardous voltage is present.
Failure to verify that power is removed before working on the drive, or failure to verify that no hazardous voltages are present before working on the drive can result in personal injury or death.
Darkened display light-emitting diode (LED) status indicators are not an indication that capacitors have discharged to safe voltage levels.

**SHOCK HAZARD:** To avoid electrical shock, open the appropriate upstream protection (disconnect switch or branch circuit protection) before connecting and disconnecting cables.
Risk of shock exists. Unused receptacles must be capped, the environmental rating might not be maintained with uncapped receptacles.

Do not operate controls or open covers without appropriate personal protective equipment. Failure to comply can result in serious injury or death.

**WARNING:** Circumstances that can cause an explosion could exist, which could lead to personal injury or death, property damage, or economic loss. Tripping of the instantaneous-trip circuit breaker is an indication that a fault current has been interrupted. Current-carrying components of a drive must be examined and replaced if they are damaged, to reduce the risk of fire or electrical shock.

**ATTENTION:** Solid-state equipment has operational characteristics that differ from the characteristics 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 rok.auto/literature, describes some important differences between solid-state equipment and hard-wired electromechanical devices.

## Precautions for Cold Temperature Conditions

**ATTENTION:** To make sure that the cables and the Armor PowerFlex connection points are at the same temperature within specifications at the time of installation, place the Armor PowerFlex and cables in an environment warmer than -25 °C (-13 °F) for a minimum of 1 hour, before connecting the cables to the Armor PowerFlex.

**ATTENTION:** Before operating a motor with the Armor PowerFlex in a -25…-30 °C (-13…-22 °F) environment, power up the Armor PowerFlex for approximately 45 minutes, to allow the internal temperature to stabilize.

## Precautions for Motor Start/Stop

**ATTENTION:** A contactor or other device that routinely disconnects and reapplies the AC line to the drive to start and stop the motor can cause drive hardware damage. The drive is designed to use control input signals that start and stop the motor. If used, the input device must not exceed one operation per minute or drive damage can occur.

## Avoid Electrostatic Discharge

**ATTENTION:** This Armor PowerFlex drive contains Electrostatic Discharge (ESD) sensitive parts and assemblies. Static control precautions are required when you install, test, service, or repair this assembly. Component damage can result if ESD control procedures are not followed. If you are not familiar with static control procedures, see an applicable ESD protection handbook.

## Environmental Considerations

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

## Mounting Orientation

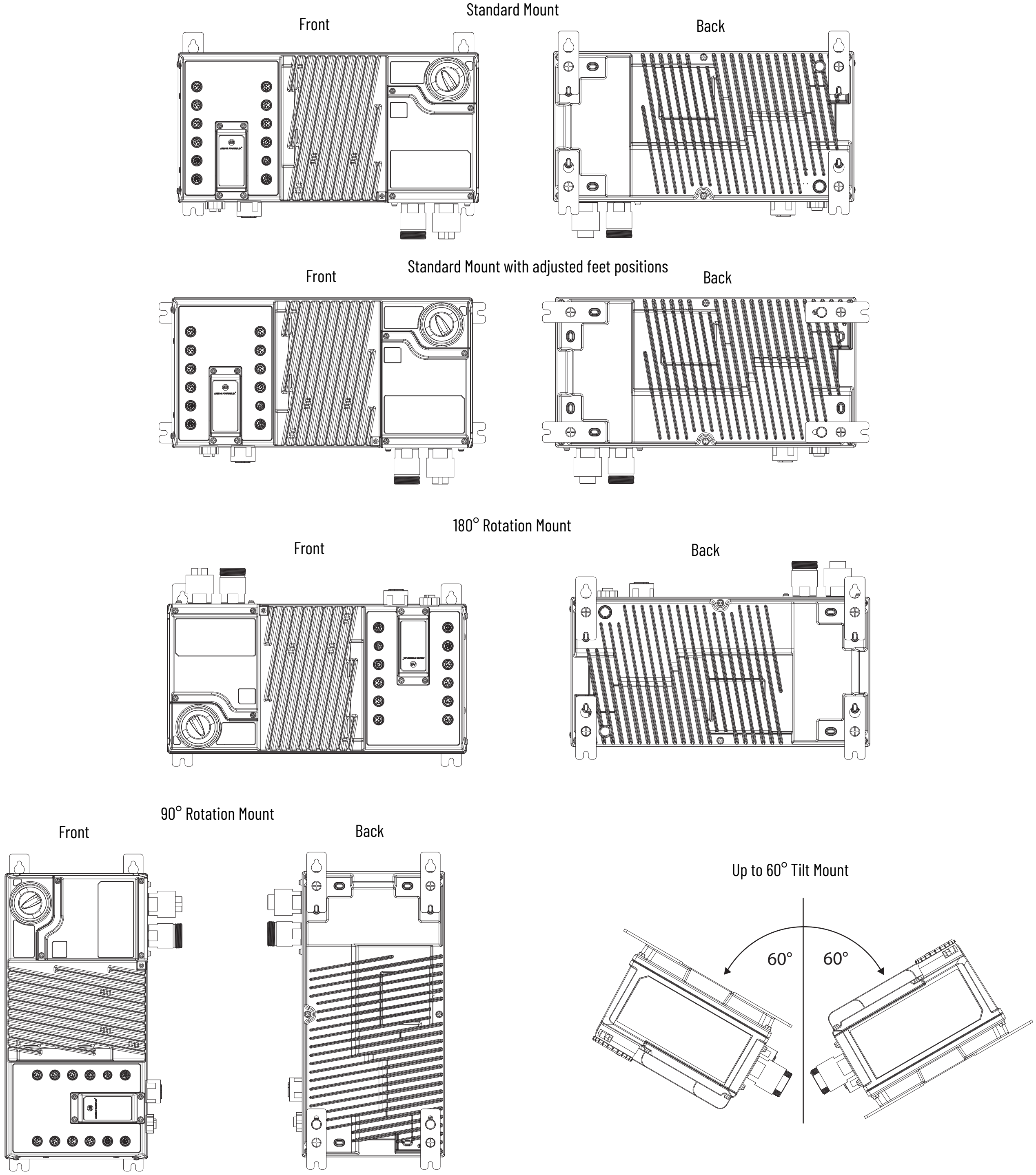
Standard orientation is with the X-axis horizontal (left-right), Y-axis vertically aligned with gravity, and the Z-axis out from a standard panel orientation; this results in the high-voltage connectors pointing toward the earth.

Acceptable limits of deviation from the standard orientation are as follows:

- Up to 60° tilt about the vertical axis (forward or back)
- 90° rotation (with local disconnect pointing up)
- 180° rotation (with high-voltage connectors pointing up)

These deviations from the standard orientation may result in thermal or power derating. For additional details, see Configure Motor Protection on page 154.

**Figure 11 - Mount Positions with Mounting Feet Shown**

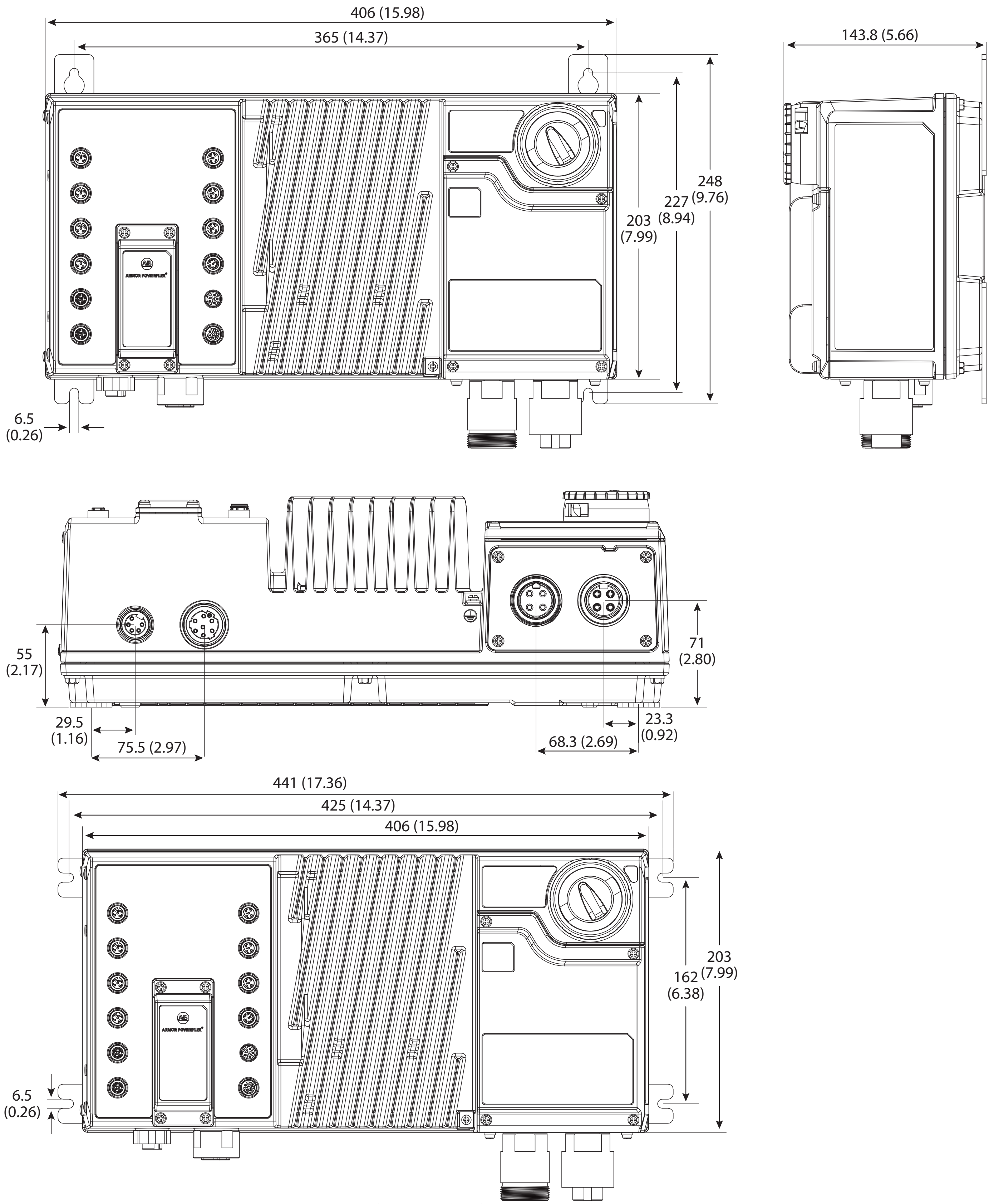



**ATTENTION:** For proper heat dissipation and product operation, mount in one of the orientations shown in Figure 11.

## Armor PowerFlex Drive Dimensions

Dimensions are shown in millimeters (inches). Dimensions are not intended to be used for manufacturing purposes. All dimensions are subject to change.

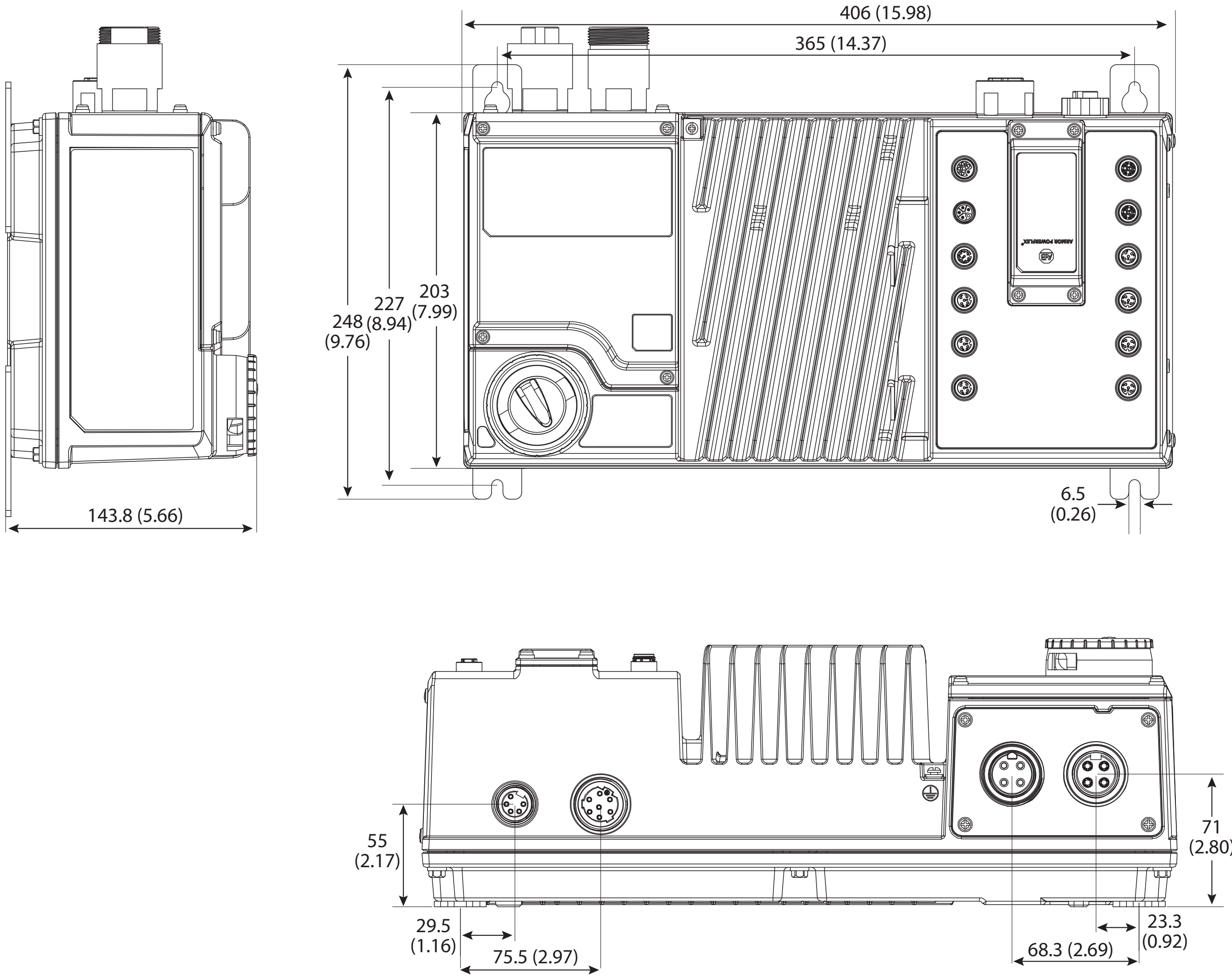
**Figure 12 - Armor PowerFlex Frame Size A: Standard Mounting Position**




Alternate mounting bracket orientation

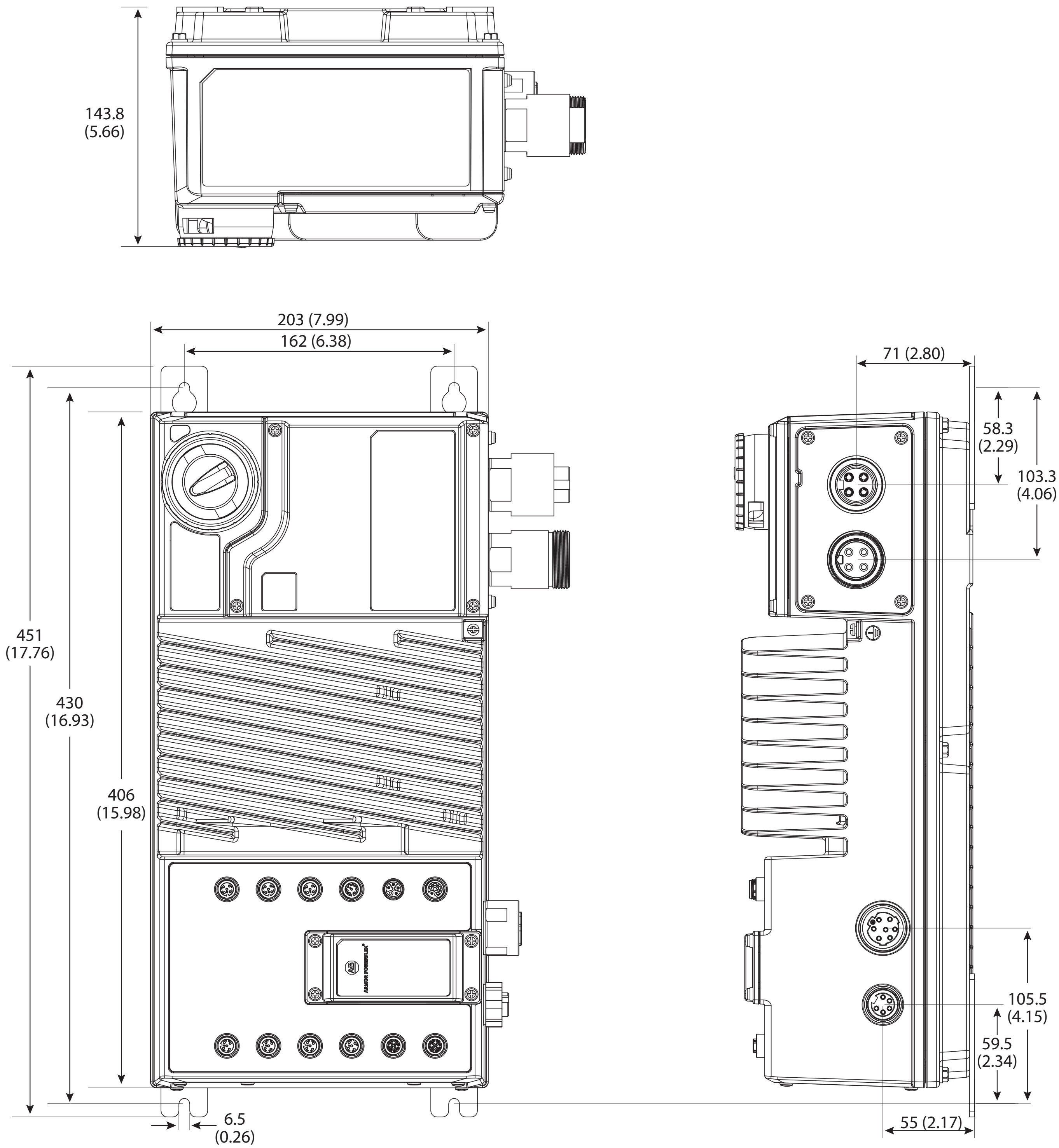
Dimensions are shown in millimeters (inches). Dimensions are not intended to be used for manufacturing purposes. All dimensions are subject to change.

**Figure 13 - Armor PowerFlex Frame Size A: 180° Mount Position**



Dimensions are shown in millimeters (inches). Dimensions are not intended to be used for manufacturing purposes. All dimensions are subject to change.

**Figure 14 - Armor PowerFlex Frame Size A: 90° Mount Position**



## Wiring and Workmanship Guidelines

In addition to conduit and seal-tite raceway, it is acceptable to use cable that is rated Tray Cable Exposed Runs (TC-ER), for power and control wiring on Armor PowerFlex installations. The National Electrical Code (NEC) and NFPA 79 outline the following guidance for installations in the USA and Canada.

In industrial establishments where the conditions of maintenance and supervision verify that only qualified persons service the installation, and where the exposed cable is continuously supported and protected against physical damage, by using mechanical protection, such as struts, angles, or channels, Type TC tray cable that complies with the crush and impact requirements of Type MC (Metal Clad) cable and is identified for such use with the marking Type TC-ER (Exposed Run) shall be permitted between a cable tray and the utilization equipment or device as open wiring. The cable shall be secured at intervals not exceeding 1.8 m (6 ft) and installed in a good workmanlike manner. Equipment grounding for the utilization equipment shall be provided by an equipment grounding conductor within the cable.

While the Armor PowerFlex drive is intended for installation in factory floor environments of industrial establishments, the following must be considered when locating the Armor PowerFlex drive in the application:

- Cables that include control voltage cables, for example, 24V DC and communications, are not to be exposed to operator or building traffic on a continuous basis.
- Location of the Armor PowerFlex drive to minimize exposure to continual traffic is recommended. If location to minimize traffic flow is unavoidable, other barriers to minimize inadvertent exposure to the cabling must be considered.
- Cables must be routed to minimize inadvertent exposure and/or damage.
- If conduit or other raceways are not used, we recommend that strain relief fittings be used when installing the cables for the control and power wiring through the conduit openings.
- Power cabling, such as three-phase, source brake, and dynamic brake, must be kept at least 150 mm (6 in.) away from the EtherNet/IP network and I/O cables to avoid noise issues.

See Wiring on page 42 for additional cable location requirements.

The Armor PowerFlex drive is meant to be disconnected and replaced after proper lockout/tagout procedures have been employed.

## Electromagnetic Compatibility

The following guidelines are provided for Electromagnetic Compatibility (EMC) installation compliance.

### Cabling and Grounding

| | |
|---|---|
| **IMPORTANT** | For EMC, the motor cable connector that is selected must provide good 360° contact and low transfer impedance from the shield or armor of the cable to the conduit entry plate at both the motor and the Armor PowerFlex drive, for electrical bonding.<br>The motor cable must be kept as short as possible to avoid electromagnetic emissions and capacitive currents. CE conformity of Armor PowerFlex drive with EMC Directive does not confirm that the entire machine installation complies with CE EMC requirements. |

The Electromagnetic Interference (EMI) filter can achieve relatively high ground leakage currents. Therefore, the filter must only be used in installations that are solidly grounded (bonded) to the building power distribution ground. Grounding must not rely on flexible cables and must exclude any form of plug or socket that would permit inadvertent disconnection. Some local codes can require redundant ground connections. The integrity of all connections must be periodically checked.

### Wiring

Wire in an industrial control application can be divided into three groups: power, control, and signal. The following recommendations for physical separation between these groups, are provided to reduce the coupling effect:

- Minimum spacing between different wire groups in the same tray must be 16 cm (6 in.).
- Wire runs outside an enclosure must be run in conduit or have shielding/armor with equivalent attenuation.
- Different wire groups must be run in separate conduits.
- Minimum spacing between conduits that contain different wire groups must be 8 cm (3 in.).

## Product Grounding

Grounding is done for two basic reasons: safety, and noise containment or reduction. While the safety ground scheme and the noise current return circuit can sometimes share the same path and components, they must be considered different circuits with different requirements.

The objective of grounding is to verify that all metal work is at the same ground (or Earth) potential at power frequencies. Impedance between the drive and the building scheme ground, must conform to the requirements of national and local industrial safety regulations or electrical codes. These requirements vary based on country, type of distribution system, and other factors. Periodically check the integrity of all ground connections.

General safety dictates that all metal parts are connected to earth with separate copper wire or wires of the appropriate gauge. To determine the proper conductor size, see the NEC table 250.122 or your local electrical code. Most equipment has specific provisions to connect a ground and PE (protective earth) directly to it.

The following considerations apply to ungrounded and high resistive distribution systems:

**ATTENTION:** The Armor PowerFlex drive contains protective Metal Oxide Varistors (MOVs) that are referenced to a ground. These devices must not be disconnected or installed on an ungrounded and high resistive distribution system.

**ATTENTION:** Do not apply the EMI filter to grounded or ungrounded delta power source. The EMI requires a solidly grounded wye (Y) power source (for example, 480/277 or 400/230V AC, 3-phase power source). If applied to a grounded or ungrounded 480V AC delta power source, the EMI filter maybe damaged.

The installer can connect the product ground in two different ways. The first method is to use the conduit/cord gland plate or the factory installed quick connect power connectors.

The second method is to connect the device's external ground to a solid earth ground connection.

**Armor PowerFlex External Ground**

The ground wire is sized according to the application needs and your local electrical code.

If the product is mounted to a non-grounded surface, the installer must use a second ground that uses the external ground point.

See the National Electrical Code (NEC) NFPA 70 and/or the Electrical Standard for Industrial Machinery, NFPA 79 for proper installation details.

The ground must be connected to earth ground. This ground point must be connected to adjacent building ground (girder, joist), a floor ground rod, busbar, or building ground grid. Grounding points must comply with national and local industrial safety regulations or electrical codes. Some codes can require redundant ground paths and periodic examination of connection integrity.

**ATTENTION:** To avoid electrolytic corrosion on the external earth terminal, avoid the spraying of moisture directly on the terminal. When used in washdown environments apply a sealant or other corrosion inhibitor on the external ground terminal to minimize any negative effects of galvanic or electro-chemical corrosion. Ground connections must be inspected regularly.

## Shielding and Grounding of Motors and Motor Cables

The motor frame or stator core must be connected directly to the protective earth (PE) connection with a separate ground conductor. We recommend that each motor frame is grounded to building ground at the motor.

### *Motor Cable Considerations*

Most recommendations about motor cable address issues come from the nature of the drive output. A pulse width modulation (PWM) drive creates AC motor current by sending DC voltage pulses to the motor in a specific pattern. These pulses affect the wire insulation and can be a source of electrical noise. The rise time, amplitude, and frequency of these pulses must be considered when choosing a wire/cable type. The choice of cable must consider:

1. The effects of the drive output after the cable is installed
2. The need for the cable to contain drive output noise
3. The amount of cable-charging current available from the drive
4. Possible voltage drop (and subsequent loss of torque) for long wire runs

Keep the motor cable lengths less than 14 m (45.9 ft) unless otherwise noted in the device specifications.

*Unshielded Motor Cable*

An unshielded motor cable is allowed for installations that do not require EMC compliance. The use of cables without shielding is generally acceptable for installations where drive electrical noise does not interfere with the operation of other devices such as: communication cards, photoelectric switches, weigh scales, and others. Be certain the installation does not require shielded cable to meet specific EMC standards for CE, RCM, FCC and any other applicable standards. The type of installation determines the cable specifications.

**ATTENTION:** Shielded motor cable is mandatory for EMC emission compliant installations.

## Power Considerations

The following items should be considered for the power circuit design.

### Branch Circuit Protection Requirements

When using ArmorConnect three-phase power media or fixed wire (such as cord or conduit), with the Armor PowerFlex drive, protective devices that meet local applicable electrical codes can be used for the feeder branch circuit protection. The Armor PowerFlex drive is self protected, therefore the feeder protective device is only intended to protect the line-side power conductors.

**ATTENTION:** Select the branch circuit protection that complies with NFPA 79 or NFPA 70 (NEC) and any other governing regional or local codes.

**WARNING:** If the branch circuit protective device trips, you must verify that the Source Brake function is still operational before putting the equipment back in service. If the source brake function is not working properly, loss of brake function or motor damage can occur.

**WARNING:** Do not install the Armor PowerFlex drive where the maximum available fault current exceeds the product rating.

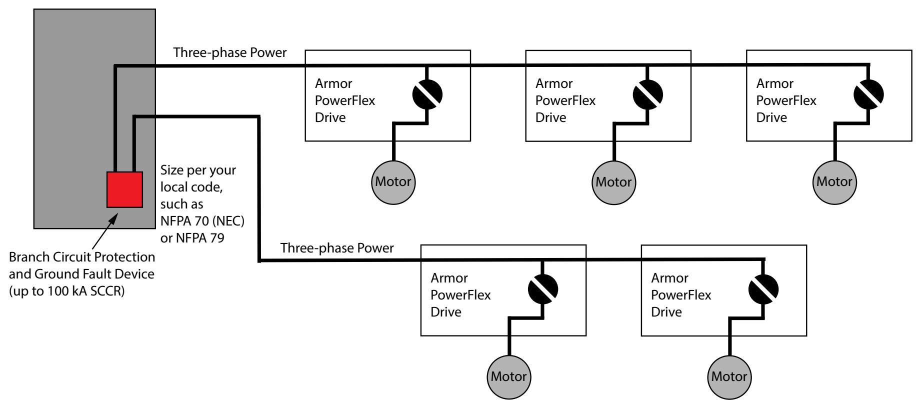
## Group Motor Installations for USA and Canada Markets

The Armor PowerFlex drive integrates the motor branch short circuit and ground fault protection devices and it is considered self-protected. Therefore, no additional motor control branch circuit protection is required. Multiple Armor PowerFlex drives can be applied in a group application; as each Armor PowerFlex is self-protected. The installer must follow the local electrical codes for the protection of the feeder conductors using recommended branch circuit protection devices.

Motor cable assemblies are not supplied and have to be ordered separately. To comply with the UL Listing of the drive, use the Rockwell Automation® motor cable assembly that is specified by the instructions for the drive. See the On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect Products Selection Guide, publication, 280PWR-SG001.

Figure 15 shows an example that illustrates installations involving multiple motors with a single Branch Circuit Protection Device (BCPD) protecting the entire “Group”.

**Figure 15 - Group Motor Installation**




Rockwell Automation offers a wide range of branch circuit protection that will protect your branch circuit conductors that feed power to your Armor PowerFlex drive group.

Our molded case circuit breakers have multiple frame sizes to accommodate your required current ratings and breaking capabilities. These breakers provide protection of circuits against overload, short circuit, and ground fault. For more information, see Molded Case Circuit Breakers.

Our disconnect switches are available in both fixed- and variable-depth styles with flange- or door-mounting styles. Our switches are NEMA, IEC, and UL rated. We offer a variety of fused and non-fused versions from 20…1250 A, in both open and enclosed configurations. For more information, see Fusible Disconnect Switches.

## Auxiliary Power Connections

The 24V DC auxiliary power is supplied by one or two external power supplies or by the optional internal power supply (IPS). If you choose an external power supply configuration, our current offering of auxiliary power cables and receptacles have an IP66, UL Type 1/12 rating. You must confirm that this rating is acceptable for the intended application.

Auxiliary power provides:

- Input/sensor power — sourced from unswitched 24V DC
- Output power — sourced from switched 24V DC
- Communications power — sourced from unswitched 24V DC

## Power Supply Requirements

You can apply the Armor PowerFlex drive with an external 24V DC auxiliary power supply. The external auxiliary power supply will power up communication, inputs, and outputs. The external power supply provides unswitched and switched 24V DC to the Armor PowerFlex drive.

You can install, configure, and operate the I/O without three-phase power connected if you order an Armor PowerFlex drive with the external power supply configuration and if you provide external unswitched 24V DC to the product.

These are the requirements for an external auxiliary power supply:
- Rated for 24V DC nominal (tolerance 24V DC ±15%)
- The supply should be PELV or SELV type
- The supply must be capable of 150% current boost power for at least one second

As an option, you can select an internal power supply (IPS). With this option selected, you do not require an external power supply. The Armor PowerFlex drive will internally source the 24V DC power for communications, inputs, and outputs.

The 24V DC IPS is sourced from the three-phase power coming into the Armor PowerFlex drive. The IPS circuitry connects to the line side of the local disconnect, which means that when the local disconnect on the Armor PowerFlex drive is in the Off position, the IPS will continue to provide 24V DC power. To shutdown the IPS output power, the main disconnect must be set to the Off position, to remove all three-phase power coming into the Armor PowerFlex drive.

**IMPORTANT** There is an instantaneous inrush of 6.5 A for 15 milliseconds. The external 24V DC power supply must be able to support this demand when multiple Armor PowerFlex drives are turned ON simultaneously. For supplies without this capacity, we recommend applying unswitched power first and after a 2…4 second delay, apply switched power. If auxiliary power falls below 20.4V DC, there is a higher risk of communications issues or device faults.

**IMPORTANT** Both a switched and unswitched 24V supply from this source are provided to the safety subsystem. The installer is responsible for providing safety power that is PELV or SELV rated.

**IMPORTANT** To comply with the CE Low Voltage Directive (LVD), all connections to this equipment must be powered from a source compliant with the following:
- Safety extra low voltage (SELV) Supply
- Protected extra low voltage (PELV) Supply

To comply with UL/cUL requirements, this equipment must be powered from a source compliant with the following:
- IEC 60950-1 Ed. 2.1, Clause 2.2 - SELV Circuits

## Field Earth Jumper

There is a "Field Earth" (FE) jumper that is located on the I/O board. The purpose of the FE jumper is to filter the noise on the auxiliary (AUX) power rail.

- Connect the FE jumper to pin 1 and pin 2 of the B17 connector to configure the drive into the Field Earth Not Connected (FENC) mode.
- Connect the FE jumper to pin 2 and pin 3 of the B17 connector to configure the drive into the Field Earth mode.

The default position of the FE jumper is in the FENC mode. Do **not** change this position if there are other Armor PowerFlex drives that are not daisy-chained with AUX 24V power, because the Field Earth pin on the AUX POWER IN connector is connected to field earth irrespective of FE jumper position.

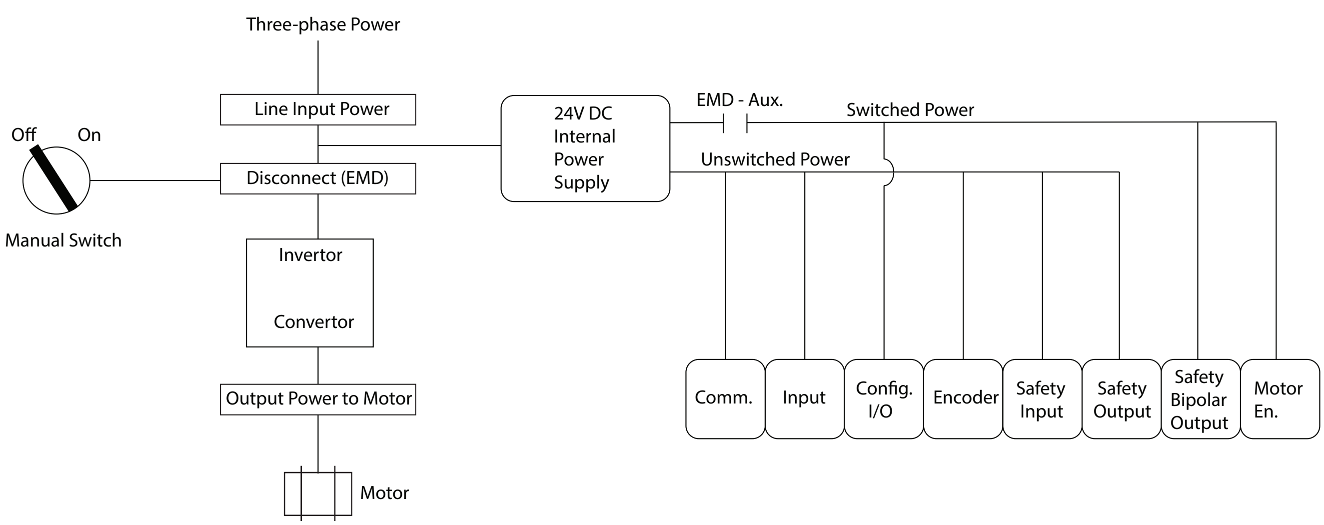
Change the jumper position to the Field Earth mode when there are other Armor PowerFlex drives that are daisy chained with AUX 24V power. This helps to filter the noise on the AUX 24V power cable in this daisy-chained drive configuration. See Table 5.

**Table 5 - Field Earth Jumper Configuration**

| Field Earth Jumper Position | Description |
|---|---|
| Pin 1 to Pin 2 (default) | Field Earth Not Connected (FENC) mode:<br>For multiple drives that are **not** daisy chained with 24V auxiliary power. |
| Pin 2 to Pin 3 | Field Earth mode:<br>For multiple drives that are daisy chained with 24V auxiliary power. |

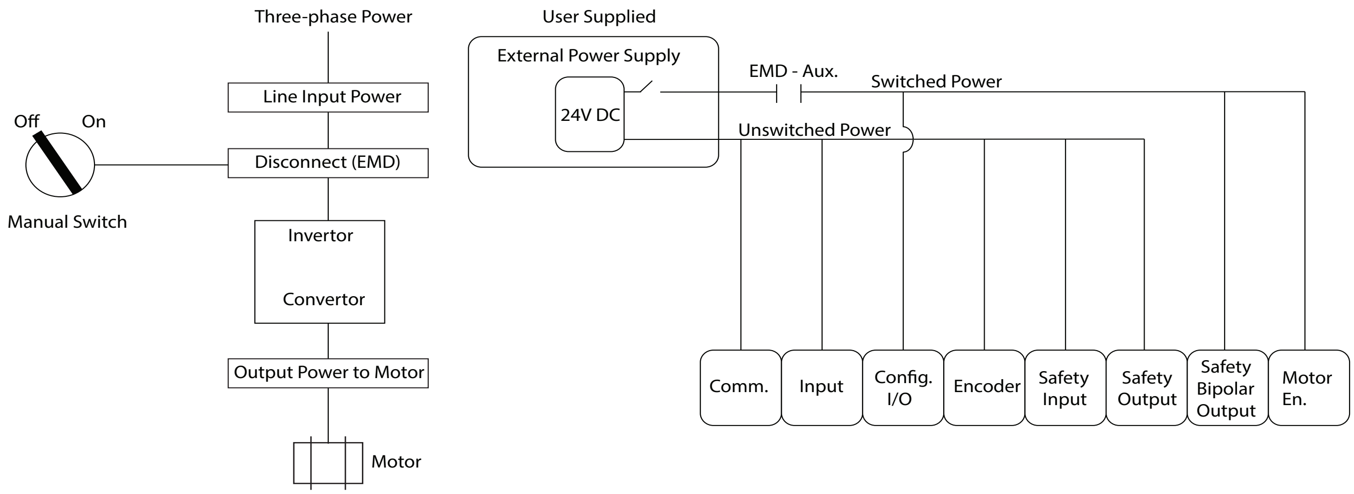
## Internal Power Supply Wiring and Local Disconnect Behavior

**Figure 16 - Internal Power Supply (optional)**



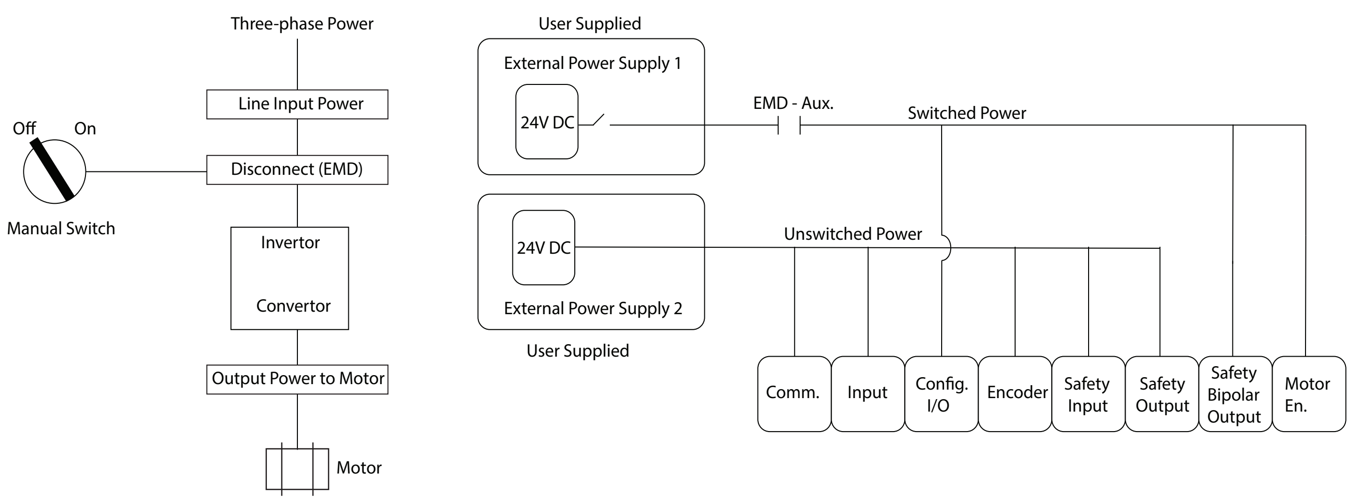
## Single External Power Supply Wiring and Local Disconnect Behavior

**Figure 17 - Single External Power Supply**



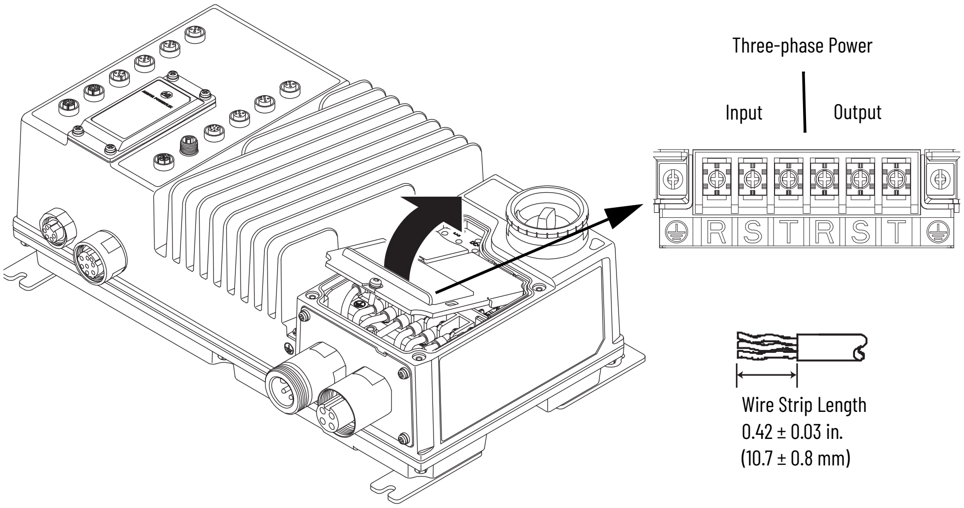

## Multiple External Power Supply Wiring and Local Disconnect Behavior

**Figure 18 - Multiple External Power Supplies**



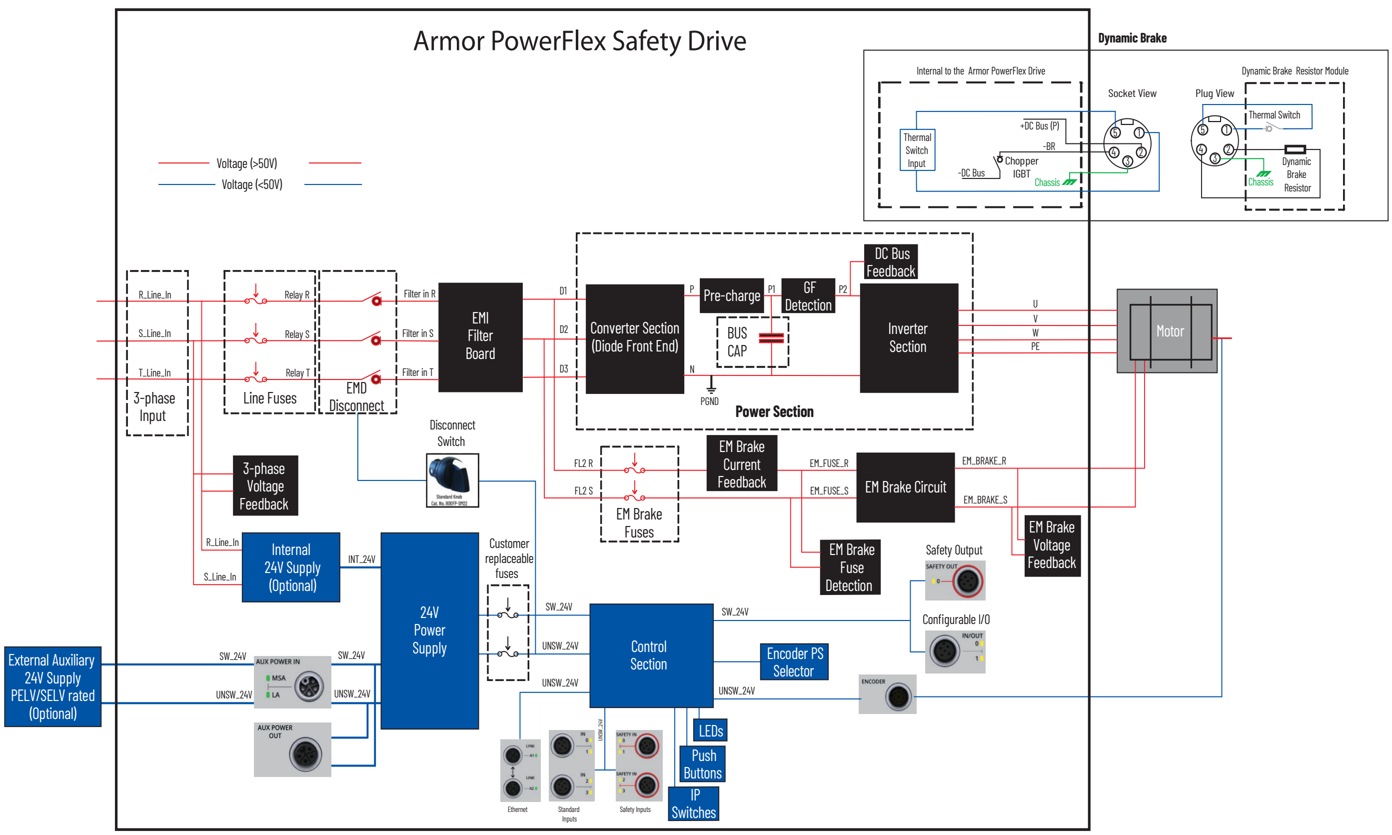
## Power Terminal Location and Internal Wiring

**Figure 19 - Armor PowerFlex Safety Drive Terminals**



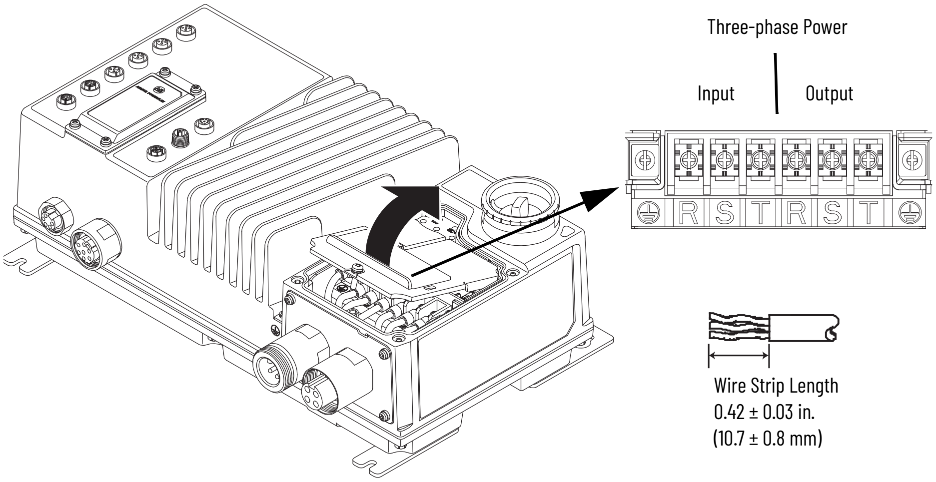

| Terminal Block | Signal | Terminal Size |
|---|---|---|
| **Power In** | | |
| Ground terminal | Ground | 8…18 AWG |
| R | Line 1 (input) | |
| S | Line 2 (input) | |
| T | Line 3 (input) | |
| **Power Out** | | |
| R | Line 1 (output) | 8…18 AWG |
| S | Line 2 (output) | |
| T | Line 3 (output) | |
| Ground Terminal | Ground | |

**Figure 20 - Bulletin 35S — Integrated Safety Version Armor PowerFlex Drive Internal Wiring**



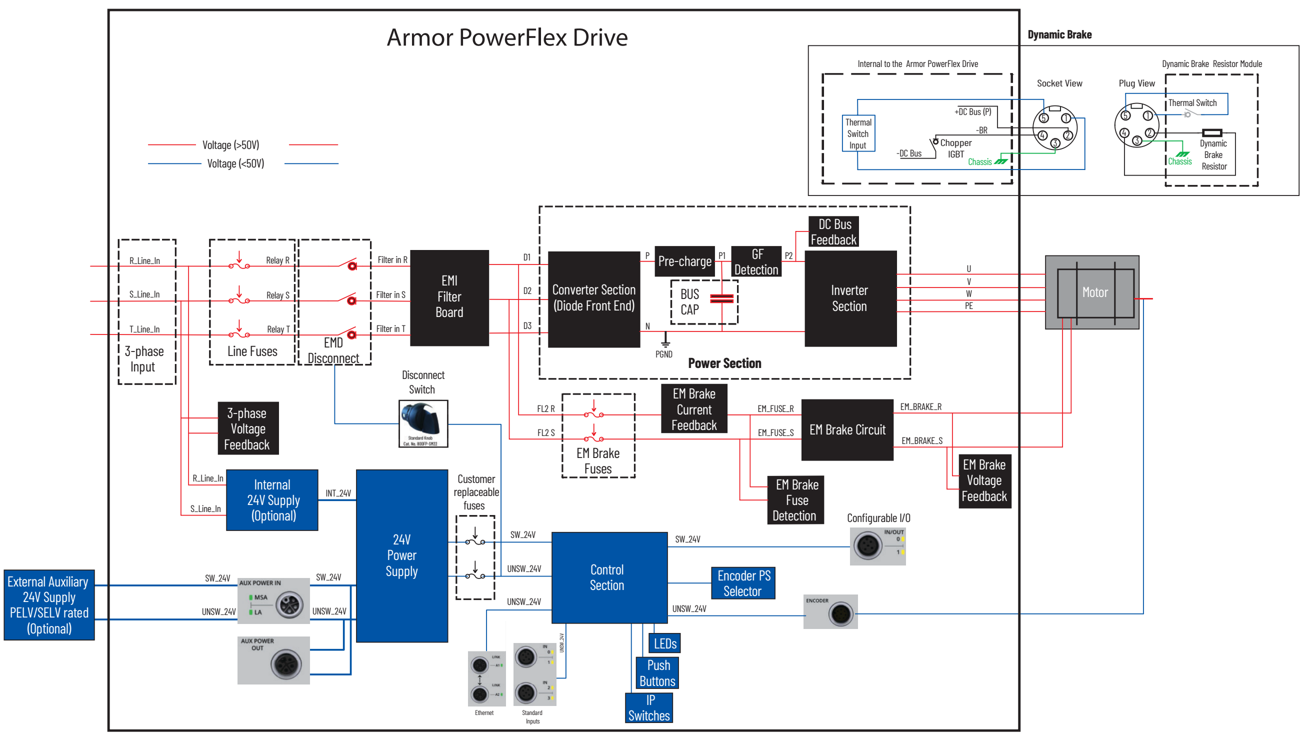

| IMPORTANT | The Electronic Motor Disconnect (EMD) board monitors when the Armor PowerFlex gets a fault. The CPU (Armor PowerFlex firmware) provides a signal to the EMD indicating if a fault is present. When a fault is present, the EMD disconnect opens. When a Dynamic Brake is used, this functionality will serve as an isolating contactor. For additional information about the EMD, see the Local Disconnect Behavior. For details about not using an isolating contactor, see Configure Dynamic Brake on page 166. |
|---|---|

**Figure 21 - Bulletin 35E — Armor PowerFlex Standard Drive Terminals**




| Terminal Block | Signal | Terminal Size |
|---|---|---|
| **Power In** | | |
| Ground terminal | Ground | 8…18 AWG |
| R | Line 1 (input) | |
| S | Line 2 (input) | |
| T | Line 3 (input) | |
| **Power Out** | | |
| R | Line 1 (output) | 8…18 AWG |
| S | Line 2 (output) | |
| T | Line 3 (output) | |
| Ground Terminal | Ground | |

**Figure 22 - Bulletin 35E — Standard Version Armor PowerFlex VFD Internal Wiring**

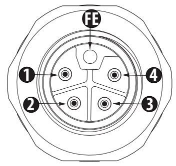



| | |
|---|---|
| **IMPORTANT** | The Electronic Motor Disconnect (EMD) board monitors when the Armor PowerFlex gets a fault. The CPU (Armor PowerFlex firmware) provides a signal to the EMD indicating if a fault is present. When a fault is present, the EMD disconnect opens. When a Dynamic Brake is used, this functionality will serve as an isolating contactor. For additional information about the EMD, see the Local Disconnect Behavior. For details about not using an isolating contactor, see Configure Dynamic Brake on page 166. |

## Power and Motor Connector Pinouts and Cable Torques

| | |
|---|---|
| **IMPORTANT** | You must connect cables properly and use sealing caps or dust covers as needed, to achieve specified enclosure ratings. |

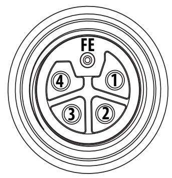
### Auxiliary Power IN (M12, plug)




Pin 1: +24V unswitched power (sensor power) (brown)
Pin 2: Switched power ground (white)
Pin 3: Unswitched power ground (blue)
Pin 4: +24V switched power (black)
FE: FE pass-through jumper (gray)

**Cable Connector Torque**
0.6…0.65 N•m (5.3…5.8 lb•in)

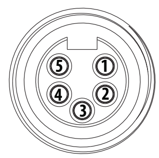
### Auxiliary Power OUT (M12, socket)




Pin 1: +24V unswitched power (sensor power) (brown)
Pin 2: Switched power ground (white)
Pin 3: Unswitched power ground (blue)
Pin 4: +24V switched power (black)
FE: FE pass-through jumper (gray)

**Cable Connector Torque**
0.6…0.65 N•m (5.3…5.8 lb•in)

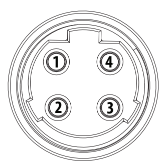
### Dynamic Brake Connection (M22, socket)



Pin 1: DB temp SW-
Pin 2: DB resistor T1
Pin 3: Chassis (PE)
Pin 4: DB resistor T2
Pin 5: DB temp SW+

**Cable Connector Torque**
1.69 N•m (15 lb•in)

### Motor without EM brake (M29, socket)



Pin 1: Motor T1 (black)
Pin 2: Motor T2 (white)
Pin 3: Motor T3 (red)
Pin 4: Ground (green/yellow)

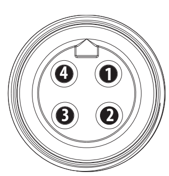
**Cable Connector Torque**
2.26 N•m (20 lb•in)

### Motor with EM brake (M29, socket)

Pin 1: Motor T1 (black)
Pin 2: Motor T2 (white)
Pin 3: Motor T3 (red)
Pin 4: Ground (green/yellow)
Pin 5: EM brake T1
Pin 6: EM brake T2
Pin 7: Drain wire

**Cable Connector Torque**
2.26 N•m (20 lb•in)

### Three-Phase Power IN with Round Connector (M35, plug)

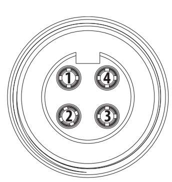


Pin 1: L1 (black)
Pin 2: Ground (green/yellow)
Pin 3: L3 (red)
Pin 4: L2 (white)

Use when application requires UL or CE compliance as standard

**Cable Connector Torque**
4.52 N•m (40 lb•in)

### Three-Phase Power OUT with Round Connector (M35, socket)

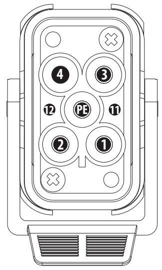


Pin 1: L1 (black)
Pin 2: Ground (green/yellow)
Pin 3: L3 (red)
Pin 4: L2 (white)

Use when application requires UL or CE compliance as standard

**Cable Connector Torque**
4.52 N•m (40 lb•in)

### Three-Phase Power IN with Square Connector — plug

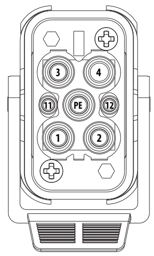


Pin 1: Line input 1
Pin 2: Line input 2
Pin 3: Line input 3
Pin 4: not used
Pin 11: not used
Pin 12: not used
Center Pin: Chassis (PE)

Use when application requires CE compliance as standard

**Cable Connector Torque**
Snap in place (no torque)

### Three-Phase Power OUT with Square Connector — socket



Pin 1: Line input 1
Pin 2: Line input 2
Pin 3: Line input 3
Pin 4: not used
Pin 11: not used
Pin 12: not used
Center Pin: Chassis (PE)

Use when application requires CE compliance as standard

**Cable Connector Torque**
Snap in place (no torque)

## Standard I/O Connections and Cable Torques

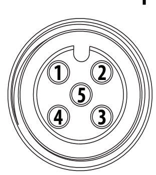
| | |
|---|---|
| **IMPORTANT** | You must connect cables properly and use sealing caps or dust covers as needed, to achieve specified enclosure ratings. |

**ATTENTION:** No power should be applied to the input connectors. The 24V and Chassis (PE) terminals are only meant to supply power from the Armor PowerFlex drive to external sensor devices (power output). If the drive is powered via the input connectors, there is no fuse protection on the 24V supply and an input power overcurrent fault will occur, that cannot be cleared.

The following characteristics are common to the I/O connections for Armor PowerFlex standard versions:

- 5-pin female connectors (M12)
- Four fixed inputs (two per connector)
- Two configurable points on one connector

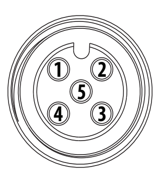
### I/O Standard Input (M12, socket)



**Input**
Pin 1:+24V unswitched (sensor) power
Pin 2: Input n+1
Pin 3: Input Common
Pin 4: Input n
Pin 5: Chassis (PE)

**Cable Connector Torque**
0.5…0.6 N•m (4.4…5.3 lb•in)
(hand tight)

### I/O Configurable Input or Output (M12, socket)



**Input**
Pin 1: +24V switched power
Pin 2: Input 1
Pin 3: I/O Common
Pin 4: Input 0
Pin 5: Chassis (PE)

**Output**
Pin 1: Not used (+24V)
Pin 2: Output 1
Pin 3: I/O Common
Pin 4: Output 0
Pin 5: Chassis (PE)

**Cable Connector Torque**
0.5…0.6 N•m (4.4…5.3 lb•in)
(hand tight)

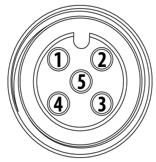
## Safety I/O Connections and Cable Torques

The following input and output characteristics are common to the I/O connections for Armor PowerFlex safety versions:

- Four single-channel or two dual-channel 24V DC safety input
- Two single-channel 24V DC test output
- One bipolar 24V DC safety output

For specific user safety I/O wiring examples, see Safety Drives Configuration on page 29.

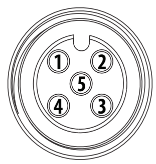
### I/O Safety: Configurable 2-channel safety input with test outputs (M12, socket)



Pin 1: Test Output 1
Pin 2: Safety Input n+1
Pin 3: Common
Pin 4: Safety Input n
Pin 5: Test Output 0

**Cable Connector Torque**
0.5…0.6 N•m (4.4…5.3 lb•in)
(hand tight)

### I/O Safety: Configurable bipolar output (M12, socket)

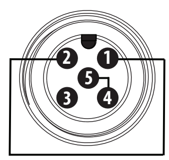


Pin 1: NC (no connection)
Pin 2: Output n (N) sinking
Pin 3: Output Power Common
Pin 4: Output n (P) sourcing
Pin 5: Output Power Common

**Cable Connector Torque**
0.5…0.6 N•m (4.4…5.3 lb•in)
(hand tight)

### I/O Safety: Jumper Bypass Plug

Used when no cables are connected to the safety inputs. Only one jumper is required and can be attached to Safety In 0/1 or Safety In 2/3 (but not both), to enable torque in hardwired mode.



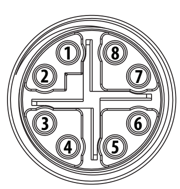
Pin 1: connect to Pin 2
Pin 2: connect to Pin 1
Pin 3: NC (no connection)
Pin 4: connect to Pin 5
Pin 5: connect to Pin 4

**Cable Connector Torque**
0.5…0.6 N•m (4.4…5.3 lb•in)
(hand tight)

## Ethernet Connections and Cable Torque

The Armor PowerFlex drive uses a sealed X-coded M12 (micro) style Ethernet connector.

### EtherNet 1 GB (M12, socket)



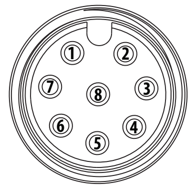
Pin 1: D1+ (white/orange)
Pin 2: D1- (orange)
Pin 3: D2+ (white/green)
Pin 4: D2- (green)
Pin 5: D4+ (white/brown)
Pin 6: D4- (brown)
Pin 7: D3- (blue)
Pin 8: D3+ (white/blue)

**Cable Connector Torque**
0.5…0.6 N•m (4.4…5.3 lb•in)
(hand tight)

## Encoder Connections and Cable Torque

Encoder systems are sensors that are mounted on the rotor shaft that can record information about the instantaneous rotor position and speed.

**Encoder (M12, socket)**

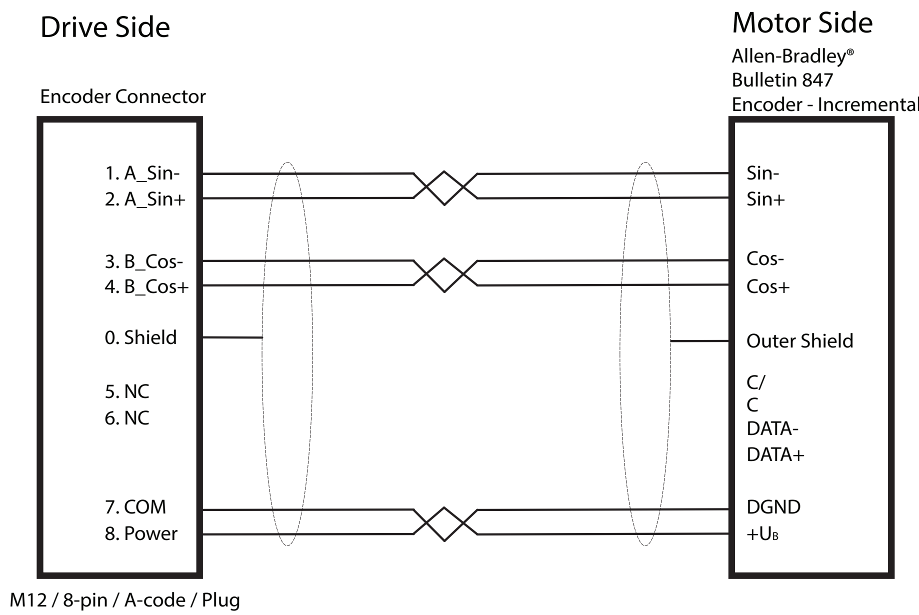



Pin 1: Output A, SIN- (white)
Pin 2: Output A, SIN+ (brown)
Pin 3: Output B, COS- (green)
Pin 4: Output B, COS+ (yellow)
Pin 5: not used (grey)
Pin 6: not used (pink)
Pin 7: Encoder supply ground (blue)
Pin 8: Encoder supply power (5V or 12V) (red)

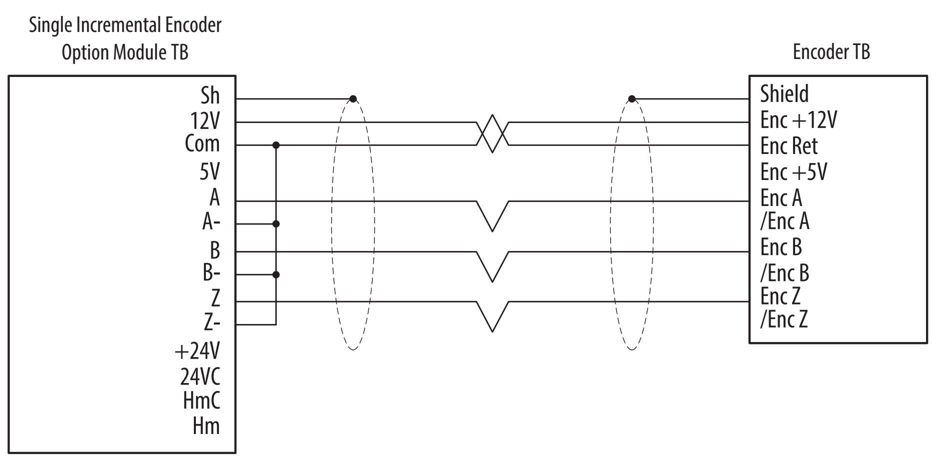
**Cable Connector Torque**
0.5…0.6 N•m (4.4…5.3 lb•in)
(hand tight)

## Encoder Wiring Examples

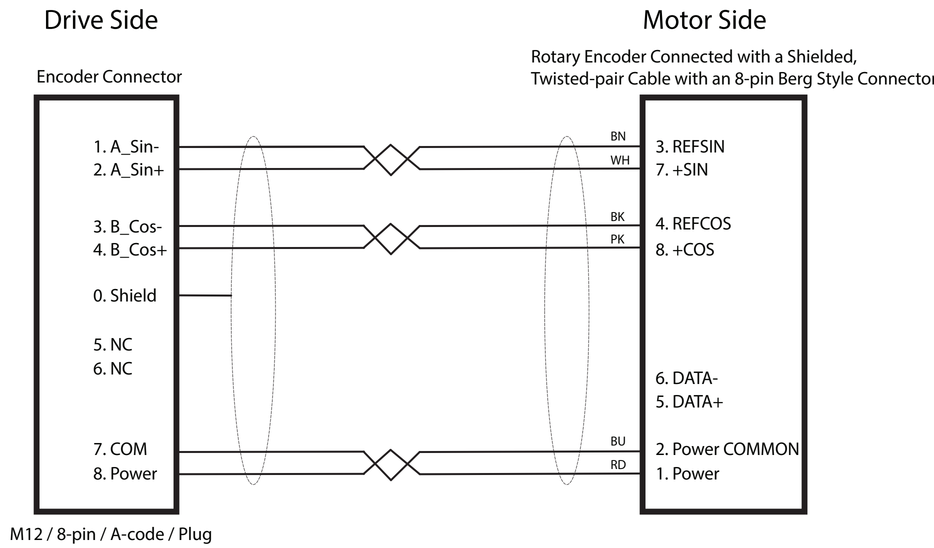
**Sin-Cosin Encoder Wiring Example**




**Differential (AqB) Single-ended Encoder Wiring Example**



**Hiperface (analog only) Encoder Wiring Example**




## ArmorConnect Media

Details of ArmorConnect power media are described in the On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect Products Selection Guide, publication, 280PWR-SG001.

The ArmorConnect power media offers both three-phase and auxiliary power cable cord set systems, including patchcords, receptacles, tees, reducers and accessories, to be used with the Armor PowerFlex drive. These cable system components facilitate quick connection of Armor PowerFlex drives, reducing installation time. They allow repeatable, consistent connection of the three-phase and auxiliary power to the Armor PowerFlex drive and motor by providing a plug and play environment that also avoids system mis-wiring.

**IMPORTANT** We do not recommend using a tool to tighten the connectors. The connectors should be hand tightened and verified by a torque measurement tool. See the ArmorConnect instructions for the recommended tightening torque.

**IMPORTANT** The UL Listing of the Armor PowerFlex drive requires its mating output motor and input power cable assemblies to be only those assemblies that are specified by the instructions for the controller. By using other cable assemblies, you violate the Listing of the controller, which NFPA 79 prohibits (see 1.5 of NFPA 79 and 110.3(B) of NFPA 70 (NEC).

**IMPORTANT** For proper operation of the Armor PowerFlex drive, the maximum total encoder cable length is 20 m (65.6 ft).

**IMPORTANT** For proper operation of the Armor PowerFlex drive, the maximum total cable length for 24V Auxiliary Power IN, is 20 m (65.6 ft).

**SHOCK HAZARD:** Risk of electrical shock. Do not disconnect or connect power cables under load.

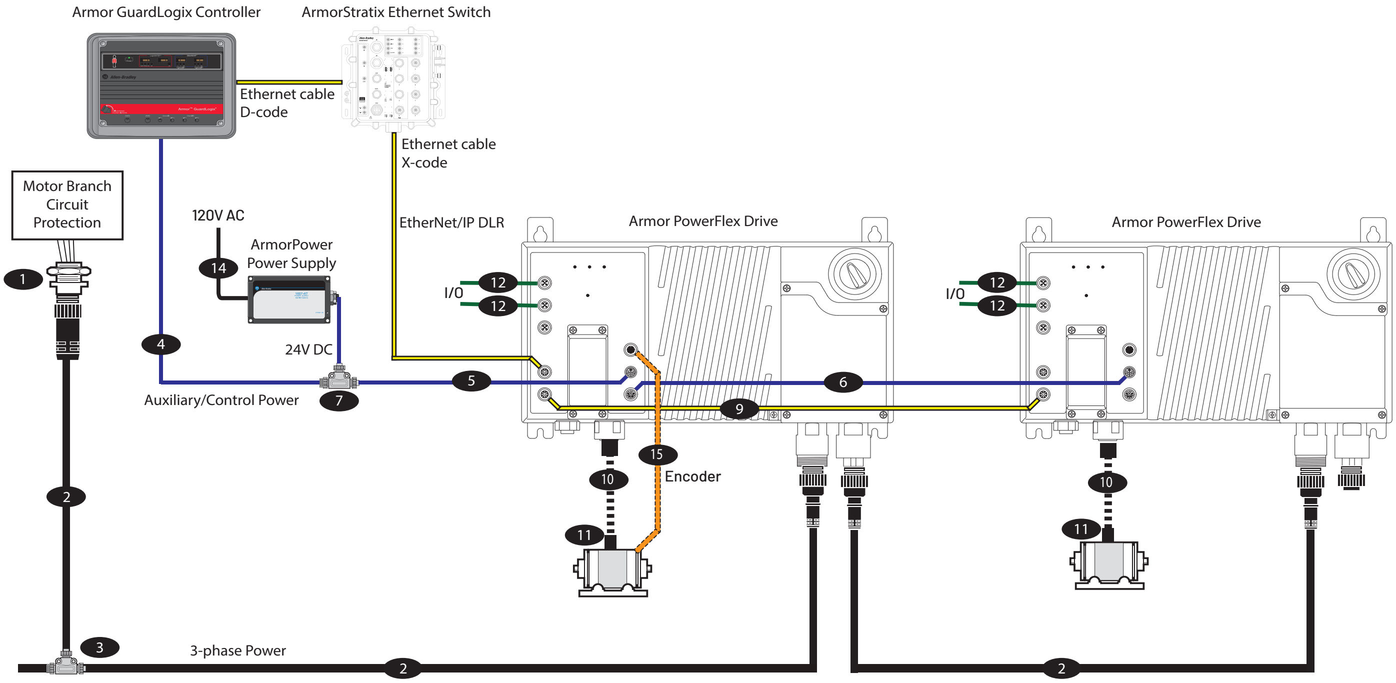
**ATTENTION:** ArmorConnect cables are not intended to be connected or disconnected under load. Connecting or disconnecting ArmorConnect cables under load can result in physical injury or equipment damage, as a result of high make and break currents and potential fault currents.

**ATTENTION:** If you choose to purchase your own cables without connectors and terminate them on site, Rockwell Automation cannot be responsible for failure of the published environmental ratings.

**ATTENTION:** If you install a motor cable that has a connector on one end and floating leads for a field-attachable connector on the other end, use the connector end to attach to the Armor PowerFlex drive.

Figure 23 shows example configurations for power, control, and communication media.

**Figure 23 - Cable System Overview (Armor PowerFlex Drive Standard Version shown)**




| Item | Description | Example Cat. No. |
|---|---|---|
| 1 | Three-phase power receptacle, round<br>or<br>Three-phase power receptacle, square | 280-M35F-Mxx(1)<br>or<br>HARTING® 61 04 201 2753 |
| 2 | Three-phase power cable, round<br>or<br>Three-phase power cable, square | 280-PWRM35A-Mxx(1)<br>or<br>HARTING 61 04 202 2953 Lxxx(1) |
| 3 | Three-phase power t-port, round<br>or<br>Three-phase power t-port, square | 280-T35<br>or<br>HARTING 09 12 008 4720 |
| 4<br>5<br>6 | Auxiliary/Control power cable, 4-pin<br>Auxiliary/Control power cable, 4 to 5-pin<br>Auxiliary/Control power cable, 5-pin | 889N-F4AFNM-xx(1)<br>889L-R5JFN4M-xx(1)(2)<br>889L-R5JFLE-xx(1)(2) |
| 7 | Auxiliary/Control power t-port, 4-pin | 898N-43PB-N4KF |
| not shown | Auxiliary/Control power receptacle, 4-pin | 888N-D4AF1-xx(1) |
| 8<br>9<br>10 | Ethernet patchcord 10/100 MB, D-code to D-code<br>Ethernet patchcord 10/100 MB, X-code to D-code<br>Ethernet patchcord 1 GB, X-code to X-code | 1585D-M4TBDM-xx(1)<br>1585D-E8TGD4E-xx(1)<br>1585D-E8TGDE-xx(1) |
| 11 | Motor cable (with EM brake), 7-pin<br>or<br>Motor cable (without EM brake), 4-pin | 357-PWRM29A-Mxx(1)<br>or<br>280-PWRM29A-Mxx(1)<br>284-PWRM29A-Mxx(1) |
| 12 | Motor receptacle (with EM brake), 7-pin<br>or<br>Motor receptacle (without EM brake), 4-pin | 357-M29M-M05<br>or<br>284-M29M-M03 |
| 13 | I/O cables, standard | 889D-R5ACDE-xx(1) |
| 14 | 120V AC line in cable | 889N-F3AFC-F-xx(1) |
| 15 | Encoder cable | 889D-R8FBDE-xx(1) |
| 16 | Encoder receptacle | 888D-F8AB3-xx(1) |

(1) *xx* specifies the available cable lengths.
(2) Our current offering of 5-pin, auxiliary power cables and receptacles have an IP66, UL Type 1/12 rating. You must confirm that this rating is acceptable for the intended application.

For details, see On-Machine Media for Armor PowerFlex, ArmorStart, and ArmorConnect Products Selection Guide, publication 280PWR-SG001.

## Local Disconnect Behavior

The Armor PowerFlex drive has a local, at-motor disconnect switch that is positioned on the front of the unit. The disconnect is a two position maintained switch. Turn right for the On position and turn left for the Off position.

The local disconnect removes power from the motor terminals and outputs when in the Off condition. The disconnect switch does not remove the test output power for the safety inputs, but it does remove output power for the bi-polar safety output.

When the disconnect switch is in the On position and a short circuit or ground fault event occurs, the Armor PowerFlex drive will fault but the switch handle will **NOT** change state to a fault position. In this case, you need to manually turn the disconnect switch to the Off position.

When the switch is in the Off position, it can be locked in place to provide lockout/tagout (LOTO) for servicing the equipment.

**ATTENTION:** You must verify that hazardous voltages have dissipated before servicing the equipment. For details, see Remove Power Before Servicing the Armor PowerFlex Drive on page 205.

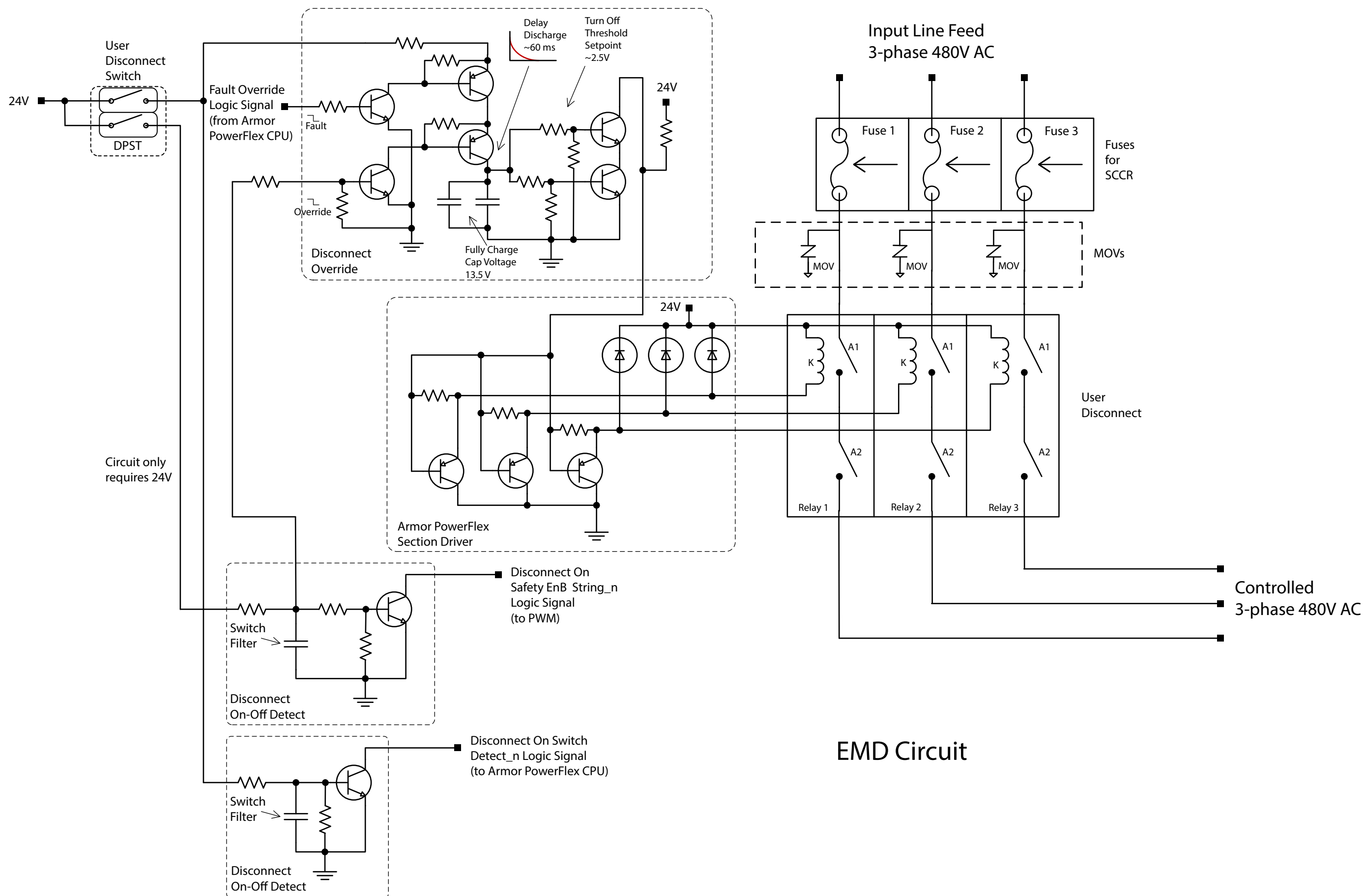
**Figure 24 - Local Disconnect in OFF Position**

## Electronic Motor Disconnect

The Armor PowerFlex local, at-motor disconnect switch uses a patent pending design for Electronic Motor Disconnect (EMD). The EMD design provides a reliable means for automatically or manually, disconnecting the motor and Armor PowerFlex drive, from the three-phase power supply. The EMD design can disconnect power in case of fault conditions, device failures, for maintenance, or other shutdown reasons.

Figure 25 shows a high-level schematic of the EMD control blocks, followed by an explanation of each control block functionality.

**Figure 25 - EMD Circuit**




### *Control Block Explanations*

- **Disconnect Switch** – A low voltage (24V DC) Double Pole Single Throw (DPST) switch that provides manual switching control from the three-phase supply.
- **3-phase Dual Form A Contact Mechanical Relays** (wired in series) – The physical means to disconnect the motor and Armor PowerFlex drive from three-phase power. The relays are controlled by the Driver Control block.
- **Driver** – Circuit that controls the Mechanical Relays of each phase independently to open or close. The Drive Control Block commands come from the Disconnect Override Control block.
- **Disconnect Override** – This circuit controls the Driver Block which commands the relays to open or close. The Disconnect Override Control Block will command the Driver Block to close the Mechanical Relays only if the following conditions are met:

- The first contact of the Disconnect Switch is on, providing 24V DC to the Disconnect Override Control Block
- The Fault Override Logical Signal from the CPU (Armor PowerFlex firmware) is off (24V signal is high)
- The Override Signal from the EnB On-Off Disconnect Detection circuit is off (24V signal is high)

The EMD Disconnect Override Block gets a Fault Signal form the CPU indicating that the Armor PowerFlex drive is faulted. When this occurs, the EMD will open. So if the drive sensed a DB Resistor Thermal event, a fault will be created and the EMD will open, which is what an isolating contactor would be used for.

- **On-Off Disconnect Detection** – Circuit that monitors the state of each of the contacts of the DPST Disconnect Switch. Each contact is monitored independently by the On-Off Disconnect Detection Block to provide redundant feedback of the state of the Disconnect Switch to the CPU (Armor PowerFlex firmware). If either of the feedback signals detects an open contact in the Disconnect Switch, the PWM Driver will be commanded to disable the gate firing of the Inverter Insulated Gate Bipolar Transistors (IGBTs) so power is cut off to the motor connector.

# EtherNet/IP Operation

Armor PowerFlex drives incorporate the advantages of EtherNet/IP communication for access to configuration, status, and diagnostics. These controllers feature:

- Dual-port embedded switch with 1 GB performance[a]
- Star Linear and Device Level Ring topologies

For more information on EtherNet/IP light-emitting diode (LED) indication status, see EtherNet/IP Status Indicators on page 199.

The Armor PowerFlex drive supports:

- Ten connected messaging connections
- One exclusive owner standard I/O connection
- Input and output safety connections for Armor PowerFlex safety drive (35S)

| | |
|---|---|
| **IMPORTANT** | When applying an Armor PowerFlex drive with a two programmable controller architecture; one for standard connection and the other for safety connection, the safety connection must be made before the standard connection or there will be a connection fault. If the standard connection is made first, the drive enters protected mode and will reject the safety connection causing a fault. |

## Set the IP Address

There are different methods available for setting the IP address of the Armor PowerFlex drive. You can choose from the following:

- Set the IP Address using Rotary Switches
- Set the IP Address using the BOOTP/DHCP Server Utility
- Set the IP Address using the FactoryTalk Linx Application

### Set the IP Address using Rotary Switches

Use this procedure if you cannot or do not want to use the BOOTP/DHCP tool.

There are four rotary switches that are used to set the IP address; one Mode switch and three address switches. The Mode switch is used to set one of the five predefined private IP addresses, except for the last octet. The last octet is set by the three address switches. The Armor PowerFlex drive ships with the Mode switch set to 0 and the three address switches set to 999. This configuration has no IP address set for the drive and DHCP is enabled.

(a) Products with EtherNet/IP embedded switch technology have two ports to connect to a linear or DLR network in a single subnet. You cannot use these ports as two Network Interface Cards (NICs) connected to two different subnets.

*Remove Front Logic Cover*

The IP address rotary switches are located under the front logic cover of the Armor PowerFlex drive. With unswitched auxiliary power removed, remove the four screws of the logic cover, then lift it off to access the switches. See Figure 26 and Figure 27.

**Figure 26 - Logic Cover Removal**

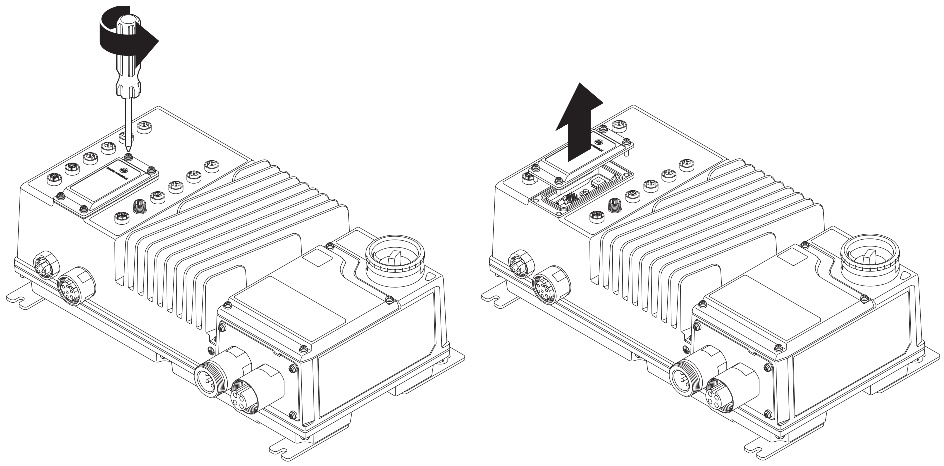
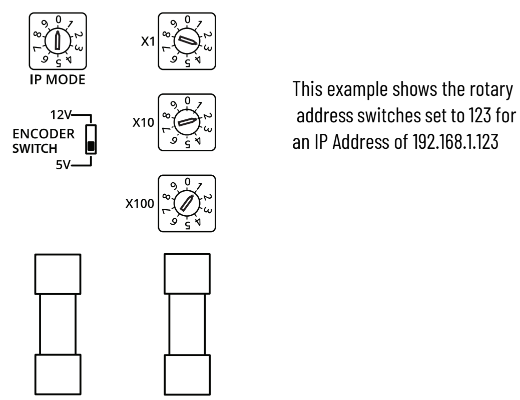


**Figure 27 - IP Address Switches**




The Mode switch operates as follows:

- The Mode switch is read and latched on power-up.
- The drive must have power cycled or reset for any Mode switch changes to be recognized.
- The Mode switch setting is ignored if the rotary switches address is not within the range of 1…254.

Table 6 describes the Mode switch settings when the rotary address switches are set to 1…254.

Set the Mode switch to one of the predefined IP Address types and then, set the rotary address switches to a value that completes the IP address.

**Table 6 - IP Address Mode Switch Settings**

| Mode Switch Setting | IP Address Type | Subnet Mask | Rotary Switches Address | Gateway Address |
|---|---|---|---|---|
| 0 | Class C private IP address = 192.168.1.x(1) | 255.255.255.0 | 1 | 0.0.0.0 |
| | | | 2…254 | 192.168.1.1 |
| 1 | Class C private IP address = 192.168.6.x(1) | 255.255.255.0 | 1 | 0.0.0.0 |
| | | | 2…254 | 192.168.6.1 |

**Table 6 - IP Address Mode Switch Settings (Continued)**

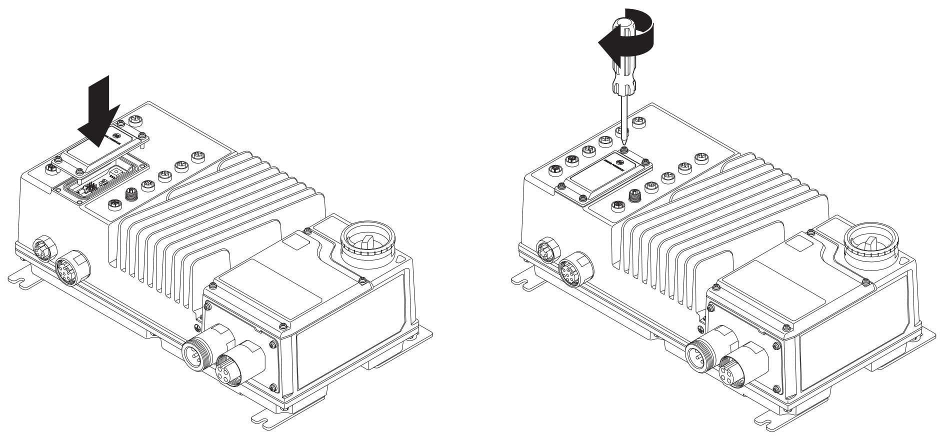
| Mode Switch Setting | IP Address Type | Subnet Mask | Rotary Switches Address | Gateway Address |
|---|---|---|---|---|
| 2 | Class A private IP address = 10.0.11.*x*(1) | 255.255.255.0 | 1 | 0.0.0.0 |
| | | | 2…254 | 10.0.11.1 |
| 3 | IP address = 136.129.6.*x*(1) | 255.255.0.0 | 100 | 0.0.0.0 |
| | | | 2…99 or 101…254 | 136.129.6.100 |
| 4 | IP address = 11.200.0.*x*(1) | 255.255.0.0 | 1 | 0.0.0.0 |
| | | | 2…254 | 11.200.0.1 |
| 5…9 | The network interface is disabled so the drive cannot communicate on the network. | | | |

(1) *x* = Address switches value.

### *Replace Front Logic Cover*

After the switches are set, replace the logic cover and tighten the screws 1.37…1.57 N•m (12.13…13.90 lb•in).

**Figure 28 - Logic Cover Replacement**



### *Example of How to Set the IP Address Switches*

This is a step-by-step example of how to set the IP address to 192.168.1.123, using the rotary switches:

1. Remove unswitched auxiliary power to the Armor PowerFlex drive. For details, see Auxiliary Power Connections on page 45.
2. Remove the Armor PowerFlex drive's logic cover. See Figure 26.
3. Set the Mode switch to 0, to select the 192.168.1.*x* private IP address, as indicated in Table 6.
4. Set the rotary address switches to 123. See Figure 27.

| | |
|---|---|
| **IMPORTANT** | When the switches are set to 192.168.1.1, the subnet mask is set to 255.255.255.0 and the gateway address is set to 0.0.0.0. Switch settings 000 and 255…998 are reserved and cannot be used. |

5. Replace the Armor PowerFlex drive's logic cover. See Figure 28.
6. Re-apply unswitched auxiliary power to the Armor PowerFlex drive.

   After the Armor PowerFlex drive goes through its boot-up sequence, the IP address is set to 192.168.1.123.

## Set the IP Address using the BOOTP/DHCP Server Utility

If the network does not use one of the five private IP addresses that can be set with the Mode switch, the Rockwell Automation BOOTP/DHCP Server Utility (or a third-party DHCP Server) can be used to set the Armor PowerFlex IP address. Before you set the IP address using DHCP, make sure that you have the following information:

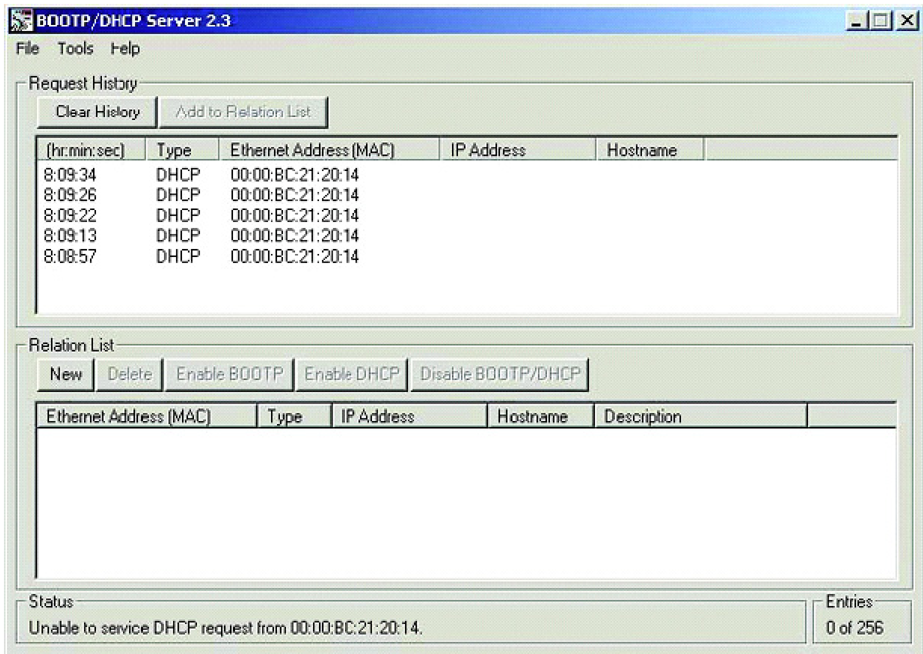
- MAC ID for the device
- Desired IP address for the Armor PowerFlex drive

To configure the Armor PowerFlex IP Address using the BOOTP/DHCP utility, after you install and power up the drive, perform the following steps:

1. Run the BOOTP/DHCP software.

   In the BOOTP/DHCP Request History panel, the hardware (MAC ID) addresses of the devices that are issuing BOOTP/DHCP requests are shown.

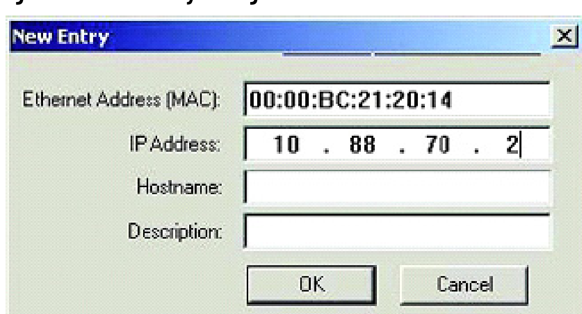
**Figure 29 - BOOTP/DHCP Request History Panel**




2. Double-click the hardware (MAC ID) address of the Armor PowerFlex drive that you want to configure.

   The New Entry dialog box with the Ethernet Address (MAC) of the device is shown.

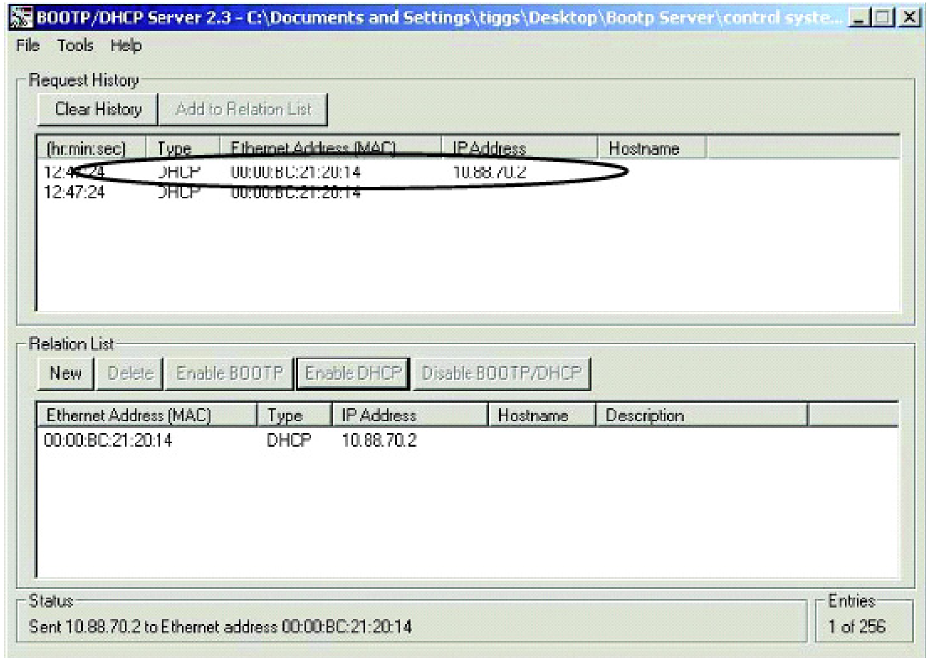
**Figure 30 - New Entry Dialog Box**




3. Enter the IP address that you want to assign to the device, and click OK.

The device is added to the Relation List, which displays the Ethernet Address (MAC) and the corresponding IP address, host name, and Description (if applicable).

**Figure 31 - Relation List**



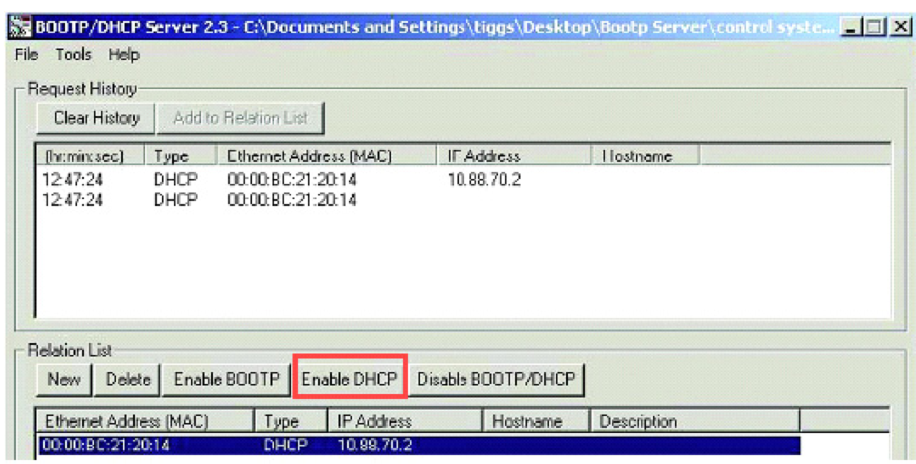

When the address is displayed in the IP address column in the Request History section, it signifies that the IP address assignment has been made.

4. To assign this configuration to the device: highlight the device in the Relation List panel, and click the Disable BOOTP/DHCP button.

   When power is cycled to the Armor PowerFlex, it uses the IP Address assigned and will not issue a DHCP request anymore.

5. If desired, DHCP can be enabled using the BOOTP/DHCP Server Utility. To enable DHCP for a device with DHCP disabled: highlight the device in the Relation List, and click the Enable DHCP button. You must have an entry for the device in the Relation List panel to re-enable DHCP.

**Figure 32 - Enable DHCP Button**



## Set the IP Address using the FactoryTalk Linx Application

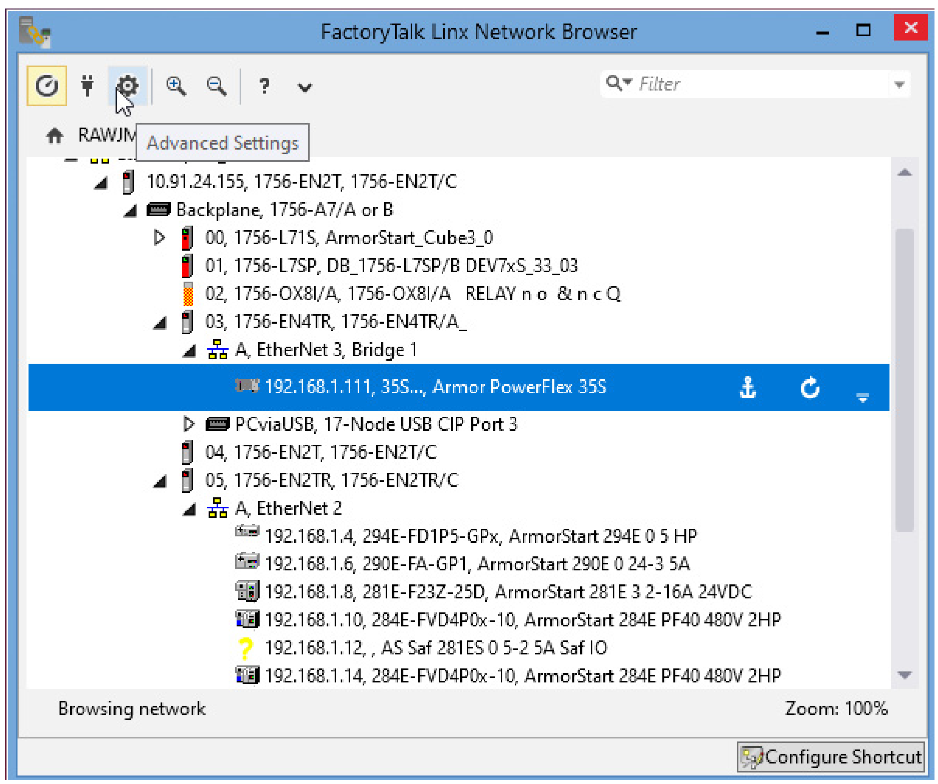
This procedure can only be used when the IP address of the Armor PowerFlex drive has already been set and needs to be changed to a different IP address.

This method can be used when the network does not use one of the five private IP addresses that can be set with the Mode switch and setting the IP address using a DHCP Server utility is not possible, or desired.

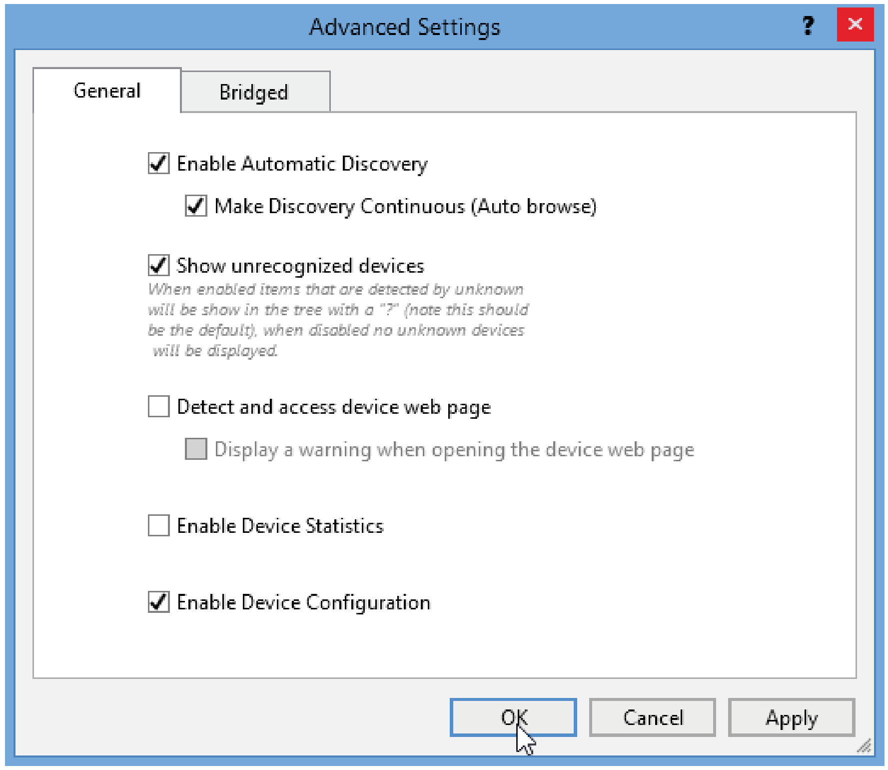
If the Armor PowerFlex is still at the factory default setting and does not have an IP address, set the IP address to 192.168.1.123 by following the steps in Example of How to Set the IP Address Switches on page 63, before proceeding.

If the Armor PowerFlex drive already has an IP address set, perform the following steps.

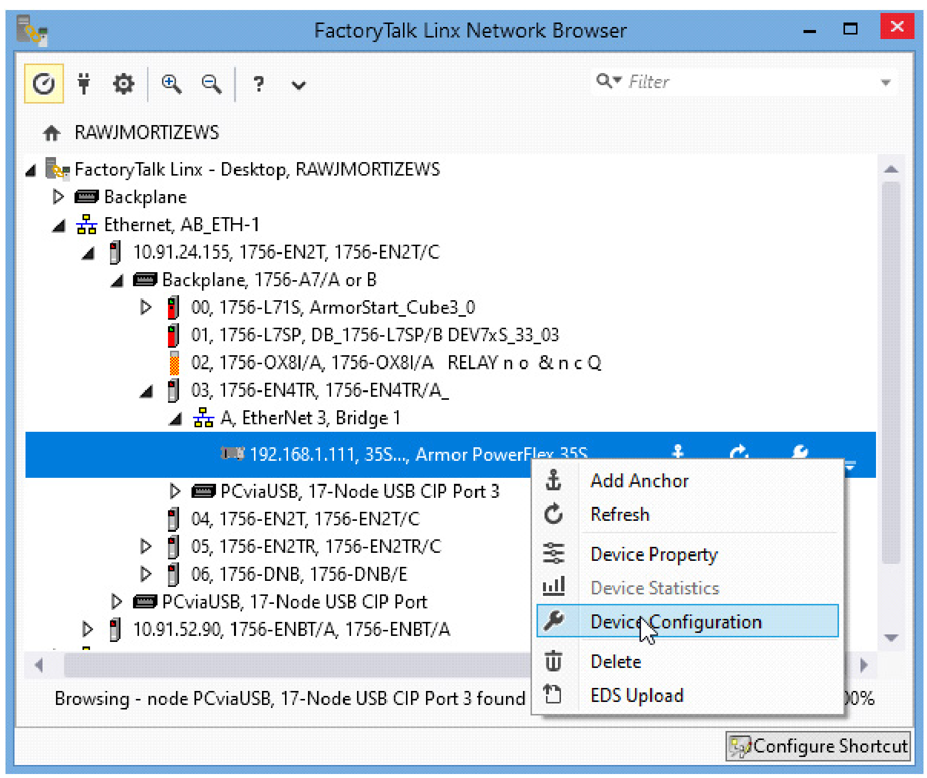
1. Launch FactoryTalk Linx and make sure that the IP Address of the Armor PowerFlex drive can be seen. The proper EtherNet driver must have been setup.
2. If the IP Address was set to 192.168.1.123 using the procedure in Example of How to Set the IP Address Switches on page 63, the address switches must be set to 999 and power cycled to the Armor PowerFlex drive.
3. Once the IP address of the Armor PowerFlex drive appears in the FatoryTalk Linx EtherNet driver, open the advance settings as shown.



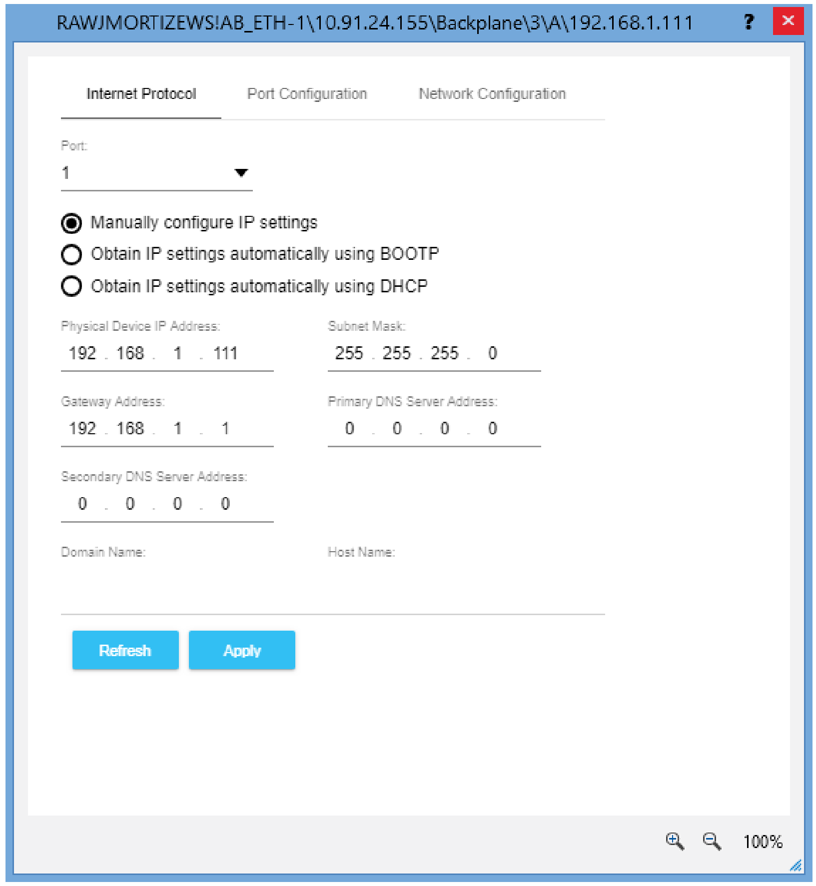
4. In Advanced Settings, check Enable Device Configuration under the General tab and click OK. This allows changing the IP address using FactoryTalk Linx.




5. Right-click the device and choose Device Configuration.



6. After the Device Configuration dialog box appears, select the Internet Protocol tab.




7. Click Manually Configure IP Settings (if not already checked) and change the appropriate fields to configure the new IP address.
8. Click Apply to make the changes.

For more information on how to configure the adapter with the BOOTP/DHCP and FactoryTalk Linx tools, see online help or the EtherNet/IP Network Devices User Manual, publication ENET-UM006.

## Device Level Ring

Device Level Ring (DLR) is an EtherNet/IP protocol that is defined by the Open DeviceNet Vendors Association (ODVA). DLR provides a means to detect, manage, and recover from single faults in a ring-based network.

A DLR network includes the following types of ring nodes.

**Table 7 - DLR Nodes**

| Node | Description |
|---|---|
| Ring supervisor | A ring supervisor provides these functions:<br>• Manages traffic on the DLR network<br>• Collects diagnostic information for the network<br>A DLR network requires at least one node to be configured as ring supervisor. By default, the supervisor function is disabled on supervisor-capable devices. |
| Ring participants | Ring participants provide these functions:<br>• Process data that is transmitted over the network.<br>• Pass on the data to the next node on the network.<br>• Report fault locations to the active ring supervisor.<br>When a fault occurs on the DLR network, ring participants reconfigure themselves and relearn the network topology. |
| Redundant gateways (optional) | Redundant gateways are multiple switches that are connected to a single DLR network and also connected together through the rest of the network. Redundant gateways provide DLR network resiliency to the rest of the network. |

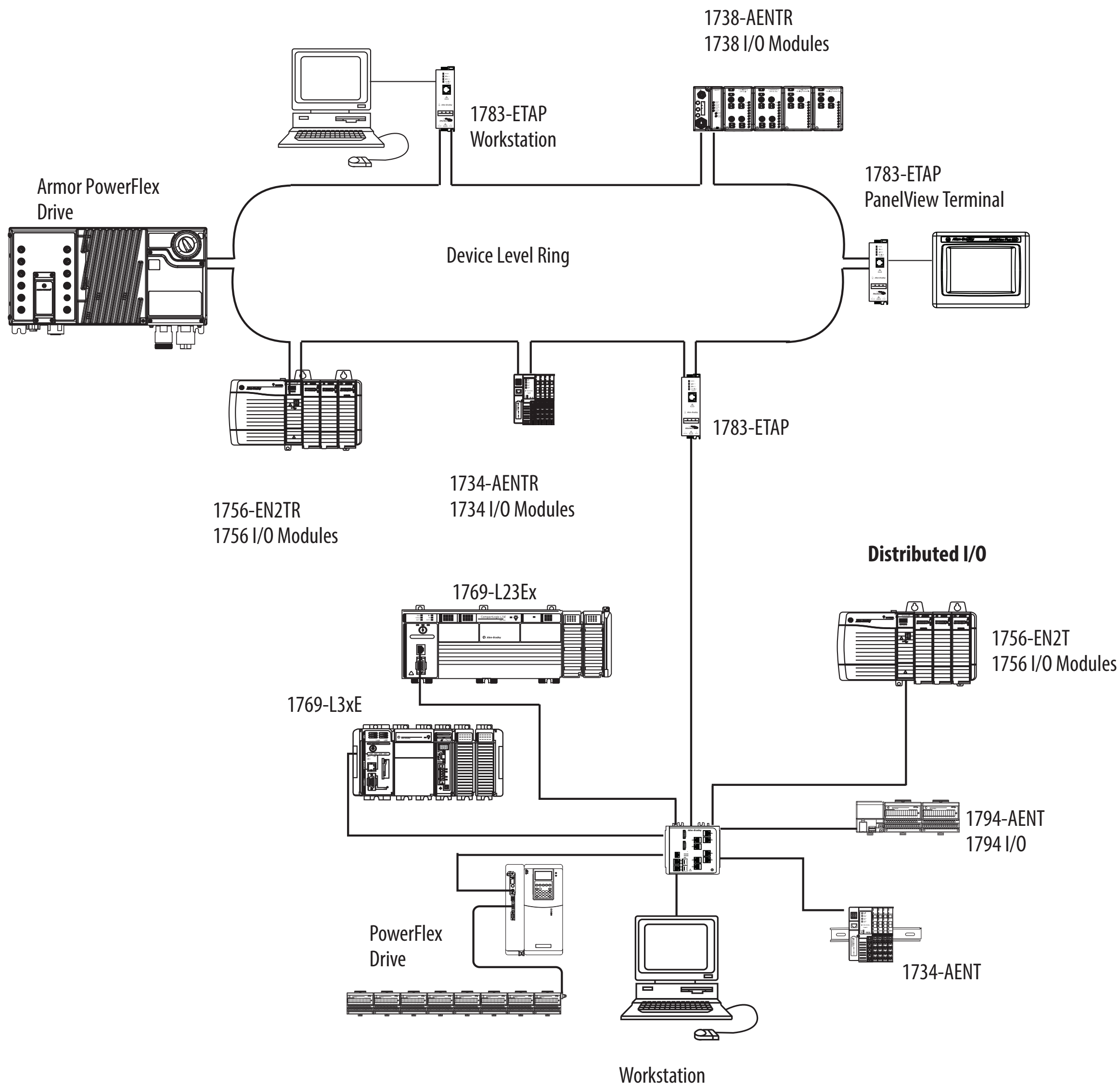
Depending on their firmware capabilities, both devices and switches can operate as supervisors or ring nodes on a DLR network. Only switches can operate as redundant gateways.

See Figure 33 on page 70 for an example of a DLR network.

| **IMPORTANT** | The Armor PowerFlex drive cannot be configured as a ring supervisor. |
|---|---|

For more information about DLR, see the EtherNet/IP Device Level Ring Application Technique, publication ENET-AT007.

**Figure 33 - Armor PowerFlex Drive in a DLR Configuration**




It is recommended that no more than 50 nodes are on a single DLR. If your application requires more than 50 nodes, it is recommended that the DLR networks be segmented.

With smaller networks:
- There is better management of traffic on the network.
- The networks are easier to maintain.
- There is a lower likelihood of multiple faults.

## Protected Operations Mode

To maintain the secure operation of your drive, operations that can disrupt drive operation are restricted based on its operating mode.

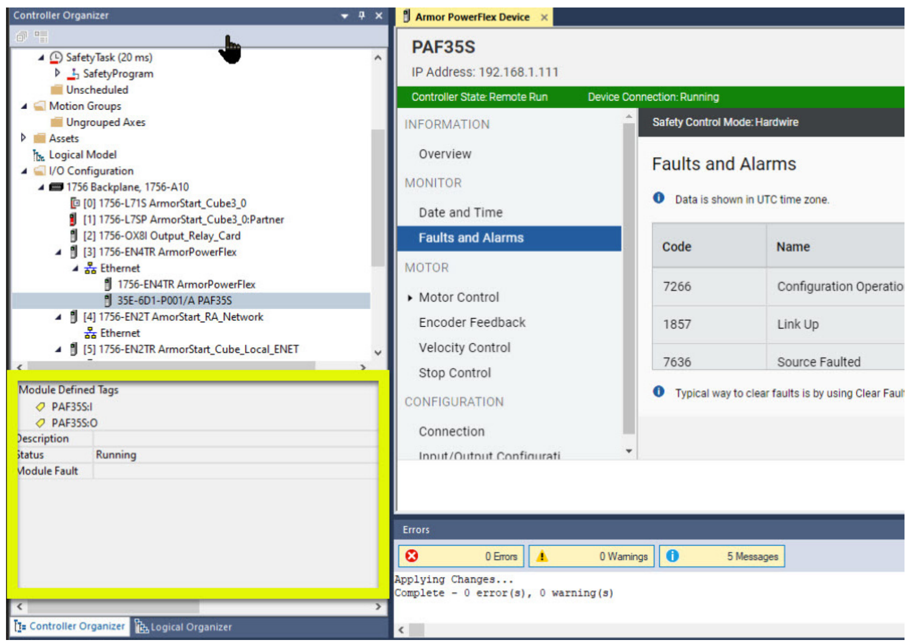
This drive is in protected mode when: there are standard or safety I/O connections, the drive is running.

When there is a Standard I/O connection, or the drive is running, the following features are disabled:

- Configuration of standard control attributes
- Configuration of Network Attributes
- Enabling/Disabling Physical Ports
- Remote Resets
- Security Configurations (except to preexisting configuration over previously made secure connection)
- Firmware Updates

When there is a Safety I/O connection, remote reset and firmware updates are disabled, along with reconfiguration of safety parameters. Safety configurations are allowed when there is a standard I/O connection to support commissioning efforts.

If an attempt is made, a device state conflict error is reported.




## Ethernet Communication Troubleshooting

The EtherNet/IP communication module can experience intermittent network connectivity due to these conditions:

- Duplex mismatch
- Electrical noise that is induced into a cable or results from a Logix/switch ground potential difference
- Bad hardware, such as a cable or switch port

To help troubleshoot the EtherNet/IP network, you must use a managed switch.

Here are the important features in a managed switch:

- Internet Group Multicast Protocol (IGMP) snooping
- Support for Virtual Local Area Networks (VLAN)
- Port mirroring

**IMPORTANT** Use a switch that is equipped with wire-speed switching fabric. The switch fabric is a measure of the maximum traffic that a switch can handle without dropping a packet and without storing a packet in memory. Wire-speed switching fabric refers to a switch that can handle the maximum data rate of the network on each of its ports.

Switches are typically rated in Gbps. For a 10-port switch connected to EtherNet/IP products, the maximum data rate that is needed, is typically 100...200 MB/s. Therefore, a 10-port-switch that is rated at least 1 GB/s is adequate for an EtherNet/IP application.

For more information on EtherNet/IP networks, see these resources:

**Table 8 - Resources for EtherNet/IP Network Information**

| Publication | Description |
|---|---|
| Troubleshoot EtherNet/IP Networks Application Technique, publication ENET-AT003 | Describes troubleshooting techniques for Integrated Architecture products on EtherNet/IP networks. |
| EtherNet/IP Device Level Ring Application Technique, publication ENET-AT007 | Describes DLR topologies, configuration considerations, and diagnostic methods, including how to monitor your EtherNet/IP network. |
| Ethernet Design Considerations Reference Manual, publication ENET-RM002 | Describes basic Ethernet concepts, infrastructure components, and infrastructure features. |

Chapter 4

# Keypad Operation

The Armor PowerFlex drive has a front panel keypad with four buttons to allow user input.

- LOCAL/AUTO, F0
- FWD/REV, F1
- JOG, F2
- FAULT CLEAR

The keypad also has status indicator LEDs, which indicate the mode that the keypad is in and the status of the buttons.

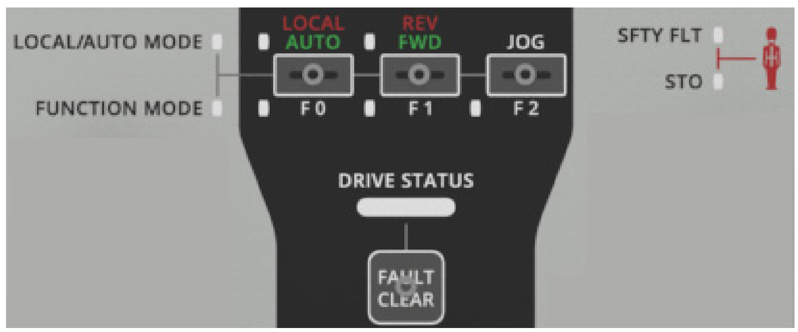



**Table 9 - Keypad Button Operation**

| Button | Description | Status Indicator | Mode |
|---|---|---|---|
| Fault Clear | • Pressing Fault Clear can clear all existing non-critical standard faults. (Clearing all faults might require additional actions, such as cycling main input power.)<br>• It does not clear any alarms. | — | — |
| Local/Auto | • Press this button to toggle between Local and Auto modes. The default mode is Auto.<br>• Local is a manual override mode that provides local control via the Forward/Reverse and Jog keypad buttons.<br>• Auto is for control of the drive where all reference and sequencing commands come from a network connection. When in Auto mode, the Forward/Reverse and Jog keypad buttons are not operational. | Local/Auto— Red | Local |
| | | Local/Auto— Green | Auto |
| Forward/Reverse | • When in Local mode, press this button to toggle between forward and reverse direction for running the motor. Forward is the default direction, which is set at power-up.<br>• Direction is maintained when switching between Local and Auto modes. | Fwd/Rev — Steady green | Local mode forward direction |
| | | Fwd/Rev — Steady red | Local mode - reverse direction |
| | | Fwd/Rev — Blink | Local mode - Jog button pressed |
| | | Fwd/Rev — Off | Auto mode |
| Jog | • When in Local mode, pressing and holding the Jog button jogs the motor.<br>• The Fwd/Rev blinks when the drive is modulating. | Fwd/Rev — Blink green | Jog forward direction |
| | | Fwd/Rev — Blink red | Jog reverse direction |

| Button | Description | Status Indicator | Mode |
|---|---|---|---|
| Function Mode (F0, F1, F2) | • To enable Function mode, see Temporarily Disable Keypad Motor Control via Message Instruction on page 75.<br>• In Function mode, the three buttons provide generic inputs whose function can be set by using program logic. Pressing the F0, F1, or F2 button has no direct effect on product behavior. The button state is reported to let user-defined logic take action based on the state of the button. The buttons are momentary, meaning that they are active when pressed and de-activated when released.<br>• When pressed, the button state reported to the network is 1. When released, the button state reported to the network is 0. | Function Mode — Steady amber | Function mode |
| | | F0, F1, F2 — Steady amber | F0key is pressed or,<br>F1 key is pressed or,<br>F2 key is pressed |
| | | F0, F1, F2 — Off | F0key is not pressed or,<br>F1 key is not pressed or,<br>F2 key is not pressed |

**IMPORTANT** You cannot use the LOCAL/AUTO button to change the mode while the drive is running.

One button press is recognized at a time. To switch from jogging forward to jogging reverse, first remove the jog, press reverse, and then reassert the jog. This does not mean that the motor must be at rest.

## Keypad Modes

The keypad operates in three different modes: Auto, Local, and Function. The keypad is used for motor control and will only block network motor control commands, while in Local mode.

- Auto – Motor control via the keypad is enabled, but not active. Local control from the embedded keypad is ignored. The Armor PowerFlex drive is only controlled via the EtherNet network.
- Local – Motor control via the keypad is enabled and it is active.The Armor PowerFlex drive is controlled from the embedded keypad only. If the unit is connected to a network, any commands are ignored.
- Function – Motor control via the keypad is disabled, the keypad button state is still reported. The F0, F1, and F1 buttons are used as inputs and not for control.

### Local/Auto (Local Motor Control) Modes Operation

Local and Auto modes are used when the keypad is enabled for motor control operation. In these modes, the three keypad buttons have a specific function:

- LOCAL/AUTO toggles between Auto or Local modes with the status indicator displaying the current mode (local is default). The drive must not be running to use the button to switch modes in Auto mode, the Forward/Reverse and Jog buttons don't do anything
- Forward/Reverse toggles between directions in Local mode. The indicator displays the current direction (forward is default). At power-up, the keypad direction is set to forward. The direction is maintained when switching between LOCAL/AUTO mode.
- Pressing Jog causes the motor to move at the jog reference velocity, in Local mode. The default jog velocity is 10 rev/s (20 Hz).

## Function Mode Operation

When Function mode is selected (see Temporarily Disable Keypad Motor Control via Message Instruction on page 75), all three buttons become generic inputs whose function can be set by using programmable controller logic.

When the keypad mode is Function, pressing the keypad buttons F0, F1, and F2 have no direct impact on product behavior. In this mode, the button state is reported to allow user-defined logic to take action based on the button state.

The F0, F1, and F2 LEDs indicate if a button is being pressed.

# Fault Clear Button Operation

When the Fault Clear button is pressed, any faults currently unacknowledged in the product are acknowledged. You cannot disable or change the function of the Clear Faults button.

# Temporarily Disable Keypad Motor Control via Message Instruction

To temporarily disable the keypad motor control operation, a MSG instruction targeting attribute 2, (Inhibit) of the Motor Control Source object, can be used. Set this attribute to 1 (true) to disable keypad motor control operation. Table 10 shows the message instruction parameter needed to temporarily disable the keypad control.

**Table 10 - Keypad Control: MSG**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x10 | Set attribute single |
| Class | 0x41c | Motor control source |
| Instance | 1 | Keypad |
| Attribute | 2 | Inhibit |
| Value | BOOL | 0 = Source not inhibited (Keypad active)<br>1 = Source inhibited (Keypad disabled) |

This configuration allows you to temporarily use Local mode of the keypad to perform maintenance tasks when needed, while disabling use of the keypad for motor control during normal operation.

**IMPORTANT** The value of the Inhibit attribute is reset to 0 (not inhibited, keypad can be used for motor control) when the drive has power cycled. If it is important that the keypad be inhibited in the application, logic should be added to resend the inhibit message instruction after a power cycle, or simply resend the inhibit message instruction, periodically.

## Keypad Actions in Local and Function Modes

Table 11 and Table 12 show what actions occur for Local and Function modes and list what LEDs are illuminated, including their color. In Disabled mode, no buttons are active and all LEDs are Off.

**Table 11 - Local Mode Keypad Actions**

| LOCAL Mode | LOCAL/AUTO Button | |
|---|---|---|
| | AUTO selected | LOCAL selected |
| Mode LEDs<br>Top: **Green**<br>Bottom: Off | Drive is remotely controlled. Keypad F/R and JOG buttons are not active. All reference and sequencing commands come from a network connection / logic controller. | Drive is in local control. Allows use of the JOG and F/R buttons |
| LOCAL/AUTO LED | Red | Green |
| Fwd/Rev LED | Off | Fwd — Green<br>Rev — Red |
| Fwd/Rev Button | Not active | Selects JOG direction |
| JOG Button pressed | Not active | Fwd/Rev LED — Blinks while JOG is pressed<br>Green — Forward JOG<br>Red — Reverse JOG<br>(the drive jogs while the JOG button is pressed) |
| JOG Button not selected | Not active | Fwd/Rev LED — Steady (no blink) based on selected direction color |
| F0 LED | Amber LED — Off | Amber LED — Off |
| F1 LED | Amber LED — Off | Amber LED — Off |
| F2 LED | Amber LED — Off | Amber LED — Off |

**Table 12 - Function Mode Keypad Actions and Status Indicators**

| FUNCTION mode | LOCAL/AUTO - F0 Button | | Fwd/Rev - F1 Button | | JOG - F2 Button | |
|---|---|---|---|---|---|---|
| | F0 selected | F0 unselected | F1 selected | F1 unselected | F2 selected | F2 unselected |
| Mode LEDs<br>Top: Off<br>Bottom: **Amber** | Network reads F0 state = '1'<br><br>All reference and commands come from the network. | Network reads F0 state = '0'<br><br>All reference and commands come from the network. | Network reads F1 state = '1'<br><br>All reference and commands come from the network. | Network reads F1 state = '0'<br><br>All reference and commands come from the network. | Network reads F2 state = '1'<br><br>All reference and commands come from the network. | Network reads F2 state = '0'<br><br>All reference and commands come from the network. |
| LOCAL/AUTO Mode LED | Off | Off | Off | Off | Off | Off |
| Fwd/Rev LED | Off | Off | Off | Off | Off | Off |
| F0 LED | Amber LED — On | Amber LED — Off | Amber LED — Off | Amber LED — Off | Amber LED — Off | Amber LED — Off |
| F1 LED | Amber LED — Off | Amber LED — Off | Amber LED — On | Amber LED — Off | Amber LED — Off | Amber LED — Off |
| F2 LED | Amber LED — Off | Amber LED — Off | Amber LED — Off | Amber LED — Off | Amber LED — On | Amber LED — Off |

Chapter 5

# Standard and Configurable I/O Operation

All Armor PowerFlex drives include four standard inputs and two standard configurable I/Os. These inputs and outputs are used with sensors and actuators respectively, for monitoring and controlling the application process.

The Armor PowerFlex safety drive (35S) includes safety I/Os: two test outputs, four safety inputs, and one bipolar safety output. See Chapter 6 for safety I/O details.

## Standard I/O Operation

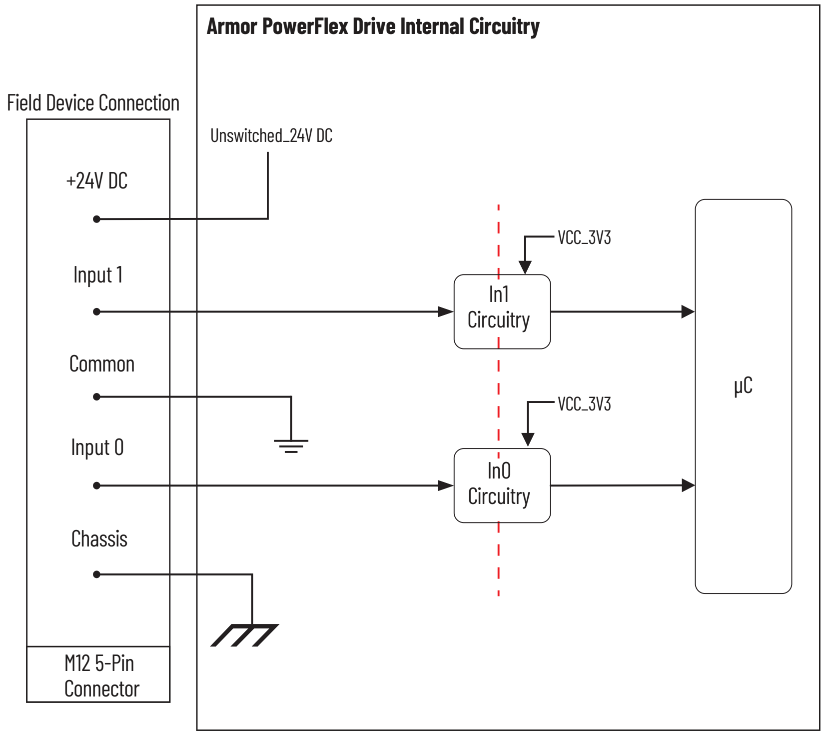
The Armor PowerFlex drives include four inputs that are single keyed (two inputs per connector) and sourced from control power. The inputs use two M12 connectors. Each input has an light-emitting diode (LED) status indication (See I/O Status Indicators on page 198 for details). They are configurable as sinking or sourcing (See Configure Safety Inputs on page 178 for configuration details).

Short-circuit protection: The maximum sourcing sensor power is 300 mA for all discrete inputs. Therefore if all six are inputs, a maximum of 50 mA is allowed per input. Or for any single input, the full 300 mA can be sourced. If maximum sourcing power is exceeded, a fault is generated.

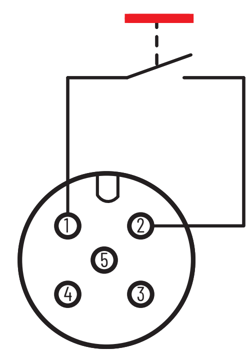
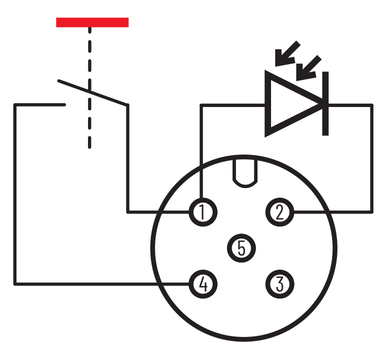
You can set an On to Off and Off to On, filter time in the programming software. This setting helps prevent rapid changes of input data due to contact bounce.

Each I/O point has a status LED see I/O Status Indicators on page 198 for details.

## Standard Input Internal Wiring Diagram




## Standard Input Wiring Examples

| Connected Devices | Connection | Schematic Diagram |
|---|---|---|
| Reset switch | Connect the reset switch between +24V Unswitched Sensor Power and Input 1 | Pin 1:+24V unswitched (sensor) power<br>Pin 2: Input 1<br>Pin 3: Input Common<br>Pin 4: Input 0<br>Pin 5: Chassis (PE)  |
| Dual input configuration | Connect the LED between 24V and Input 1 and connect the reset switch between 24V and Input 0 | Pin 1:+24V unswitched (sensor) power<br>Pin 2: Input 1<br>Pin 3: Input Common<br>Pin 4: Input 0<br>Pin 5: Chassis (PE)  |

## Configurable I/O Operation

The Armor PowerFlex drives have two configurable I/O points that are self-configurable as either an input or output, based on the electrical connection used. By default, the I/O points are configured as inputs.

The two I/O points are sourced from switched auxiliary power. The two I/O points use one single-keyed two M12 connector. Each I/O has an LED status indication (See I/O Status Indicators on page 198 for details).

The self-configuring I/O points are named I/O0 and I/O1.

Turning a self-configuring I/O point ON via the Output Tag *devicename*.O.IO_0 or *devicename*.O.IO_1, makes it behave as an output. See Table 75 on page 183. The Input Tag *devicename*:I.IO_0 or *devicename*.I.IO_1 value reflects the state of a connected input device, if one is connected, or the output state, if the point is being used to drive an output device. You must confirm that the Discrete Output Point output value is not accidentally set to 1 if the point is being used as an input.

- If an I/O point is to be an output, dedicate that point as an output with a wired load and energize it through a control program.
- Energized outputs show an associated active input that can be used as a feedback mechanism to verify that the output is on.
- If an I/O point is to be an input, wire the input device as normal and leave the associated output de-energized at all times.

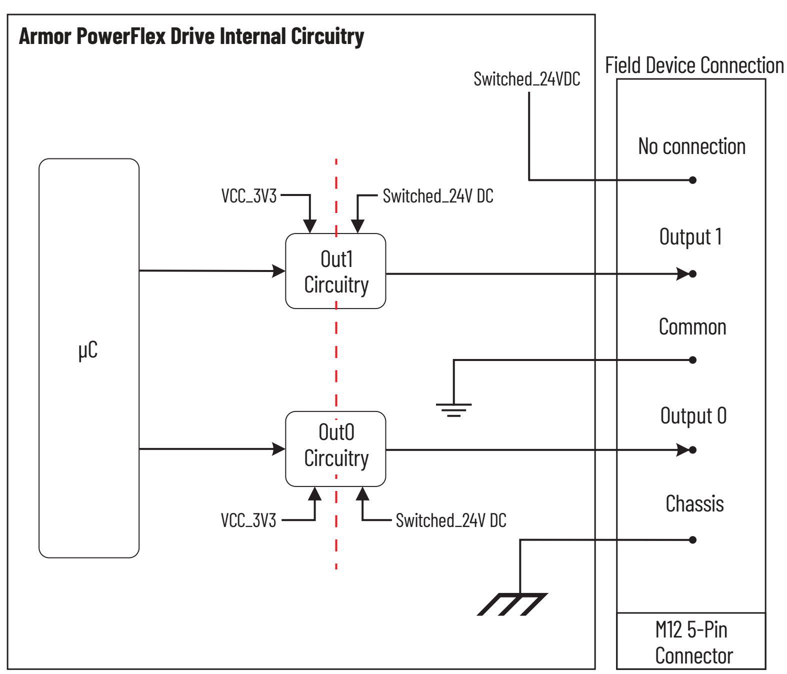
When a fault occurs, standard outputs (the self-configuring I/O points) will be set to a known state based on their configured fault action.

### Configured Fault Actions

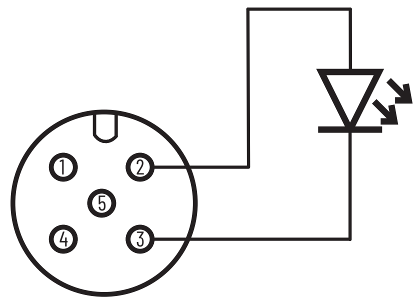
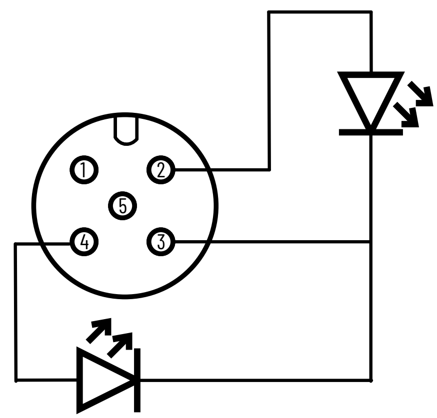
- Connection Idle (Controller Run -> Program Transition) Action
- Connection Fault Action
- Product Fault Action

To configure the fault action for the configurable I/O, see Configure Safety Inputs on page 178.

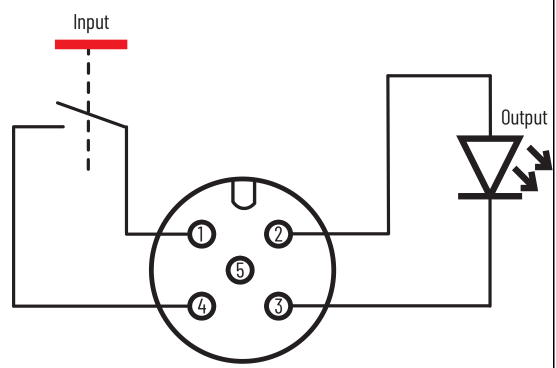
### Configurable I/O Internal Wiring Diagram (Output)



## Standard Output Wiring Examples

| Connected Devices | Connection | Schematic Diagram |
|---|---|---|
| Output drives LED (I/O configured as output) | Connect the LED between Input/Output 1 and Common | Pin 1:+24V unswitched (sensor) power<br>Pin 2: Input/Output 1<br>Pin 3: Input Common<br>Pin 4: Input/Output 0<br>Pin 5: Chassis (PE)<br> |
| Outputs drive LEDs (Both of the I/Os are configured as outputs) | Connect the first LED between Input/Output 1 and Common<br><br>Connect the second LED between Input/Output 0 and Common | Pin 1:+24V unswitched (sensor) power<br>Pin 2: Input/Output 1<br>Pin 3: Input Common<br>Pin 4: Input/Output 0<br>Pin 5: Chassis (PE)<br> |

## Standard I/O Wiring Example

| Connected Devices | Connection | Schematic Diagram |
|---|---|---|
| Output drives LED and Input as reset switch | Output: Connect the LED between Input/Output 1 and Common<br><br>Connect the reset switch between Input/Output 0 and +24V Unswitched Sensor Power | Pin 1:+24V unswitched (sensor) power<br>Pin 2: Input/Output 1<br>Pin 3: Input Common<br>Pin 4: Input/Output 0<br>Pin 5: Chassis (PE)<br> |

# Safety Functions

This chapter only applies to the Armor PowerFlex safety version (35S) used in a safety application. If you are using an Armor PowerFlex standard version (35E), this chapter does not apply to you.

The Armor PowerFlex safety version provides hard-wired Safe Torque Off (STO), integrated Safe Torque Off (STO), integrated drive-based Safe Stop 1 functions, Safe Brake Control (SBC), and integrated controller-based Safe Monitor functions, capability.

**Table 13 - Integrated Safety Functions and Compatible Controllers**

| **Integrated Safety Over the EtherNet/IP Network** | | |
|---|---|---|
| | **Safety Function** | **Minimum Controller Required** |
| Drive-based stop functions | • Timed Safe Stop 1 (SS1)<br>• Monitored Safe Stop 1 (SS1)(1)<br>• Safe Brake Control (SBC) | • GuardLogix 5580<br>• Compact GuardLogix 5380 |
| Controller-based stop functions | • Monitored Safe Stop 1 (SS1)(1)<br>• Safe Brake Control (SBC) | |
| Controller-based monitor functions | • Safely Limited Speed (SLS)(1)<br>• Safely Limited Position (SLP)(1)<br>• Safe Direction (SDI)(1) | |
| Safety feedback function | Safety Feedback Interface (SFX)(1) | |
| Integrated STO mode | Safe Torque Off (STO) | |

(1) Monitored safety functions require an encoder to be configured in the safety configuration.

**Table 14 - Hardwired Safety Functions and Compatible Controllers**

| **Hardwired Safety — No Safety Connection** | | |
|---|---|---|
| | **Safety Function** | **Minimum Controller Required for Standard Connection** |
| Hardwired STO mode | Safe Torque Off (STO) | • ControlLogix 5570 or 5580<br>• Armor ControlLogix 5570<br>• GuardLogix 5570 or 5580<br>• Armor GuardLogix 5370<br>• CompactLogix 5370 or 5580<br>• Armor CompactLogix 5370 includes GuardLogix variants<br>• Compact GuardLogix 5370 or 5580 |

| | |
|---|---|
| **IMPORTANT** | The functional safety part of the product does not need any maintenance (apart from proof testing, if applicable). For the functional safety part of the product, no spare parts are available and no repair is possible or intended by the user. If there is a permanent fault, the device has to be taken out of use and replaced by another device. |

## Safety Considerations

**ATTENTION:** The drive is suitable for performing mechanical work on the drive train or affected area of a machine only. It does not provide electrical safety.

**ATTENTION:** The drive does not remove dangerous voltages at the drive output. Before performing any electrical work on the drive or motor, turn off the input power to the drive, and follow all safety procedures.

**ATTENTION:** Failure to maintain the specified ambient temperature can result in a failure of the safety function.

**ATTENTION:** Personnel responsible for the application of safety-related programmable electronic systems (PES) must be aware of the safety requirements in the application of the system and must be trained in use of the system.

**ATTENTION:** When designing your system, consider how various personnel can interact with the machine. Additional safeguard devices can be required for your specific application.

**ATTENTION:** In circumstances where external influences (for example, suspended loads that can fall) are present, additional measures (for example, mechanical brakes) can be necessary to help prevent any hazard.

The system operator is responsible for the following:

- Setup, safety rating, and validation of any sensors or actuators connected to the system
- Completion of a machine-level risk assessment and reassess the system anytime a change is made
- Certification of the machine to the desired ISO 13849-1 performance level or EN/IEC 62061 SIL CL level
- Project management and proof testing in accordance with ISO 13849-1
- Programming the application software and the drive 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
- Validation and documentation of all safety functions used
- Performance of necessary proof tests and periodic safety checks

## Stop Category Definitions

There are two stop categories that apply to Armor PowerFlex drives:

- Stop Category 0 is achieved with immediate removal of power to the machine actuators, which results in an uncontrolled coast-to-stop. An STO accomplishes a Stop Category 0 stop.
- Stop Category 1 is achieved with a Ramp to Stop followed with immediate removal of power to the machine actuators. An SS1 with STO accomplishes a Stop Category 1 stop.

| | |
|---|---|
| **IMPORTANT** | When designing the machine application, consider the timing and distance for a coast-to-stop (Stop Category 0 or Safe Torque Off). For more information on stop categories and Safe Torque Off, see EN 60204-1 and EN/IEC 61800-5-2. |

## Performance Level and Safety Integrity Level

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

See the ISO 13849-1, IEC 61508, and IEC 62061 standards for complete information on requirements for PL and SIL determination. See rok.auto/certifications for product certifications.

## Proof Tests

IEC 61508 requires you to perform various proof tests of the equipment that issued in the system. Proof tests are performed at user-defined times. For example, proof tests can be once a year, once every 15 years, or whatever time frame is appropriate.

The Armor PowerFlex drive has a useful life of 20 years; no proof test is required. Other components of the system, such as safety I/O devices, sensors, and actuators, can have different useful life times.

| | |
|---|---|
| **IMPORTANT** | The time frame for the proof test interval depends on the specific application. |

## 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 the order-of-magnitude ranges of its average probability of failure to perform its safety function on demand or, simply, the average probability of a dangerous failure on demand ($PFD_{avg}$).

The SIL value for a High Demand/Continuous mode safety-related system is directly related to the average frequency of a dangerous failure (PFH) per hour.

For redundant parts of a PDS (SR) which cannot be tested without disrupting the application in which the PDS (SR) is used (machine or plant) and where no justifiable technical solution can be implemented, the following maximum diagnostic test intervals can be considered as acceptable. See Table 15.

**Table 15 - Maximum Diagnostic Test Intervals**

| To achieve the listed safety rating | Maximum STO demand interval |
|---|---|
| SIL 3/Category 4, PLe | one STO operation per day |
| SIL 3/Category 3, PLe | one STO operation per three months |
| SIL 2/Category 3, PLd | one STO operation per year |

## Safety Data for Armor PowerFlex Drives

The following sections list safety data for Hardwired STOand Integrated STO and Safety Functions.

**Table 16 - PFD and PFH for Armor PowerFlex Drives Hardwired STO**

| Attribute | Value |
|---|---|
| $PFD_{(average)}$ | 2.65 E-04 |
| PFH (1/hour) | 3.04 E-09 |
| SIL | 3 |
| PL | e |
| Category | 4 |
| MTTFd years | 139.7 (high) |
| $DC_{avg}$% | 97.2% (medium) |
| HFT (hardware fault tolerance) | 1 |
| Mission time | 20 years |

### Safety Data for Integrated STO and Integrated Safety Functions

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

**Table 17 - PFD and PFH for Armor PowerFlex Drives Integrated STO and Timed SS1**

| Attribute | Value |
|---|---|
| $PFD_{(average)}$ | 1.56 E-4 |
| PFH (1/hour) | 1.76 E-9 |
| SIL | 3 |
| PL | e |
| Category | 4 |
| MTTFd years | 171.3 (high) |
| $DC_{avg}$% | 97.7% (medium) |
| HFT | 1 |
| Mission time | 20 years |

Table 18 provides PFH values to add for safety functions that use the safety I/O provided on the Armor PowerFlex drive.

**Table 18 - PFD or PFH to Add When Safety Functions Use Safety I/O**

| Attribute | Single Channel Safety I/O | Dual Channel Safety I/O |
|---|---|---|
| PFD (average) | 6.64 E-4 | 1.12 E-4 |
| PFH (1/hour) | 7.58 E-9 | 1.28 E-9 |
| SIL | 2 | 3 |
| PL | d | e |
| Category | 2 | 4 |
| MTTFd years | 760.3 | 757.6 |
| $DC_{avg}$% | 95% | 95% |
| HFT | 0 | 1 |
| Mission time | 20 years | 20 years |

**IMPORTANT** Single channel safety I/O is only certified for use in functional safety applications with process safety times greater than or equal to 300 ms; or applications with demand rates for both input and output, less than or equal to 1 demand per 30 s.

**IMPORTANT** If single channel safety I/O is used, pulse testing (external pulse testing for safety inputs, pulse testing for safety outputs) MUST be enabled on the single channel I/O points.

## Safety Data for Safety Functions with Safety Feedback

Table 19 provides $PFD_{avg}$ and PFH values to add to the $PFD_{avg}$ and PFH values from Table 17 or Table 18 for safety functions that require safe encoder feedback. Safety functions that use safe encoder feedback include: drive based Monitored Safe Stop 1 and controller-based safety functions SS1, SLS, SLP, and SDI.

In general, the $PFD_{avg}$ and PFH values from Table 19 should be added to Table 17 and Table 18 when Safety Instance is set to 'Single Feedback Monitoring'.

**Table 19 - PFD or PFH to Add When Safety Functions Use Safety Feedback**

| Attribute | Single Encoder Feedback |
|---|---|
| PFD (average) | 2.88 E-5 |
| PFH (1/hour) | 3.29 E-10 |
| SIL | 2 |
| PL | d |
| Category | 3 |
| MTTFd years | 2154.3 |
| DCavg% | 97.3% |
| HFT | 1 |
| Mission time | 20 years |

| | |
|---|---|
| **IMPORTANT** | Achievable safety rating depends on each system component. For Safe Feedback, the safety rating of the selected encoders could limit the safety rating of the system. |

## Safety Reaction Time

The safety reaction time is the length of time from a safety-related event as input to the system until the system is in the safe state. Table 20 on page 86 shows the safety reaction time from an input signal condition that triggers a safe stop, to the initiation of the configured Stop Type. For details on how to calculate system reaction times with GuardLogix controllers, see the GuardLogix Controller Systems Safety Reference Manuals that are listed in the Additional Resources on page 13.

**Table 20 - Safety Reaction Time**

| Function | Reaction Time |
|---|---|
| Hardwired STO | 12 ms |
| Integrated STO | 10 ms |
| Safety Output | 10 ms |

| | |
|---|---|
| **IMPORTANT** | The safety reaction time that was previously listed, excludes the connection reaction time. |

A number of factors influence the safety reaction time, including the configuration of the safety I/O on your device and the configuration of your safety controller. These factors include:

- Safety Input On to Off and Off to On delay settings, if applicable
- Safety Input Connection Reaction Time Limit settings
- Safety controller Safety Task Period and Watchdog settings
- Produced and consumed safety Connection Reaction Time Limit settings
- Safety Output Connection Reaction Time Limit settings

See Safety Input and Output Connection Settings (safety variants only) on page 169, for information on how to configure these settings.

For details on reaction time calculation of your safety system, see Reaction Times in the GuardLogix Controller Systems Safety Reference Manual, for your safety programmable controller. These manuals are listed in the Additional Resources on page 13.

## Spurious Trip Rate

Table 21 shows the Spurious Trip Rate (STR) and Mean Time to Failure Spurious ($MTTF_{Spurious}$) values, calculated according to the ISA TR-84 method.

**Table 21 - STR and MTTF Spurious Rates**

| Attribute | Value |
|---|---|
| Spurious Trip Rate (per hour) | 6.61 E-6 |
| MTTF Spurious (years) | 1.73 E+1 |

## Contact Information If Safety Failure Occurs

If you experience a failure with any safety-certified device, contact your local Allen-Bradley distributor to request any of these actions:

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

## Safe Torque Off Function

The TÜV Rheinland group has approved Armor PowerFlex drives with hardwired and integrated Safe Torque Off (STO) for use in safety-related applications up to ISO 13849-1 Performance Level e (PLe), SIL CL 3 per IEC 61508, IEC 61800-5-2, and EN/IEC 62061, in which removing the motion-producing power is considered to be the safe state.

For product certifications currently available from Rockwell Automation, go to rok.auto/certifications. All components in the system must be chosen and applied correctly to achieve the desired level of operator safeguarding.

### Description of Operation

The Armor PowerFlex STO circuit is designed to turn off all output-power transistors when the STO function is requested. You can use the Armor PowerFlex STO circuit in combination with other safety devices to achieve a Stop Category 0 stop as described in Stop Category Definition for STO on page 88, and protection-against-restart as specified in IEC 60204-1.

**ATTENTION:** When designing your system, consider how various personnel can interact with the machine. Additional safeguard devices can be required for your specific application.

**ATTENTION:** If there is a failure of two output IGBTs in the Armor PowerFlex drive, the Armor PowerFlex drive can provide energy for up to 180° of rotation in a 2-pole motor before torque production in the motor ceases.

The STO feature provides a method, with sufficiently low probability of failure, to force the power-transistor control signals to a disabled state. When disabled, or anytime power is removed from the safety enable inputs, all drive output-power transistors are released from the On state. This results in a condition where the drive performs a Category 0 Stop (see Stop Category Definition for STO on page 88). Disabling the power transistor output does not provide physical isolation of the electrical output that is required for some applications.

See Safe Brake Control Function on page 105 for information on how to use a mechanical brake with the drive.

**ATTENTION:** When STO is demanded, the motor output provides mechanical isolation of the electrical output that is required for some applications.

**ATTENTION:** In circumstances where external influences (for example, falling of suspended loads) are present, additional measures (for example, mechanical brakes) may be necessary to help prevent any hazard.

## Stop Category Definition for STO

Stop Category 0 as defined in IEC 60204 or Safe Torque Off as defined by IEC 61800-5-2 is achieved with immediate removal of motion-producing power to the actuator.

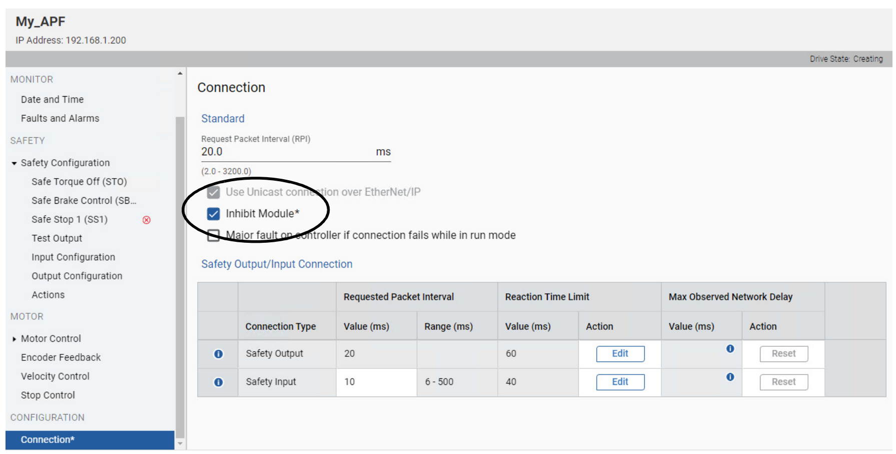
| | |
|---|---|
| **IMPORTANT** | If there is a malfunction, the most likely stop category is Stop Category 0. When designing the machine application, timing and distance must be considered for a coast-to-stop. For more information regarding stop categories, see IEC 60204-1. |

## Reset Ownership

After the integrated safety connection configuration is applied to the drive at least once, you can restore the Armor PowerFlex drive to the out-of-box state by resetting ownership in the Logix Designer application while online. When you reset the Armor PowerFlex drive, all configuration settings, including standard and safety I/O configurations are returned to their out-of-box settings. Resetting Ownership using the Add On Profile (AOP) requires that the Module Connection is inhibited.

Follow these steps to inhibit the module connection:

1. Right-click the device and choose Properties.
2. Choose Connection.
3. Check the Inhibit Module checkbox.

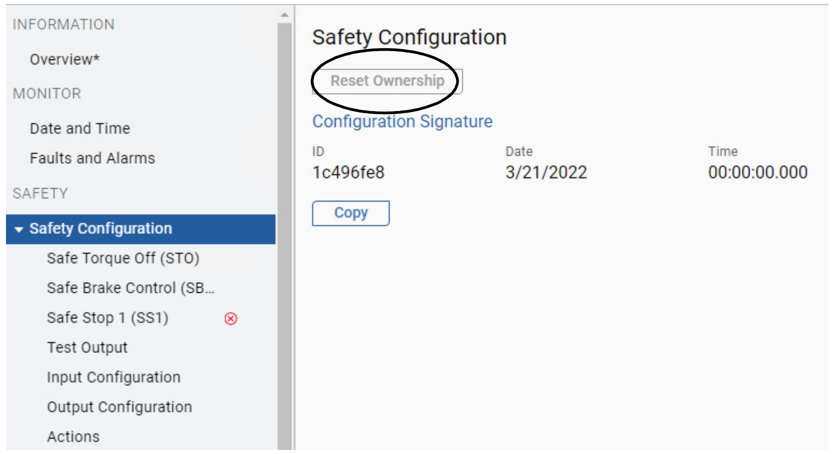



4. Click Apply and then OK.

Follow these steps to reset the device to its out-of-box configuration when online.

1. Right-click the module and choose Properties.
2. Choose Safety Configuration.

3. Click Reset Ownership.




## Out-of-Box State

Out-of-Box is the state in which the Armor PowerFlex drive is delivered from the factory. All configuration settings including standard and safety I/O configurations, are returned to factory default values.

In the Out-of-Box state, the drive is in Hardwired STO mode, which means it is ready for hardwired connections to the safety I/O. See Description of Operation on page 87.

## Reset to Out-of-Box State

You can reset the Armor PowerFlex drive to the out-of box state in two ways:

- By resetting ownership via the Logix Designer application. See Reset Ownership
- By setting the IP address switches to 888 using the following procedure:
  a. Remove power from the product. Wait for it to power down.
  b. Set the network address switches to 888. See Set the IP Address on page 61 for instructions on how to set the IP address.
  c. Apply power to the product.
  d. Wait for 60 seconds.
  e. Remove power from the product. Wait for it to power down.
  f. Set the network address switches to 1 to 254 or 999.
  g. Apply power to the product.
  The product's configuration settings have been restored to their factory default values.

| | |
|---|---|
| **IMPORTANT** | Only authorized personnel should attempt to reset ownership. The safety connection must be inhibited before the reset is attempted. If any active connection is detected, the safety reset is rejected. |

## Recognize Out-of-box State Using a Message Instruction

A message instruction can be used to query the Safety Supervisor Object to determine if the device is in the out-of-box state.

The safety supervisor state provides information on the state of the integrated safety connection and the mode of operation. There is only one safety supervisor object per drive module.

Table 22 shows the message instruction parameter needed to query the Safety Supervisor Object. Table 23 shows the possible response values and their relation to the safety connection. For a message instruction example, see Appendix B on page 219.

**Table 22 - Safety Supervisor State: MSG**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x0E | Get attribute single |
| Class | 0x39 | Safety supervisor |
| Instance | 1 | Revision |
| Attribute | 0x0B<br>11 (decimal) | Device status |
| Data Type | SINT | Short integer |

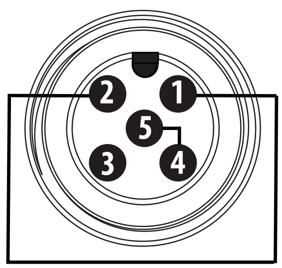
**Table 23 - Safety Supervisor States**

| Value | Display Text | Definition |
|---|---|---|
| 1 | Testing | Device is performing test diagnostics |
| 2 | Idle | No active connections |
| 3 | Test Flt | A fault has occurred while executing test diagnostics |
| 4 | Executing | Normal running state |
| 5 | Abort | A major recoverable fault has occurred |
| 6 | Critical Flt | A critical fault has occurred |
| 7 | Configuring | Transition state |
| 8 | Waiting | Out-of-box state |
| 51 | Wait w Trq | Out-of-box state |
| 52 | Exec w Trq | STO bypass state |

## STO Bypass Operation

To support commissioning of the product, a STO bypass plug may be used to enable torque. The STO bypass plug can be used on either pair of inputs to enable torque.

**Figure 34 - Hardwired STO - Safety Bypass Plug**




Pin 1: Test Output 1
Pin 2: Safety Input 1
Pin 3: Input Common
Pin 4: Safety Input 0
Pin 5: Test Output 0

**IMPORTANT** To use the 35S drive in an application without safety or to bypass the STO feature while commissioning or testing the drive, the drive must be in Hardwired mode and either safety input pair must be wired to enable torque. The safety bypass jumper plug can be used for this purpose.

**ATTENTION:** If you bypass the STO feature, the safety system permits motor torque that could result in unintended motion. Use additional preventive measures to maintain the safety integrity of the machinery.

# Hardwired Safe Torque Off Function

Armor PowerFlex safety drives (35S) are configured for Hardwired Safe Torque Off (STO) mode when the Connection is set to Standard in the Device Definition dialog box of the Logix Designer application (see Configure the Device Definition on page 143 for details). To be configured for Hardwired STO mode, it is also required that no Network Safety connection has been made.

## Hardwired STO Operation

If the Safety Supervisor state is waiting (8) or waiting with torque permitted (51), then the safety control is in the out-of-box state. See Table 23 on page 90.

For hardwired control of the STO:

- The STO function must be in Hardwired STO mode.
- The safety inputs must be wired appropriately.

Two of the four 24V DC discrete safety inputs control the STO function. Safety Input 0 and 1 along with Test Output 0 and 1 are intended to interface to dual-channel equivalent safety devices. Safety Inputs 2 and 3 are intended to interface to Output Solid State Devices (OSSD). Only one pair of inputs can be used at a time. See Safety I/O Operation on page 120 for additional information.

If either pair of safety inputs are energized (SI0 and SI1, or SI2 and SI3), the output power transistors will turn on. If either of the safety enable inputs are de-energized, then all output power transistors turn off. The hardwired STO response time is less than 12 ms. Figure 37 shows the timing diagram of the hardwired STO in normal operation. Figure 38 show the timing diagram of the hardwired STO function while Safety Inputs are discrepant.

All safety inputs in hardwired mode are configured for 100 ms Off to On delay, and 1 ms On to Off delay, to reject pulse testing. Both pairs are also configured for a 0.9 s discrepancy time. In hardwired mode, safety inputs 0 and 1 are configured for pulse testing. Safety inputs 2 and 3 are not configured for pulse testing. Torque is enabled when either safety input pair is enabled.

Figure 35 and Figure 36 show wiring examples for both hardwired input pair.

**Figure 35 - Hardwired STO - Dual Channel Device**

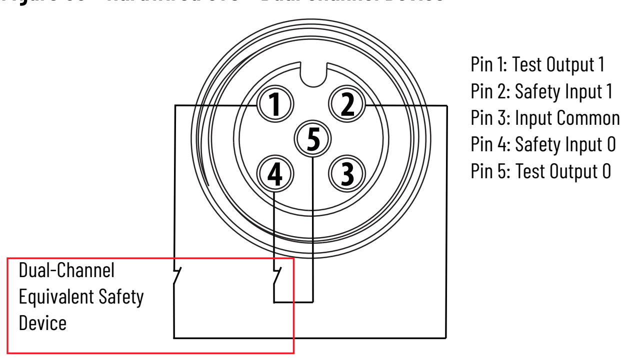


Figure 36 - Hardwired STO - Signal Switching Device

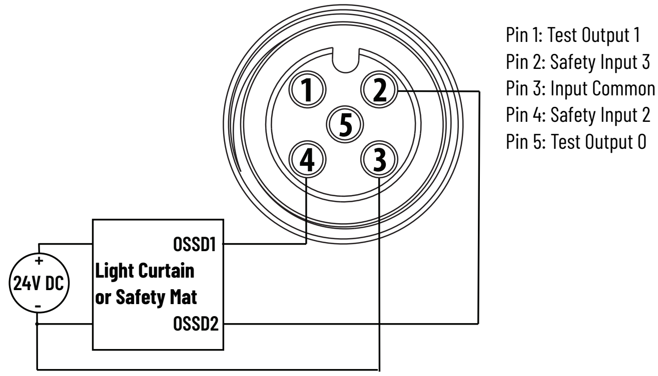
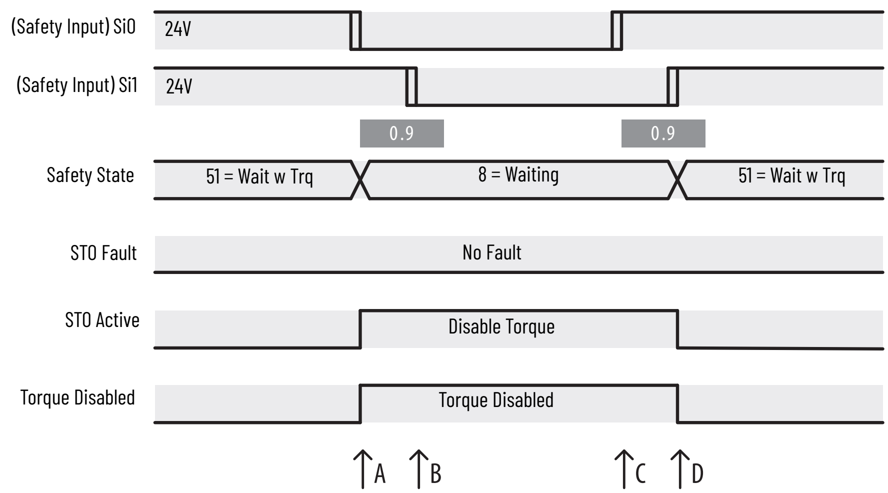



Figure 37 - Normal Operation



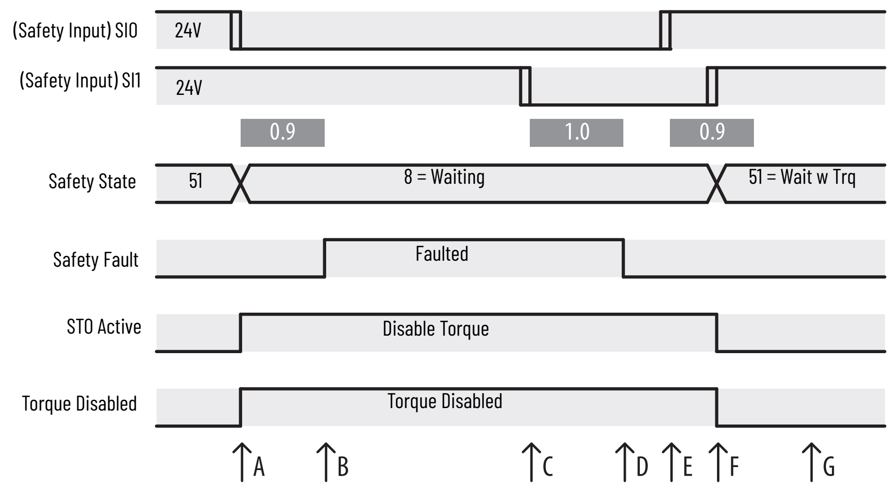

| Letter | Description |
|---|---|
| A | Set Safety Input SI0 = 0 volts |
| B | Set Safety Input SI1 = 0 volts within 0.9 seconds |
| C | Set Safety Input SI0 = 24 volts |
| D | Set Safety Input SI1 = 24 volts within 0.9 seconds |

## Hardwired STO Fault Operation

Both STO safety inputs must turn off together, otherwise a Hardwired Discrepancy (102) STO fault occurs, even if the first safety input gets turned on again. All hardwired inputs must be set to zero for 1 ms, for the fault to be cleared. Figure 38 and Figure 39 describe this operation.

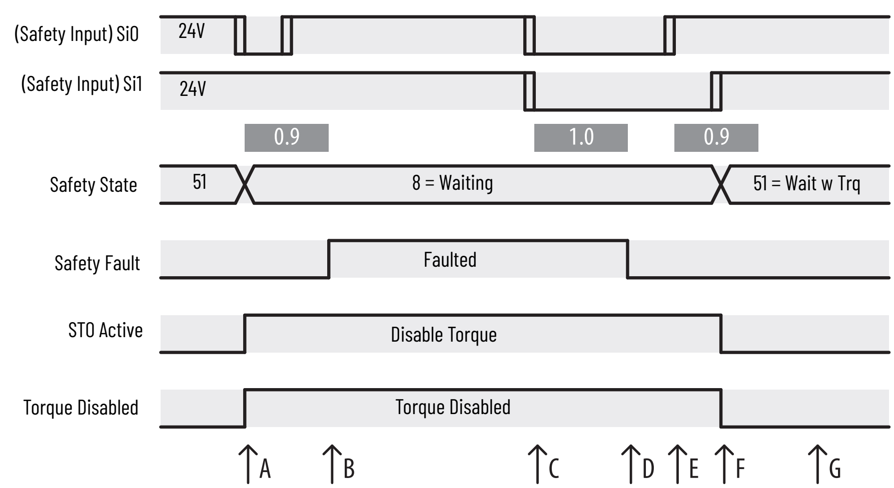
If both input pairs become energized (SI0 or SI1, and SI2 or SI3), a Both Pairs Active (105) STO Fault type will occur. All inputs must be set to zero for 1 ms for the fault to be cleared.

**Figure 38 - System Operation when Safety Enable Inputs Mismatch Occurs**




| Letter | Description |
|---|---|
| A | Set Safety Input SI0 = 0 volts |
| B | Discrepancy fault after 0.9 seconds |
| C | Set Safety Input SI1 = 0 volts |
| D | Discrepancy fault cleared after 1.0 seconds |
| E | Set Safety Input SI0 = 24 volts |
| F | Set Safety Input SI1 = 24 volts |
| G | Clear Armor PowerFlex Fault |

**Figure 39 - System Operation in the Event That the Safety Enable Inputs Mismatch Momentarily**




| Letter | Description |
|---|---|
| A | Set Safety Input SI0 = 0 volts |
| B | Discrepancy fault after 0.9 seconds |
| C | Set Safety Input SI1 = 0 volts |
| D | Discrepancy fault cleared after 1.0 seconds |
| E | Set Safety Input SI0 = 24 volts |
| F | Set Safety Input SI1 = 24 volts |
| G | Clear Armor PowerFlex Fault |

**ATTENTION:** The STO fault is detected upon demand of the STO function. After troubleshooting, a safety function must be executed to verify correct operation.

| IMPORTANT | A Hardwired Input Discrepancy fault (102) and both pairs active fault (105), can be reset by placing all inputs in the off state for more than 1 second. Any other STO fault types can only be cleared in hardwired STO mode by power cycling or resetting the device. |
|---|---|

## Integrated Safety Features

The Armor PowerFlex drive is suitable for use in a safety-control network that meets the requirements up to and including the following:

- SIL CL 3 according to IEC 62061 and IEC 61508
- Category 4, PLe as defined in ISO 13849-1

The TÜV Rheinland group has approved Armor PowerFlex drives with integrated Safe Torque Off (STO) and Safe Stop 1 functions (Timed SS1 and Monitored SS1 and SBC) for use in safety-related applications up to ISO 13849-1 Performance Level e (PLe), SIL CL 3 per IEC 61508, IEC 61800-5-2, and IEC 62061, in which removing the motion-producing power is considered to be the safe state. See the GuardLogix Safety Application Instruction Set Reference Manual, publication 1756-RM095, for more information on the Drive Safety instructions and TÜV Rheinland certification.

### Integrated Safety Applications

Armor PowerFlex 35S drives feature integrated safety I/O (4 safety inputs, 2 test outputs, and 1 bipolar safety output) as well as integrated Safe Stop and Safe Monitor functions.

Drive-based safe stop functions that are built in to the Armor PowerFlex 35S drives are:

- Safe Torque Off
- Timed Safe Stop 1
- Monitored Safe Stop 1
- Safe Brake Control, stop functions

Controller-based safety functions operate in GuardLogix 5580 or Compact GuardLogix 5380 controllers and use the EtherNet/IP network to communicate with the safety I/O. Drive Safety instructions use safety feedback, provided by the Armor PowerFlex drive to the safety task of the controller, to perform safe monitor functions.

The supported Drive Safety instructions are:

- Safety Feedback Interface (SFX)
- Safe Stop 1 Monitored (SS1)
- Safely-limited Speed (SLS)
- Safely limited Position (SLP)
- Safe Direction (SDI)
- Safe Brake Control (SBC)

When used for safe speed monitoring, the drive is configured for single-feedback to achieve the following safety rating:

Single-feedback configurations using safety encoders provide up to SIL 2 PLd capability.

| IMPORTANT | Drive Safety instructions are only available in Logix Designer V31 or greater and can only be used with Compact GuardLogix 5380 and GuardLogix 5580 controllers. |
|---|---|

## Integrated Safety System Application Requirements

Safety application requirements include evaluating average frequency of dangerous failure rates (PFH), system reaction time settings, and functional verification tests that fulfill the SIL criteria. Create, record, and verify the safety signature as part of the required safety application development process. The safety controller creates the safety signature. The safety signature consists of an identification number, date, and time that uniquely identifies the safety portion of a project. This signature covers all safety logic, data, and safety I/O configuration. For safety system requirements, including information on the safety network number (SNN), verifying the safety signature, and functional verification tests, see the GuardLogix Controller Systems Safety Reference Manuals. See Additional Resources on page 13.

| | |
|---|---|
| **IMPORTANT** | You must read, understand, and fulfill the requirements that are detailed in the appropriate GuardLogix controller systems safety reference manual before operating a safety system that uses a GuardLogix controller and an Armor PowerFlex drive. See Additional Resources on page 13. |

## Drive-based Integrated Safe Stop Functions

| | |
|---|---|
| **IMPORTANT** | Safety Output Monitor Value is not safety data and has no defined safe state. Use Output Monitor Value for diagnostic purposes only. |

The information in this section describes information that is common to the integrated Safe Torque Off, Timed Safe Stop 1, Monitored Safe Stop 1, and Safe Brake Control stop functions that are built into the drive. Detailed information for each function follows this topic.

- Safe Torque Off page 96
- Timed Safe Stop 1 page 102
- Monitored Safe Stop 1 page 103
- Safe Brake Control page 105

*Safety Output Assembly Safe Stop Function Tags*

The safety output assembly for Integrated Safe Speed consists of different Logix tags:

- Pass thru status and faults
- Safety stop function commands
- Safety I/O commands

See Safety Output Tags on page 186 for a list of Safety Output Assembly Tags.

*Safety Input Assembly Safe Stop Function Tags*

The safety input assembly for Integrated Safe Speed consists of different Logix tags:

- Connection status
- Safety feedback and stop function status
- Safety I/O status

See Safety Input Tags on page 184 for a list of Safety Input Assembly Tags.

**ATTENTION:** Safety I/O connections and produced/consumed connections cannot be automatically configured to fault the controller if a connection is lost and the system transitions to the safe state. If you must detect a device fault so that the system maintains the required SIL level, you must monitor the Safety I/O CONNECTION_STATUS bits and initiate the fault via program logic.

*Safety Function in Response to Connection Event*

The drive allows for a safety function to be executed when the safety connection to the drive is lost or the connection enters the idle state. This operation is referred to as the connection action. There are two configurable connection actions that are defined as follows:

- Connection Loss Action - The safety function to be executed if the network connection from the drive to the safety controller is lost or closed.
- Connection Idle Action - The safety function to be executed if the safety controller that is connected to the drive enters program mode.

In both of theses cases, the safety function must be executed by the drive. Therefore, only the drive-based safety functions are used in these cases.

The following drive-based safety functions are supported as a connection loss action and connection idle action:

- STO
- SS1

The action can be configured in the Logix Designer application on the Actions page. See Configure Safety Actions on page 181, for more information.

## Integrated Safe Torque Off Function

The Safe Torque Off (STO) feature provides a method, with sufficiently low probability of failure, to force the output power to a disabled state. When the command to execute the STO function is received by the Armor PowerFlex drive, the output power device transitions to an Off state, which results in a condition where the motor is coasting.

The Integrated STO response time is less than 10 ms.

**ATTENTION:** Safe Torque Off (STO) will prevent the motor from applying torque to a system but in some systems torque is also applied to the mechanical system by a suspended load, unbalanced load, back pressure, and so on. In such a system, application of a mechanical brake is required to hold the load while motor torque is disabled by STO.

You can use the STO circuit in combination with other safety devices to achieve the stop and protection-against-restart as specified in IEC 60204-1. These conditions must be met for integrated control of the STO function:

- You must have a GuardLogix family of safety controllers project with an EtherNet/IP network connection configured.
- You must add the drive to the Ethernet network connection in the safety controller I/O tree.

| | |
|---|---|
| **IMPORTANT** | Integrated STO will not work unless an IP address has been configured for the drive. See Set the IP Address on page 61. |

The safety reaction time is the time from when the Armor PowerFlex drive STO command receives the CIP Safety™ packet that triggers a safe stop to the initiation of the configured Stop Type. See Safety Data for Safety Functions with Safety Feedback on page 85, for details.

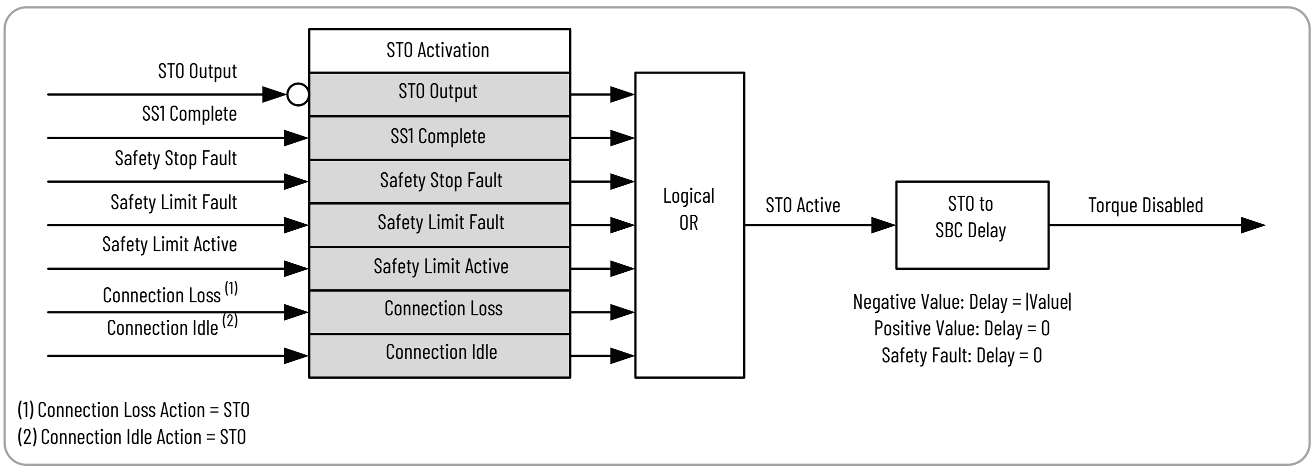
### *Safe Torque Off Activation*

Safe Torque Off can be initiated by one or more sources:

- STO Output – Setting the Safety Output Assembly Tag (*devicename*:SO.STOOutput1 = 0)
- SS1 Complete – Completion of a Safe Stop 1
- Stop Fault – Any Safety Fault
- Connection Loss – Loss of connection to the safety controller
- Connection Idle – Safety controller in program mode

When STO is activated, all sources of activation are stored in an attribute as a bit mask. The attribute can then be read to determine the causes of a STO activation. Figure 40 shows the operation of the STO activation attribute. The STO Activation attribute can be read with a Message (MSG) Instruction (see attribute 265 in Armor PowerFlex AC Drives CIP Objects and Attributes Reference Data, publication 35-RD001).

**Figure 40 - Safe Torque Off Activation**




### *Safe Torque Off Reset*

After torque is disabled due to a STO activation, the STO function must be reset to enable torque. When the STO function must be reset, the following attribute values are set:

- *devicename*:SI.STOActive = 1
- *devicename*:SI.RestartRequired = 1

The steps to reset the STO function depend on the cause of STO activation and the Restart/Cold Start Type configured in the module.

- Safety Fault STO Activation Reset

| | |
|---|---|
| **IMPORTANT** | When a Safety Fault activates the STO function, the cause of the safety fault must be removed before STO can be reset, regardless of the configured restart type. |

Once the cause of the fault is removed, a 0 to 1 transition on the *devicename*:SO.ResetRequest tag resets the STO function to the Torque Enabled state.

- Connection Loss/Idle STO Activation Reset

  If a connection loss/idle event activates the STO function, the connection must be re-established and running before the STO function can be reset. The function must be reset based on the configured Cold Start type.

- Automatic Cold Start/Restart Type Operation

  If there are no Safety Faults and no safety demands, the STO function can be reset.

- Manual Cold Start/Restart Type Operation

  If there are no Safety Faults and no safety demands present in the module, the STO function can be reset by a 1 to 0 transition on the *devicename*:SO.STOOutput tag then a 0 to 1 transition on *devicename*:SO.ResetRequest tag.

Setting *devicename*:SO.STOOutput = 1 and *devicename*:SO.RequestReset = 1 in the same program scan, enables torque.

### *Safe Torque Off Delay*

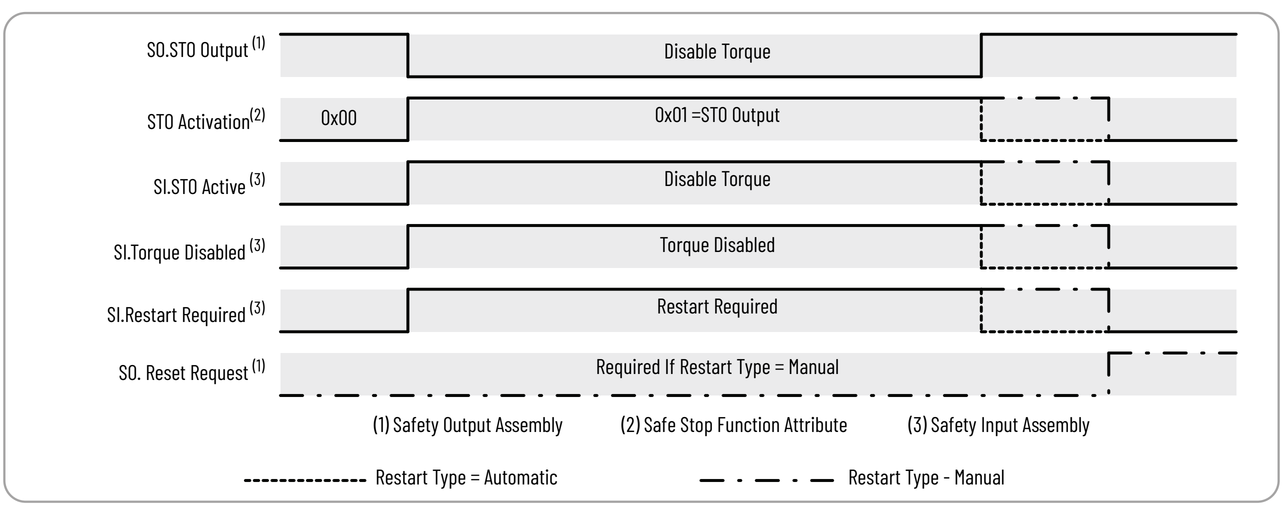
A delay to provide time for the drive to stop the load in response to STO Active can be programmed. This delay time is referred to as STO Delay. If no delay is desired, set the STO Delay to zero. The STO Delay must be a positive integer value.

If Safe Brake Control is being used, the STO delay must be zero. If an STO delay is desired with the use of the Safe Brake Control function, see Safe Brake Control Function on page 105 for information on how to configure STO to SBC delay. If STO is activated by a safety fault, any configured delay is ignored, and torque is disabled instantly.

### *Safe Torque Off Operation*

The operation of the STO function and its attributes is dependent on the configuration of the STO function and the activation reason. For all STO activations besides safety fault, the operation of STO is dependent on STO Delay. For STO activations caused by a safety fault, the operation ignores STO Delay. See the following sections for more information.

**Figure 41 - STO Without Delay**

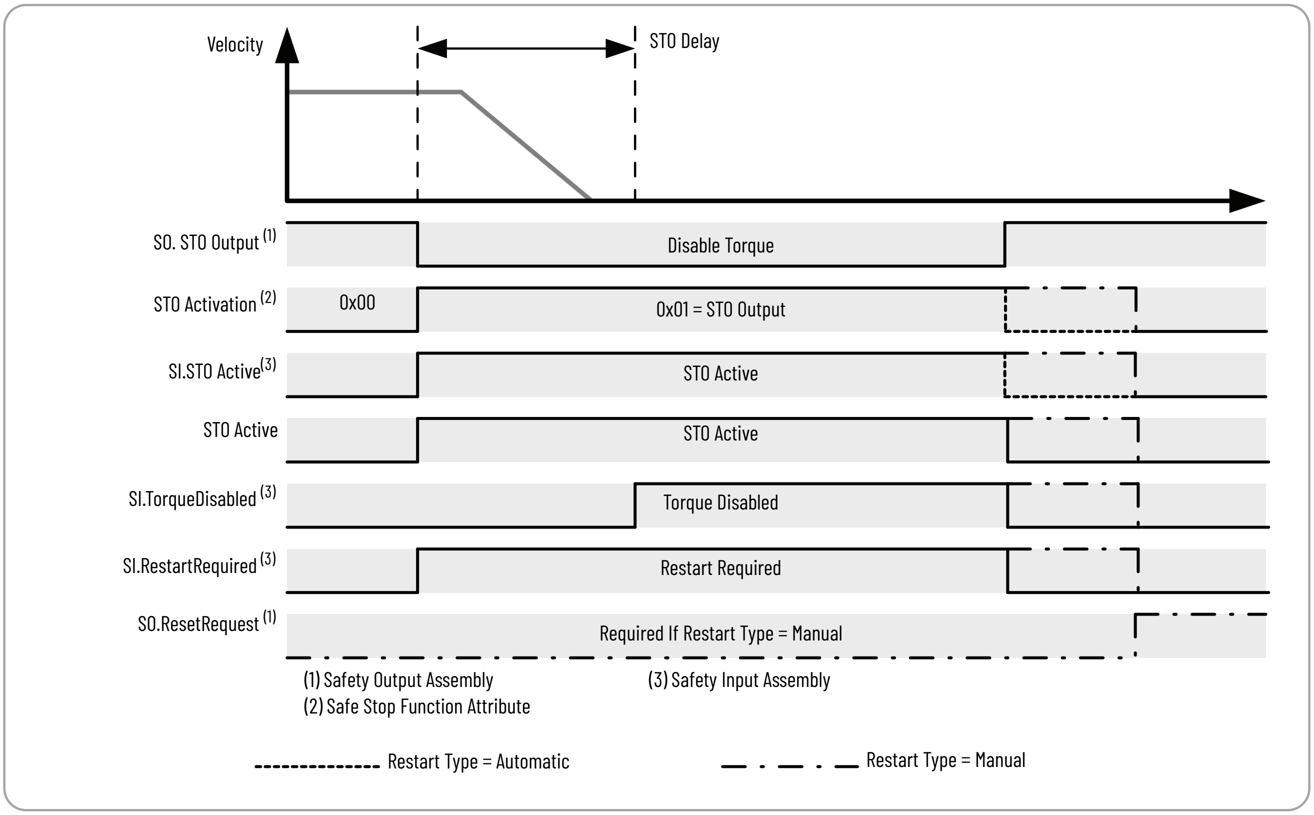


### *Safe Torque Off With Delay Operation*

When the STO Delay is configured for a positive nonzero value, the delay is inserted between STO Active and Torque Disabled. The STO Delay is meant to serve as a delay between the configured STO drive stop action and when torque is disabled. The delay allows the drive to complete the stop before torque is disabled. This operation is effectively a Timed Safe Stop 1 function. See Safe Stop 1 Function on page 100 for information on how to configure a drive stop type in response to a STO activation.

Figure 42 shows the timing of STO status and torque attributes in response to a STO activation, along with the restart type behavior, when STO Delay is configured.

**Figure 42 - STO with Delay**




| | |
|---|---|
| **IMPORTANT** | The Safe Brake Control (SBC) Mode must be set to 'Not Used' to permit STO Delay. If Mode is not set to 'Not Used', Delay is set to zero. |

## Safe Torque Off Safety Fault

When the Armor PowerFlex drive experiences a STO Fault, the Armor PowerFlex drive is placed in the safe state and the cause of the fault is recorded. If the STO function detects a fault, it sets the following attributes:

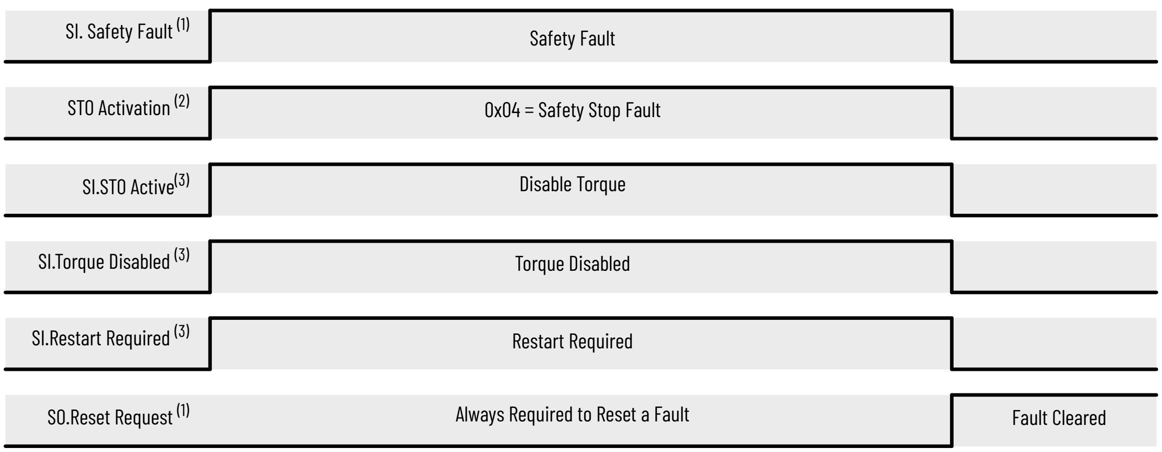
- *devicename*:SI.SafetyFault = 1
- *devicename*:SI.RestartRequired = 1
- STO Fault Type, see Safe Torque Off Fault on page 117

For more information on STO Fault Types and troubleshooting methods, see Monitor Safety Status and Faults via a Message Instruction on page 116.

When a safety fault occurs in the module, the STO function is forced to the Safe State, which is the Torque Disabled state. In this case, the configured STO Delay value is bypassed and torque is immediately disabled. Figure 43 shows the timing of STO and torque attributes in response to STO activation by a Safety Fault.

Clearing a Safety Fault requires correcting the fault condition, then a 0 to 1 transition on Request Reset.

**Figure 43 - STO with Safety Fault**




(1) Safety Output Assembly (2) Safe Stop Function Attribute (3) Safety Input Assembly

**ATTENTION:** If STO activation by a safety fault occurs, the configured STO Delay time is ignored, and torque is immediately disabled.

## Safe Stop 1 Function

The Safe Stop 1 (SS1) function signals the configured SS1 Stop Action Source to initiate a stopping action, then the safety module monitors the stop. When the Safe Stop 1 is complete, STO is activated and torque is disabled. If the drive does not complete the stop within the limits that are configured in the Safe Stop 1 function, an SS1 Fault is annunciated.

### *Safe Stop 1 Activation*

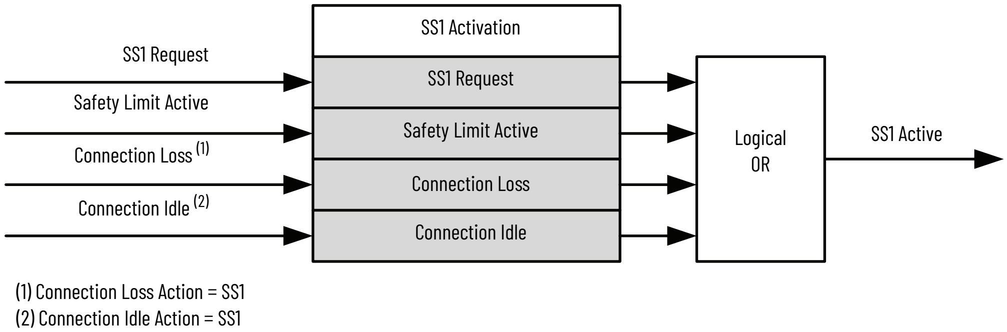
Safe Stop 1 can be initiated by one or more sources:

- SS1 Request – Setting the Safety Output Assembly Tag (*devicename*:SO.SS1Request1 = 1)
- Limit Active – Reserved for future use
- Connection Loss – Loss of connection to the safety controller
- Connection Idle – Safety controller in program mode

When SS1 is activated, all sources of activation are stored in an attribute as a bit mask and the attribute can then be read to determine the causes of an SS1 activation. Figure 44 shows the operation of the SS1 activation attribute. The SS1 Activation attribute can be read with a message instruction (see attribute 289 in Armor PowerFlex AC Drives CIP Objects and Attributes Reference Data, publication 35-RD001).

Unlike the STO function, SS1 does not get activated by a safety fault.

**Figure 44 - Safe Stop 1 Activation**




### *Safe Stop 1 Reset*

After an SS1 action is complete, the SS1 function must be reset to enable torque. When the SS1 Function needs to be reset, the following attribute values are set:

- *devicename*:SI.SS1Active = 1
- *devicename*:SI.RestartRequired = 1

The steps to reset the SS1 function depend on the cause of SS1 activation and the Restart/Cold Start Type configured in the module.

- Connection Loss/Idle SS1 Activation Reset

  If a connection loss/idle event activates the SS1 function, the connection must be re-established and running before the SS1 function can be reset. The function must be reset based on the configured Cold Start type.
- Automatic Cold Start/Restart Type Operation

  If there are no Safety Faults present in the module, the SS1 function can be reset by a 1 to 0 transition on the *devicename*:SO.SS1Request1 tag.
- Manual Cold Start/Restart Type Operation

  If there are no Safety Faults in the module, the SS1 function can be reset by a 1 to 0 transition on the *devicename*:SO.SS1Request1 tag then a 0 to 1 transition on *devicename*:SO.ResetRequest tag.

### *SS1 Safety Fault*

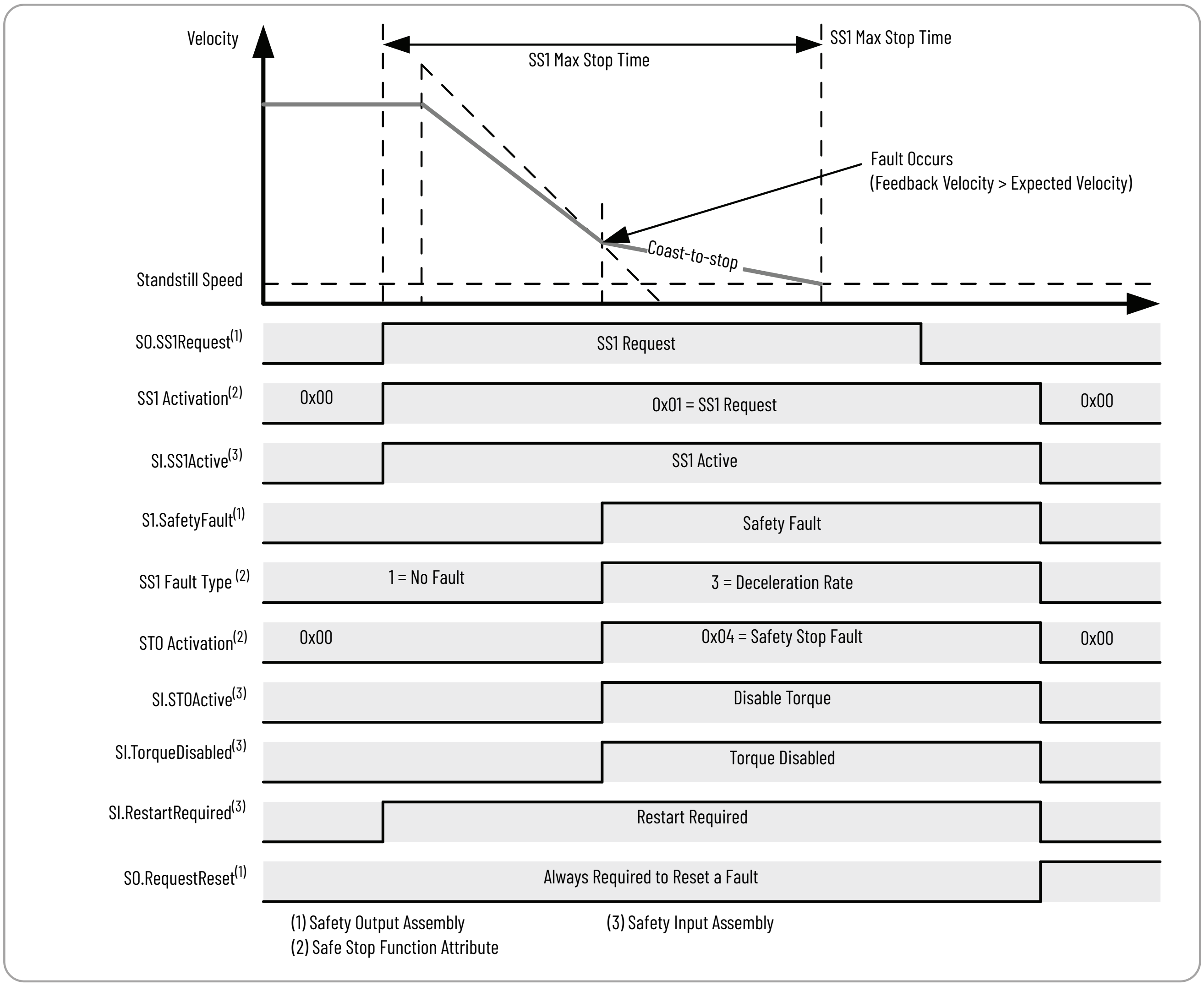
When an SS1 Safety Fault occurs, the STO function is activated immediately and torque is disabled. Figure 45 describes the operation of SS1 when an SS1 fault is detected.

The 'Safe State' of the SS1 function is the Torque Disabled state. If the SS1 function detects a fault, it sets:

- *devicename*:SI.SafetyFault = 1
- *devicename*:SI.RestartRequired = 1
- SS1 Fault Type, see Safe Stop 1 Fault on page 118

Clearing a Safety Fault requires correcting the fault condition and a 0 to 1 transition on Request Reset. For more information on SS1 Safety Faults, see Monitor Safety Status and Faults via a Message Instruction on page 116.

**Figure 45 - Safe Stop 1 Fault Operation**




### *Timed Safe Stop 1*

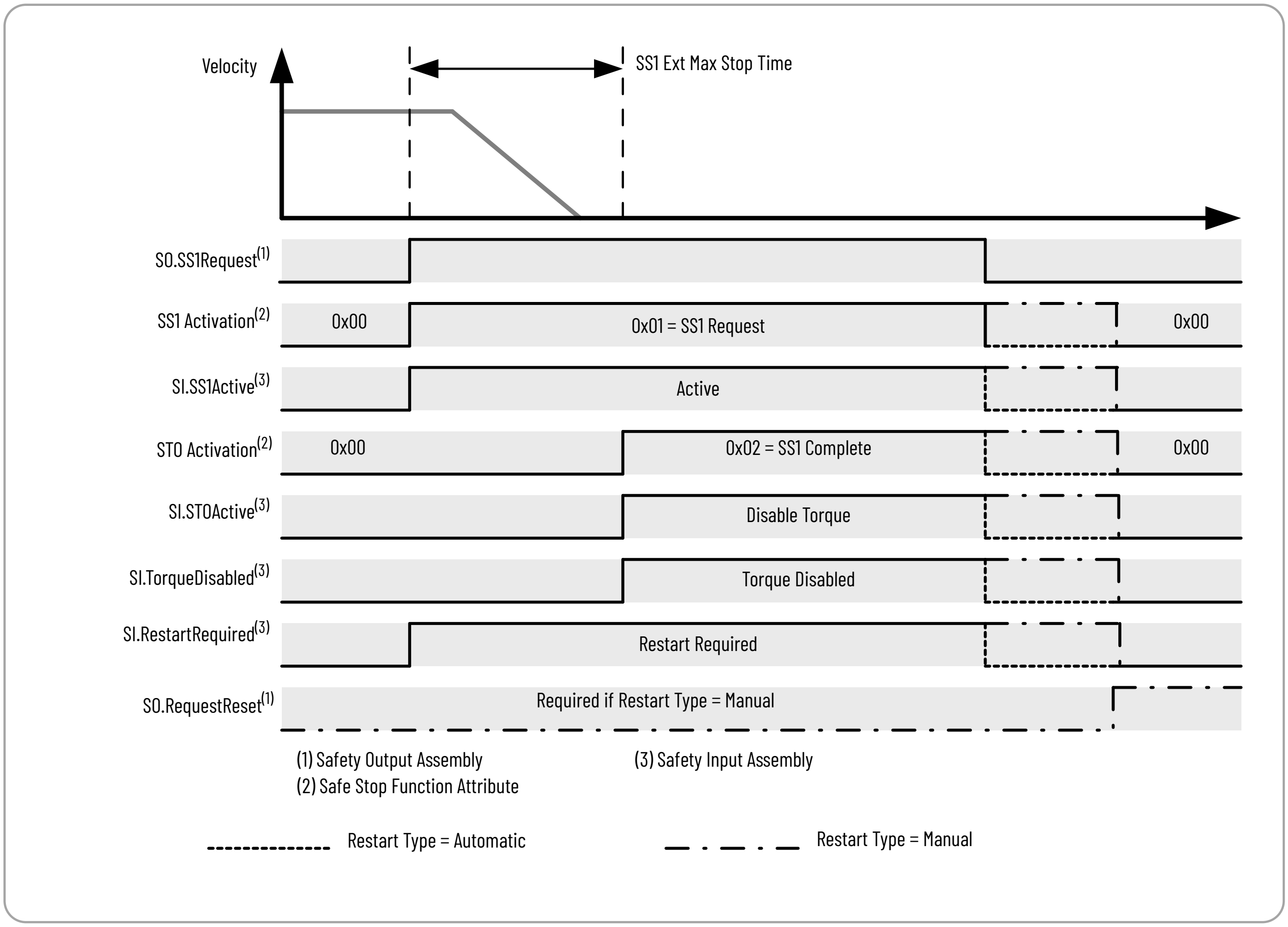
A Timed Safe Stop 1 involves initiating motor deceleration and initiating the STO function after the configured time delay.

### *Timed Safe Stop 1 Operation*

When the Armor PowerFlex drive is configured for Timed Safe Stop 1 Mode, the Safe Stop 1 function is initiated by setting the *devicename*:SO.SS1Request1 safety output tag. This sets the 'SS1 Request' bit in the SS1 Activation attribute and sets the *devicename*:SI.SS1Active safety input tag.

The SS1 function waits for the configured SS1 Max Stop Time, then sets the SS1 Complete flag in the STO Activation attribute, which sets STO Active to Disable Torque. In Timed Safe Stop 1 mode, speed and deceleration are not monitored so this mode does not require Safety Feedback. Figure 46 shows the timing of SS1 status and torque attributes in response to an SS1 activation, along with the restart type behavior.

**Figure 46 - Timed Safe Stop 1**




### *Monitored Safe Stop 1*

A Monitored Safe Stop 1 involves monitoring the motor feedback deceleration rate and time, then initiating an STO activation when the motor feedback speed is below a specified limit.

### *Monitored Safe Stop 1 Operation*

When the Armor PowerFlex drive is configured for Monitored Safe Stop 1 Mode, the Safe Stop 1 function is initiated by setting the *devicename*:SO.SS1Request1 safety output tag. This sets the 'SS1 Request' bit in the SS1 Activation attribute, and also sets the *devicename*:SI.SS1Active safety input tag.

After the SS1 Active bit is set, the configured SS1 Decel Monitor Delay timer begins. After the configured Decel Monitor Delay expires, an internal speed ramp value is computed every time that the encoder is sampled. If the magnitude of *devicename*:SI.FeedbackVelocity exceeds the sum of the internal ramp plus Decel Speed Tolerance, the SS1 Fault Type attribute is set to 'Deceleration Rate' and the SS1 Fault attribute is set to Faulted.

Figure 47 describes the equations that are used for computing the deceleration (decel) reference rate and tolerance.

**Figure 47 - SS1 Deceleration Reference Rate and Tolerance Calculation**

$$Decel\ Reference\ Rate = \frac{Decel\ Reference\ Speed}{1000 \times Stop\ Delay}$$

**If Time Units = Seconds,**

$$SS1\ Decel\ Ref\ Rate = -\frac{Decel\ Reference\ Rate \times Position\ Scaling}{Feedback\ Resolution}$$

$$SS1\ Decel\ Tolerance = \frac{Decel\ Reference\ Tolerance \times Position\ Scaling}{Feedback\ Resolution}$$

**If Time Units = Minutes,**

$$SS1\ Decel\ Ref\ Rate = -\frac{Decel\ Reference\ Rate \times Position\ Scaling}{Feedback\ Resolution \times 60}$$

A Configured Decel Reference Rate of 0 disables the ramp check. SS1 faults if the drive does not slow to less than the Standstill Speed.

If the magnitude of *devicename*:SI.FeedbackVelocity is not less than the configured Standstill Speed before Max Stop Time expires, the SS1 Fault Type is set to 'Maximum Time' and the SS1 Fault attribute is set to 'Faulted'. Figure 48 describes the equations that are used for computing the standstill speed.

**Figure 48 - SS1 Standstill Speed Calculation**

**If Time Units = Seconds,**

$$SS1\ Standstill\ Speed = \frac{Standstill\ Speed \times Position\ Scaling}{Feedback\ Resolution}$$

**If Time Units = Minutes,**

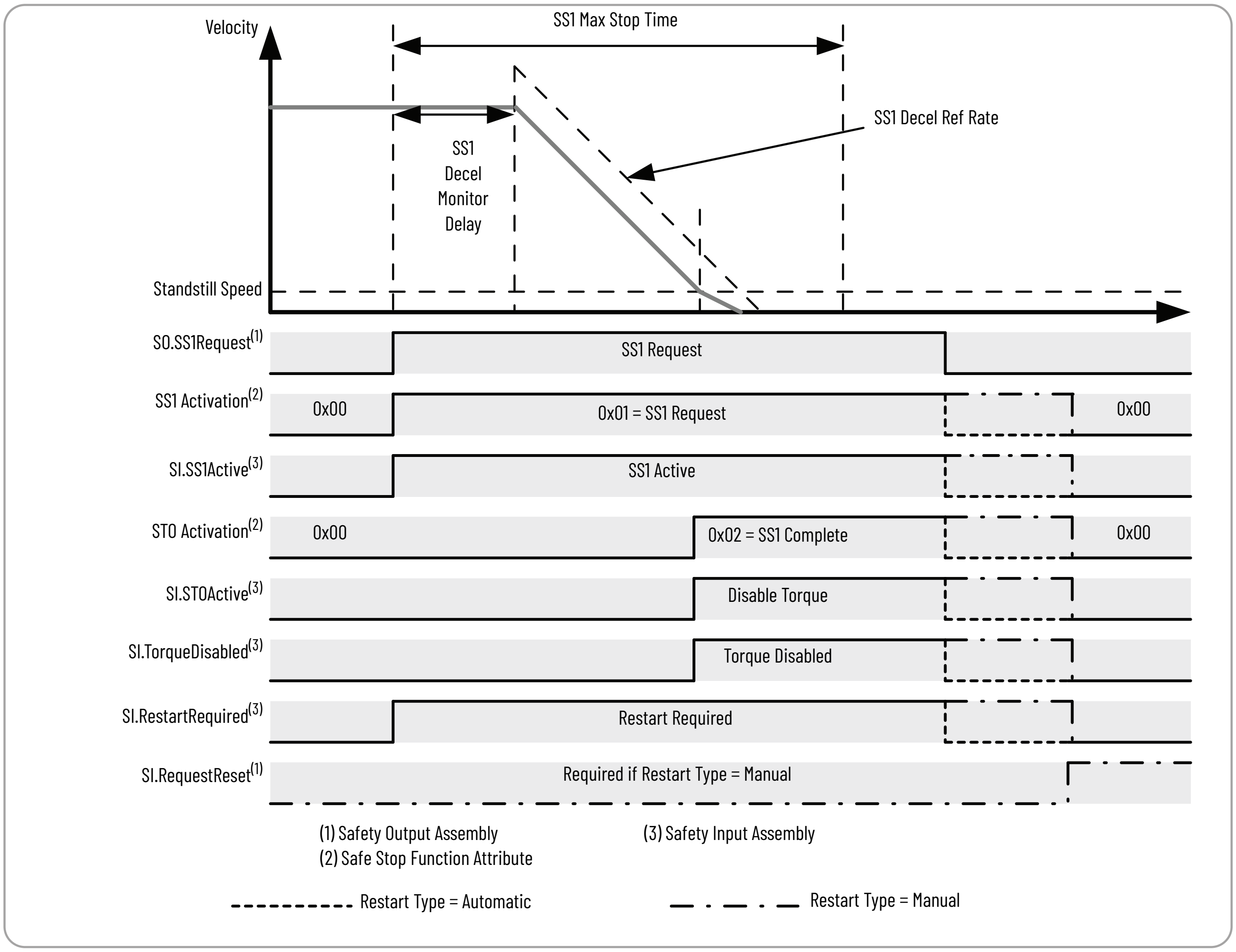
$$SS1\ Standstill\ Speed = \frac{Standstill\ Speed \times Position\ Scaling}{Feedback\ Resolution \times 60}$$

Where *Standstill Speed*, *Position Scaling*, and *Feedback Resolution* are user-configured values.

When the magnitude of *devicename*:SI.FeedbackVelocity is less than the Standstill Speed, the SS1 Complete flag in the STO Activation attribute is set, and STO Active is set. If STO Delay is positive (and SBC Mode = Not Used) or if STO to SBC Delay is negative (and STO Activates SBC = Linked), then the Torque Disabled attribute is set after the configured time delay. Otherwise, the Torque Disabled attribute is set immediately.

Figure 49 shows the timing of the Monitored SS1 operation, along with the restart type behavior.

**Figure 49 - Monitored Safe Stop 1**




Speed units are configured by the 'Position Units' and 'Time Units' Add-on Profile Controls on the Scaling page.

A Configured Decel Reference Rate of 0 disables the ramp check. SS1 will fault if the drive does not slow to less than the Standstill Speed within Max Stop Time.

## Safe Brake Control Function

The Safe Brake Control (SBC) function uses the module's safety outputs to control an electromechanical brake that is attached to the motor. The SBC function releases the brake to allow motion or engages the brake to prevent motion.

### *Safe Brake Control Activation*

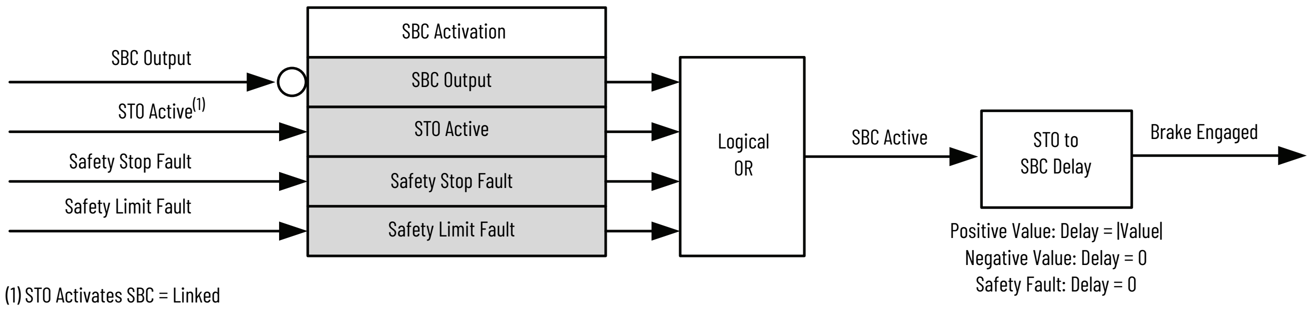
Safe Brake Control can be initiated by one or more sources:

- SBC Output – Clearing the Safety Output Assembly Tag (*devicename*:SO.SBCOutput1 = 0)

- STO Active – SBC is configured as 'Linked'
- Safe Stop Fault – Any Safety Fault
- Safe Limit Fault – Reserved for future use

When SBC is activated, all sources of activation are stored in an attribute as a bit mask, and the attribute can then be read to determine the causes of an SBC activation. Figure 50 shows the operation of the SBC activation attribute. The SBC Activation attribute can be read with a message instruction (see attribute 365 in Armor PowerFlex AC Drives CIP Objects and Attributes Reference Data, publication 35-RD001).

**Figure 50 - Safe Brake Control Activation**




(1) STO Activates SBC = Linked

If the SBC Activation bit mask indicates that only STO Active is the source of activation, then the STO to SBC Delay is executed. If the activation is not by STO Active, or other activation bits are also set, the STO to SBC Delay is not executed and the brake is immediately engaged.

### *Safe Brake Control Reset*

After the brake is engaged due to an SBC activation, the SBC function must be reset to release the brake. When the SBC function must be reset, the following attribute values are set:

- *devicename*:SI.SBCActive = 1
- *devicename*:SI.RestartRequired = 1

The steps to reset the SBC function depend on the cause of SBC activation and the Restart/Cold Start Type configured in the module.

| | |
|---|---|
| **IMPORTANT** | When the SBC function is activated by a Safety Fault, the cause of the safety fault must be removed before the SBC function can be reset, regardless of the configured restart type. |

- Safety Fault SBC Activation Reset

  Once the fault is removed, a 0 to 1 transition on *devicename*:SO.ResetRequest tag resets the SBC function to the Brake Released state.
- Automatic Cold Start/Restart Type Operation

  If there are no Safety Faults in the module, the STO function can be reset by a 0 to 1 transition on the *devicename*:SO.SBCOutput tag.
- Manual Cold Start/Restart Type Operation

  If Restart Type is set to 'Manual' and there are no Safety Faults in the module, the SBC function can be reset by a 0 to 1 transition on the *devicename*:SO.SBCOutput tag, then a 0 to 1 transition on *devicename*:SO.ResetRequest tag.

Setting *devicename*:SO.SBCOutput = 1 and *devicename*:SO.RequestReset = 1 in the same scan enables torque.

### Safe Brake Control Modes

SBC Mode specifies if the SBC functionality is used and how the safety outputs controlling the brake operate. The mode also changes the instances of the CIP objects controlling the safety outputs. The module supports the following modes.

#### Not Used

In 'Not Used' mode, the SBC function is not used by the application. The associated safety outputs are not under SBC control, and can be configured independently. The safety outputs are mapped to the following CIP objects:

- So0: Safety Discrete Output Point Object Instance 1
- So1: Safety Discrete Output Point Object Instance 2
- Safety Dual Channel Output Object Instance 1

| | |
|---|---|
| **IMPORTANT** | If the Safe Brake Mode is set to 'Not Used', then the state of the two safety outputs So0 and So1 is controlled by the Safety Output Assembly tags; otherwise, the two Safety Outputs are controlled by the Safe Brake Function. |

| | |
|---|---|
| **IMPORTANT** | If the Safe Brake Mode is set to 'Not Used', then setting the Safety Output tag *devicename*:SO.SBCOutput1 = 1 sets the SBC Fault and sets the SBC Fault Type to 'Config'. |

#### Used, No Test Pulses

In 'Used, No Test Pulses' mode, the associated safety outputs are not pulse tested. The associated safety outputs are under SBC control and cannot be configured independently. The safety outputs are mapped to the following CIP objects:

- So0: Safety Discrete Output Point Object Instance 3
- So1: Safety Discrete Output Point Object Instance 4
- Safety Dual Channel Output Object Instance 2

#### Used, Test Pulses

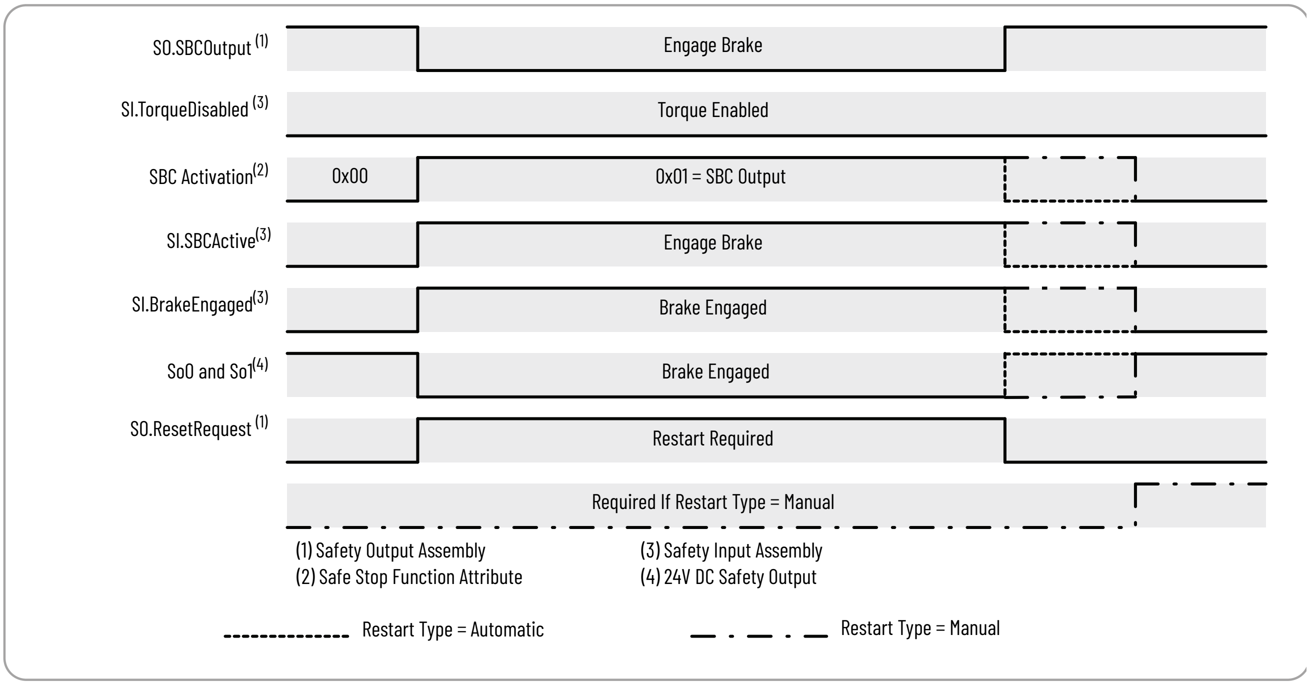
In the 'Used, Test Pulses' mode, the safety outputs are under SBC control and cannot be configured independently. The safety outputs are mapped to the same CIP objects as the 'Used, No Test Pulses' mode.

There is no difference in implementation of Safety Outputs pulse testing in SBC control versus direct control. See Safety I/O Operation on page 120 for pulse test behavior.SBC Operation when Activated by Safety Output Assembly.

| | |
|---|---|
| **IMPORTANT** | If the Safe Brake Mode is set to 'Used', then the Safety Input Assembly tags associated with safety outputs will be forced to:<br>*devicename*:SI.Out00Monitor = 0<br>*devicename*:SI.Out01Monitor = 0<br>*devicename*:SI.Out00Status = 0<br>*devicename*:SI.Out01Status = 0<br>*devicename*:SI.Out00Ready = 0<br>*devicename*:SI.Out01Ready = 0 |

When the SBC function is activated by clearing the *devicename*:SO.SBCOutput tag, the associated safety outputs are de-energized, which forces the brake to engage, and torque is still enabled. Figure 51 shows the timing of SBC attributes when the SBC function is executed independently.

**Figure 51 - SBC Operation by Safety Output Assembly**




### *STO Activates SBC Operation*

If the SBC function is configured to link STO and SBC activation, any STO activation will cause the SBC function to be activated as well. The brake is engaged (de-energized) by the SBC function when torque is disabled by the STO function.

If the SBC function is configured to link STO activation to SBC activation, you can configure an STO to SBC Delay time where:

- STO to SBC Delay > 0 configures a delay between when STO is activated and the brake is engaged. Figure 52 describes this operation.
- STO to SBC Delay < 0 configures the brake to engage when STO is activated and delays disabling torque. Figure 53 describes this operation.

Figure 52 - SBC Linked to STO with Positive Delay

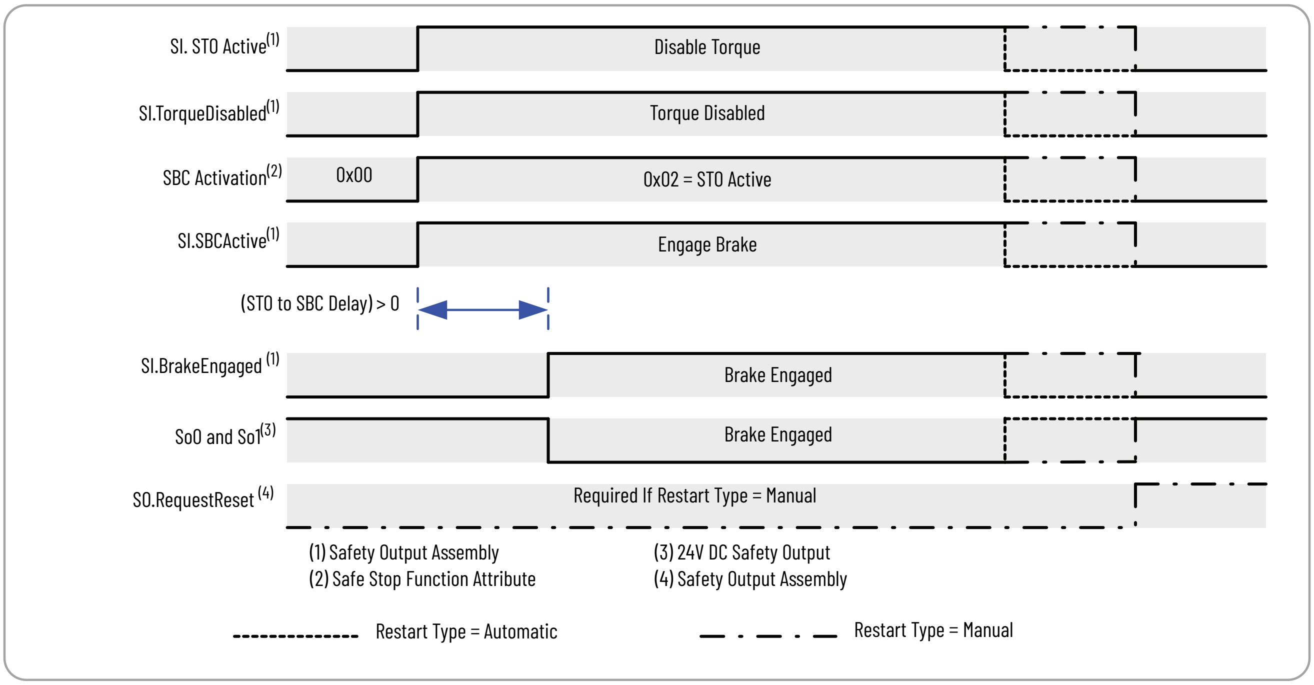
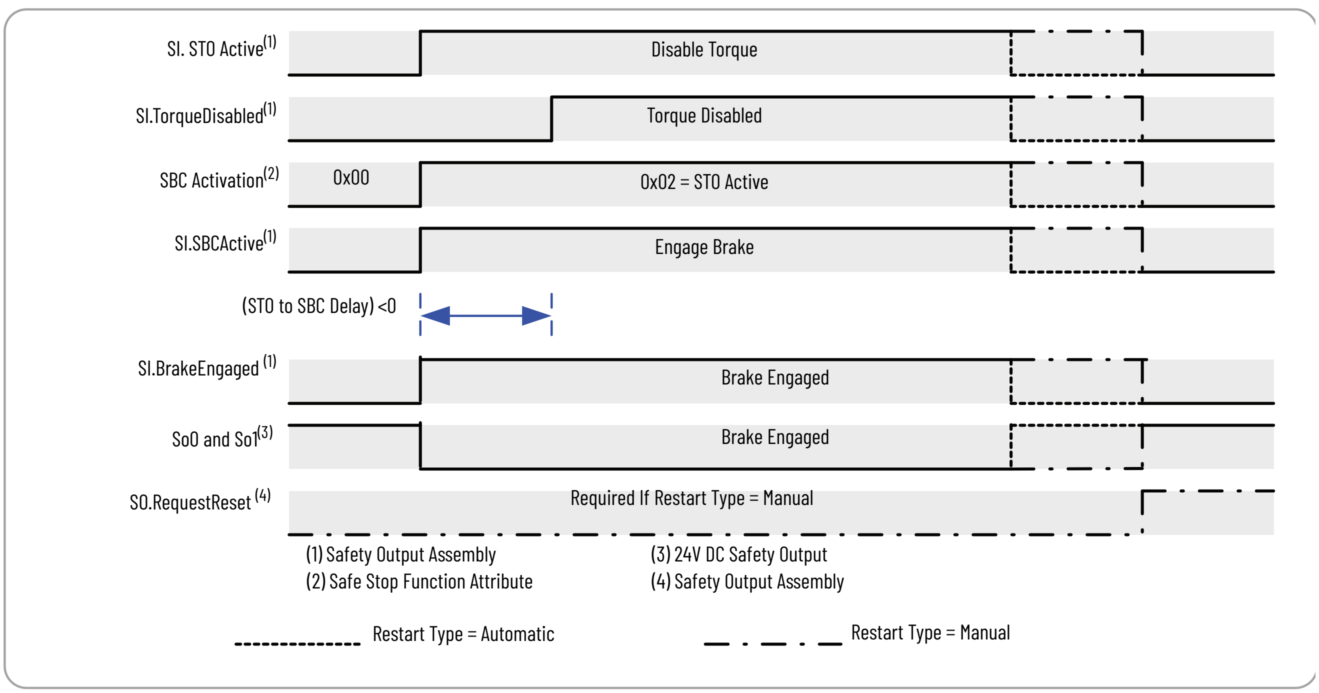



Figure 53 - SBC Linked to STO with Negative Delay




### *SBC Safety Fault*

When the module experiences an SBC Fault, the device is placed in the safe state and the cause of the fault is recorded.

If SBC function detects a fault, it sets:

- *devicename*:SI.SafetyFault = 1
- *devicename*:SI.RestartRequired = 1
- *devicename*:SI.SBCReady = 0

For more information on SBC fault types and troubleshooting methods, see Monitor Safety Status and Faults via a Message Instruction on page 116.

*Connecting a Safety Brake*

| | |
|---|---|
| **IMPORTANT** | If you want a specific system safety rating, you need a safety brake that is rated at least to your desired system safety rating. In a safety chain, the lowest safety rated component limits the overall system safety rating. |

The safety brake control function uses the bipolar safety outputs S00 and S01 to control a safety brake.

The design of a safety brake circuit is application-dependent and is based on the following factors:

- Choice of safety brake for the application
- If the brake provides feedback in the application
- If the application uses single or dual channel

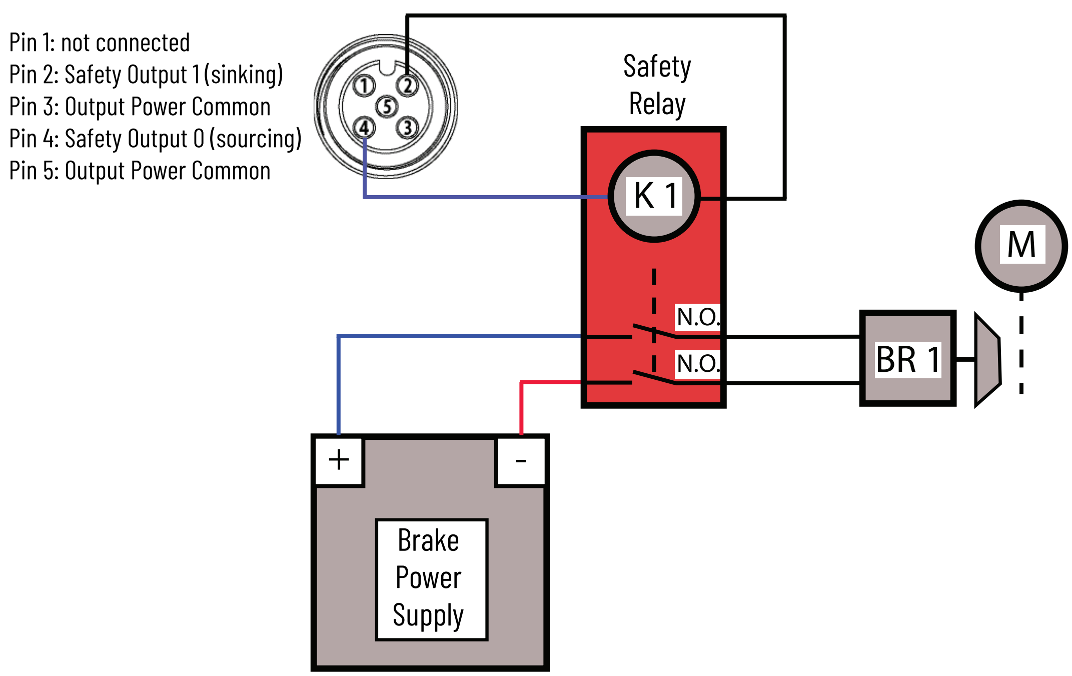
The safety brake function interfaces to the safety brake through the safety outputs S00 and S01. Figure 54 shows a wiring example for connecting a brake to the module.

Usually the voltage and current rating of the safety brake is much higher than the safety outputs can directly control. To support brakes with that require higher voltage and higher current, an interposing safety relay such as the 700S-CF Safety Control Relay is required.

Safety brakes typically require a voltage suppression device. Most safety brakes provide a suppression device as an option or they specify a diode or MOV to use. Use the recommended suppression devices.

The drive-based SBC function does not implement checking of brake feedback; however, the available safety inputs can be used to send the status of brake feedback to the safety controller that is programmed with a diagnostic check.

**Figure 54 - Safety Brake Wiring Example**



## Safety Feedback

| | |
|---|---|
| **IMPORTANT** | For fault-free operation of the encoder, the cable shield of the connecting cable must be grounded on both sides (encoder and control) using large area connections. On the encoder side, this is typically done in the plug connector or via the connecting cable. |

| | |
|---|---|
| **IMPORTANT** | Achievable safety rating depends on each system component. If you want SIL 2 PLd safe feedback, you need an encoder that is rated at SIL 2 PLd or greater. In a safety chain, the lowest safety rated component limits the overall system safety rating. |

**Table 24 - Supported Encoder Types**

| Encoder Type | Achievable System Safety Rating |
|---|---|
| Sine/Cosine | • SIL 2 PLd with safety-rated encoder<br>or<br>• PLd with standard encoder(1) |
| Digital AqB | SIL 2 PLd with safety-rated encoder |

(1) When using a standard sine/cosine encoder, safety relevant data (MTTF) and safety diagnostic measures to achieve the required diagnostic coverage, must be considered. Encoder diagnostics for sine/cosine encoders that are provided by the Armor PowerFlex drive, include: encoder voltage monitoring, $\sin^2 + \cos^2$ vector length monitoring, zero crossing detection, and signal offset. Additional (customer supplied) diagnostics may be required. You must determine the suitability of the encoder and the system safety rating.

The Armor PowerFlex product supports encoder feedback for safe speed monitor functions. Table 24 describes the supported encoder types and achievable safety ratings

You can achieve a PLd rating if using a standard, (not certified) sine/cosine encoder and you can get the relevant failure rate data from the manufacturer and do the calculations to show that this is acceptable for your application.

Rockwell Automation offers the Bulletin 843ES CIP Safety encoders, which provide safety feedback directly to a safety programmable controller via the EtherNet/IP network.

## Safety Encoder Diagnostics

The following encoder diagnostics are available for all supported encoder types:

- Encoder Voltage Monitoring (Configurable)
- Maximum Speed Limit (Configurable)
- Maximum Acceleration (Configurable)
- Maximum Encoder Input Frequency

See Chapter 7, for information on how to configure the diagnostics.

| | |
|---|---|
| **IMPORTANT** | These diagnostics are based on the capability of the chosen encoder and its rated limits. They do not provide a safety-rated safety function. |

*Encoder Voltage Monitoring*

The voltage monitoring diagnostic samples the voltage being supplied to the encoder to confirm that its level is within its configured range. If the voltage monitoring diagnostic detects a voltage that is out of the configured range, the safety feedback instance reports a voltage monitoring fault and causes the module to enter the safe state.

The following voltage monitoring ranges are supported:
- 4.75…5.25V
- 11.4…12.6V

If a voltage range is not specified, then the voltage monitoring diagnostic is not performed.

*Maximum Speed Limit*

The maximum speed limit diagnostic detects when encoder speed is above a configured limit. If the speed of the encoder is greater than the configured max speed limit, an exceeded max speed fault is reported by the safety feedback instance. This causes the module to enter the safe state.

If the encoder being used specifies a maximum speed, set the maximum speed limit configuration value to this value or lower. If the limit is configured as 0, this diagnostic is not performed.

*Maximum Acceleration*

The maximum acceleration diagnostic detects when encoder acceleration is above a configured limit. If the module detects that the acceleration of the encoder has exceeded the configured limit, a max acceleration fault is reported by the safety feedback instance. This causes the module to enter the safe state.

If the encoder being used specifies a maximum acceleration, set the maximum acceleration configuration value to this value or lower. If the maximum acceleration is configured as 0, this diagnostic is not performed.

*Maximum Encoder Input Frequency*

The maximum encoder input frequency diagnostic confirms that the safety feedback signals do not exceed the maximum frequency (encoder counts per second) supported by the module. This value is not configurable and has fixed values based on the encoder type. Table 25 shows the maximum frequency based on encoder type.

**Table 25 - Encoder Maximum Frequency**

| Encoder Type | Maximum Frequency |
|---|---|
| Digital AqB | 250 kHz |
| Sine/Cosine and Hiperface | 163.8 kHz |

If the module detects an encoder input frequency above the limit, a max frequency fault is reported in the safety feedback instance and the module enters the safe state.

## Digital AqB Diagnostics

The following non-configurable diagnostic functions are implemented in the module to perform diagnostics for digital AqB encoders:
- Inverse Signal Monitoring
- Quadrature Error Detection

*Inverse Signal Monitoring*

The inverse signal monitoring diagnostic confirms that the inverted and noninverted signals are always at opposite signal levels. If the module detects that the Digital AqB Encoder signals are not inverse, a feedback signal lost fault is reported in the safety feedback instance and the module enters the safe state. This diagnostic is meant to detect encoder wiring errors, such as open, short, or short to power.

*Quadrature Error Detection*

The quadrature error detection confirms that the A and B signals from the digital AqB encoder do not change simultaneously. This diagnostic is also referred to as an exclusive bit check. If the module detects a quadrature error, the safety feedback instance reports a quadrature error fault and enters the safe state. A simultaneous change indicates an error with the encoder wiring or an issue with the encoder itself.

## Sine/Cosine and Hiperface Diagnostics

The following non-configurable diagnostic functions are implemented in the module to perform diagnostics on Hiperface and or Sine/Cosine type encoders:

- $Sin^2 + Cos^2$ Vector Length Monitoring
- Zero-crossing Detection
- Signal Offset (Sine/Cosine Encoder Type Only)

| **IMPORTANT** | The digital feedback is not compatible with Armor PowerFlex drives and should not be used. Only the analog signals should be used. |
|---|---|

*$Sin^2 + Cos^2$ Vector Length Monitoring*

The $Sin^2 + Cos^2$ vector length monitoring diagnostic confirms that the sine and cosine signals are sinusoidal and 90° apart. This diagnostic is meant to detect errors in the wiring of the encoder and problems within the encoder itself. Table 26 describes the tolerance of encoder output signal amplitudes for this diagnostic. Table 27 describes the phase tolerance of the diagnostic. If the module detects that the amplitude and or phase of the signals is out of range, the safety feedback instance reports a $Sin^2 + Cos^2$ fault and the module is placed in the safe state.

**Table 26 - $Sin^2 + Cos^2$ Vector Length Monitoring Amplitude Range**

| Maximum | Minimum |
|---|---|
| 1.3V p-p | 0.7V p-p |

**Table 27 - $Sin^2 + Cos^2$ Vector Length Monitoring Phase Tolerance**

| Tolerance |
|---|
| 90° ± 20° |

*Zero-crossing Detection*

The zero-crossing detection diagnostic confirms that the sine and cosine signals have a similar offset to ground. The offset tripping point is ± 50 mV. If the offset of the sine and cosine signals is greater than the tripping point, the zero-crossing detection diagnostic fails, a signal lost fault is reported in the safety feedback instance, and the module is placed in the safe state.

### *Signal Offset*

The signal offset diagnostic confirms that a Sine/Cosine type encoder is producing the proper offset on the Sine and Cosine signals. This diagnostic is not performed when the feedback device type is configured as Hiperface. Table 28 describes the offset tolerance of the diagnostic. If the offset of the Sine and or Cosine signals are outside the tolerance range, the safety feedback instance reports a signal offset fault and the module is placed in the safe state.

**Table 28 - Signal Offset Tolerance**

| Maximum | Minimum |
|---|---|
| 3.0V | 2.0V |

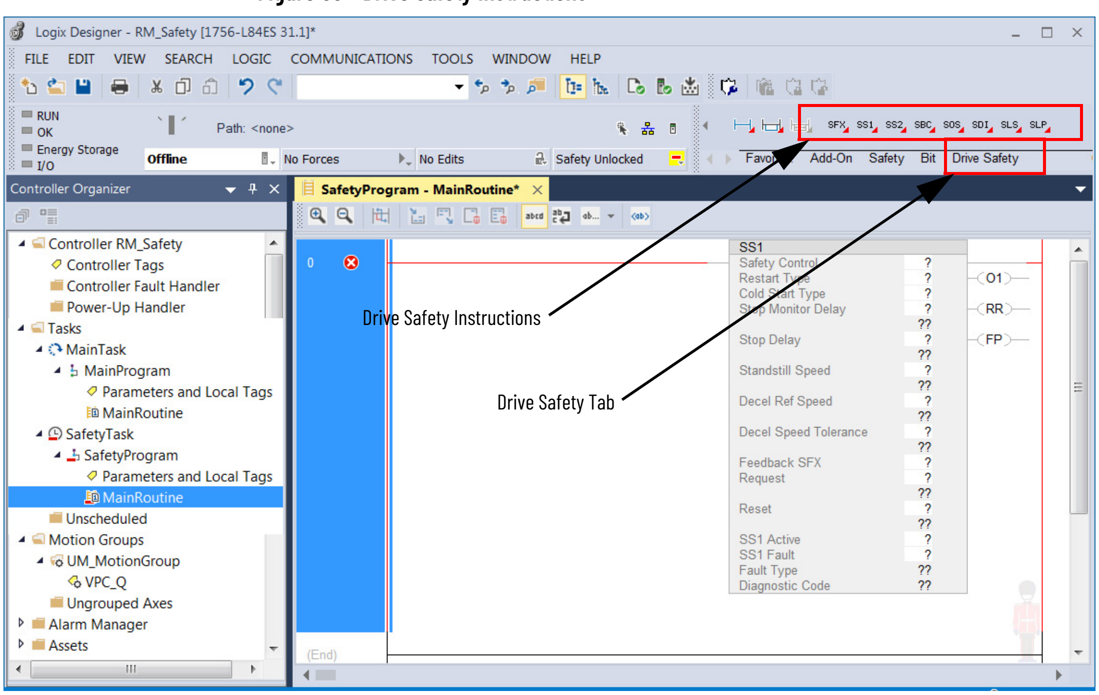
## Controller-based Safe Monitor Functions

The Drive Safety instructions (see Table 29 on page 114) are available in the Studio 5000 Logix Designer® application, version 32.00 or later, in the Drive Safety instruction element group that is enabled when the Safety Program - MainRoutine is open (see Figure 55 on page 114 ).

**Table 29 - Safety Instructions**

| Safety Instruction | | Description |
|---|---|---|
| Safety Feedback Interface | SFX | The SFX function scales feedback position into position units and feedback velocity into position units per time unit. SFX is used with other Drive Safety instructions.SFX also provides unwind for rotary applications and position homing. |
| Safe Stop 1 | SS1 | The SS1 function monitors the motor deceleration rate within set limits during motor stopping and provides an indication to initiate Safe Torque Off (STO) function when the motor speed is below the specified limit. |
| Safely-limited Speed | SLS | The SLS function prevents the motor from exceeding the specified speed limit. |
| Safely-limited Position | SLP | The SLP function prevents the motor shaft from exceeding the specified position limits. |
| Safe Direction | SDI | The SDI function prevents the motor shaft from moving in the unintended direction. |
| Safe Brake Control | SBC | The SBC function provides safe output signals to control an external brake. |

**Figure 55 - Drive Safety Instructions**



## Before Adding the Safety Instructions

Before adding Drive Safety instructions to your Logix Designer application, you must:
- Add the Armor PowerFlex drive to your safety controller project.
- Configure a safety instance of Single Feedback Monitoring.

## Drive Safety Instruction Example

Drive Safety instructions provide the following information. In this example, the Safely-limited Speed (SLS) instruction is shown.

**Figure 56 - SLS Drive Safety Instruction**

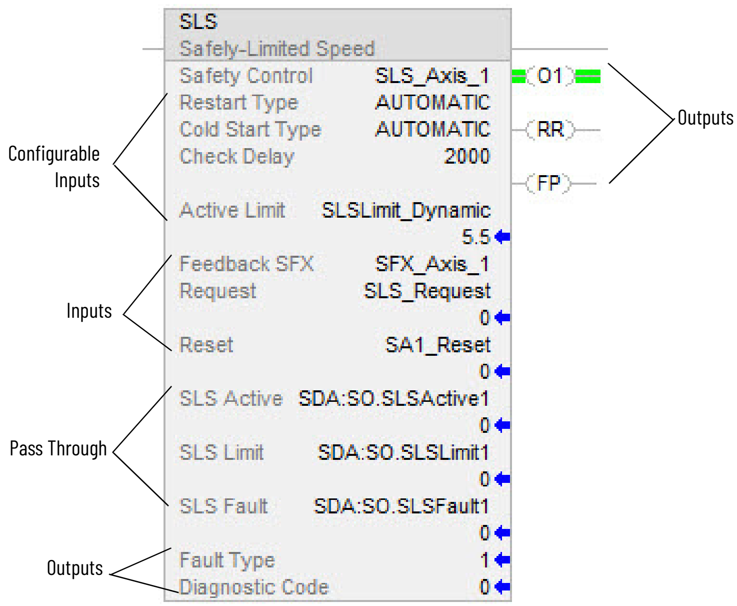



**Table 30 - Drive Safety Instruction Definitions**

| Instruction Information | Description |
|---|---|
| Configurable Inputs | Safety function parameters that are used to define how the safety function operates. |
| Inputs | • Feedback SFX is the link to the SFX instruction for a safety drive.<br>• Request initiates the safe monitoring function.<br>• Reset initiates a safety instruction reset. |
| Pass Through | Safety Output Assembly Object tags pass safety function status information from the Safety Task of the safety controller to the safety instance of the drive module. In standard I/O mode, datalinks must also be configured to provide status information to the standard controller. |
| Outputs | • Fault Type is the instruction fault code that indicates the type of fault that occurred.<br>• Diagnostic Code provides additional details on the fault.<br>• O1 - Output 1 indicates the status of the instruction. When ON (1), it indicates that the input conditions are satisfied.<br>• RR - Reset Required indicates when a reset is needed to restart the instruction or to clear faults.<br>• FP - Fault Present indicates whether a fault is present in the instruction. |

## Safety Feedback Interface Instruction Operation

Although the Safety Feedback Interface (SFX) instruction is a safety instruction, it alone does not perform a safety function.

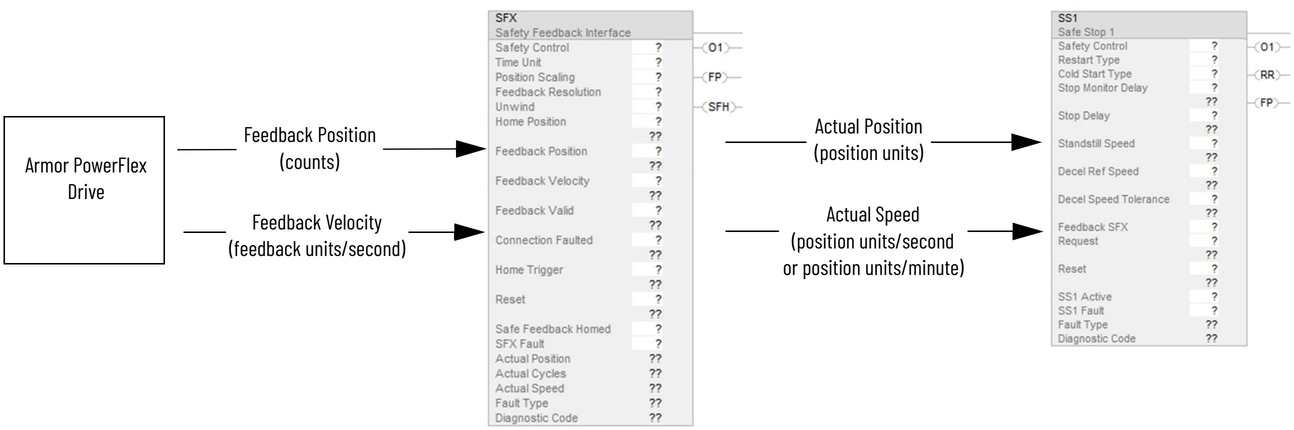
The Safety Feedback Interface (SFX) instruction scales feedback position into position units and feedback velocity into speed units per unit of time. Feedback position and velocity are read from the safety input assembly and become inputs to the instruction. The SFX instruction also sets a reference position from a home input and performs position unwind in rotary applications. Typically, one SFX instruction is used per safety drive. This instruction provides the position and velocity feedback that is used by other safety instructions, also used by the same safety drive.

The drive provides safe position and velocity feedback.

The outputs of the SFX instruction are used as inputs to other Drive safety instructions. For any drive to execute a controller-based safety function, an SFX instruction is required.

In Figure 57, the SS1 instruction uses the Actual Speed output from the SFX instruction during execution of the SS1 safety function.

**Figure 57 - SS1 Instruction**




## Monitor Safety Status and Faults via a Message Instruction

To obtain more detailed information about any faults that are detected in the drive, most faults have a corresponding fault-type attribute. Use an MSG instruction in the ladder program to read the specific attribute information. Details of the various fault-type attributes are described in the following sections.

See Example: Read SS1 Fault Type on page 221 on for an example of using the MSG instruction to read status.

### Safety Supervisor State

The Safety Supervisor State provides information on the state of the safety connection and the mode of operation. It can be read in the user's Logix program using an MSG instruction.

**Table 31 - Safety Supervisor State: MSG**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x0E | Get Attribute Single |
| Class | 0x39 | Safety Supervisor |
| Instance | 1 | – |
| Attribute | 0x0B<br>11 (decimal) | Device Status |
| Data Type | SINT | Unsigned Short Integer |

**Table 32 - Device Status**

| Value | Description |
|---|---|
| 1 | Device is performing test diagnostics |
| 2 | No active connections |
| 3 | A fault has occurred while executing test diagnostics |
| 4 | Normal running state |
| 5 | A major recoverable fault has occurred |
| 6 | A critical fault has occurred |
| 7 | Transition state (configuring) |
| 8 | Out-of-box state: waiting |
| 51 | Out-of-box state: waiting with torque permitted |
| 52 | STO bypass state: executing with torque permitted |

## Safety Core Fault

The Safety instance has detected a nonrecoverable fault or internal error. When this detection happens, the Safety instance reboots itself and attempts to re-establish normal operation.

If this fault persists through power cycles, return the drive for repair. If malfunction or damage occurs, no attempts at repair should be made.

## Safe Torque Off Fault

The Safe Torque Off (STO) function detected a fault. The safe stop function records the specific fault type in the STO Fault Type attribute. Table 33 describes the parameters for an MSG instruction. Table 34 describes the fault types.

**Table 33 - Safe Torque Off Fault Type: MSG**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x0E | Get attribute single |
| Class | 0x5A | Safety stop functions |
| Instance | 1 | Drive-module safety instance |
| Attribute | 0x108 | STO fault type |
| Data Type | SINT | Short integer |

**Table 34 - STO Fault Types**

| STO Fault Type Value | STO Fault Type Name | Description |
|---|---|---|
| 1 | No Fault | No fault is present |
| 3 | Circuit Error | Internal STO diagnostics has found an issue with STO circuitry. |
| 4 | Stuck Low Internal STO health and/or power input stuck low | Internal STO diagnostics indicate an STO signal is stuck low |
| 5 | Stuck High Internal STO health and/or power input stuck high | Internal STO diagnostics indicate an STO signal is stuck high |
| 102 | Hardwired Input Discrepancy | Hardwired input pair are not matching. |
| 104 | Hardwired Input Active in Integrated Mode | A hardwired input is being used while in integrated mode |
| 105 | Both Pairs Active | (Both Safety Input pairs are active, only one can be active for hardwired STO control) |

## Safe Stop 1 Fault

The Safe Stop 1 (SS1) function detected a fault. The safe stop function records the specific fault type in the Safe Stop Fault attribute. Table 35 describes the parameters for an MSG instruction. The drive immediately disables torque, ignoring STO delay, if an SS1 fault is detected. If the SS1 Fault Type is reported as 1 (no fault), the SS1 fault was generated by the connected safety controller and reported to the drive over the safety connection. Table 36 describes the SS1 fault types.

**Table 35 - Safe Stop 1 Fault Type: MSG**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x0E | Get attribute single |
| Class | 0x5A | Safety stop functions |
| Instance | 1 | Drive-module safety instance |
| Attribute | 0x11c<br>284 (decimal) | SS1 fault type |
| Data Type | SINT | Short integer |

**Table 36 - SS1 Fault Types**

| SS1 Fault Type Value | SS1 Fault Type Name | Description |
|---|---|---|
| 1 | No Fault | No Fault is present |
| 2 | Invalid Configuration | The drive-based SS1 function has been requested when it has been configured as 'not used'. |
| 3 | Deceleration Rate | Applies only when SS1 is configured for Monitored SS1 mode. The SS1 function has detected that the feedback speed is not decelerating as fast as expected. |
| 4 | Maximum Time | Applies only when SS1 is configured for Monitored SS1 mode. The SS1 function has detected that the device has not reached standstill speed within the maximum stopping time. |

## Safe Brake Control Fault

The Safe Brake Control (SBC) function detected a fault. The safe stop function records the specific fault type in the SBC Fault Type attribute. The SBC fault type is also recorded in [SBC Fault Type], attribute 364. Table 37 describes the parameters for an MSG instruction. Table 38 describes the fault types.

**Table 37 - SBC Fault Type: MSG**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x0E | Get attribute single |
| Class | 0x5A | Safety stop functions |
| Instance | 1 | Drive-module safety instance |
| Attribute | 0x16C<br>364 (decimal) | SBC fault type |
| Data Type | SINT | Short integer |

**Table 38 - SBC Fault Types**

| STO Fault Type Value | STO Fault Type Name | Description |
|---|---|---|
| 1 | No Fault | No Fault is present. |
| 2 | Invalid Configuration | The drive-based SBC function has been requested when it has been configured as 'not used'. |

## SLS, SLP, and SDI Faults

The drive does not support drive-based SS2, SOS, SLS, SLP, and SDI safe stop/ safety limit functions. The safety controller supports the SLS, SLP, and SDI safety function instructions. If the drive reports one of these faults, either the safety controller detected the fault and reported to the drive over the safety output connection, or the request tag was set through the safety output assembly. Additional information for these faults must be obtained from the safety controller that is associated with the drive. In addition, the safety controller is responsible for issuing a torque disable request.

## Safety Feedback Faults

When configured for safety feedback, the drive performs periodic diagnostics to make sure that the feedback device is operating correctly. Use an explicit message to read the fault type information from the drive. For example, if an error is detected, the Safe Feedback object (class code 0x58) updates the Feedback Fault Reason attribute (attribute ID 0x09) with the reason for the fault.

**Table 39 - Safety Feedback Faults**

| Safety Feedback Fault Reason Value | Safety Feedback Fault Reason Name | Description |
|---|---|---|
| 1 | No Fault | No Fault is present. |
| 2 | Invalid Configuration | The encoder's configuration is invalid. |
| 3 | Exceeded Max Speed | The encoder speed has exceeded the configured maximum speed. |
| 4 | Exceeded Max Acceleration | The encoder acceleration has exceeded the configured maximum acceleration. |
| 5 | $Sin^2$+$Cos^2$ Error | The encoder has failed the vector length or aspect ratio checks. |
| 6 | Quadrature Error | The encoder has exceeded the maximum number of quadrature signal errors. |
| 9 | Supply Voltage Error | The associated dual channel feedback instance has detected a fault in the other encoder |
| 11 | Feedback Signal Loss | A feedback signal is missing, shorted, or open. |
| 107 | Max input frequency | Max Frequency of the configured encoder has been exceeded. |
| 109 | Position Rollover | Position has exceeded the maximum value supported by this product. Please reset the device |

## Safety Fault Reset

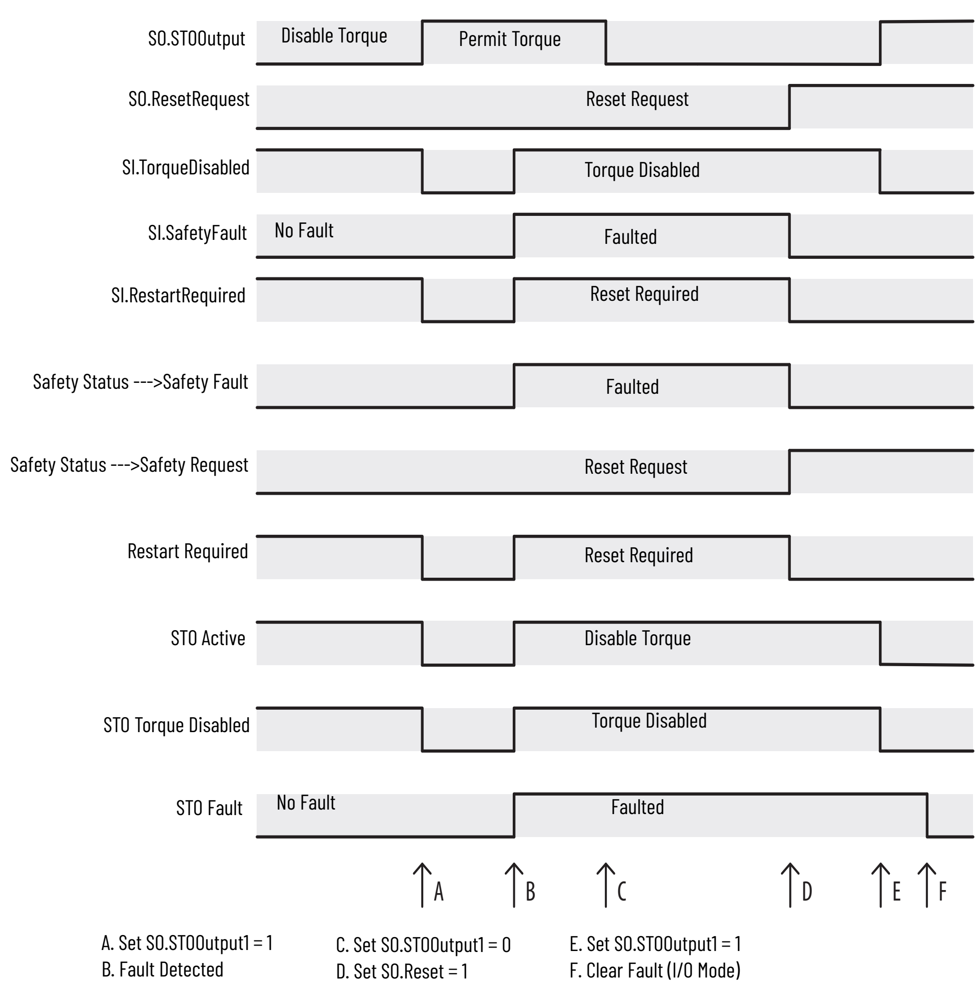
If the drive detects a fault, the input assembly tag *device*:SI.SafetyFault is set to one.

A Safety Fault can result from the SS1 stopping function, STO function, safety feedback, SBC function, or other safety diagnostics.

To acknowledge or clear this fault, remove the source of the safety fault and send a fault reset to the safety logic.

See Figure 58 on page 120 for more information about the Integrated Safety Functions option module, state restart functionality.

Figure 58 - Reset Safe Stop Fault Diagram




## Safety I/O Operation

24V DC safety inputs and outputs:

- 4 safety inputs; 2 test outputs; 1 bipolar safety output
- Single channel safety inputs up to SIL 2, Category 2, PLd
- Dual channel safety inputs and bipolar output up to SIL 3, Category 4, PLe
- Safety output can be configured for SBC or control via the safety output assembly
- Communication for safety I/O data is performed through safety connections that support CIP Safety protocol over an EtherNet/IP network.

There are status indicators for each I/O point, see View Status Indicators on page 197.

## Safe State

The following are the safe states of the Armor PowerFlex safety I/O:

- Safety outputs from network data: OFF (single channel and dual channel equivalent)
- Safety input data to network: OFF (single channel and dual-channel equivalent)
- Safety input data to network: OFF/ON for input channels n/n+1 (dual-channel complimentary, See Dual Channels, Complementary on page 123 for additional details)

The safety I/O is designed for use in applications where the safe state is the off state.

## Safety Input Features

- Safety devices, such as emergency stop push buttons, gate switches, and safety light curtains, can be connected.
- Dual-channel mode evaluates consistency between two input signals (channels), which allows use of the module for safety Category 3 and 4 and in applications that are rated up to and including Performance Level e/SIL 3 when both channels' Point Mode configurations are set to Safety Pulse Test.
- Single-channel mode evaluates one input signal (channel), which allows use of the module for safety Category 2 and in applications that are rated up to and including Performance Level d/SIL 2 when the channel's Point Mode configuration is set to Safety Pulse Test.
- You can configure a discrepancy time to control how long two channels are allowed to be discrepant before a fault is declared.
- An external wiring short-circuit check is possible when inputs are wired in combination with test outputs. The drive must be wired in combination with test outputs when this function is used.
- Independently adjustable on- and off-delays are available per channel.
- Separate test outputs are provided for short-circuit detection of a safety input or inputs.
  - Power (24V) can be supplied to devices, such as safety sensors.
  - Test outputs can be configured as standard outputs.

## Safety Input Operation

Safety inputs are used to monitor a safety input device and can be configured as single or dual channel inputs. They also support configuration of on- and off-delay times. A configurable latch error time allows you to specify the minimum amount of time that a safety input alarm is reported.

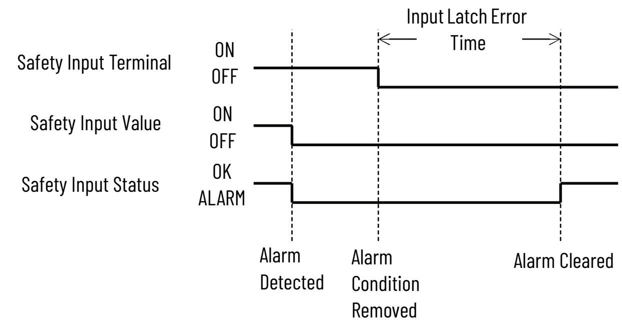
### *Single-channel Mode (Safety Inputs)*

The next paragraph describes the status and value that the I/O subsystem reports for normal and alarm states. In normal operation, the I/O value that is reported is the value being read on the input terminal. The I/O status is on. When a fault is detected, the Safety Input value and status are forced Off.

The safety input subsystem allows for a configurable time for which an alarm state is held, which is referred to as Input Latch Error Time. In single channel mode, the input latch error time describes the period between when the alarm condition is removed and when the safety input stops reporting the alarm.

Figure 59 shows the operation of input latch error time in single channel mode. See Safety Input or Output Fault Recovery on page 136 for information on how to remove an alarm.

**Figure 59 - Single-channel Mode**




### *Dual-channel Mode and Discrepancy Time (Safety Inputs)*

To support redundant safety devices, the consistency between signals on two input points can be evaluated, which is referred to as dual-channel operation. Two modes are available when using dual-channel inputs: equivalent and complementary.

When using either dual-channel input mode, the time from when a discrepancy is created and when the discrepancy is reported can be configured, which is referred to as Discrepancy Time. The configured discrepancy time is 0 (deactivated)…65,535 ms in increments of 1 ms.

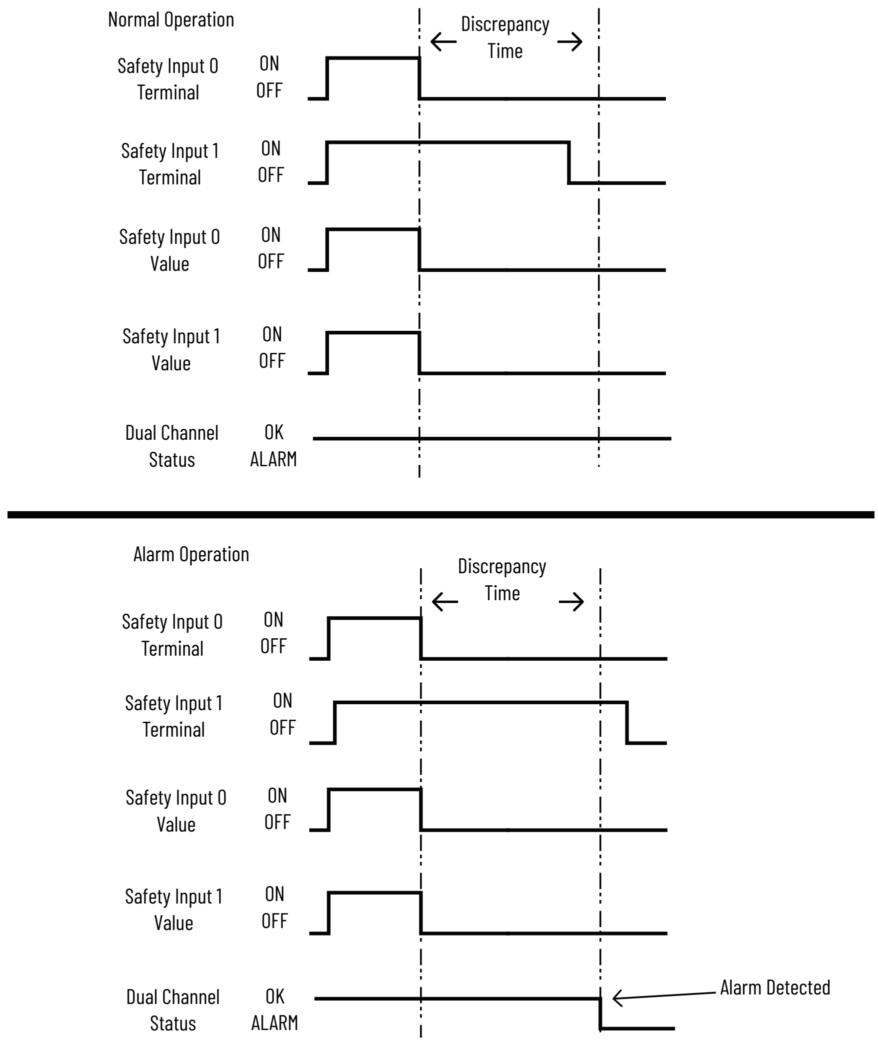
| | |
|---|---|
| **IMPORTANT** | The dual-channel function is used with two consecutive inputs that are paired together, this process starts at an even input number, such as inputs 0 and 1; 2 and 3; and so on. |

| | |
|---|---|
| **IMPORTANT** | Do not set the discrepancy time longer than necessary. The purpose of the discrepancy time is to allow for normal differences between contact switching when demands are placed on safety inputs. For discrepancy checking to operate correctly, only one demand on the safety input is expected during the discrepancy time. If the discrepancy time is set too high, and multiple demands occur during this time, then both safety input channels will alarm. |

### *Dual-channel, Equivalent*

In Equivalent mode, both inputs of a pair must be in the same (equivalent) state. When a transition occurs in one channel of the pair before the transition of the second channel of the pair, a discrepancy occurs. If the second channel transitions to the appropriate state before the discrepancy time elapses, the inputs are considered equivalent. If the second transition does not occur before the discrepancy time elapses, the channels transition to the alarm state. In the fault state, the input and status for both channels are set low (Off). When configured as an equivalent dual pair, the data bits for both channels are sent to the controller as equivalent, both high or both low.

**Figure 60 - Equivalent, Normal Operation and Fault Detection (Not to Scale)**

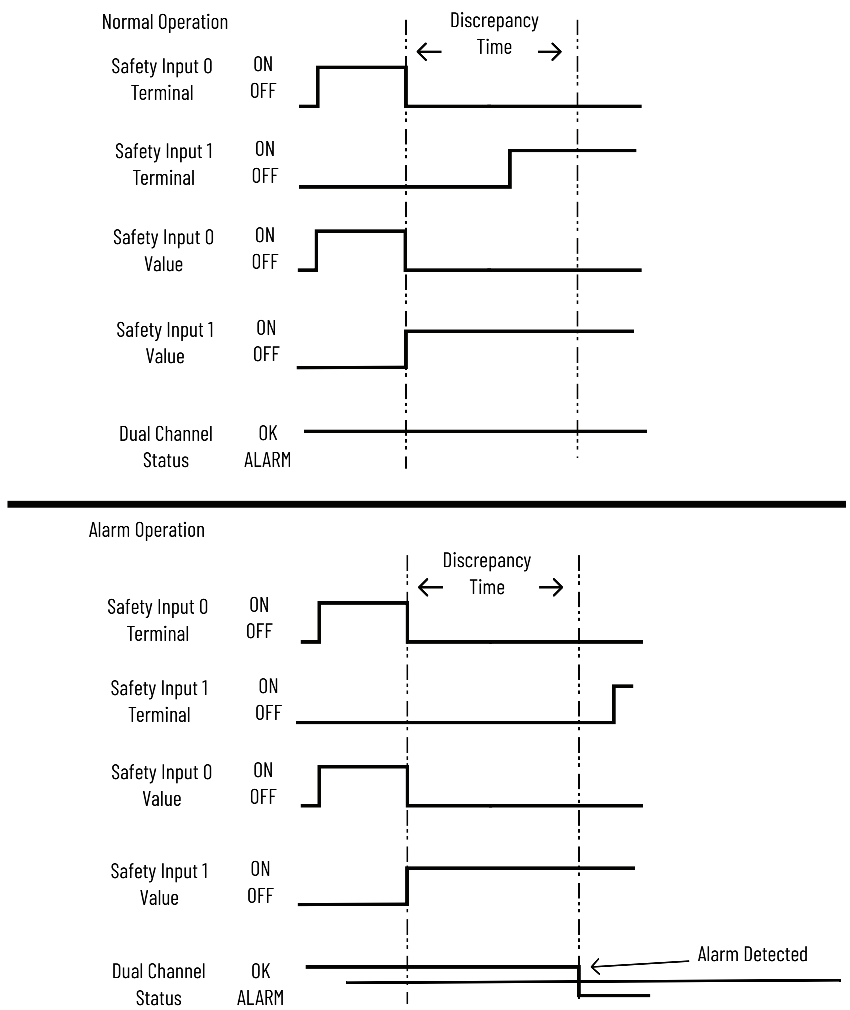



### *Dual Channels, Complementary*

In Complementary mode, the inputs of a pair must be in the opposite (complementary) state. When a transition occurs in one channel of the pair before the transition of the second channel of the pair, a discrepancy occurs. If the second channel transitions to the appropriate state before the discrepancy time elapses, the inputs are considered complementary.

If the second transition does not occur before the discrepancy time elapses, the channels transition to the alarm state. The alarm state of complementary inputs is the even-numbered input that is turned Off and the odd-numbered input turned On. Note that if faulted, both channel status bits are set low. When configured as a complementary dual-channel pair, the data bits for both channels are sent to the controller in complementary, or opposite states.

**Figure 61 - Complementary, Normal Operation and Fault Detection (not to scale)**



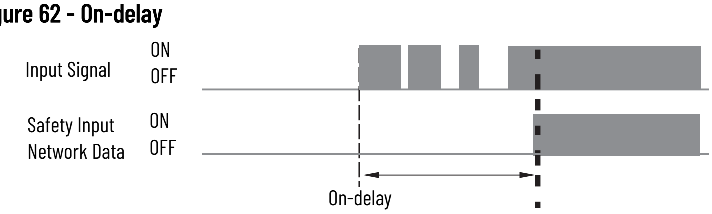

### Input Delays

Each safety input has a configurable filter time for sampling the input. Both the on→off and off→on filter values can be configured.

#### Off to On Delay

On-delay—An input signal is treated as Logic 0 during the on-delay time (0…65,535 ms, in increments of 1 ms) after the rising edge of the input contact. The input turns on only if the input contact remains on after the on delay time has elapsed. This setting helps prevent rapid changes of the input data due to contact bounce.

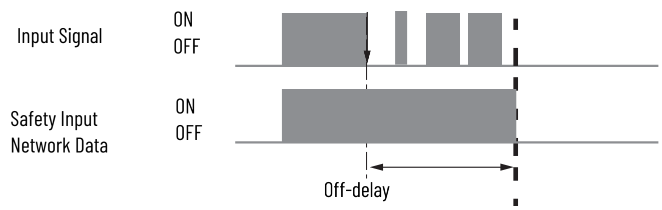
**Figure 62 - On-delay**



### *On to Off Delay*

Off-delay—An input signal is treated as Logic 1 during the off-delay time (0…65,535 ms, in increments of 1 ms) after the falling edge of the input contact. The input turns off only if the input contact remains off after the off delay time has elapsed. This setting helps prevent rapid changes of the input data due to contact bounce.

**Figure 63 - Off-delay**




### *Using a Test Output with a Safety Input*

A test output can be used in combination with a safety input for short circuit, cross-channel, and open-circuit fault detection. Configure the test output as a pulse test source and associate it to a specific safety input.

**Figure 64 - Test Output Wiring Example**

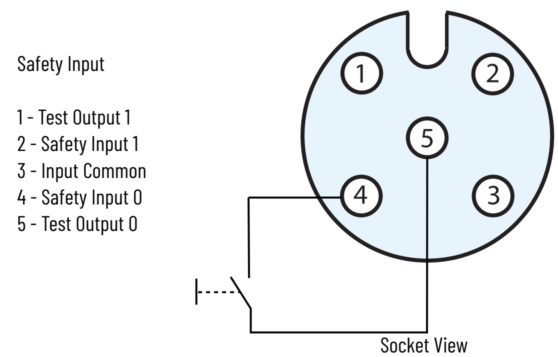
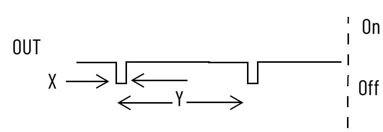


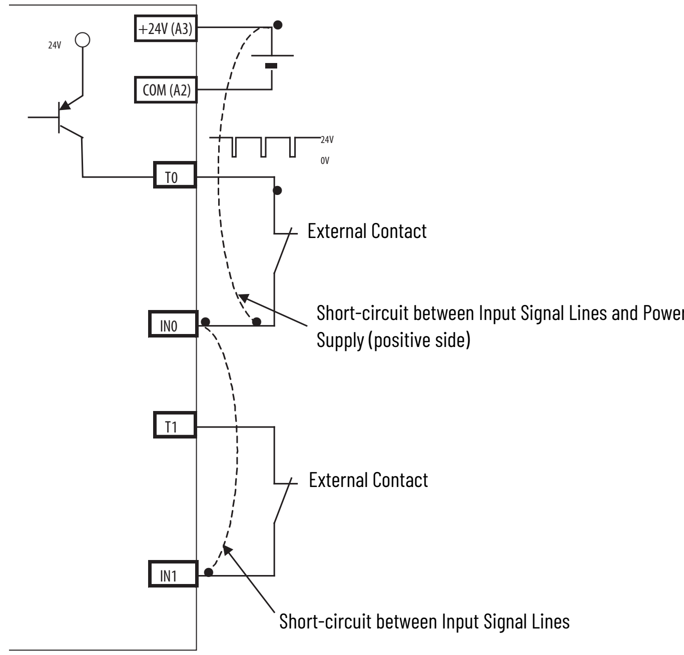

**Figure 65 - Test Pulse in a Cycle**




The pulse width (X) is typically 500 µs. The pulse period (Y) is typically 300 ms. The relation between pulse period and width is fixed.

When the external input contact is closed, a test pulse is output from the test output terminal to diagnose the field wiring and input circuitry. By using this function, short-circuits between inputs and 24V power, and between input signal lines and open circuits can be detected. See Figure 66.

Figure 66 - Short-circuit between Input Signal Lines




| | |
|---|---|
| **IMPORTANT** | Depending on the targeted SIL, Category/PL and the safety application, fault exclusions for short circuits between any two conductors/cables may be necessary. See ISO 13849-2, Annex D for additional information. |

## Safety Input Status Data

The Safety Input data can be monitored through:

- Safety Input Assembly
- Message Instruction

| | |
|---|---|
| **IMPORTANT** | Only the Safety Input Value and Status in the Safety Input Assembly can be considered safety data. Input values that are read through CIP messages are not safety data. Do not use standard inputs for safety purposes. |

The following Safety Input data is available:

- Safety Input Status
- Safety Input Value (Data)
- Safety Input Valid

Each safety input point reports its own status, value, and valid attributes.

Table 40 shows the relation between physical Safety Input terminal states, and the data and status reported by the Safety Input subsystem.

**Table 40 - Terminal Safety Input Status and Controller I/O Data**

| Dual-channel Mode | Input Terminal | | Controller Input Data and Status | | | | Dual-channel Resultant Data | Dual-channel Resultant |
|---|---|---|---|---|---|---|---|---|
| | IN0 | IN1 | Safety Input 0 Data | Safety Input 1 Data | Safety Input 0 Status | Safety Input 1 Status | | |
| Dual-channels, Equivalent | OFF | OFF | OFF | OFF | ON | ON | OFF | Normal |
| | OFF | ON | OFF | OFF | OFF | OFF | OFF | Alarm |
| | ON | OFF | OFF | OFF | OFF | OFF | OFF | Alarm |
| | ON | ON | ON | ON | ON | ON | ON | Normal |
| Dual-channels, Complementary | OFF | OFF | OFF | OFF | OFF | OFF | OFF | Alarm |
| | OFF | ON | OFF | ON | ON | ON | ON | Normal |
| | ON | OFF | ON | OFF | ON | ON | ON | Normal |
| | ON | ON | OFF | OFF | OFF | OFF | OFF | Alarm |

### *Safety Input Status*

The safety input status indicates whether an alarm is present in the safety input point. The safety input status is provided in the safety input assembly, as shown in Table 41. Table 42 describes the attributes for reading the safety status via CIP messaging.

**Table 41 - Safety Input Assembly Tags for Safety Input Status**

| Safety Input Assembly Tag Name (safety controller) | Type/[bit] | Description |
|---|---|---|
| *devicename*:SI.InputStatus | SINT | A collection of safety input values and status for each safety input |
| *devicename*:SI.In00Status | [4] | Status of Safety Input 0<br>0 = Alarm<br>1 = OK |
| *devicename*:SI.In01Status | [5] | Status of Safety Input 1<br>0 = Alarm<br>1 = OK |
| *devicename*:SI.In02Status | [6] | Status of Safety Input 2<br>0 = Alarm<br>1 = OK |
| *devicename*:SI.In03Status | [7] | Status of Safety Input 3<br>0 = Alarm<br>1 = OK |

**Table 42 - MSG Configuration for Safety Input Status**

| | | |
|---|---|---|
| **Service Code** | 0x0E | Get attribute single |
| **Class** | 0x3D | Safety Discrete Input Point Object |
| **Instance** | i + 1 | Where i is the number of the safety input |
| **Data Type** | USINT | |
| **Attribute** | 0x4<br>4 (decimal) | Safety Status<br>0 = Alarm<br>1 = OK |

### *Safety Input Value*

The safety input value is the value of the input after safety and on/off delay evaluations when the safety input is not in the alarm state. If the safety input is in the alarm state, this value will always be 0.

The safety input value is provided in the safety input assembly, as shown in Table 43. Table 44 describes the attributes for reading the safety value via CIP™ messaging.

**Table 43 - Safety Input Assembly Tags for Safety Input Values**

| Safety Input Assembly Tag Name (safety controller) | Type/[bit] | Description |
|---|---|---|
| *devicename*:SI.InputStatus | SINT | A collection of safety input values and status for each safety input |
| *devicename*:SI.In00Data | [0] | Value of Safety Input 0<br>0 = OFF<br>1 = ON |
| *devicename*:SI.In01Data | [1] | Value of Safety Input 1<br>0 = OFF<br>1 = ON |
| *devicename*:SI.In02Data | [2] | Value of Safety Input 2<br>0 = OFF<br>1 = ON |
| *devicename*:SI.In03Data | [3] | Value of Safety Input 3<br>0 = OFF<br>1 = ON |

**Table 44 - MSG Configuration for Safety Input Value**

| | | |
|---|---|---|
| **Service Code** | 0x0E | Get attribute single |
| **Class** | 0x3D | Safety Discrete Input Point Object |
| **Instance** | *i* + 1 | Where *i* is the number of the safety input |
| **Data Type** | USINT | |
| **Attribute** | 0x7<br>7 (decimal) | Safety Input Logical Value<br>0 = OFF<br>1 = ON |

### *Safety Input Valid*

When set, the safety input valid attribute indicates that the safety input is configured for safety use and producing valid data. If this value is not set, the data that is associated with the safety input is no longer valid safety data.

**IMPORTANT** The Safety Input Valid attribute should be checked before using safety input data in a safety application.

The safety input valid attribute is provided in the safety input assembly, as shown in Table 45. Table 46 describes the attributes for reading the safety value via CIP messaging.

**Table 45 - Safety Input Assembly Tags for Safety Input Valid**

| Safety Input Assembly Tag Name (safety controller) | Type/[bit] | Description |
|---|---|---|
| *devicename*:SI.IOSupport | SINT | A collection of bits that describe safety IO functionality |
| *devicename*:SI.In00Valid | [0] | Safety Input 0 Valid<br>0 = Data invalid<br>1 = Data valid |
| *devicename*:SI.In01 Valid | [1] | Safety Input 1 Valid<br>0 = Data invalid<br>1 = Data valid |
| *devicename*:SI.In02 Valid | [2] | Safety Input 2 Valid<br>0 = Data invalid<br>1 = Data valid |
| *devicename*:SI.In03 Valid | [3] | Safety Input 3 Valid<br>0 = Data invalid<br>1 = Data valid |

Table 46 - MSG Configuration for Safety Input Valid

| | | |
|---|---|---|
| **Service Code** | 0x0E | Get attribute single |
| **Class** | 0x3D | Safety Discrete Input Point Object |
| **Instance** | *i* + 1 | Where *i* is the number of the safety input |
| **Data Type** | USINT | |
| **Attribute** | 0x64<br>100 (decimal) | Safety Input Valid<br>0 = Data invalid<br>1 = Data Valid |

Table 47 - Safety Input Specifications

| Input Type | Current Sinking |
|---|---|
| IEC 61131-2 (input type) | Type 3 |
| Voltage, on-state | 11…30V DC |
| Voltage, off-state | -3…5V DC |
| Current, on-state, minimum | 2 mA |
| Current, off-state, maximum | 1.5 mA |

## Safety Input Alarms

The safety input logic can detect configuration, circuit, and discrepancy errors for each safety input. When an error is detected, the associated safety input data is put into the safe state, and the alarm type attribute is set.

*Configuration Error*

A configuration error occurs when a safety input's configuration data is invalid. If this error occurs, check to make sure that the configuration attributes for the safety input are valid. A configuration error can also occur if the safety input is selected for external pulse testing and the associated test output's configuration is not valid for this mode.

*Circuit Error*

A circuit error occurs in a safety input when a pulse test fails. There are two types of circuit errors that can be reported:

- Internal Circuit Error
  - An internal circuit error occurs when an internal pulse test fails. This means that circuitry inside the module has failed. An internal circuit error may not be recoverable; replacing the module may be required.
- External Circuit Error
  - An external circuit error occurs when pulse testing by the safety input's associated test output fails. This error indicates the input circuitry external to the card has failed.

*Discrepancy and Dual Channel Errors*

The discrepancy and dual channel errors are related, as a discrepancy can only occur when the safety input is in dual channel mode. A discrepancy error occurs when one of the dual channel safety inputs is not reporting the expected safety input value. The safety input with the unexpected value reports the discrepancy error. The other associated safety input will also be put in the safe state and report a dual channel error alarm.

## Determining Safety Input Alarm Type

To determine if a safety input is reporting an alarm, examine the safety input's input status attribute (see Safety Input Status on page 127 for information on accessing this attribute). If the input is reporting an alarm, the alarm type can be accessed through CIP messaging.

The safety input alarm type can be read via CIP messaging. See Table 48 for the attributes that are required to read the alarm type.

**Table 48 - MSG Configuration for Safety Input Alarm Type**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x0E | Get attribute single |
| Class | 0x3D | Safety Discrete Input Point Object |
| Instance | i + 1 | Where i is the number of the safety input |
| Data Type | USINT | Unsigned integer value |
| Attribute | 0x6E<br>110 | Safety Input Alarm Type<br>0 = No Alarm<br>1 = Configuration Error<br>2 = External Circuit Error<br>3 = Internal Circuit Error<br>4 = Discrepancy Error<br>5 = Dual Channel error |

## Safety Input Alarm Recovery

If an error is detected, the safety input data remains in the off state. Follow this procedure to activate the safety input data.

1. Remove the cause of the error.
2. Place the safety input (or safety inputs if in dual channel mode) into the safe state.

   The safety input status turns on (alarm cleared) after the input-error latch time has elapsed.

If the latch error time has expired, but the safety input is not yet in the safe state, the alarm will not be cleared. Once the safety input is in the safe state, the alarm will clear immediately.

## Safety Output Operation

The safety outputs can operate only in dual channel bipolar mode. The safety output can also be configured to run pulse test diagnostics.

The safety output assembly controls the bipolar output only when the drive is not using the SBC function. If the SBC function is used, it controls the output.

### *Safety Output Features*

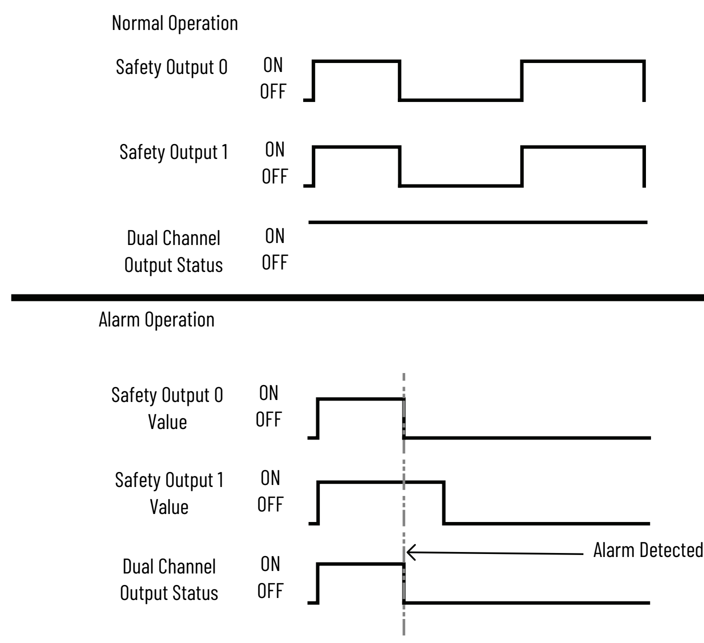
- Current sourcing/current sinking-bipolar pair
- Dual-channel mode provides redundant control by using two output signals (channels), which allows use of the module for safety Category 4, and applications that are rated up to and including Performance Level e/ SIL 3 when both channels' Point Mode configurations are set to Safety Pulse Test.
- Safety output can be pulse tested to detect field wiring short circuits to 24V DC.
- Safety output can be configured for SBC or control via the safety output assembly

### *Dual-channel Mode (Safety Outputs)*

When the data of both channels is in the on state, and neither channel has an alarm, the outputs are turned on. The status is normal. If an alarm is detected on one channel, the safety output data and individual safety output status turn off for both channels.

Figure 67 shows the operation of dual channel outputs under normal and alarm conditions.

**Figure 67 - Dual-channel Setting (Not to Scale)**




In dual-channel mode, the output latch error time describes the period between when the alarm condition is removed and when the dual channel safety output stops reporting the alarm. Figure 68 shows the normal operation of output latch error time in dual channel mode. When one or both of the associated output points have an alarm (such as a Pulse Test Failure), and there is a discrepancy between the two channels, the alarm and discrepancy must be cleared before the latch error timer begins counting. Figure 69 shows this special case operation. See Safety Input or Output Fault Recovery on page 136 for information on how to remove an alarm.

**Figure 68 - Dual Channel Output Latch Error Behavior**

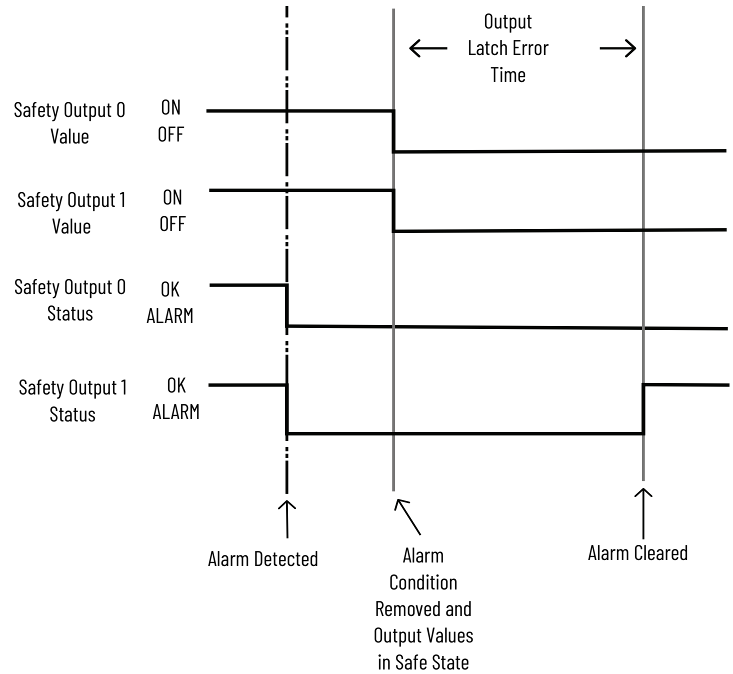
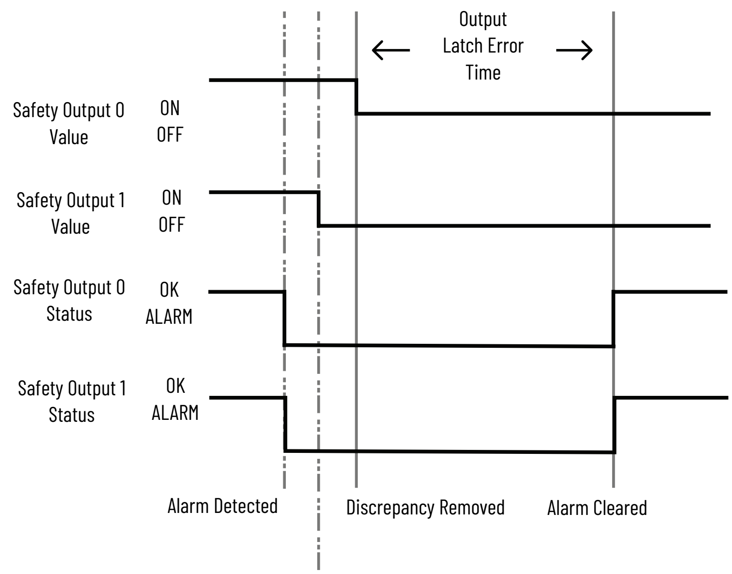


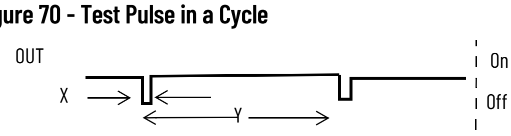

**Figure 69 - Dual Channel Output Latch Error Behavior With Alarm and Discrepancy**




### *Safety Output with Test Pulse*

When the safety output is on, the safety output can be configured to pulse test the safety output channel. By using this function, you can continuously test the ability of the safety output to remove power from the output terminals of the module. If an error is detected, the safety output data and individual safety output status turn Off.

**Figure 70 - Test Pulse in a Cycle**



For the Armor PowerFlex drives, the pulse width (X) is typically 500 µs; the pulse period (Y) is typically 300 ms.

| | |
|---|---|
| **IMPORTANT** | To help prevent the test pulse from causing the connected device to malfunction, pay careful attention to the input response time of the output device. |

## Safety Output Data

The safety output data can be monitored through:
- Safety input assembly
- Message Instruction

The following safety output data is available:
- Safety output status
- Safety output ready
- Output monitor value

Each safety output point reports its own status, monitor value, and ready attributes.

### *Safety Output Status*

The safety output status indicates whether an alarm is present in the safety output point. The safety output status is provided in the safety input assembly, as shown in Table 49. Table 50 describes the attributes for reading the safety status via CIP messaging.

**Table 49 - Safety Input Assembly Tags for Safety Output Status**

| Safety Input Assembly Tag Name (safety controller) | Type / [bit] | Description |
|---|---|---|
| *devicename*:SI.OutputStatus | SINT | A collection of safety output status, safety output monitor values, and test output status |
| *devicename*:SI.Out00Status | [2] | Status of Safety Output 0<br>0 = Alarm<br>1 = OK |
| *devicename*:SI.Out01Status | [3] | Status of Safety Output 1<br>0 = Alarm<br>1 = OK |

**Table 50 - MSG Configuration for Safety Output Status**

| | | |
|---|---|---|
| **Service Code** | 0x0E | Get attribute single |
| **Class** | 0x3B | Safety Discrete Output Point Object |
| **Instance** | i + 1 | Where *i* is the number of the safety output |
| **Data Type** | | USINT |
| **Attribute** | 0x5<br>5 (decimal) | Safety Status<br>0 = Alarm<br>1 = OK |

**Table 51 - Safety Output Specifications**

| Attribute | Value |
|---|---|
| Output type | Bipolar output |
| Output current | 1 A |
| Test Pulse width | 500 µs |
| Test Pulse period | 300 ms |

### Safety Output Ready

When set, the safety output ready attribute indicates that the safety output is configured for safety use and ready to be commanded.

| IMPORTANT | Check the Safety Output Ready attribute before commanding the safety output. |
|---|---|

The safety output ready attribute is provided in the safety input assembly, as shown in Table 52. Table 53 describes the attributes for the Safety Output Ready attribute via CIP messaging.

**Table 52 - Safety Input Assembly Tags for Safety Output Ready**

| Safety Input Assembly Tag Name (safety controller) | Type/[bit] | Description |
|---|---|---|
| *devicename*:SI.IOSupport | SINT | A collection of bits describing safety IO functionality |
| *devicename*:SI.Out00Ready | [4] | Safety Output 0 Ready<br>0 = Not Ready<br>1 = Ready |
| *devicename*:SI.Out01Ready | [5] | Safety Output 1 Ready<br>0 = Not Ready<br>1 = Ready |

**Table 53 - MSG Configuration for Safety Output Ready**

| | | |
|---|---|---|
| **Service Code** | 0x0E | Get attribute single |
| **Class** | 0x3B | Safety Discrete Output Point Object |
| **Instance** | i + 1 | Where *i* is the number of the safety output |
| **Data Type** | USINT | |
| **Attribute** | 0x64<br>100 (decimal) | Safety Status<br>0 = Not Ready<br>1 = Ready |

### Safety Output Monitor Value

| IMPORTANT | Safety Output Monitor Value is not safety data and has no defined safe state. Use Output Monitor Value for diagnostic purposes only. |
|---|---|

The output monitor value of a safety output is the value of the output that is read by the module. It is expected that the output monitor value is the same as the commanded safety output value in normal operation. The output monitor value can be used to diagnose output alarms.

The output monitor value is provided in the safety input assembly, as shown in Table 54. Table 55 describes the attributes for reading the output monitor value via CIP messaging.

**Table 54 - Safety Input Assembly Tags for Safety Output Monitor Value**

| Safety Input Assembly Tag Name (safety controller) | Type/[bit] | Description |
|---|---|---|
| *devicename*:SI.OutputStatus | SINT | A collection of safety output status, safety output monitor values, and test output status |
| *devicename*:SI.Out00Monitor | [0] | Output Monitor Value of Safety Output 0<br>0 = OFF<br>1 = ON |
| *devicename*:SI.Out01Monitor | [1] | Output Monitor Value of Safety Output 1<br>0 = OFF<br>1 = ON |

Table 55 - MSG Configuration for Safety Output Monitor Value

| | | |
|---|---|---|
| **Service Code** | 0x0E | Get attribute single |
| **Class** | 0x3B | Safety Discrete Output Point Object |
| **Instance** | i + 1 | Where *i* is the number of the safety output |
| **Data Type** | USINT | Unsigned integer value |
| **Attribute** | 0x4<br>4 (decimal) | Output Monitor Value<br>0 = OFF<br>1 = ON |

## Test Output Operation

The test outputs of the Integrated Safety Function module can be configured in the following modes:

- Test pulse output. When in test output mode, the test output point operates with a safety input to perform pulse testing on the external safety input circuitry.
- Power supply output. In power supply output mode, the output point is forced on, and only shuts off for a critical fault. For safety input and output specifications, see Armor PowerFlex AC Drives Specifications Technical Data, publication 35-TD001.

**ATTENTION:** As soon as the firmware boots and power is supplied to the I/O, the test outputs will turn on if they configured for either Pulse Test or Power Supply. These configured functions are independent of the I/O connections to the module.

**ATTENTION:** If a module with Test Outputs configured as Pulse Test or Power Supply is incorrectly installed in an application where actuators are connected to these Test Output points, the actuators are activated as soon as the firmware boots and power is supplied to the I/O.
To help prevent this possibility, follow these procedures.

- When installing or replacing a module, be sure that the module is correctly configured for the application or in the out-of-box condition before you apply input power.
- Reset modules to their out-of-box condition when removing them from an application.
- Be sure that all modules in the replacement stock are in their out-of-box condition.

**ATTENTION:** Do not use test outputs as safety outputs. Test outputs do not function as safety outputs.

### *Test Output Specifications*

| **Output Type** | **Bipolar** |
|---|---|
| Output current | 1 A |
| Test pulse width | 500 µs |
| Test Pulse Period | 300 ms |
| Field capacitance, maximum | 950 nF |
| Residual voltage, maximum | 0.3V |
| Leakage current, maximum | 0.1 mA |
| Short circuit protection | yes |
| Reaction time from message to Output safe, maximum | <10 ms |

## Safety Input or Output Fault Recovery

If an error is detected, the safety data remains in the Off state. Follow this procedure to activate the safety data again.

1. Remove the cause of the error.
2. Place the safety input or safety output into the safe state.
3. Allow the input- or output-error latch time to elapse.

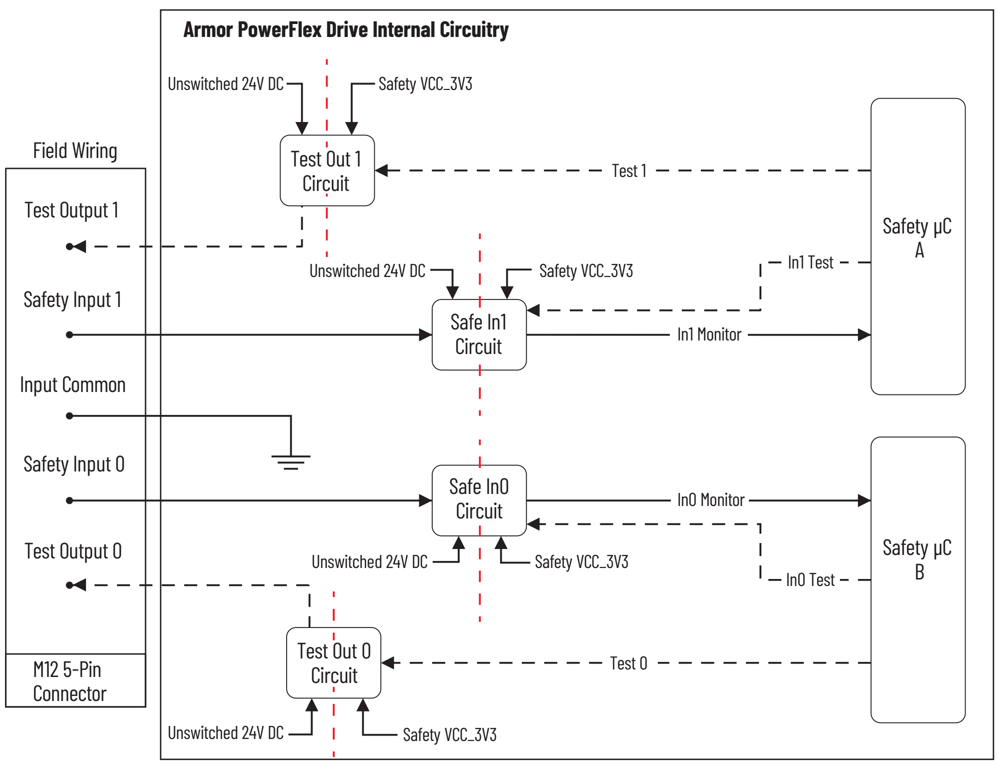
After these steps are completed, the I/O indicator (red) turns Off. The safety input or output data is now active.

**IMPORTANT** Stuck high faults on safety outputs require a power reset to clear the error.

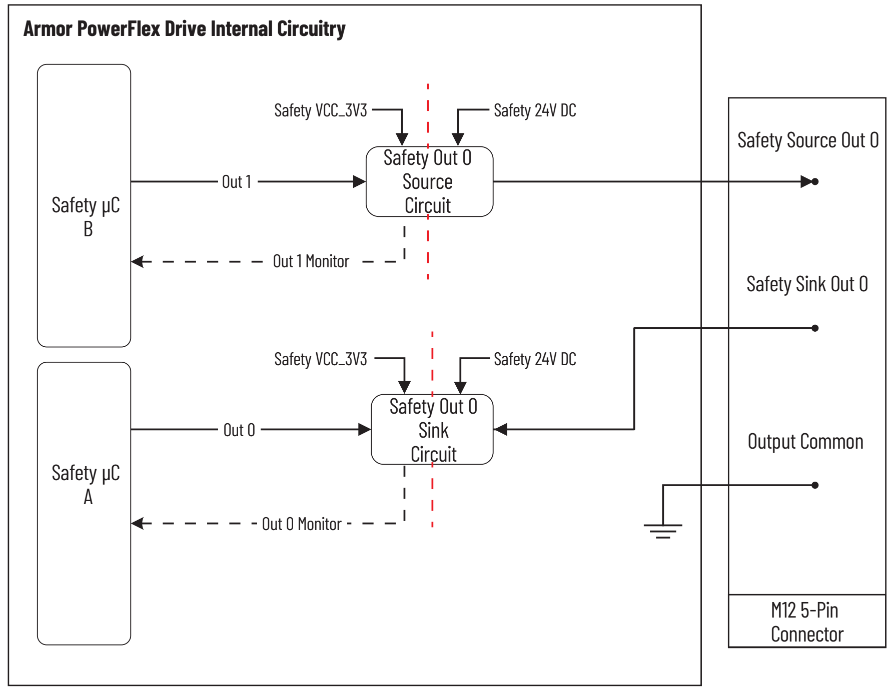
# Safety I/O Wiring

**IMPORTANT** The wiring examples that are shown here are not a guarantee of Safety Category and Performance Level ratings. You must perform your own risk assessment to validate the requirements of your system.

## Safety Input Internal Wiring Diagram Example



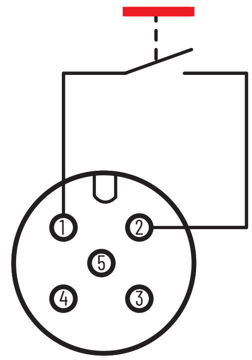
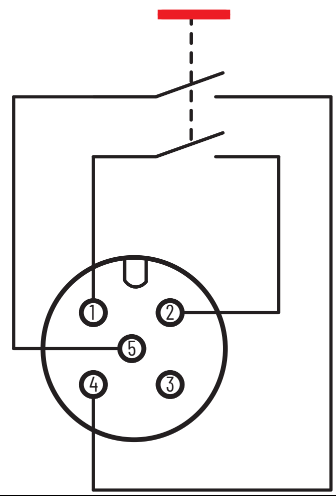
## Safety Output Internal Wiring Diagram Example



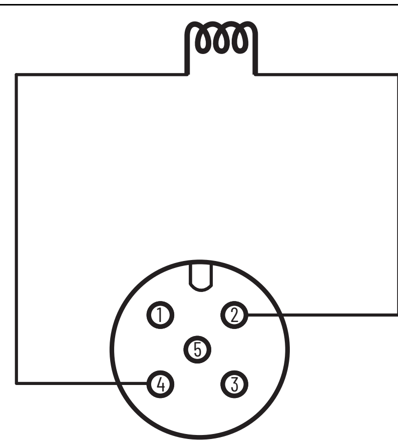

## Status and Faults

Each Safety I/O point has a status LED see I/O Status Indicators on page 198 for details.

## Safety Input Wiring Examples

| Connected Devices | Output Pulse from Output Test | Connection | Schematic Diagram | Up to Safety Category | Up to Performance Level |
|---|---|---|---|---|---|
| Reset switch | No | Connect the switch between Test Out 1 and Input 1 | Pin 1: Test Out 1<br>Pin 2: Input 1<br>Pin 3: Input Common<br>Pin 4: Input 0<br>Pin 5: Test Out 0<br> | 2 | PLc |
| Emergency stop switch<br>Door monitor | No | Connect the switch between Test Out 1 and Input 1 and between Test Out 0 and Input 0 | Pin 1: Test Out 1<br>Pin 2: Input 1<br>Pin 3: Input Common<br>Pin 4: Input 0<br>Pin 5: Test Out 0<br> | 4 | PLe |

## Safety Output Wiring Examples

| Connected Devices | Output Pulse from Output Test | Connection | Schematic Diagram | Up to Safety Category | Up to Performance Level |
|---|---|---|---|---|---|
| Drive inductive load | No | Connect the switch between Output 0 (sink) and Output 0 (source) | Pin 1: No connection<br>Pin 2: Output 0 (sink)<br>Pin 3: Output Power Common<br>Pin 4: Output 0 (source)<br>Pin 5: Output Power Common<br> | 4 | PLe |

**IMPORTANT** Depending on the targeted SIL, Category/PL and the safety application, fault exclusions for short circuits between any two conductors/cables may be necessary. See ISO 13849-2, Annex D for additional information.

## Replacing an Armor PowerFlex Drive on a Safety Network

GuardLogix controllers retain I/O device configuration onboard and are able to download the configuration to the replacement device.

| | |
|---|---|
| **IMPORTANT** | If the Armor PowerFlex drive was used previously, clear the existing configuration before installing it on a safety network by resetting the device to out-of-box condition. See Reset Ownership on page 88. |

Replacing an Armor PowerFlex drive that sits on an integrated safety network is more complicated than replacing standard devices because of the safety network number (SNN). The device number and SNN constitute the safety device's DeviceID. Safety devices require this more complex identifier to make sure that duplicate device numbers do not compromise communication between the correct safety devices. The SNN is also used to provide integrity on the initial download to the device.

### Replace an Armor PowerFlex drive in a GuardLogix System

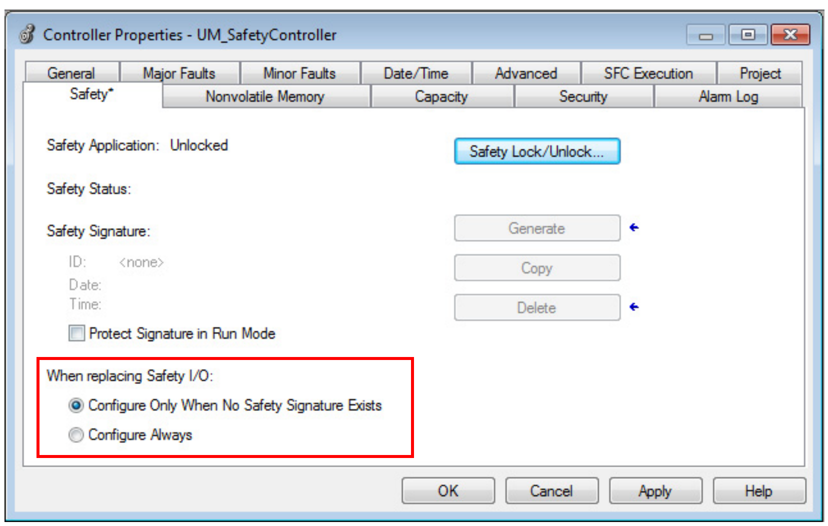
When you replace an Armor PowerFlex drive, the replacement device must be configured properly and the replacement Armor PowerFlex drive's operation be user-verified.

**ATTENTION:** During an Armor PowerFlex drive replacement or functional test, the safety of the system must not rely on any portion of the affected Armor PowerFlex drive.

There are two options for Armor PowerFlex drive replacement available on the Safety page of the Controller Properties dialog box in the Logix Designer application:

- Configure Only When No Safety Signature Exists
- Configure Always

**Figure 71 - Armor PowerFlex Drive Replacement Options**



## Configure Only When No Safety Signature Exists

This setting instructs the GuardLogix controller to automatically configure an Armor PowerFlex drive only when the safety task does not have a safety task signature, and the replacement Armor PowerFlex drive is in an out-of-box condition, meaning that a safety network number does not exist in the Armor PowerFlex drive.

If the safety task has a safety task signature, the GuardLogix controller automatically configures the replacement CIP Safety I/O device only if the following is true:

- The device already has the correct safety network number.
- The device electronic keying is correct.
- The node or IP address is correct.

For detailed information, see the user manual for your GuardLogix controller.

## Configure Always

When the Configure Always feature is enabled, the controller automatically checks for and connects to a replacement Armor PowerFlex drive that meets the following requirements:

- The controller has configuration data for a compatible Armor PowerFlex drive at that network address
- The Armor PowerFlex drive is in out-of-box condition mode or has an SNN that matches the configuration

**ATTENTION:** Enable the Configure Always feature only if the entire integrated safety control system is not being relied on to maintain SIL 2/PLd or SIL 3/PLe behavior during the replacement and functional testing of the product. If other parts of the integrated safety control system are being relied upon to maintain SIL 2/PLd or SIL 3/PLe, make sure that the controller's Configure Always feature is disabled.
It is your responsibility to implement a process to make sure proper safety functionality is maintained during device replacement in safety control systems that are not being relied upon for SIL 2/PLd or SIL 3/PLe. See the GuardLogix user manual appropriate for your Logix 5000 controller:

- ControlLogix 5580 and GuardLogix 5580 Controllers User Manual, publication 1756-UM543
- CompactLogix 5380 and Compact GuardLogix 5380 Controllers User Manual, publication 5069-UM001

# Configure the Armor PowerFlex Drive

The Armor PowerFlex drive is configured by using the Studio 5000 Logix Designer application. The drive's operation is based on the settings that are defined in a set of CIP objects and attributes, which you can configure via the user interface in the Logix Designer application.

For the list of CIP objects and attributes, see Armor PowerFlex AC Drive CIP Objects and Attributes Reference Data, publication 35-RD001.

## Install Armor PowerFlex Add-on Profile

Download and install the Add-on Profile (AOP) for the Armor PowerFlex drive so that the Studio 5000 Logix Designer application can fully support the features of the Armor PowerFlex drive. Download AOPs from the Product Compatibility Download Center (PCDC) website at rok.auto/pcdc.

## Create a Logix Designer Project

Before you can add the Armor PowerFlex drive, you must create a Logix Designer project that includes a Logix 5000 controller with a connection to the EtherNet/IP network. The Armor PowerFlex has an embedded dual port EtherNet module so there is no need for an optional EtherNet communication module.

If you are using integrated Safe Torque Off (STO), drive-based, or controller-based safety functions or the Armor PowerFlex drive's safety I/O, your system must include an integrated safety controller, see Integrated Safety Functions and Compatible Controllers on page 81. See Additional Resources on page 13, for a listing of integrated safety controller user manuals.

The pages of configuration dialog boxes that are available in the Logix Designer application vary depending on which version of Armor PowerFlex drive you have and also on the configuration choices you make when you set up your drive. See Table 56.

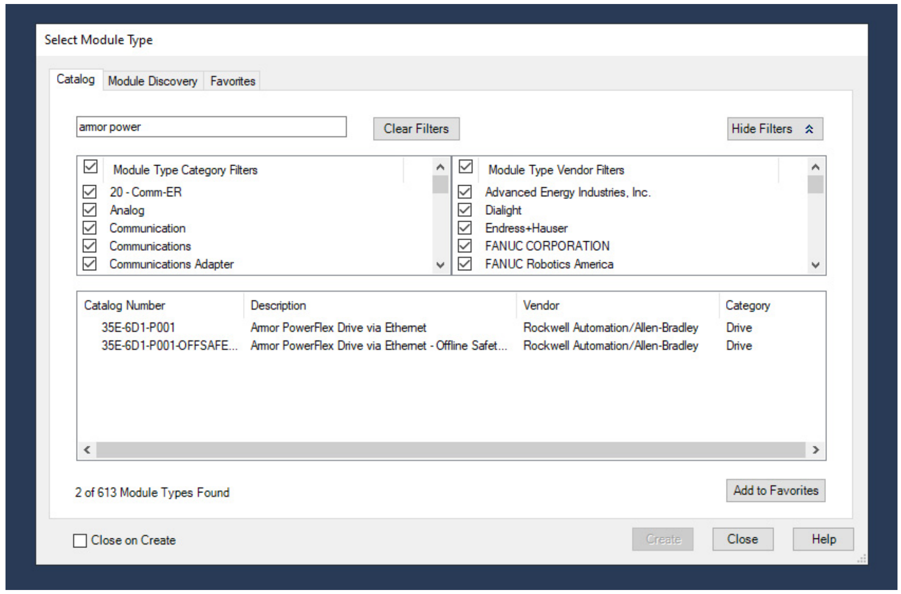
**Table 56 - Pages Available Based on the Configured Variant Type**

| Configured Variant Type | Page |
|---|---|
| Standard Only | Overview<br>Date and Time<br>Faults and Alarms<br>Motor Control<br>Flying Start<br>Auto Restart<br>Encoder Feedback<br>Velocity Control<br>Stop Control<br>Connection<br>Input/Output Configuration |
| Standard and Safety | Overview<br>Date and Time<br>Faults and Alarms<br>Safety Configuration<br>Safety Feedback<br>Scaling<br>Safe Torque Off (STO)<br>Safe Brake Control (SBC)<br>Safe Stop 1 (SS1)<br>Test Output<br>Input Configuration<br>Output Configuration<br>Actions<br>Motor Control<br>Flying Start<br>Auto Restart<br>Encoder Feedback<br>Velocity Control<br>Stop Control<br>Connection<br>Input/Output Configuration |
| Safety Only | Overview<br>Date and Time<br>Faults and Alarms<br>Safety Configuration<br>Safety Feedback<br>Scaling<br>Safe Torque Off (STO)<br>Safe Brake Control (SBC)<br>Safe Stop 1 (SS1)<br>Test Output<br>Input Configuration<br>Output Configuration<br>Actions<br>Connection<br>Input/Output Configuration |

**IMPORTANT** For any new entires or modifications that you make to a page, you must click Apply or OK when finished, to save the entered values.

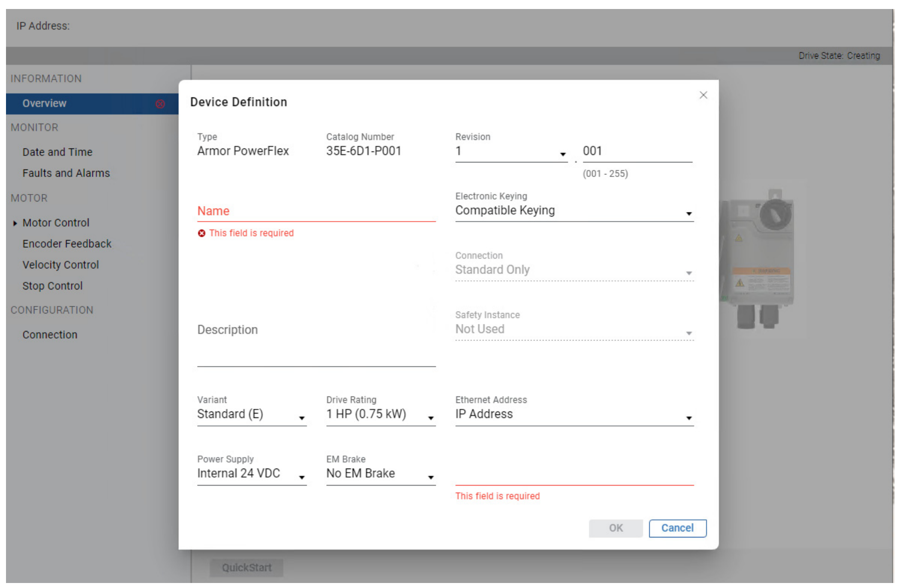
## Add an Armor PowerFlex Drive to the Project

1. Right-click the Ethernet network and choose New Module.
2. Select the appropriate option and click Create.




## Configure the Device Definition

When the Armor PowerFlex module is first created, the software automatically launches the Device Definition window since the Name and IP Address of the module is the minimal configuration that is needed to create the module. To make any changes to the Device Definition at a later time, you will need to launch Device Definition from the Overview page.



Perform the following steps to enter your device details.

1. Enter values and use pull-down menus to configure the device definition. See Table 57.

**Table 57 - Device Definition Settings**

<table>
<tr><th>Field</th><th colspan="2">Description</th></tr>
<tr><td>Name</td><td colspan="2">Name for your Armor PowerFlex drive</td></tr>
<tr><td>Revision</td><td colspan="2">Firmware revision, including major and minor revision levels<br>The available major firmware revisions in the pull-down menu are dependent on the AOP version that is installed.</td></tr>
<tr><td>Description</td><td colspan="2">Optionally add a description of your Armor PowerFlex drive</td></tr>
<tr><td rowspan="5">Electronic Keying</td><td>Exact Match</td><td>Indicates that all keying attributes must match to establish communication. If any attribute does not match precisely, communication with the device does not occur.</td></tr>
<tr><td>Compatible Module (default)</td><td>Lets the installed device accept the key of the device that is defined in the project, when the installed device can emulate the defined device. With Compatible Module, you can typically replace a device with another device that has the following characteristics:<br>• Same catalog number<br>• Same or higher Major Revision<br>• Minor Revision as follows:<br>– If the Major Revision is the same, the Minor Revision must be the same or higher.<br>– If the Major Revision is higher, the Minor Revision can be any number.</td></tr>
<tr><td>Disable Keying</td><td>Indicates that the keying attributes are not considered when attempting to communicate with a device. With Disable Keying, communication can occur with a device other than the type specified in the project.</td></tr>
<tr><td></td><td>ATTENTION: Be cautious when using Disable Keying; if used incorrectly, this option can lead to personal injury or death, property damage, or economic loss.<br>We strongly recommend that you do not use Disable Keying.<br>If you use Disable Keying, you must take full responsibility for understanding whether the device being used can fulfill the functional requirements of the application.</td></tr>
<tr><td>IMPORTANT</td><td>Changing Electronic Keying parameters online interrupts connections to the device and any devices that are connected through the device. Connections from other controllers can also be broken. If an I/O connection to a device is interrupted, the result can be a loss of data.</td></tr>
<tr><td rowspan="3">Connection</td><td>Standard Only (35E or 35S)</td><td>An exclusive standard I/O connection that lets the standard input and standard output connections be configured for Data or Listen Only connections. The safety input and output connections are set to None.</td></tr>
<tr><td>Safety Only (35S)</td><td>An exclusive safety I/O connection where a programmable controller owns the communication channel and provides safety data and configuration from the safety I/O. The standard input and output connections, if available on the drive, are set to None.</td></tr>
<tr><td>Standard and Safety (35S)</td><td>There is a data connection and separate safety connection that provides an exclusive communication channel for standard I/O and safety I/O data.</td></tr>
<tr><td>Ethernet Address</td><td colspan="2">Type the IP address. This setting must match the IP address that you set on the Armor PowerFlex drive by using one of the methods that are outlined in Set the IP Address on page 61.<br>IP Address - Enter an IP address, subnet mask, and gateway address for the drive. This is the IP address that the controller uses to communicate with the drive.<br>Private Network - Type or select the desired address. This is the IP address that the controller uses to communicate with the drive.<br>Host Name - Type the host name of the host Ethernet drive.</td></tr>
<tr><td rowspan="2">Safety Instance Type</td><td>Safe Stop Only</td><td>STO function and Timed SS1 Safe Stop functions are available.</td></tr>
<tr><td>Single Feedback Monitoring</td><td>Primary feedback is used in the safety object for safe monitoring.</td></tr>
<tr><td rowspan="2">Variant</td><td>Standard (E)</td><td>Standard drive</td></tr>
<tr><td>Safety (S)</td><td>Integrated Safety drive</td></tr>
</table>

| Field | Description | |
|---|---|---|
| Drive Rating | 1 HP (0.75 kW) | Power rating for drive |
| | 2 HP (1.5 kW) | |
| | 3 HP (2.2 kW) | |
| Power Supply | Internal 24V DC | Auxiliary/control power is supplied by the drive. |
| | External 24V DC | You are supplying the power supply for the auxiliary/control power |
| EM Brake | No EM Brake | The drive does not have a mechanical brake option |
| | EM Brake | The drive has the mechanical brake control option |

**IMPORTANT** For an Armor PowerFlex drive with safety (35S), the safety and standard connections can both be managed by one Safety controller, or the safety connection can be managed by a Safety controller and the standard connection managed by a second controller. For example, a GuardLogix controller manages the safety connection and a CompactLogix controller manages the standard connection.

In the case that one Safety Controller will manage the safety connection and another controller will manage the standard connection, the safety connection must be done first and then, the standard connection. If the standard connection from a controller is done first, the safety connection from the different Safety Controller will be rejected.

2. After the values are entered, click OK.

## View or Generate a Safety Network Number

The Logix Designer application automatically assigns a Safety Network Number (SNN) to each Armor PowerFlex safety drive as it is added to the project. The SNN is a time-based number that uniquely identifies subnets across all networks in the safety system. All Armor PowerFlex safety drives in a same system use the same SNN by default.

Manual manipulation of an SNN is required in the following situations:

- If safety consumed tags are used
- If the project consumes safety input data from a device whose configuration is owned by some other device
- If a safety project is copied to another hardware installation within the same routable safety system

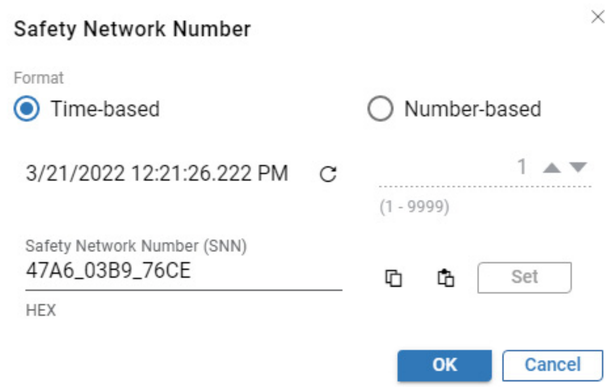
If an SNN is assigned manually, the SNN has to be unique.

**IMPORTANT** If you assign an SNN manually, make sure that the system expansion does not result in duplication of SNN and node address combinations.

A warning appears if your project contains duplicate SNN and node address combinations. You can still verify the project, but we recommend that you resolve the duplicate combinations.

To edit the SNN, follow these steps.

1. To open the Safety Network Number dialog box, click Edit, (to the right of the Safety Network Number), in the Device Definition dialog box.




2. Select either Time-based or Number-based.
3. If you select Number-based, enter a value from 1…9999 decimal.
4. Click Set.
5. Click OK to close the Safety Network Number dialog box.
6. Click OK again, to close the Device Definition dialog box.

If needed, the Device Definition dialog box can be reaccessed via the Overview page.

## QuickStart

QuickStart is an optional wizard that allows you to quickly set up the drive and test the motor. QuickStart is only available if a connection between the Armor PowerFlex drive and the programmable controller is inhibited.

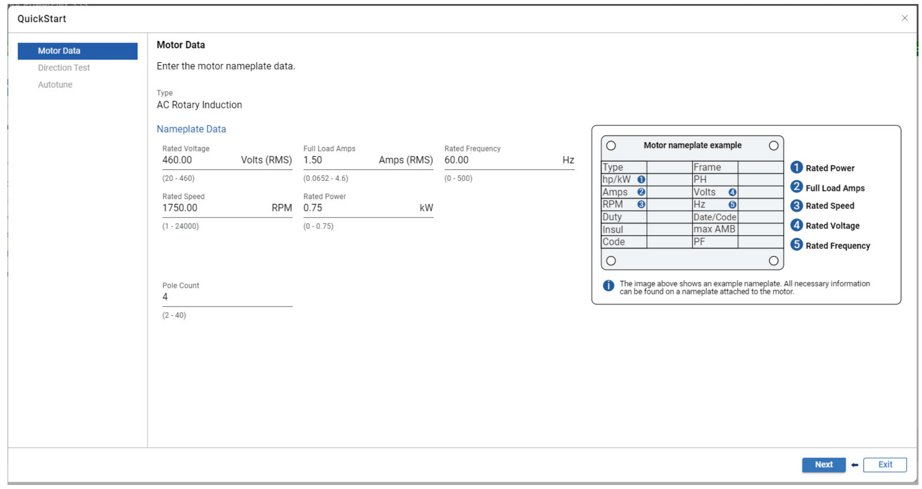
The QuickStart will launch automatically after the OK button is pressed in the Device Definition window, when the module is first created. After that, the QuickStart can be launched independently from the Overview page.

Data that is written during the QuickStart procedure is immediately saved to the Armor PowerFlex drive.

Follow the prompts on the three pages:

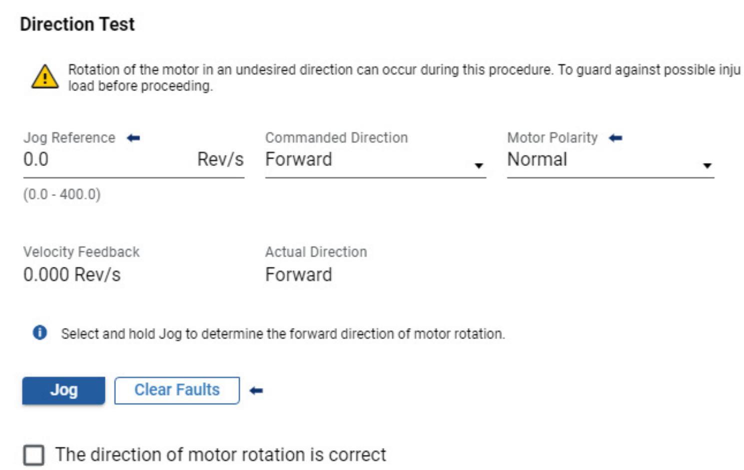
- Motor Data
- Direction Test
- Autotune

### Motor Data Page




1. As prompted, enter input data from the motor nameplate.
2. Click Next, when finished.

### Direction Test Page




3. As prompted, jog to confirm that the motor is moving in the correct direction. Adjust if necessary.
4. Adjust the Motor Polarity field, or swap two of the motor cables to change the motor rotation direction.

**WARNING:** Before swapping motor cables, take appropriate precautions to remove power to the motor.

5. Once the motor is rotating in the correct direction, click Next to access the Autotune page.

### Autotune Page

See Configure Autotune on page 156.

## Configure Motor Control

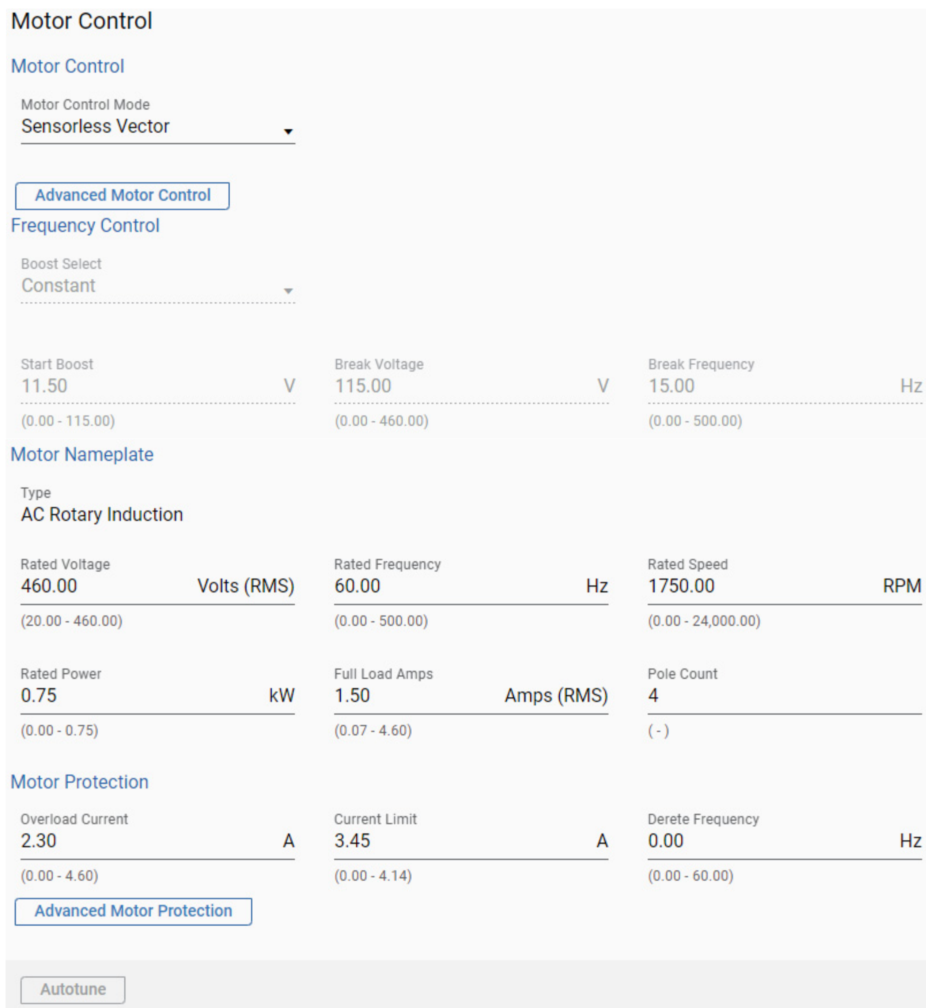
Motor control configuration is concerned with the configuration of the control mode and control method.

Basic motor control involves the control of the state of a connected motor. The state can either be stopped (no power applied to motor) or running (power applied to motor). Basic motor control also allows the direction of motion of the motor to be controlled.

When the Armor PowerFlex drive is configured for standard and safety or standard only connections, the following categories are available in the Module Properties window, for motor configuring operation:

- Motor Control
- Encoder Feedback
- Velocity Control
- Stop Control

Click Motor Control.



## Configure Motor Control Mode

Control mode specifies what parameters the motor control in the device is controlling. Basically it indicates the property or properties of the motor output that are being actively managed by the motor control algorithms. Armor PowerFlex drives use velocity control.

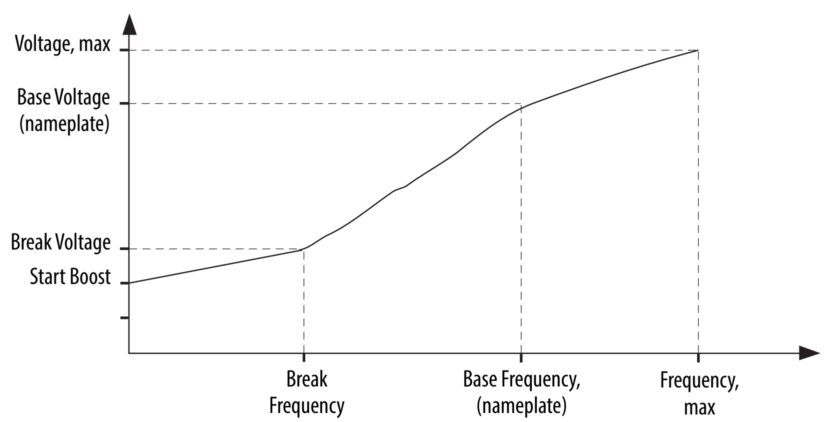
1. On the Motor Control page, choose a Motor Control Mode.

| Motor Control Mode | Description |
|---|---|
| Volts/Hertz | If you choose this mode, you can adjust the Frequency control settings as described in Voltz/Hertz Control Mode See Volts/Hertz Control Mode. |
| Sensorless Vector | The motor is controlled using current feedback, assuming that the total current is the vector sum of the torque- and flux-producing components. In this mode, you cannot adjust the Frequency Control settings. See Configure Advanced Motor Control, for the next steps. |
| Velocity Vector Control (VVC) | A high-speed bandwidth regulator and adaptive controller are used to provide continuous regulation of the motor speed and improved overall control.. It is recommended to use an encoder when using VVC mode. In this mode, you cannot adjust the Frequency Control settings. See Configure Advanced Motor Control, for next steps. |

### *Volts/Hertz Control Mode*

The Volts/Hertz Control Mode uses a a fixed relationship between frequency and voltage, forming what is known as a "Volts per Hertz" curve. When you select Volts/Hertz mode, you can adjust the Frequency Control settings to influence the curve.

**Figure 72 - Volts per Hertz Curve Example**




2. On the Motor Control page, choose a Boost Select method.

| Boost Select Types | Description |
|---|---|
| Custom V/Hz | Custom V/Hz allows a wide variety of patterns for the V/Hz ratio. The default configuration is a straight line from zero to rated voltage and frequency. The volts/ hertz ratio can be changed to provide increased torque performance when required. See Figure 72. |
| Variable | Variable frequency control selects a curve suitable for variable torque loads such as fans and pumps. This type of curve has no starting / acceleration boost. See Figure 73 on page 150. |
| Constant | Constant frequency control selects a curve suitable for constant torque loads such as conveyors and compressors. See Figure 74 on page 150. |

**Figure 73 - Variable Frequency Example**

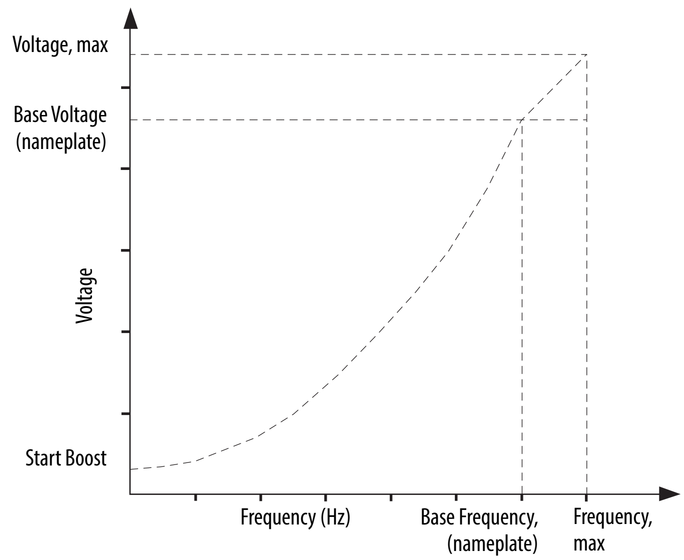
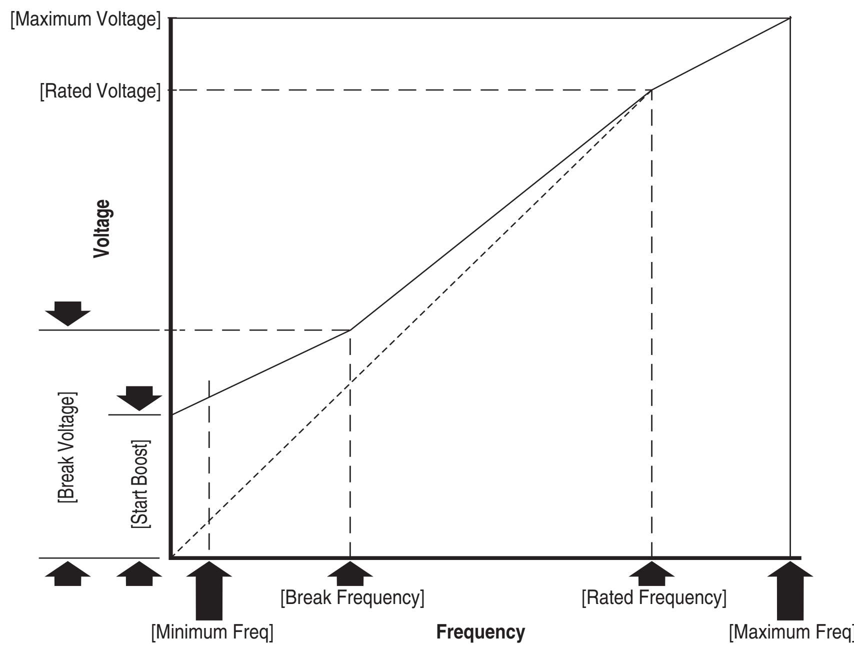



**Figure 74 - Constant Frequency Example**




The frequency control parameters that are configurable depend upon which Boost Select method that you choose. See Table 58 on page 151 to help you set the frequency control values.

**Table 58 - Frequency Control Parameters**

| Frequency Control Value | Description | Configurable in this Boost Select method: | | |
|---|---|---|---|---|
| | | Custom V/Hz | Variable | Constant |
| Start Boost | This setting redefines the Volts/Hz curve. It is used to create additional torque for breakaway from zero speed and acceleration of heavy loads at lower speeds.<br>The boost voltage is only applied until the specified break voltage/frequency point on the curve is reached.<br>The range is 0…115 V, with a default setting of 11.5V. | ✓ | | ✓ |
| Break Voltage | Type a value to set the output voltage of the drive at the Break Frequency where boost ends. This setting is used to increase the slope of the lower portion of the Volts / hertz curve, providing additional torque.<br>The range is 0…460 V, with a default setting of 115V. | ✓ | ✓ | |
| Break Frequency | Type a value to set the output frequency of the drive device at the Break Voltage where boost ends. Used to increase the slope of the lower portion of the Volts / hertz curve, providing additional torque.<br>The range is 0.0…500.0 Hz, with a default setting of 15.0 Hz. | ✓ | ✓ | |

### *Sensorless Vector Control*

The components of the Sensorless Vector Control algorithm must be tuned correctly to provide optimal velocity control performance. The Armor PowerFlex drive provides an Autotune feature to accomplish this. See Configure Autotune on page 156 for instructions on performing the Autotune application. The motor tuning data can also be entered manually with values that are available from the motor manufacturer.

### *Velocity Vector Control*

The proper motor tuning data needs to be present to provide optimal velocity control performance. The Armor PowerFlex drive provides an Autotune feature to accomplish this. See Configure Autotune on page 156 for instructions on performing the Autotune application. The motor tuning data can also be entered manually with values that are available from the motor manufacturer.

## Configure Advanced Motor Control

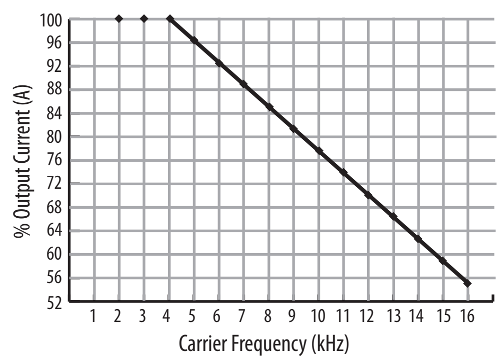
Advanced Motor Control configuration is used to adjust the Slip/Droop attribute or the Maximum Pulse Width Modulated (PWM) Frequency attribute.

1. From the Motor Control page, click Advanced Motor Control.


2. Enter your desired values for these two attributes:

| Attribute | Range | Description |
|---|---|---|
| Full Load Slip/Droop | -600…+600 RPM | This setting compensates for the inherent slip in an induction motor. This speed is added to the commanded output frequency based on motor current.<br>Positive values indicate slip compensation, negative values indicate droop compensation. |
| Maximum PWM Frequency | 2000…16,000 Hz | This setting limits the carrier frequency of the PWM output waveform. Figure 75 on page 152 provides derating guidelines that are based on the PWM frequency setting. |

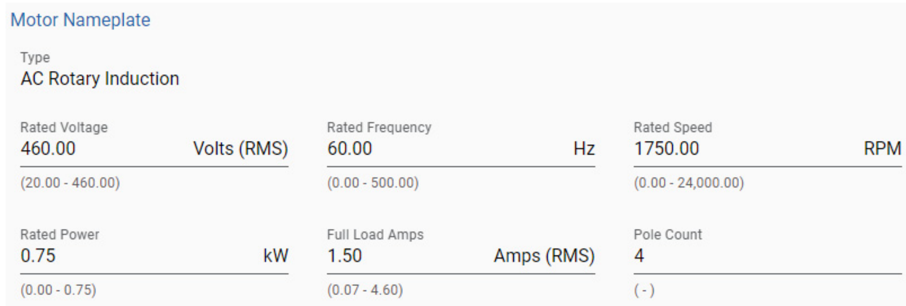
**Figure 75 - Maximum PWM**




3. Click Close to close the Advanced Motor Control dialog box.

## Configure Motor Nameplate

From the Motor Control page, enter Motor Nameplate values based on your system configuration.




Enter motor nameplate data for Voltage, Frequency, and Full Load Current.

| IMPORTANT | The motor nameplate values entered must match the actual characteristics of the connected motor. Do not use the default values if they do not match. If these values are incorrect, poor motor control performance, faults, and other undesired behavior can result. |
|---|---|

### Size: 1 Hp (35S-6D1-*, 35E-6D1-*)

| Motor Nameplate | Minimum | Maximum | Default |
|---|---|---|---|
| Voltage | 20V AC | 460V AC | 460V AC |
| Frequency | 0 Hz | 500 Hz | 60 Hz |
| Rated Speed | 0 RPM | 24,000 RPM | 1750 RPM |
| Rated Power | 0 kW | 0.75 kW | 0.75 kW |
| Pole Count | 2 | N/A | 4 |
| Full Load Amps rms | 0.0652 A | 2.3 A | 2.3 A |

### Size: 2 Hp (35S-6D2-*, 35E-6D2-*)

| Motor Nameplate | Minimum | Maximum | Default |
|---|---|---|---|
| Voltage | 20V AC | 460V AC | 460V AC |
| Frequency | 0 Hz | 500 Hz | 60 Hz |
| Rated Speed | 0 RPM | 24,000 RPM | 1750 RPM |
| Rated Power | 0 kW | 1.5 kW | 1.5 kW |
| Pole Count | 2 | N/A | 4 |
| Full Load Amps rms | 0.0652 A | 4.0 A | 4.2 A |

### Size: 3 Hp (35S-6D3-*, 35E-6D3-*)

| Motor Nameplate | Minimum | Maximum | Default |
|---|---|---|---|
| Voltage | 20V AC | 460V AC | 460V AC |
| Frequency | 0 Hz | 500 Hz | 60 Hz |
| Rated Speed | 0 RPM | 24,000 RPM | 1750 RPM |
| Rated Power | 0 kW | 2.2 kW | 2.2 kW |
| Pole Count | 2 | N/A | 4 |
| Full Load Amps rms | 0.0652 A | 6.0 A | 6.0 A |

## Configure Motor Protection

1. From the Motor Control page, enter the values for Motor Protection.


| Attribute | Range | Description |
|---|---|---|
| Overload Current | 0…4.6 A | Set the overload current to the maximum allowable current. |
| Current Limit | 0.00…4.14 A | Configure the Current Limit, which sets the maximum motor output current that is allowed before current limiting occurs. |
| Derate Frequency | 0…60 Hz | Set the Derate Frequency, which lets the thermal capacity be reduced when the frequency being output to the motor is below this value. |

### *Derating for High Altitude*

The drive can be used without derating at a maximum altitude of 1000 m (3300 ft). If the drive is used above 1000 m (3300 ft):

- Derate the maximum ambient temperature by 5 °C (9 °F) for every additional 1000 m (3300 ft), subject to limits listed in Table 59.

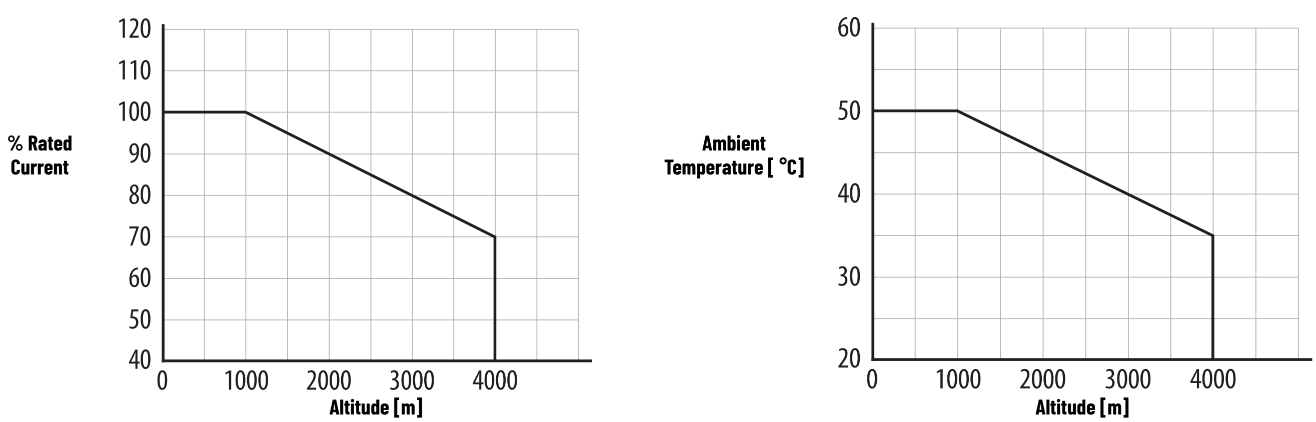
  Or

- Derate the output current by 10% for every additional 1000 m (3300 ft), subject to limits listed in Table 59.

**Table 59 - Altitude Limit (Based on Voltage)**

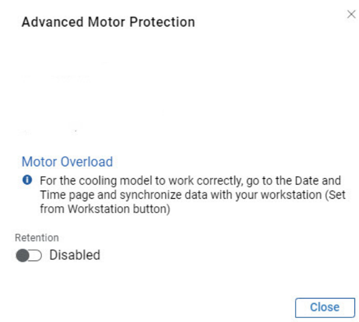
| Drive Rating | Center Ground (Wye Neutral) | Corner Ground, Impedance Ground, or Ungrounded |
|---|---|---|
| 100…120V, 1-Phase | 6000 m | 6000 m |
| 200…240V, 1-Phase | 2000 m | 2000 m |
| 200…240V, 3-Phase | 6000 m | 2000 m |
| 380…480V, 3-Phase | 4000 m | 2000 m |
| 525…600V, 3-Phase | 2000 m | 2000 m |

**Figure 76 - Derating Curves for High Altitude**



## Configure Advanced Motor Protection

1. From the Motor Control page, click Advanced Motor Protection to access Motor Overload Retention attributes.




2. Choose a Motor Overload Retention setting. See Table 60.

**Table 60 - Advanced Motor Protection Parameters**

| Attribute | Range | Description |
|---|---|---|
| Motor Overload | Enabled/Disabled | This defines the behavior of the motor thermal overload feature when the device powers up.<br>• Enabled (toggle switch left) - The value of the Thermal Capacity Utilized attribute is reset to 0 on power up. This assumes that the motor is fully cool.<br>• Disabled (toggle switch right) - The value of the Thermal Capacity Utilized attribute is saved at power down and restored on power up. This assumes that the motor has not cooled down at all while the product was off. |

3. Click close to close the Advanced Motor Protection dialog box.

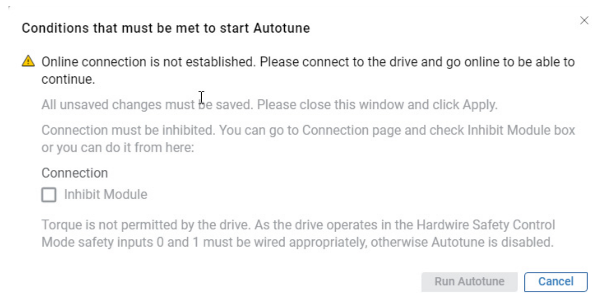
## Configure Autotune

The Autotune procedure can be run using the QuickStart procedure on the Overview page or it can be selected from the Motor Control page.

Autotune provides an automatic method for determining various motor tuning attribute values, by measuring physical attributes of the motor that is connected to the Armor PowerFlex drive. By actually measuring these motor characteristics for the specific motor that is being used (instead of relying on default values, typical values for the motor type and size, or nominal values provided by a motor manufacturer), motor control performance is improved. The drive can perform static and rotate Autotune operations.

To run Autotune, you must be online with the programmable controller (the programmable controller can be in either Program or Run mode). If the Autotune window is launched while the project is offline, an error is displayed indicating that the project online connection has not been established and the Run Autotune button will be grayed out.

**Online Connection Error**



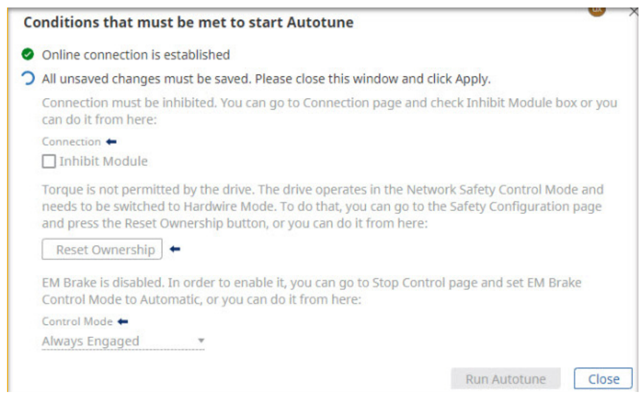

The software will check if the drive is ready to run before allowing the Autotune step. If torque is disabled, the drive is not ready to run and this will result in an error.

| | |
|---|---|
| **IMPORTANT** | For systems with an EM brake, you must release the motor EM brake manually before performing the tune procedure. The EM brake state is not controlled or checked during the Tune procedure. For successful Tune results, the motor shaft should not be restricted by load or EM Brake. |

| | |
|---|---|
| **IMPORTANT** | If motor control performance is important, the Autotune function should be performed. If the performance does not improve after the Autotune function is completed, contact the motor manufacturer for the optimal motor characteristic references and overwrite the values that are identified in the Autotune step. |

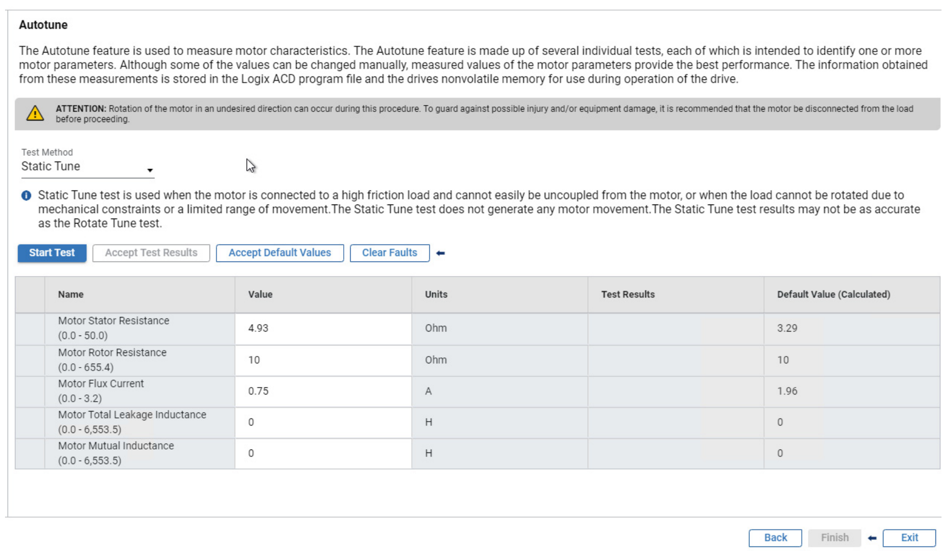
| | |
|---|---|
| **IMPORTANT** | Autotune cannot be performed when torque is disabled in an Armor PowerFlex safety drive (35S). Install the safety bypass jumper (hardwired STO mode), see Hardwired STO Operation on page 91, or enable torque via a separate safety controller (network STO mode), see Integrated Safe Torque Off Function on page 96.<br>Autotune cannot be performed when a safety connection has been configured. |

**ATTENTION:** Rotation of the motor in an undesired direction can occur during this procedure. To guard against possible injury and/or equipment damage, we recommend disconnecting the motor from the load before you continue.




1. Click Run Autotune.

### Autotune page



2. From the Autotune dialog box, choose an option. See Table 61.

   Different quantities are measured based on the Autotune option that is selected and based on the type of motor that is connected to the drive.

**Table 61 - Autotune Options**

| Options | Description |
|---|---|
| 1 "Static Tune" | A static Autotune operation performs measurements of physical attributes of the attached motor without causing movement of the motor. Some electrical energy is output to the motor, but it is not driven in a way to cause movement.<br><br>The number of physical quantities that can be measured during a static tune are limited. For induction motors, the following are measured during a static Autotune:<br>• Induction Motor Stator Resistance<br>• Induction Motor Rotor Resistance<br><br>Use this Autotune operation when no motor movement is allowed or when the motor cannot be uncoupled from the load. |
| 2 "Rotate Tune" | A rotate Autotune operation performs measurements of physical attributes of the attached motor while the motor is moved. Moving the motor allows more physical quantities to be made and in some cases, more accurate measurements can be made.<br><br>For induction motors, the following are measured during a rotate Autotune:<br>• Induction Motor Stator Resistance<br>• Induction Motor Rotor Resistance<br>• Induction Motor Flux Current<br>• Induction Motor Total Leakage Inductance<br>• Induction Motor Mutual Inductance<br><br>Use this Autotune operation when motor movement is allowed and the load can be uncoupled from the motor. The LOAD MUST BE DISCONNECTED / UNCOUPLED or the measurements will not be accurate. |

**IMPORTANT** For Velocity Vector Control (VVC), the recommended tune method is Rotate tune and not Static tune. If Static tune is used, the precision of motor control will be diminished.

**ATTENTION:** Autotune cannot be performed when a safety connection has been configured.
**ATTENTION:** Rotation of the motor in an undesired direction can occur during this procedure. To guard against possible injury and/or equipment damage, we recommend disconnecting the motor from the load before you continue.

3. When the autotune procedure is done, you can choose to enter tuning values manually, accept test results, or acknowledge default values.
4. To use the measured quantities, click Accept Test Results.
5. Click Exit, when complete.

   The Autotune process inhibits the Armor PowerFlex connection without exiting the Autotune window. Once the Autotune process is completed, you must uninhibit the connection.

6. See Standard Connection Settings on page 168 to uninhibit the connection.

   If Autotune was run from the QuickStart application, continue with Configure Motor Control on page 148.

## Configure Flying Start

Enabling Flying Start lets the drive reconnect to a spinning motor at actual RPM.

1. From the Motor Control pull-down menu, click Flying Start.
2. Choose to enable or disable Flying Start by checking or unchecking the check box, respectively.

## Configure Auto Restart

The auto restart feature provides the ability for the drive to automatically perform a fault reset followed by a start attempt without any user intervention.

1. From the Motor Control pull-down menu, click Auto Restart.


If Auto Restart is enabled, it can be configured to perform multiple fault clear/start attempt cycles in response to a single start request.

2. Choose the number of Auto Restart Tries (up to 9), which sets the maximum number of times the drive attempts to reset a fault and restart.

**IMPORTANT** The Auto Restart feature only clears a limited number of the following motor control related faults. Any other faults will not be cleared and the drive will not restart. The drive will also not restart after multiple simultaneous faults of any type occur.

- Inverter - Ground Fault (event code 0x04250002)
- Motor Thermal Overload - Overload, Hard (event code 0x04320001)
- Load Monitor - Above Level (Shear Pin) (event code 0x04340001)
- Load Monitor - Below Level (Load Loss) (event code 0x04340002)
- Temperature Sensor - Overtemperature, Hard (event code 0x04230002)

3. Choose an Auto Restart Delay time (up to 120 s), which defines the time between restart attempts if Auto Restart Tries is set to a value greater than zero.

**ATTENTION:** Equipment damage and/or personal injury can result if this function is used in an inappropriate application. Do not use this function without review of applicable local, national, and international codes, standards, regulations, or industry guidelines.

## Configure Encoder Feedback

The default setting for Encoder Feedback is Disable Encoder Feedback, which is selected when no encoder is used.

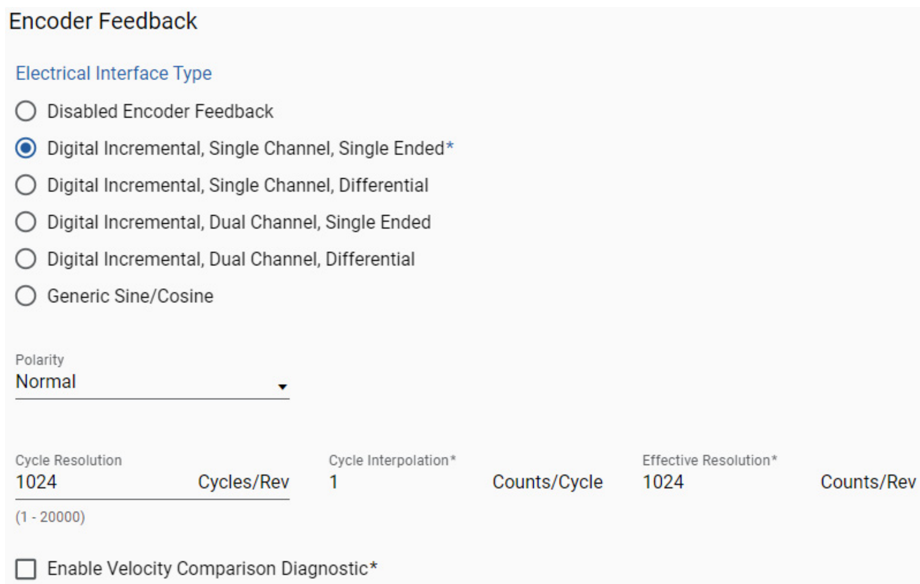
When an encoder is being used in the system configuration, you must adjust the Encoder Feedback parameters for the type of encoder that is used.

To achieve speed range/accuracy for SVC and VVC closed loop control, a minimum of 1024 PPR encoder is recommended. The encoder pulse is approximately 250 kHz. See Table 62 for encoder specifications.

**Table 62 - Encoder Specifications**

| | |
|---|---|
| Type | Incremental |
| Supply | User-selectable 5V or 12V, 250 mA |
| Quadrature Phasing | 90 ± 27° @ 25° C (77° F) |
| Duty Cycle | 50%, +10% |
| Requirements | Encoders must be line driver type, quadrature (dual channel) or pulse (single channel) output, single-ended or differential and capable of supplying a minimum of 10 mA per channel. Allowable input is DC up to a maximum frequency of 250 kHz. The encoder inputs automatically scale to allow 5V, 12V DC nominal input signal voltages. |

1. If you are using an encoder, click Encoder Feedback.




2. Choose the Electrical Interface Type:
   - Digital Incremental, Single Channel, Single Ended
   - Digital Incremental, Single Channel, Differential
   - Digital Incremental, Dual Channel, Single Ended
   - Digital Incremental, Dual Channel, Differential
   - Generic Sine/Cosine
3. From the Encoder Feedback page, select the encoder parameters. See Table 63 on page 161.

**Table 63 - Encoder Feedback Parameters**

| Attribute | Range | Description |
|---|---|---|
| Polarity | Normal/Inverted | Choose between Normal (default) or Inverted as appropriate for your application.<br>This is based on encoder rotation and evaluation requirements. |
| Cycle Resolution | 1…20,000 cycles/rev | This setting is used in the Effective Resolution calculation. The actual motor encoder cycle resolution. This is the raw encoder cycle resolution of the motor or encoder device type. |
| Cycle Interpolation | 4 (default) | This is used in the Effective Resolution calculation. The safety primary-feedback interpolated counts as oppose to the motion axis-feedback interpolated counts. For the Integrated Safety Functions module, this value is 4 and cannot be changed. |
| Effective Resolution | 1…80,000 cycles/rev | This calculated value is the product of cycle resolution and cycle interpolation for the primary safety function evaluation. |
| Enable Velocity Comparison Diagnostic | Enable/disable | When enabled, this diagnostic compares the velocity that is determined by the encoder and the predicted or estimated velocity based on the motor control model. If the difference is too large, a Feedback Velocity Comparison Failure fault occurs. |

## Configure Velocity Control

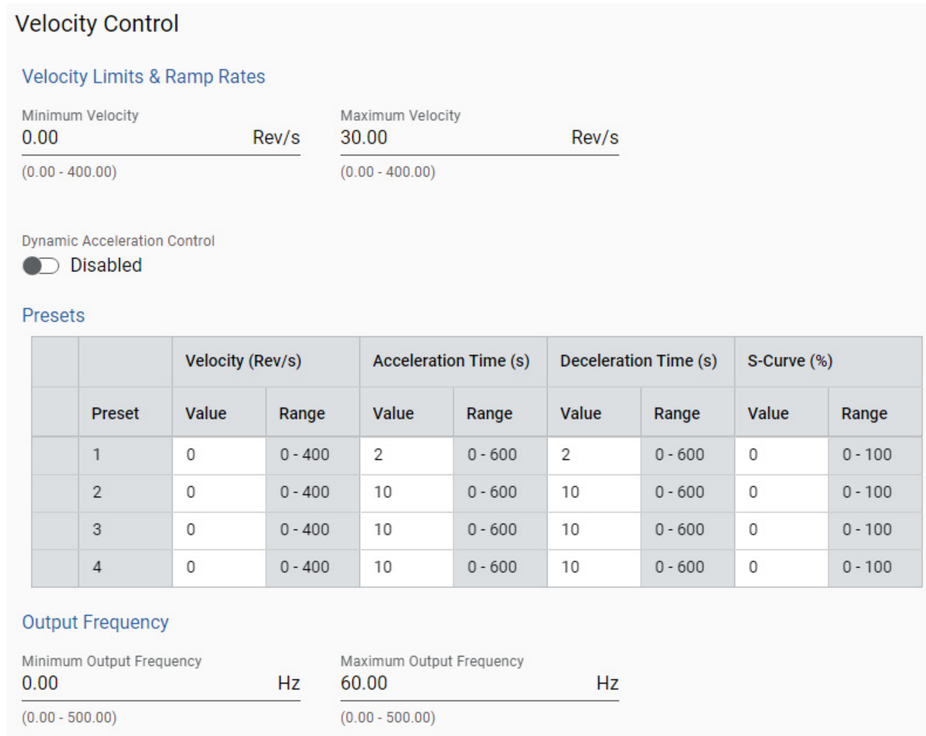
Velocity control refers to controlling of the speed of a connected motor. A speed is commanded by the user, and the motor control algorithms determine the output to the motor necessary to achieve this speed.

Additionally, the motor control method and optional feedback device determine how accurately the commanded speed can be met (closed loop control versus open loop control).

The Velocity Control settings include: setting the velocity limits, enabling or disabling the dynamic acceleration control, entering up to four preset values for velocities, acceleration times, deceleration times, and s-curves, and setting the minimum and maximum output frequencies.

Follow these steps to configure the Velocity Control settings.

1. Click Velocity Control.




## Velocity Limits

2. Enter the Velocity Limits (Minimum Velocity and Maximum Velocity). See Table 64.

**Table 64 - Velocity Limits**

| Attribute | Range | Description |
|---|---|---|
| Minimum Velocity | 0…400 Rev/s | Sets the minimum velocity for the drive. |
| Maximum Velocity | 0…400 Rev/s | Sets the maximum velocity for the drive.<br>**IMPORTANT** Stop the drive before changing this setting. |

## Dynamic Acceleration Control

3. Click Enabled or Disabled for the Dynamic Acceleration Control. See Table 65.

**Table 65 - Dynamic Acceleration Control**

| Attribute | Description |
|---|---|
| Enabled | You can change the values of Acceleration and Deceleration Times currently being used and the changes are implemented in real time, even if the drive is running. |
| Disabled | You must wait for the drive to stop before any changes made to the Acceleration and Deceleration Times will take effect. |

## Preset Velocity, Acceleration Time, Deceleration Time, S-Curve

Enter up to four Presets for: Velocity, Acceleration Time, Deceleration Time, and S-Curve.

4. The Preset Velocity to be used, is selected using the output tags *devicename*.O.VelocityRefSelect_x (where x can be 0, 1, or 2). Table 66 and Table 67 show the bit definitions to select the Preset Velocities, Acceleration Times, Deceleration Times, and S-curves.

**Table 66 - Preset Velocity Output Tag Bit Configuration**

| VelocityRefSelect_2 | VelocityRefSelect_1 | VelocityRefSelect_0 | Preset Velocity to be used |
|---|---|---|---|
| 0 | 0 | 0 | **User velocity reference in output tag (CommandedVelocity)** |
| 0 | 0 | 1 | Preset 1 |
| 0 | 1 | 0 | Preset 2 |
| 0 | 1 | 1 | Preset 3 |
| 1 | 0 | 0 | Preset 4 |

**IMPORTANT** If an illegal value is entered (a value that is not defined in the table) for the Velocity Output Tag, the CommandVelocity output tag is used.

**Table 67 - Preset Acceleration/Deceleration/S-Curve Output Tag Bit Configuration**

| AccelRefSelect_2 | AccelRefSelect_1 | AccelRefSelect_0 | Preset Acceleration Time, Deceleration Time, S-Curve to be used |
|---|---|---|---|
| 0 | 0 | 0 | Preset 1 |
| 0 | 0 | 1 | Preset 1 |
| 0 | 1 | 0 | Preset 2 |
| 0 | 1 | 1 | Preset 3 |
| 1 | 0 | 0 | Preset 4 |

**IMPORTANT** If an illegal value (a value that is not defined in the table) is entered for the Preset Acceleration/Deceleration/S-Curve Output Tag, Preset 1 is used.

| Attribute | Description |
|---|---|
| Acceleration Time | Sets the rate of acceleration for all speed increases except during a jog function. See Figure 77 for a graphic example. |
| Deceleration Time | Sets the rate of deceleration for all speed decreases except during a jog function. See Figure 77 for a graphic example. |
| S Curve | Sets the percentage of acceleration or deceleration time that is applied to ramp as an S curve. Half of the time is added at the beginning and half at the end of the ramp. See Figure 78 for a graphic example. |

**Figure 77 - Ramp Acceleration and Deceleration**

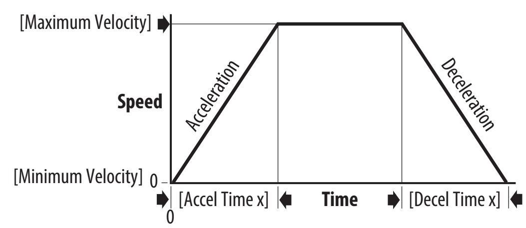
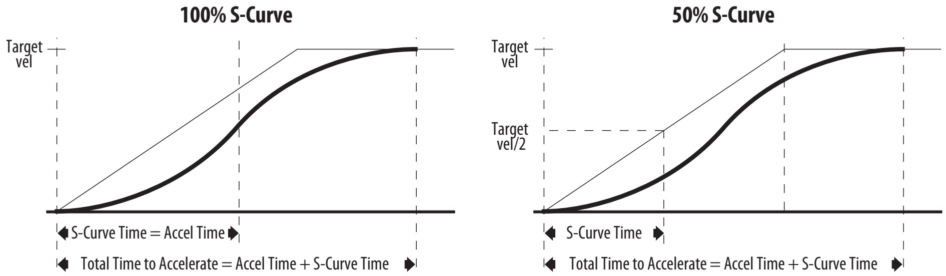
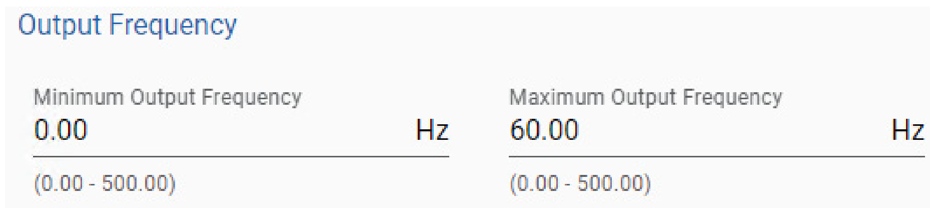


Figure 78 - S-Curve Examples




## Output Frequency

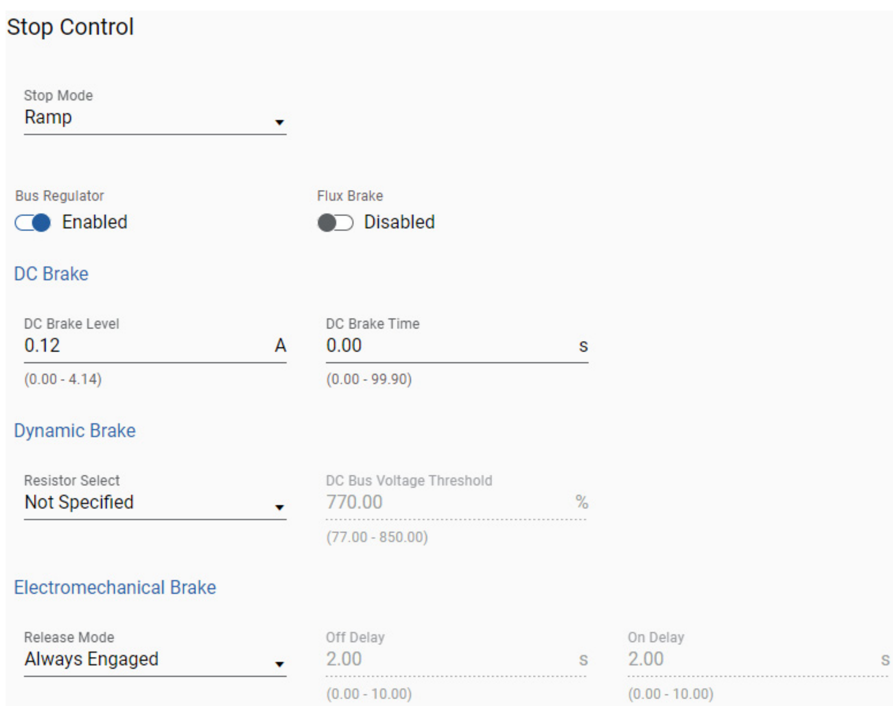
5. Enter your minimum and maximum Output Frequency settings.




# Configure Stop Control

The Stop Control page includes attributes related to the stop control of the motor.

1. Click Stop Control.



2. Choose a Stop Mode from the pull-down menu. See Table 68.

**Table 68 - Motor Stop Modes**

| Modes | Description |
|---|---|
| Coast | When a stop is initiated, power to the motor is immediately removed resulting in an uncontrolled stop. |
| Ramp (default) | When a stop is initiated, power to the motor is not interrupted, but the velocity is reduced to zero at a rate defined by the Deceleration Time. Power to the motor is not removed until zero velocity is achieved. This is a controlled stop. |
| DC Brake | When a stop is initiated, power to the motor is not interrupted, but a user configured amount of DC current is injected into the motor to produce a more rapid stop. After either a fixed period or when the velocity reaches zero, power to the motor is removed. |

3. Enable or disable the Bus Regulator function.

   The Bus Regulator reduces the Decel Rate as required to help prevent the DC Bus Voltage from increasing to the trip limit.

   **ATTENTION:** The bus regulator function is useful to help prevent nuisance overvoltage faults that result from aggressive decelerations, overhauling loads, and eccentric loads. However, it can also cause either of the following two conditions to occur.
   - Fast positive changes in input voltage or imbalanced input voltages can cause uncommanded positive speed changes
   - Actual deceleration times can be longer than commanded deceleration times – (However, a Stall Fault is generated if the drive remains in this state for 1 minute. If this condition is unacceptable, Bus Regulator must be disabled. In addition, installing a properly sized dynamic brake resistor provides equal or better performance in most cases.)

4. Enable or disable the Flux Brake function.

   The flux brake can be enabled for Ramp stop mode. It only applies to certain motor types, such as AC induction.

   Flux Braking causes over fluxing of the motor which reduces the motor speed faster than just the decel ramp alone. This feature is not intended for high inertia loads because over fluxing can cause excessive heat in the motor. Very long decel times can create heat.

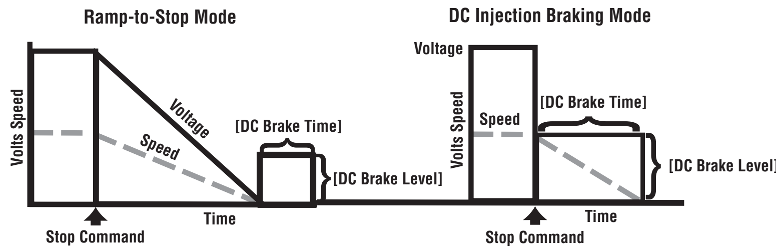
## Configure DC Brake

DC Brake attributes need to be adjusted when DC Brake is set for the Stop Mode or when the stop mode is Ramp to stop and DC Brake Injection is desired to hold the load in place for certain period of time after a ramped stop.

| Attribute | Range | Description |
|---|---|---|
| DC Brake Level | 0…4.14 A | This setting defines the maximum DC brake current, in Amps, applied to the motor when Stop Mode is set to Ramp to Stop or DC Brake Stop. See Figure 79 on page 166. |
| DC Brake Time | 0…99.9 s | This setting specifies the length of time that DC brake current is injected into the motor. See Figure 79 on page 166. |

Default values are drive rating dependent and listed in the Armor PowerFlex AC Drives CIP Objects and Attributes Reference Data, publication 35-RD001.

**Figure 79 - DC Brake Example**




**ATTENTION:** If a hazard of injury due to movement of equipment or material exists, a mechanical braking device must be used. This feature must not be used with synchronous or permanent magnet motors. Motors can be demagnetized during braking.

**ATTENTION:** Excess motor current and/or applied duration, could cause motor damage. Motor voltage can exist long after the Stop command is issued. The right combination of DC Brake Level and DC Brake Time must be determined to provide the safest, most efficient stop.

## Configure Dynamic Brake

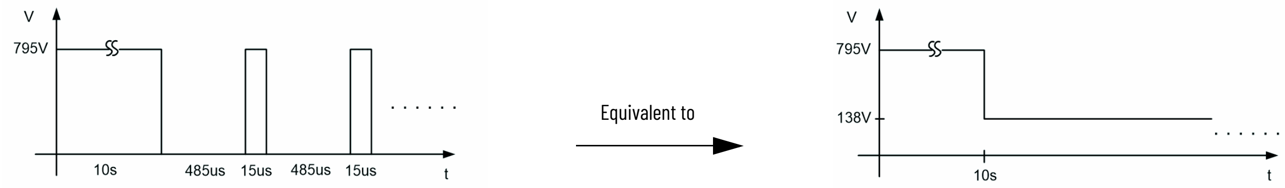
| **IMPORTANT** | Stop the drive before changing this setting. |
|---|---|

Choose a Resistor option that matches the physical Dynamic Brake connected to the Armor PowerFlex. When the External Light Duty or External Normal duty options are selected, the dynamic brake feature is enabled. Then, set the DC Bus Threshold Voltage.

| | Value | Description |
|---|---|---|
| Dynamic Brake Resistor | Not Specified | Not used; no dynamic brake |
| | External Light Duty | 3% duty cycle, for details see Light Duty Dynamic Brake Resistor Operation on page 167 |
| | External Normal Duty | 5% duty cycle, for details see Standard Duty Dynamic Brake Resistor Operation on page 167 |
| DC Bus Voltage Threshold | 77…850V DC | If the DC bus voltage falls below the value set in this parameter, the Dynamic Brake does not turn on. Lower values make the Dynamic Braking function more responsive, but can result in nuisance Dynamic Brake activation. |
| | | **ATTENTION:** Equipment damage can result if this parameter is set to a value that causes the dynamic braking resistor to dissipate excessive power. Parameter settings less than 770V DC should be carefully evaluated to confirm that the dynamic brake resistor's wattage rating is not exceeded. In general, values less than 700V DC are not needed. Do not set the parameter above 810V DC because it will cause a DC Bus Overvoltage error. |

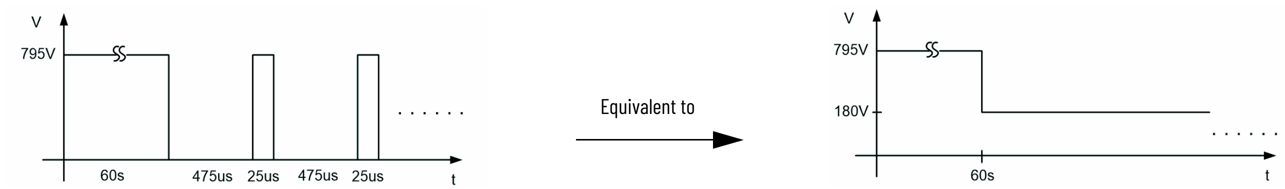
*Light Duty Dynamic Brake Resistor Operation*

When the light duty dynamic brake resistor is applied, the braking operation applies 100% duty cycle up to 10 seconds, followed by 3% duty cycle.




*Standard Duty Dynamic Brake Resistor Operation*

When the standard duty dynamic brake resistor is applied, the braking operation applies 100% duty cycle up to 60 seconds, followed by 5% duty cycle.



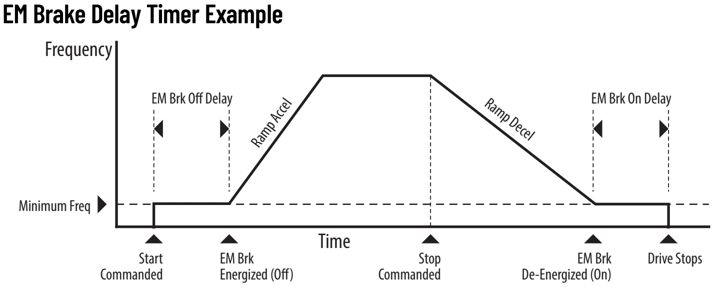

## Configure Electromechanical Brake

The Electromechanical (EM) brake control can be automatic or manual. With automatic brake control, the brake is released automatically when the motor control is started, and is applied automatically when the motor control is stopped. EM brake automatic control is only available with Ramp Stop mode. With manual brake control, you can release and engage the brake when needed, using a bit in an I/O assembly (*DeviceName*:O.EMBrakeRelease is the output tag).

Choose a Release Mode for the EM brake from the pull-down menu. If choosing Automatic, also set the Off Delay and On Delay, see Figure 80.

| EM Brake Release Mode | Description |
|---|---|
| Always Engaged (default) | The integrated EM brake contactor does not energize. Therefore, if the Armor PowerFlex drive is connected to a motor with an EM brake, it never releases. |
| Automatic | The EM brake releases automatically, once the drive starts and the Brake Off Delay timer is satisfied. It engages automatically once the drive stops and the Brake On Delay timer is satisfied (see Figure 80). When the delay is set to 0, the brake releases once a valid start is detected by the drive and engages once a valid stop condition has been detected. If Source Brake Release Mode is set to Automatic, then the Stop Mode must be set to Ramp. |

**Figure 80 - EM Brake Delay Timer Example**




Click OK to exit the Stop Control page.

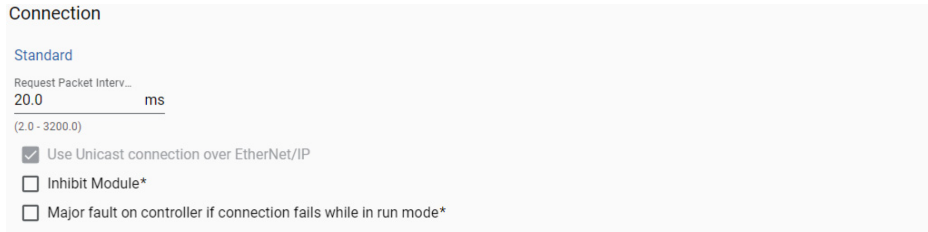
## Configure Connections

Perform the steps in the following sections to configure your standard and safety output and input connections.

### Standard Connection Settings

The module uses Unicast connections over EtherNet/IP by default. For more information on unicast and multicast connections, see the EtherNet/IP Network Devices User Manual, publication ENET-UM006.

1. To open the Connection page, click Connection in the Module Properties window of the Armor PowerFlex drive.




2. Enter a value for the RPI rate for the Standard Connection.

| | Default Setting | Range | Description |
|---|---|---|---|
| RPI Rate | 20.0 ms | 2…3200 ms | The RPI defines the slowest rate at which the drive produces input data to and consumes output data from the controller. |

3. To Inhibit the connection check the check-box and click on the Apply or OK button. To Un-Inhibit the connection, uncheck the check-box and click on the Apply or OK button. The Inhibit Module check-box is unchecked by default.

   The Inhibit Module check-box allows you to indefinitely suspend a connection, including Listen Only connections, between an owner-controller and a digital I/O module without removing the module from the configuration.

   This process lets you temporarily disable a module, to perform maintenance.

| IMPORTANT | You cannot inhibit a connection when the drive is safety-locked or a safety signature exists for the drive. This means that you cannot use the QuickStart procedure for editing the Armor PowerFlex drive. |
|---|---|

4. Configure whether a drive connection failure, while the programmable controller is in Run mode, causes a major fault in the controller. Minor fault is the default.

   The Module Fault area of the Connection page provides a fault description and error code for troubleshooting.

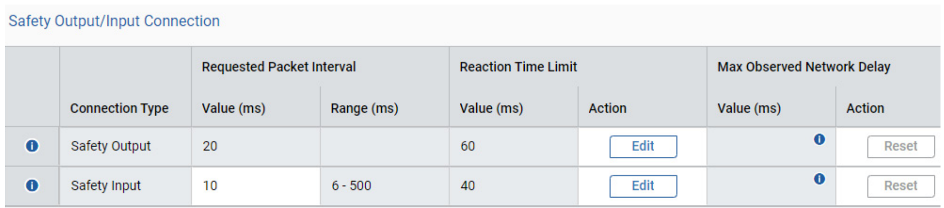
   The connection between the owner and the Armor PowerFlex drive is based on the following:

   - Armor PowerFlex drive safety network number (when there is a safety connection)
   - Controller slot number
   - GuardLogix safety controller safety network number (when there is a safety connection)

- Path from the controller to the Armor PowerFlex drive
- Armor PowerFlex drive configuration signature

If any differences are detected, the connection between the GuardLogix safety controller and the Armor PowerFlex drive is lost, and the yellow yield icon appears in the controller project tree after you download the program.

## Safety Input and Output Connection Settings (safety variants only)


Safety Output/Input Connection

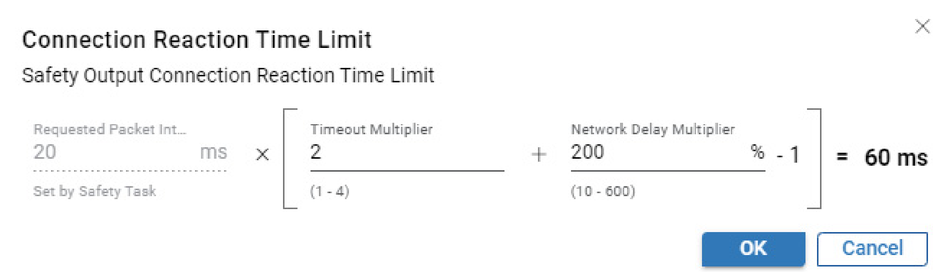
| | | Requested Packet Interval | | Reaction Time Limit | | Max Observed Network Delay | |
|---|---|---|---|---|---|---|---|
| | Connection Type | Value (ms) | Range (ms) | Value (ms) | Action | Value (ms) | Action |
| i | Safety Output | 20 | | 60 | Edit | i | Reset |
| i | Safety Input | 10 | 6 - 500 | 40 | Edit | i | Reset |

On the connections page, follow these steps:

1. The RPI (Requested Packet Interval) for the Safety Input connection can be adjusted for the application. See the following table for additional information. The RPI for the Safety Output connection is a fixed value based on the period set for the safety task in the controller.

| | Default Setting | Range | Description |
|---|---|---|---|
| RPI Rate | 10.0 ms | 6…500 ms | The RPI defines the slowest rate at which a module multicasts its data to the owner-controller. The time is sent to the module with all other configuration parameters. When the specified time frame elapses, the module multicasts data. |

2. The Reaction Time Limit for the Safety Input and the Safety Output can be adjusted for the application. Click Edit to open the Connection Reaction Time Limit configuration window.



## Configure Standard I/O Points

Follow these steps to configure the standard I/O points.

1. From the Configuration menu, choose Input/Output Configuration.

Input/Output Configuration

Input Configuration

| | | Input Delay Time (ms) | | |
|---|---|---|---|---|
| | Point | Off → On | On → Off | Range |
| | 0 | 5 | 5 | 0 - 65535 |
| | 1 | 5 | 5 | 0 - 65535 |
| | 2 | 5 | 5 | 0 - 65535 |
| | 3 | 5 | 5 | 0 - 65535 |

Input/Output Configuration

| | | Input Configuration | | | Output Configuration | | |
|---|---|---|---|---|---|---|---|
| | | Delay Time (ms) | | | Connection | | Product |
| | Point | Off → On | On → Off | Range | Idle Action | Fault Action | Fault Action |
| | 0 | 5 | 5 | 0 - 65535 | On | On | On |
| | 1 | 5 | 5 | 0 - 65535 | On | On | On |

2. Assign the Input Delay Time, Off→On (0…65,535 ms, in increments of 5 ms). The default value is zero.

   Delay time is for Off to On transition. Input must be high after input delay has elapsed before it is set logic 1. This delay time is configured per channel with each channel tuned to match the characteristics of the field device, for maximum performance.

3. Assign the Input Delay Time, On→Off (0…65,535 ms, in increments of 6 ms). The default value is zero.

   Delay time is On to Off transition. Input must be low after input delay has elapsed before it is set logic 0. This delay time is configured per channel with each channel tuned to match the characteristics of the field device, for maximum performance.

If using the configurable I/O points as inputs, define an Off→On and On→Off delay time as described previously in step 2 and step 3.

If using the configurable I/O points as outputs, the action that the output should take when one of the conditions listed below is detected, can be configured to On, Off, or Hold.

- Idle Action - Idle Network Connection to the Armor PowerFlex drive
- Fault Action - Fault Network Connection to the Armor PowerFlex drive
- Product Fault Action - Armor PowerFlex Fault

4. Enter values for the Timeout Multiplier and Network Delay Multiplier for both the Safety Output and Safety Input. These values are combined in a formula with the RPI, to calculate the Connection Reaction Time Limit. When you select appropriate RPIs, the system has maximum performance.

| | Default Setting | Range | Description |
|---|---|---|---|
| Timeout Multiplier | 2 | 1…4 | To determine what is appropriate, analyze each safety channel. The default Timeout Multiplier of 2 and Network Delay Multiplier of 200 creates a worst-case input connection-reaction time limit of 4 times the RPI, and an output connection-reaction time limit of 3 times the RPI.<br>The Connection Reaction Time Limit sets the maximum age of safety packets on the associated connection. If the age of the data that is used by the consuming device exceeds the connection reaction time limit, a connection fault occurs. |
| Network Delay Multiplier | 200% | 10…600% | |

**IMPORTANT** Changes to these settings must be approved only after a thorough review by a safety administrator.

5. After the values are entered, click OK to close the Connection Reaction Time Limit window.

   A connection status tag, called ConnectionFaulted, exists for every connection. If the RPI and connection reaction time limit for the network are set appropriately, then this status tag must always remain low. Monitor all connection status bits to verify that they are not going high intermittently due to timeouts. This could be caused by a network issue and could be used as an Ethernet troubleshooting diagnostic.
6. Click OK to close the Connection page.

For more information about the Connection Reaction Time Limit, see the user manual for your safety controller.

**IMPORTANT** To operate properly, standard outputs require a minimum load of 10 mA, otherwise an over/under current error will occur.

## Configure Safety Functions (safety variants)

Safety configuration includes the following pages:

- Safety Feedback — (only available with an encoder)
- Scaling — (only available with an encoder)
- Safe Torque Off (STO)
- Safe Brake Control (SBC)
- Safe Stop 1 (SS1)
- Test Output
- Input Configuration
- Output Configuration
- Actions

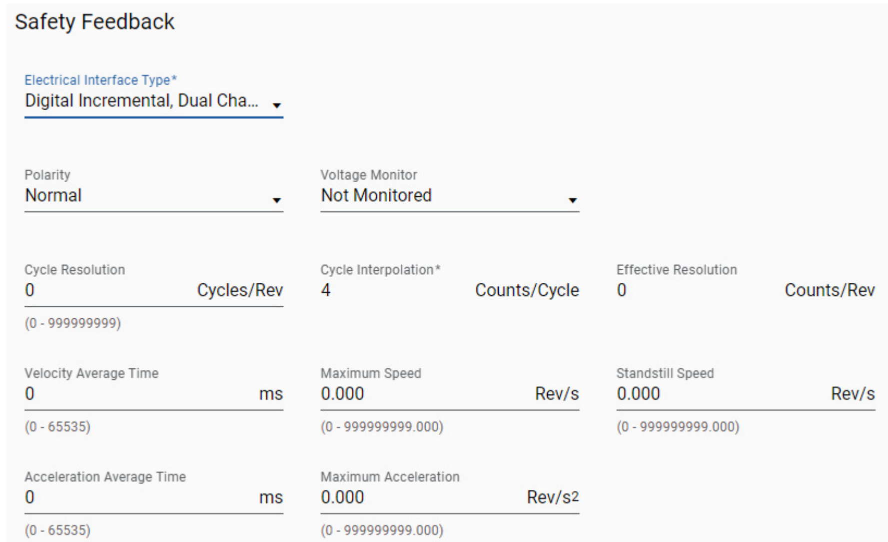
### Configure Safety Feedback

Configure primary feedback if you intend to use any drive-based or controller-based safety function that monitors motion. There are many different combinations of feedback for velocity control and safety that can be configured.

Safety Feedback only appears when Single Feedback Monitoring is selected as the Safety Instance in the Device Definition.

Follow these steps to configure the Primary Feedback.

1. Select the Safety Feedback page.

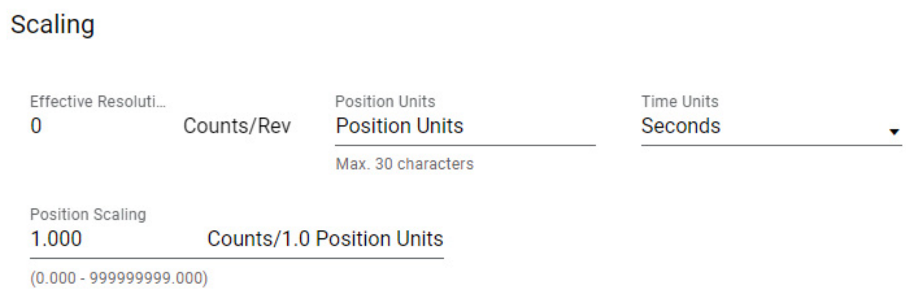



2. Enter your Safety Feedback attributes.

| Attribute | Description | Value |
|---|---|---|
| Electrical Interface Type | Select your type of feedback device. | Disabled safety feedback - not specified (default) |
| | | Digital Incremental - Sine/Cosine |
| | | Dual Channel, Differential {aka. Digital AqB} |
| | | Generic Sine Cosine<br>Hiperface |
| Polarity | Defines the direction of counting versus the direction of motion.<br>• Normal means counts increase when motion is in the positive direction.<br>• Inverted means that counts decrease when motion is in the negative direction. | Normal (default) |
| | | Inverted |
| Voltage Monitor | Selects monitoring of voltage that is supplied to power the feedback. | Not Monitored (default) |
| | | 4.75…5.25V |
| | | 11.4…12.6V |
| Cycle Resolution | Defines the number of Cycles per Unit.<br>The unit is typically meters for linear devices and revolutions for rotary devices. | cycles/rev |
| Cycle Interpolation | Defines the number of position Counts per Cycle. | counts/cycle |
| Effective Resolution | Defines the number of position Counts per Unit. | counts/rev |
| Velocity Average Time | Specifies the time period over which to average Feedback Velocity.<br>Select 0 to disable averaging. | 0 ms (default) |
| | | 1…65535 ms |
| Maximum Speed | Defines the maximum allowable speed. Exceeding this speed causes a fault.<br>Select 0 to set no maximum speed. | 0 rev/s (default) |
| | | # rev/s |
| Standstill Speed | Defines the speed below which motion is considered stopped. Feedback Velocity above standstill speed will set either Motion Negative or Motion Positive attributes to 1. | 0 rev/s (default) |
| | | # rev/s |
| Acceleration Average Time | Specifies the time period over which to average Feedback Acceleration.<br>Select 0 to disable averaging. | 0 ms (default) |
| | | 1…65535 ms |
| Maximum Acceleration | Defines the maximum allowable acceleration. Exceeding this acceleration causes a fault.<br>Select 0 to set no maximum acceleration. | 0 rev/$s^2$ (default) |
| | | # rev/$s^2$ |

## Configure Scaling

The scaling page lets you configure the position and time to be used in terms of counts per position unit (defined by the user) in the safe monitoring functions. It defines “Actual Speed” and “Actual Position” that is used to match the velocity controller.



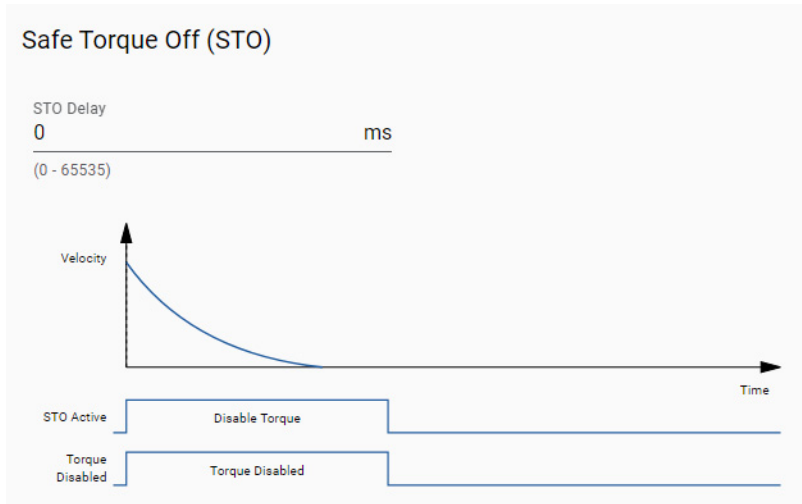

Select Scaling and enter the safety scaling attributes per the following table.

| Attribute | Description |
|---|---|
| Effective Resolution | The number of counts per motor revolution, which is determined by the Primary Feedback category. |
| Position Units | The position units for this safety application. Enter text for the name of your units. |
| Time Units | The evaluation of position per unit of time for a velocity evaluation. Choose between Seconds (default) and Minutes, as appropriate for your application. |
| Position Scaling | The conversion constant showing the counts per position units. This is the number of counts for one of your position units. |

## Configure Safe Torque Off

From the Safety Configuration menu, choose Safe Torque Off (STO).

The STO function can be configured to delay when torque is disabled, by entering an STO Delay value. To see how STO Delay affects operation, see Safe Torque Off Delay and Safe Torque Off Operation on page 98.




STO Active command becomes active if any of the following inputs to STO are asserted:

- STO Output = 0
- Safety Connection is Loss and Connection Loss Action = STO
- Safety Connection is Idle and Connection Idle Action = STO
- Drive-based SS1 Function is Complete (= 1)
- Safety Stop Fault = 1
- Critical Safety fault occurs

STO Output is a tag in the safety output assembly of the Armor PowerFlex drive that is used to activate the STO function for the drive. When any source for STO is asserted, the STO Active bit becomes high to indicate that the STO function is operating.

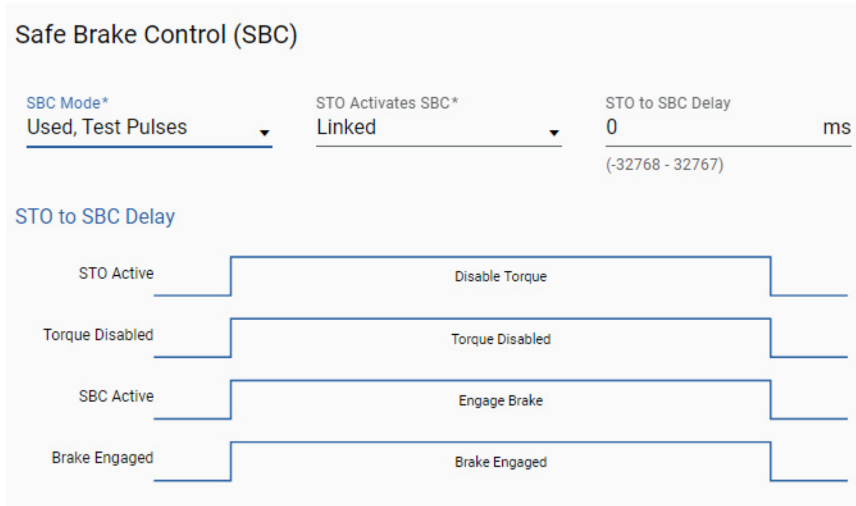
STO Delay follows this sequence of events.

1. STO becomes active and the STO delay timer begins.
2. The STO delay timer expires.
3. Torque producing power is removed from the inverter output.
   - If STO is activated by a Safety Stop fault or Critical Safety fault, torque is removed immediately without the STO delay.
   - If STO is reset by removing all inputs that cause the STO Active command to be true, torque is immediately permitted without delay.

## Configure Safe Brake Control (SBC)

From the Safety Configuration menu, choose Safe Brake Control (SBC).

SBC is configured when Safe Brake Control functionality is desired in an application.




The default mode for SBC is ‘Not Used’. If the SBC functionality is desired, setting the mode to ‘Used’, ‘Test Pulses’, or setting the mode to ‘Used, No Test Pulses’, will enable the SBC function. When configured for ‘Used, Test Pulses mode’, pulse testing of the physical brake outputs are performed. For more information on the drive-based SBC function, see Safe Brake Control Function on page 105.
See Table 69 for descriptions of the SBC attributes.

### Table 69 - SBC Attributes

| Attribute | Description |
|---|---|
| STO Activates SBC | Determines if an STO event engages the brake. If set to ‘Not Linked’, an STO event does not engage the brake. If set to ‘Linked’, the brake is engaged during an STO event based on the ‘STO to SBC Delay’ attribute. This attribute is only valid when the ‘Mode’ is set to one of the two ‘Used’ options. |
| STO to SBC Delay | The delay of brake engagement in milliseconds. If the value is a positive number, the delay specifies the time between when STO is activated and the brake is engaged. If the value is a negative number, the brake is engaged immediately after STO is activated, and the delay specifies the time between STO activation and when torque is actually disabled. This attribute is only valid when ‘STO Activates SBC’ is set to’ Linked’. |

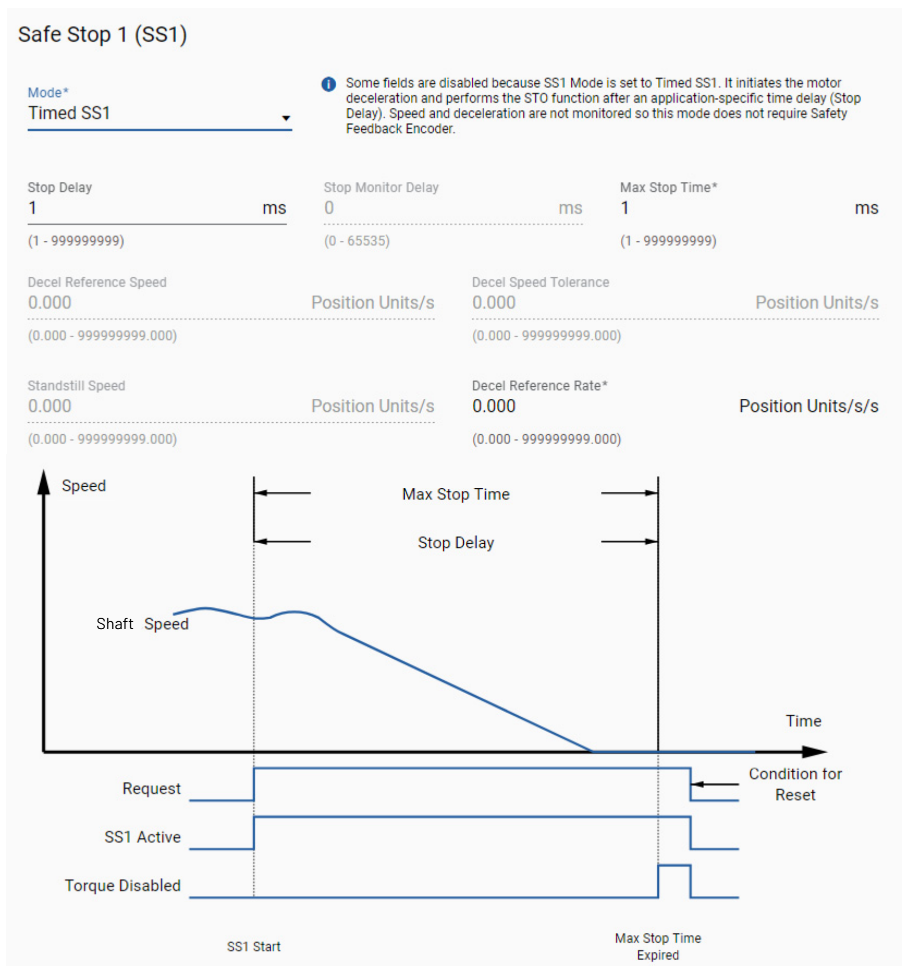
## Configure Safe Stop 1

From the Safety Configuration menu choose Safe Stop 1 (SS1).

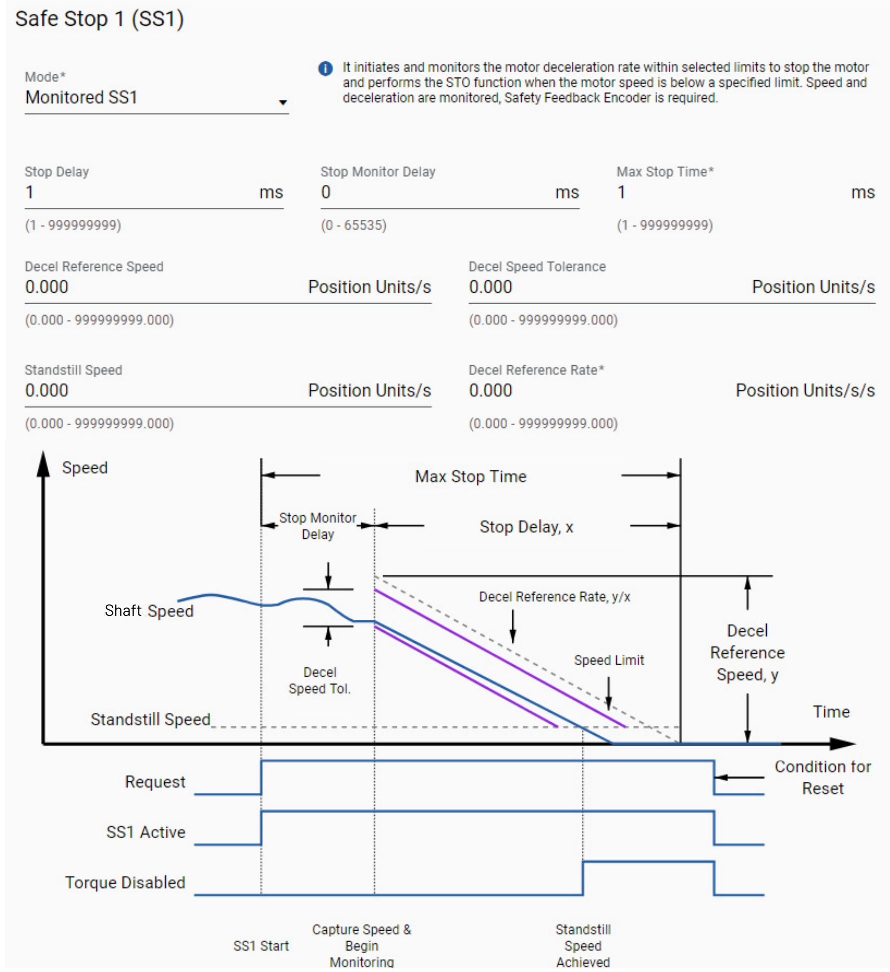
SS1 is configured when a Timed or Monitored Safe Stop 1 condition is desired.

'Timed SS1' mode is available when the module is configured with or without safety feedback monitoring. The 'Monitored SS1' mode is only available when the module Safety Instance in the Device Definition is configured for single feedback monitoring (for more information on the drive-based Safe Stop 1 function, see Safe Stop 1 Function on page 100.)

Timed SS1 is a fixed time for the motor to stop before removing torque. Motor feedback is not monitored. 'Stop Delay' is the only parameter that is used for 'Timed SS1' and determines the 'Max Stop Time'.




Monitored SS1 is a ramped safe-stop where the motion safety instance monitors the speed ramp to standstill speed, while the drive controls the deceleration to standstill speed. When standstill is reached, the motion safety instance removes torque from the motor.



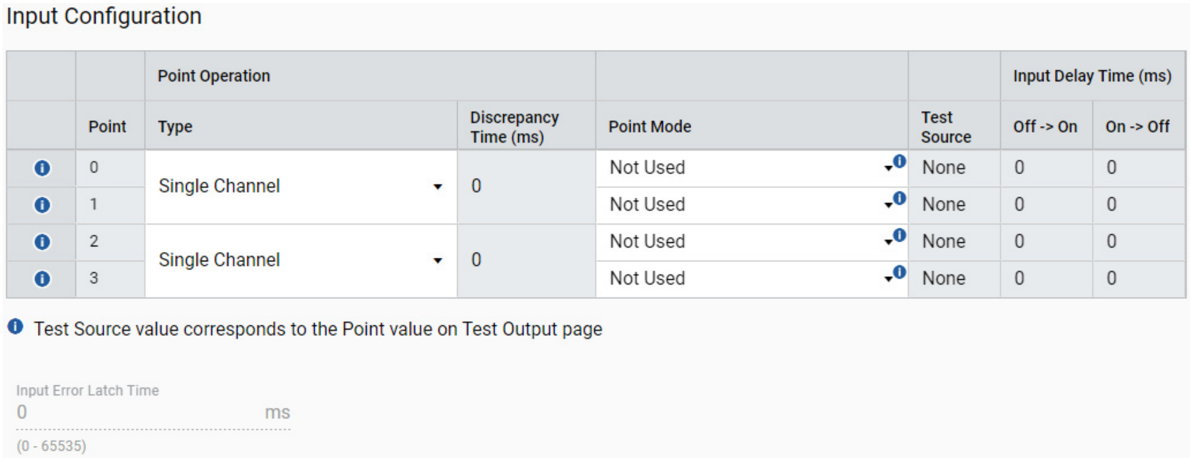

Configure these settings:

| Property | Description |
|---|---|
| Mode | Specifies the mode of the SS1 function. The Mode selection determines which parameters on the tab are available to configure. The available options are:<br>• Not Used<br>• Timed SS1<br>• Monitored SS1<br>Monitored SS1 is unavailable when the Safety Instance on the Device Definition window is set to 'Safe Stop, Only'. |
| Stop Monitor Delay | The delay time before deceleration is monitored. Valid values are 0...65535.<br>This option is not available when 'Mode' is 'Timed SS1'. |
| Stop Delay | The stop delay time used when the SS1 function is initiated by a stop type condition. |
| Max Stop Time | Displays the SS1 maximum stop time. This value is the sum of 'Stop Delay 'and 'Stop Monitor Delay'. |
| Decel Reference Speed | Specifies the deceleration speed to monitor for SS1.<br>This parameter is unavailable when 'Mode' is 'Timed SS1'. |
| Decel Reference Rate | The minimum rate of deceleration while stopping.<br>Changing the Stop Delay value recalculates the Decel Reference Rate.<br>This parameter is unavailable when 'Mode' is 'Timed SS1'. |
| Decel Speed Tolerance | The speed tolerance that is applied to the deceleration ramp check. |
| Standstill Speed | The speed limit that is used to declare motion as stopped. |

## Configure Safety Inputs

Follow these steps to configure the safety inputs.

1. From the Safety Configuration menu, choose Input Configuration.




2. In the Input Configuration dialog box, assign the Point Operation Type. See Table 70.

**Table 70 - Point Operation Types**

| Type | Description |
|---|---|
| Single Channel | Inputs are treated as single channels.<br>Dual-channel safety inputs can be configured as two individual single channels. This configuration does not affect pulse tests because it is handled on an individual channel basis.<br>**IMPORTANT:** Use single-channel mode when you intend to use the GuardLogix safety application instructions. |
| Dual Channel Equivalent | Inputs are treated as a dual-channel pair. The channels must match within the discrepancy time or an error is generated. |
| Dual Channel Complementary | Inputs are treated as a dual-channel pair. They must be in opposite states within the discrepancy time or an error is generated. |

3. When you choose Dual Channel Equivalent or Dual Channel Complementary, you must also consider the Discrepancy Time. A Discrepancy Time of 0 ms disables the discrepancy check. The Discrepancy Time accepts values of 0…65535 in increments of 1 ms.

| | |
|---|---|
| **IMPORTANT** | Configuring discrepancy time on Armor PowerFlex safety inputs masks input discrepancies that are detected by the controller safety instructions. The controller reads status to obtain this fault information. |

4. Assign the Point Mode. See Table 71.

**Table 71 - Input Point Modes**

| Point Mode | Description |
|---|---|
| Not Used | The input is disabled. If 24V is applied to the input terminal, it remains logic 0. |
| Used as Standard Input | The input point is enabled and performs as a Standard Input. |
| Used with Test Output | The input point is enabled and performs a pulse test on the input. When the input is energized, the input pulses low briefly. The pulse test detects whether the input is functioning properly. |
| Used without Test Output | The input point is enabled and does not perform a pulse test on the input. |

When the input Point Mode is Used With Test Output, test output channel 0 is mapped to input channel 0, and test output 1 is mapped to input 1.

5. Assign the Input Delay Time, Off to On (0…65,535 ms, in increments of 1 ms). The default is 0 ms.

   Filter time is for Off to On transition. Input must be high after input delay has elapsed before it is set logic 1. This delay time is configured per channel with each channel tuned to match the characteristics of the field device, for maximum performance.

6. Assign the Input Delay Time, On to Off (0…65,535 ms, in increments of 1 ms). The default is 0 ms.

   Filter time is On to Off transition. Input must be low after input delay has elapsed before it is set logic 0. This delay time is configured per channel with each channel tuned to match the characteristics of the field device, for maximum performance.

7. From the Input Error Latch Time field, enter the time that the module holds an error to make sure that the controller can detect it (0…65,535 ms, in increments of 1 ms - default 1000 ms).

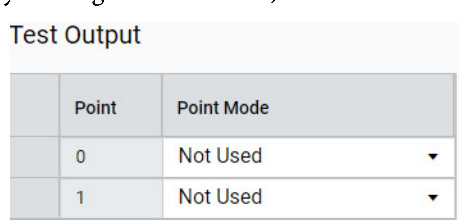
   This setting provides more accurate diagnostics. The purpose for latching input errors is to make sure that intermittent faults that can exist only for a few milliseconds are latched long enough for the controller to read. The amount of time to latch the errors are based on the RPI, the safety task watchdog, and other application-specific variables.

8. Click Apply.

## Configure Test Outputs

If you have configured safety inputs to use a test output, follow these steps to configure the test outputs:

1. From the Safety Configuration menu, choose Test Output.



2. In the Test Output dialog box, assign a point mode.

**Table 72 - Test Output Configuration**

| Point Mode | Description |
|---|---|
| Not Used | The test output is disabled. |
| Test Pulse Output | Used to test a safety input for short circuit detection. |

For test output specifications, see Test Output Specifications on page 135.

## Configure Safety Outputs

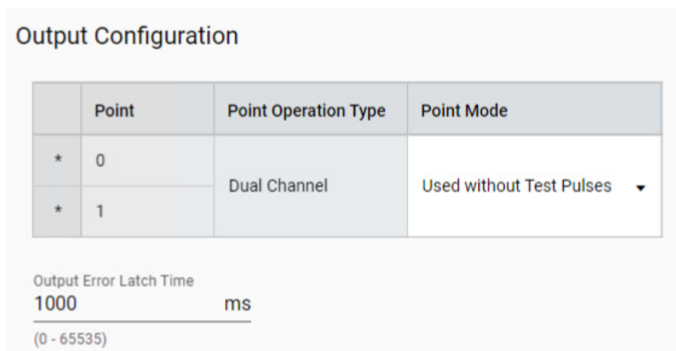
The dual channel mode features bipolar safety outputs which must be configured the same. The Armor PowerFlex drive treats the outputs as a pair and sets them high (1) or low (0), as a matched pair.

Output configuration is not available when Safe Brake Control (SBC) is enabled.

Safety logic must set both of these outputs On or Off simultaneously or the module declares a channel fault.

Follow these steps to configure the safety outputs.

1. From the Safety Configuration menu, choose Output Configuration.




2. Assign the Point Mode.

| Point Mode | Description |
|---|---|
| Not Used | The output is disabled. |
| Used without Test Pulses | The output point is enabled and does not perform a pulse test on the output. |
| Used with Test Pulses | The output point is enabled and performs a pulse test on the output. When the output is energized, the output pulses low briefly. The pulse test detects whether the output is functioning properly. |

3. Enter the Output Error Latch Time.

| Attribute | Description |
|---|---|
| Output Error Latch Time | Specifies the amount of time in milliseconds an Output error will be latched. If the error is no longer present after this time, the error condition can be reset. |

## Configure Safety Actions

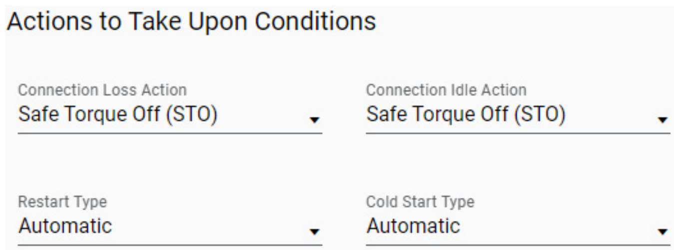
Use the settings on the Actions page to:

- Define the action to take when the safety connection is lost.
- Define the action to take when the safety connection goes idle.
- Define the restart and cold start behavior.

Restart is the restart behavior while operating. A cold start is the restart behavior when applying controller power or controller mode changes to 'Run'.

Follow these steps to configure the safety actions.

1. From the Safety Configuration menu, choose Actions




2. Choose the safety action values. See Table 73.

**Table 73 - Safety Action Value Descriptions**

| Attribute | Description | Values | Description |
|---|---|---|---|
| Connection Loss Action | • Connection loss is caused by removal of the Ethernet cable from the drive.<br>• The loss could also be an indication of excessive traffic, causing the drive to lose synchronization to the grandmaster clock controller. | SS1 | Drive-based Safe Stop 1 function is initiated and operates according to the SS1 configuration. |
| | | STO | Torque is removed according to the STO configuration. |
| Connection Idle Action | Connection idle is caused by the safety output task becoming disabled because the controller goes from run to Remote Program mode. | SS1 | Drive-based Safe Stop 1 function is initiated and operates according to the SS1 configuration. |
| | | STO | Torque is removed according to the STO configuration. |
| Restart Type | Restart type means that the safety function resets and will be ready for subsequent operation when the reset conditions are met. See specific function for more detail. | Automatic | Restart automatically allowed after safety function completes and function request is removed. If restart is required due to a fault, a manual restart must be performed. |
| | | Manual | Restart is allowed after removing any faults if present, disabling the safety function request tag, and a 0->1 transition of SO.ResetRequest bit. |
| Cold Start Type | Cold start type means that the configured safety function is ready for operation immediately after the controller enters run mode. | Automatic | Restart allowed after safety function completes and function request is removed. If restart is required due to a fault, the fault condition must also be removed. |
| | | Manual | Restart is allowed after a 0->1 transition of SO.ResetRequest bit. |

## View or Edit Additional Settings

Status of the Armor PowerFlex drive can be monitored using the FactoryTalk Linx application. See Chapter 8 for FactoryTalk Linx application details.

## Using Automatic Device Configuration

Automatic Device Configuration (ADC) supports the automatic download of drive configuration data. It is always active in the drive and cannot be disabled. Drive configuration settings are stored in the Logix controller. With ADC, the Logix controller automatically downloads the configuration settings for a particular drive each time the Logix controller connects to the Armor PowerFlex drive.

**ATTENTION: Logix holds the Master copy of the drive configuration.**
ADC is triggered any time the Armor PowerFlex drive detects a configuration signature mismatch when establishing an EtherNet/IP network I/O connection.
No other configuration tools are supported. Any Armor PowerFlex drive configuration changes must be made by editing the Module Properties in the Logix Designer project.

## Auto-generated Tags

After you configure the Armor PowerFlex drive, the drive tags are generated for standard and safety inputs and outputs. The data from the input (produced) and output (consumed) assemblies is used as descriptive tag names to simplify programming.

To find the status of the configurable I/O, see Configurable I/O Operation on page 79.

**IMPORTANT** Review the CONNECTION_STATUS Data section of the GuardLogix 5580 and Compact GuardLogix 5380 Controller Systems Safety Reference Manual, publication 1756-RM012, for information on how to use the connection status tags.

**Table 74 - Standard Input Tags**

| Input Tag | Function |
|---|---|
| DeviceName.I.DriveStatus | Bitmask of status bits below |
| DeviceName.I.Ready | 0 = Motor control is not ready to run (see run inhibits for details)<br>1 = Motor control is ready to run, there is nothing blocking a run request |
| DeviceName.I.Running | 0 = Motor control is not running, no power output to motor<br>1 = Motor control is running, power is being output to the motor |
| DeviceName.I.CommandedDirection | 0 = Current commanded direction is reverse<br>1 = Current commanded direction is forward |
| DeviceName.I.ActualDirection | Indicates the actual direction of motion when Running = 1, not valid if Running = 0<br>0 = Actual direction of motion is reverse<br>1 = Actual direction of motion is forward |
| DeviceName.I.Accelerating | Set to 1 if motor control is accelerating (increasing velocity) to achieve velocity reference |
| DeviceName.I.Decelerating | Set to 1 if motor control is decelerating (decreasing velocity) due to a stop or to achieve velocity reference |
| DeviceName.I.AtReferenceSpeed | Set to 1 if motor control is running and the current velocity is the velocity reference |
| DeviceName.I.Fault | Set to 1 if there is an unacknowledged fault present |
| DeviceName.I.SafetyIn0Monitor | Safety input 0 state, 0 = off, 1 = on (35S only) |
| DeviceName.I.SafetyIn1Monitor | Safety input 1 state, 0 = off, 1 = on (35S only) |
| DeviceName.I.SafetyIn2Monitor | Safety input 2 state, 0 = off, 1 = on (35S only) |

### Table 74 - Standard Input Tags

| Input Tag | Function |
|---|---|
| DeviceName.I.SafetyIn3Monitor | Safety input 3 state, 0 = off, 1 = on (35S only) |
| DeviceName.I.SafetyOutMonitor | Safety output 0 (bipolar output) state, 0 = off, 1 = on (35S only) |
| DeviceName.I.SafeTorqueEnabled | Set to 1 if the safety logic is permitting torque (power output to motor), else 0 (35S only) |
| DeviceName.I.SafetyFault | Set to 1 if there is a safety specific fault present (35S only) |
| DeviceName.I.In_0 | Standard input 0 state, 0 = off, 1 = on |
| DeviceName.I.In_1 | Standard input 1 state, 0 = off, 1 = on |
| DeviceName.I.In_2 | Standard input 2 state, 0 = off, 1 = on |
| DeviceName.I.In_3 | Standard input 3 state, 0 = off, 1 = on |
| DeviceName.I.IO_0 | Self-configuring I/O point 0 state when used as an input, 0 = off, 1 = on |
| DeviceName.I.IO_1 | Self-configuring I/O point 1 state when used as an input, 0 = off, 1 = on |
| DeviceName.I.KeypadButtonF0 | State of front panel keypad button F0 (Local/Auto), 0 = not pressed, 1 = pressed |
| DeviceName.I.KeypadButtonF1 | State of front panel keypad button F1 (Forward/Reverse), 0 = not pressed, 1 = pressed |
| DeviceName.I.KeypadButtonF2 | State of front panel keypad button F2 (Jog), 0 = not pressed, 1 = pressed |
| DeviceName.I.KeypadHandMode | Set to 1 if the front panel keypad is in the local state (it is in control of the motor) |
| DeviceName.I.ThreePhaseACPowerPresent | Set to 1 if there is 3-phase AC power detected on the power input connector |
| DeviceName.I.DisconnectClosed | State of the AC power disconnect switch, 0 = open/off, 1 = closed/on |
| DeviceName.I.EMBrakeReleased | Set to 1 if the EM brake is released (energized), else 0 |
| DeviceName.I.Alarm | Set to 1 if there is an active alarm condition present |
| DeviceName.I.OutputFrequency | Frequency of the output to the motor, in hertz |
| DeviceName.I.OutputVoltage | Voltage of the output to the motor, in volts, AC |
| DeviceName.I.OutputCurrent | Current being output to the motor, in amps |
| DeviceName.I.OutputPower | Power being output to the motor, in kilowatts |
| DeviceName.I.DCBusVoltage | Voltage of the internal DC bus, in volts, DC |
| DeviceName.I.DriveHeatsinkTemperature | Temperature of the motor output heatsink, degrees Celsius |
| DeviceName.I.EncoderCounts | Raw encoder (feedback device) counts |
| DeviceName.I.MotorOverloadLevel | Motor thermal overload level as a percentage (0% to 100%) |
| DeviceName.I.TripFaultCode | Fault / event code of the first fault that caused the device to enter the faulted state, 0 if no unacknowledged faults present |
| DeviceName.I.CurrentVelocity | Current estimated or measured velocity of the motor, valid if Running = 1 |

### Table 75 - Standard Output Tags

| Output Tag | Function |
|---|---|
| DeviceName.O.LogicCommand | Bitmask of command bits below |
| DeviceName.O.Stop | A 0 to 1 transition will cause motor control to perform a stop<br>Motor control is blocked from running if set to 1 |
| DeviceName.O.Start | A 0 to 1 transition will cause motor control to attempt to run |
| DeviceName.O.Run | Motor control will attempt to run when set to 1, and remain running until set back to 0 |
| DeviceName.O.Jog | Motor control will attempt to jog (run with preset speed) when set to 1, and remain jogging until set back to 0 |

### Table 75 - Standard Output Tags

| Output Tag | Function |
|---|---|
| DeviceName.O.DirectionCmd_0<br>DeviceName.O.DirectionCmd_1 | 0,0 or 1,1 = No direction commanded, current direction is maintained<br>1,0 = Forward direction commanded<br>0,1 = Reverse direction commanded |
| DeviceName.O.ClearFault | A 0 to 1 transition will acknowledge or clear all active faults |
| DeviceName.O.AccelRefSelect_0<br>DeviceName.O.AccelRefSelect_1<br>DeviceName.O.AccelRefSelect_2 | 0,0,0 = Use default acceleration reference (usually Acceleration Preset 1)<br>For configuration, see Table 67 on page 163.<br>0,0,1 = Use Acceleration Preset 1<br>0,1,0 = Use Acceleration Preset 2<br>0,1,1 = Use Acceleration Preset 3<br>1,0,0 = Use Acceleration Preset 4 |
| DeviceName.O.VelocityRefSelect_0<br>DeviceName.O.VelocityRefSelect_1<br>DeviceName.O.VelocityRefSelect_2 | 0,0,0 = Use velocity reference in output tag (CommandedVelocity)<br>For configuration, see Table 66 on page 163.<br>1,0,0 = Use Velocity Preset 1<br>0,1,0 = Use Velocity Preset 2<br>1,1,0 = Use Velocity Preset 3<br>0,0,1 = Use Velocity Preset 4 |
| DeviceName.O.IO_0 | Controls the state of the self-configuring I/O point 0<br>0 = output off / input mode, 1 = output on<br>If using this I/O point as an input, this should remain 0 |
| DeviceName.O.IO_1 | Controls the state of the self-configuring I/O point 1<br>0 = output off / input mode, 1 = output on<br>If using this I/O point as an input, this should remain 0 |
| DeviceName.O.EMBrakeRelease | 1 = Manually release (energize) the EM brake<br>(This tag member is ignored on units without EM brake control circuitry) |
| DeviceName.O.CommandFrequency | Dynamic velocity reference value, used if DeviceName:O.VelocityRefSelect = 0,0,0 |

### Table 76 - Safety Input Tags

| Safety Input Tags | Function |
|---|---|
| DeviceName.SI.ConnectionStatus | Bitmask of status bits below |
| DeviceName.SI.RunMode | Safety Connection:<br>0 = Idle<br>1 = Run |
| DeviceName.SI.ConnectionFaulted | Safety Connection:<br>0 = Normal<br>1 = Faulted |
| DeviceName.SI.FeedbackPosition | Indicates the actual position of the feedback device. |
| DeviceName.SI.FeedbackVelocity | Indicates the Feedback velocity, the actual velocity of the feedback device. |
| DeviceName.SI.StopStatus | A collection of the following bits. |
| DeviceName.SI.STOActive | Safe Torque Off (STO) function status<br>0 = Permit Torque<br>1 = Disable Torque |
| DeviceName.SI.SBCActive | Safe Brake Control (SBC) function status<br>0 = Release Brake<br>1 = Engage Brake |
| DeviceName.SI.SS1Active | Safe Stop 1 (SS1) function status:<br>0 = Not Active<br>1 = Active |
| DeviceName.SI.SafetyFault | 1 = Safe Stop Fault present |
| DeviceName.SI.RestartRequired | 1 = Fault Reset or Stop Restart is required |
| DeviceName.SI.SafeStatus | A collection of the following bits. |
| DeviceName.SI.TorqueDisabled | 0 = Torque Permitted<br>1 = Torque Disabled |

## Table 76 - Safety Input Tags

| Safety Input Tags | Function |
|---|---|
| DeviceName.SI.BrakeEngaged | Indicates the status of SBC function:<br>0 = Brake Released<br>1 = Brake Engaged |
| DeviceName.SI.MotionStatus | Reserved for future use; always 0. |
| DeviceName.SI.MotionPositive | Indicates positive motion:<br>0 = No Positive Motion<br>1 = Positive Motion |
| DeviceName.SI.MotionNegative | Indicates negative motion:<br>0 = No Negative Motion<br>1 = Negative Motion |
| DeviceName.SI.FunctionSupport | Reserved for future use; always 0. |
| DeviceName.SI.PrimaryFeedbackValid | Indicates that valid feedback is being produced by a connected feedback device:<br>0 = Feedback Invalid<br>1 = Feedback Valid |
| DeviceName.SI.SBCReady | Indicates whether SBC function is ready for operation:<br>0 = Not Ready<br>1 = Ready |
| DeviceName.SI.SS1Ready | Indicates whether SS1 function is ready for operation:<br>0 = Not Ready<br>1 = Ready |
| DeviceName.SI.OutputStatus | A collection of safety output status, safety output monitor values, and test output status |
| DeviceName.SI.Out00Monitor | Output Monitor Value of Safety Output 0<br>0 = OFF<br>1 = ON |
| DeviceName.SI.Out01Monitor | Output Monitor Value of Safety Output 1<br>0 = OFF<br>1 = ON |
| DeviceName.SI.Out00Status | Status of Safety Output 0<br>0 = Alarm<br>1 = OK |
| DeviceName.SI.Out01Status | Status of Safety Output 1<br>0 = Alarm<br>1 = OK |
| DeviceName.SI.Test00Status | Status of Test Output 0<br>0 = Alarm<br>1 = OK |
| DeviceName.SI.Test01Status | Status of Test Output 1<br>0 = Alarm<br>1 = OK |
| DeviceName.SI.InputStatus | A collection of safety input values and status for each safety input |
| DeviceName.SI.In00Data | Value of Safety Input 0<br>0 = OFF<br>1 = ON |
| DeviceName.SI.In01Data | Value of Safety Input 1<br>0 = OFF<br>1 = ON |
| DeviceName.SI.In02Data | Value of Safety Input 2<br>0 = OFF<br>1 = ON |
| DeviceName.SI.In03Data | Value of Safety Input 13<br>0 = OFF<br>1 = ON |
| DeviceName.SI.In00Status | Status of Safety Input 0<br>0 = Alarm<br>1 = OK |
| DeviceName.SI.In01Status | Status of Safety Input 1<br>0 = Alarm<br>1 = OK |
| DeviceName.SI.In02Status | Status of Safety Input 2<br>0 = Alarm<br>1 = OK |

## Table 76 - Safety Input Tags

| Safety Input Tags | Function |
|---|---|
| DeviceName.SI.In03Status | Status of Safety Input 3<br>0 = Alarm<br>1 = OK |
| DeviceName.SI.IOSupport | A collection of bits describing safety IO functionality |
| DeviceName.SI.In00Valid | Safety Input 0 Valid<br>0 = Data invalid<br>1 = Data valid |
| DeviceName.SI.In01Valid | Safety Input 1 Valid<br>0 = Data invalid<br>1 = Data valid |
| DeviceName.SI.In02Valid | Safety Input 2 Valid<br>0 = Data invalid<br>1 = Data valid |
| DeviceName.SI.In03Valid | Safety Input 3 Valid<br>0 = Data invalid<br>1 = Data valid |
| DeviceName.SI.Out00Ready | Safety Output 0 Ready<br>0 = Not Ready<br>1 = Ready |
| DeviceName.SI.Out01Ready | Safety Output 1 Ready<br>0 = Not Ready<br>1 = Ready |

## Table 77 - Safety Output Tags

| Safety Output Tags | |
|---|---|
| DeviceName.SO.PassThruDataA1 | 32-bit data container holding general-purpose safety data passed from the safety controller. |
| DeviceName.SO.PassThruDataB1 | 32-bit data container holding general-purpose safety data passed from the safety controller. |
| DeviceName.SO.PassThruStopStatus | See the following descriptions of Safe Stop Function Status bits. |
| DeviceName.SO.SBCIntegrity | Status of an external Safety Brake controlled by SBC function.<br>0 = SBC fault. The brake status, released or engaged, is undetermined.<br>1 = No faults detected. |
| DeviceName.SO.SBCActive | Indicates that the SBC function is active and the sequence to set the Safety Brake has started. This function is only available as a controller-based function.<br>0 = SBC Function is not Active<br>1 = SBC Function is Active |
| DeviceName.SO.SBCBrakeEngaged | Indicates that the External Safety Brake is engaged by the controller-based SBC function.<br>0 = Brake is Engaged<br>1 = Brake is Released |
| DeviceName.SO.SS1Active | Indicates that the controller-based SS1 function is active.<br>0 = SS1 Function is not Active<br>1 = SS1 Function is Active |
| DeviceName.SO.SS2Active | Indicated that the controller-based SS2 function is active.<br>0 = SS2 Function is not Active<br>1 = SS2 Function is Active |
| DeviceName.SO.SOSActive | Indicates that the controller-based SOS function is active.<br>0 = SOS Function is not Active<br>1 = SOS Function is Active |
| DeviceName.SO.SOSStandstill | Indicates that the controller-based SOS function has detected Standstill according to the function configuration.<br>0 = Monitored axis is not at Standstill<br>1 = Monitored axis is at Standstill |
| DeviceName.SO.PassThruSpeedLimitStatus1 | See the following descriptions of Limit Function Status bits. |
| DeviceName.SO.SSMActive | For use with a controller-based SSM function. |

### Table 77 - Safety Output Tags

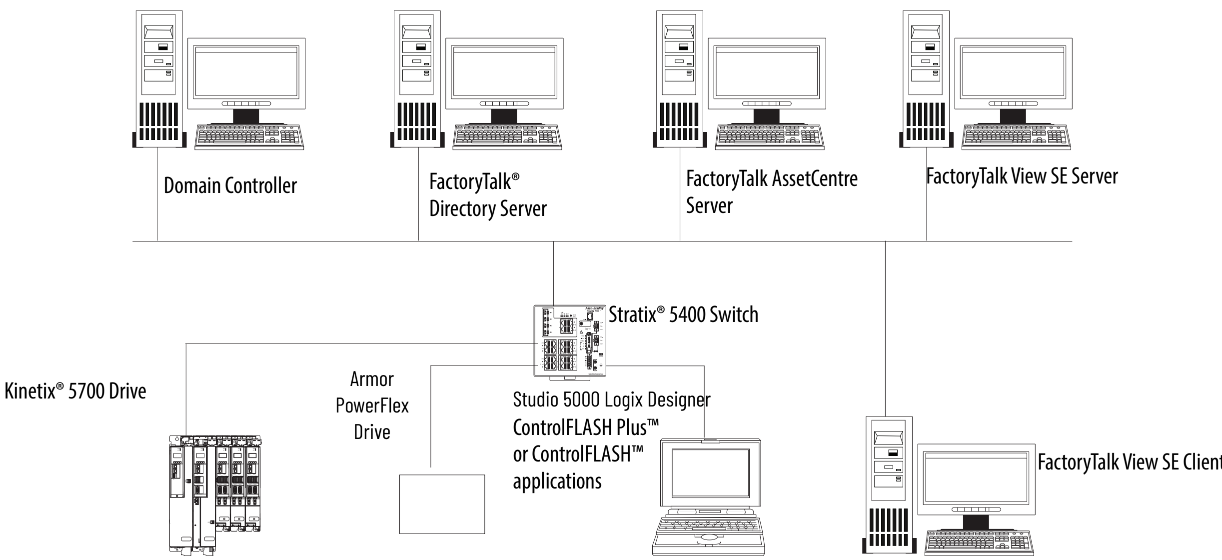
| Safety Output Tags | |
|---|---|
| DeviceName.SO.SSMStatus | For use with a controller-based SSM function. |
| DeviceName.SO.SLSActive | Indicates that the controller-based SLS function is active.<br>0 = SLS Function is not active<br>1 = SLS Function is active |
| DeviceName.SO.SLSLimit | Indicates that the controller-based SLS function has detected the monitored axis speed above the limit setpoint.<br>0 = axis is below setpoint speed<br>1 = axis is greater than or equal to the setpoint speed |
| DeviceName.SO.SDIActive | Indicates that the controller-based SDI function is active.<br>0 = SDI Function is not active<br>1 = SDI Function is active |
| DeviceName.SO.SDILimit | Indicates that the controller-based SDI function detected motion greater than the limit in the unintended direction.<br>0 = Limit not reached<br>1 = Unintended motion |
| DeviceName.SO.PassThruPositionLimitStatus | See the following descriptions of individual bits, indicating the Monitoring Function Limit status of controller-based functions. |
| DeviceName.SO.SCAActive | For use with a controller-based SCA function. |
| DeviceName.SO.SCAStatus | For use with a controller-based SCA function. |
| DeviceName.SO.SLPActive | Indicates that the controller-based SLP function is active.<br>0 = SLP Function is not active<br>1 = SLP Function is active |
| DeviceName.SO.SLPLimit | Indicates that the controller-based SLP function has detected the monitored axis position outside of the setpoint limits.<br>0 = axis position is within the limits<br>1 = axis position is outside of the limits |
| DeviceName.SO.SFHomed | Status of the controller-based SFX position homing function.<br>1 = SFX Homed |
| DeviceName.SO.PassThruStopFaults | See the following descriptions of individual bits, indicating the Safety Fault status of controller-based safety functions. |
| DeviceName.SO.SFXFault | Indicates that a fault occurred with the controller-based SFX function.<br>0 = Normal Operation<br>1 = Fault |
| DeviceName.SO.SBCFault | Indicates that a fault occurred with the controller-based SBC function.<br>0 = Normal Operation<br>1 = Fault |
| DeviceName.SO.SS1Fault | Indicates that a fault occurred with the controller-based SS1 function.<br>0 = Normal Operation<br>1 = Fault |
| DeviceName.SO.SS2Fault | Indicates that a fault occurred with the controller-based SS2 function.<br>0 = Normal Operation<br>1 = Fault |
| DeviceName.SO.SOSFault | Not available, always 0. |
| DeviceName.SO.PassThruLimitFaults | See the following descriptions of individual bits, indicating the Safety Fault status of controller-based safety functions. |
| DeviceName.SO.SLSFault | Controller-based SLS fault.<br>0 = Normal Operation<br>1 = Fault |
| DeviceName.SO.SDIFault | Controller-based SDI fault.<br>0 = Normal Operation<br>1 = Fault |
| DeviceName.SO.SLPFault | Controller-based SLP fault.<br>0 = Normal Operation<br>1 = Fault |
| DeviceName.SO.SafetyStopFunctions | A collection of bits used to activate (request) safety functions as described in this table. |

### Table 77 - Safety Output Tags

| Safety Output Tags | |
|---|---|
| DeviceName.SO.STOOutput | Control Safe Torque Off (STO):<br>0 = Disable Torque<br>1 = Enable Torque |
| DeviceName.SO.SBCOutput | If Safe Brake Control (SBC) is configured:<br>0 = Engage Brake (So0 and So1 OFF)<br>1 = Release Brake (So0 and So1 ON)<br>If Safe Brake Control is not configured, this tag must be set to 0. If set to 1, will cause SBC fault. |
| DeviceName.SO.SS1Request | If Safe Stop 1 (SS1) is configured:<br>0 = No Request<br>1 = Request Safe Stop 1<br>If Safe Stop 1 is not configured, this tag must be set to 0. If set to 1, will cause SS1 fault. |
| DeviceName.SO.ResetRequest | A 0 to 1 transition is required to reset Safety Faults. If Restart Type is 'Manual', a 0 to 1 transition is required to restart a Safety Stop Functions. |
| DeviceName.SO.SafetyIOCommands | See the following descriptions of individual bits. |
| DeviceName.SO.Out00Output | Command Safety Output 0 |
| DeviceName.SO.Out01Output | Command Safety Output 1 |

# Develop Secure Applications

To enhance overall security, integrate your drive with these system components.




FactoryTalk® Security and FactoryTalk® Directory applications let you:

- Manage user accounts and configure user groups to support the separation of duties and least privileged
- Identify, authenticate, and authorize users
- Configure strong password requirements

FactoryTalk® AssetCentre application allows you:

- Inventory assets
- Configure and use auditable events
- Manage audit storage capacity
- Manage a diagnostics and health log
- Manage change detection and reporting
- Schedule backups
- Recover from disruptions if they occur

For additional information to help you develop secure applications, reference these publications:

| Topic | Publication |
|---|---|
| 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. | System Security Design Guidelines Reference Manual, SECURE-RM001 |
| Network architecture recommendations | Converged Plantwide Ethernet (CPwE) Design and Implementation Guide, publication ENET-TD001 |
| Windows® infrastructure recommendations (domain controller)<br>How to configure and use these Rockwell Automation products:<br>• FactoryTalk® Directory<br>• FactoryTalk® Activation Manager<br>• FactoryTalk® Security<br>• FactoryTalk® AssetCentre | Security Configuration User Manual, publication SECURE-UM001. |
| How to configure and use CIP Security™ with Rockwell Automation products to improve the security of your industrial automation system, including the use of FactoryTalk® Policy Manager to define communication between zones. | CIP Security™ with Rockwell Automation Products Application Technique, publication SECURE-AT001 |

## CIP Security

CIP Security is a standard, open-source communication mechanism that helps to provide a secure data transport across an EtherNet/IP network. CIP Security lets CIP-connected devices authenticate each other before transmitting and receiving data.

CIP Security uses the following security properties to help devices protect themselves from malicious communication:

- Device Identity and Authentication
- Data Integrity and Authentication
- Data Confidentiality

Rockwell Automation uses the following products to implement CIP Security:

- FactoryTalk® Policy Manager application (includes FactoryTalk System Services, version 6.20 or later)
- FactoryTalk® Linx application, version 6.11 or later (lets workstation applications communicate securely using CIP Security)
- Studio 5000 Logix Designer® application, version 32.00 or later

This application is required to interface with CIP Security-enabled Logix controllers. The minimum application version varies by controller product family.

For more information on CIP Security, for example, a list of CIP Security capable products and publications that describe how to use the products, including limitations and considerations, see the following:

- https://www.rockwellautomation.com/en-us/capabilities/industrial-security/security-products/cip-security.html
- CIP Security with Rockwell Automation Products Application Technique, publication SECURE-AT001

## Automatic Device Configuration

Automatic Device Configuration supports control system backup and provides a means for the system to recover to a know secure state if a disruption occurs. See Using Automatic Device Configuration on page 182.

The controller maintains a copy (backup) of the drive's configuration data.

Before establishing a controlling connection, the controller compares its copy of the product's configuration data to the product's actual configuration and updates the product's configuration data if they are different.

Security configuration and network configuration settings are not included when using ADC. To use ADC:

1. Configure the drive's IP address so that it can connect to your network. See Set the IP Address on page 61.

2. Make security configuration settings using FactoryTalk Policy Manager.

3. Connect to your controller to download configuration data.

## Reset to Out-of-Box for Secure Erase

A power-up with rotary address switches set to 888 triggers a factory reset to out-of-box configuration.

A factory reset clears user-configurable settings such that the data cannot be retrieved with commercially available tools.

It does not erase the following types of data:
- Diagnostic data like, power on time
- Security log data
- Elapsed and remaining life data for components that are monitored for predictive maintenance

Start is inhibited during a reset operation. For the reset procedure details, see Reset to Out-of-Box State on page 89.

## Syslog Event Logging

The Armor PowerFlex drive supports syslog event logging for security-related events. Choose a syslog collector that supports the following: RFC-5424 syslog protocol ability to receive messages from the drive.

To set the IP address of the syslog collector, use FactoryTalk Policy Manager software. For more information, see CIP Security with Rockwell Automation Products Application Technique, publication SECURE-AT001.

## Disable Ethernet Ports

Restrict the use of unnecessary ports, for example disable communication on network port 2 if only network port 1 is needed for application.

| IMPORTANT | Remember the following:<br>• Once a port is disabled, you lose any connection that is established through the controller Ethernet port.<br>• You cannot disable Ethernet ports if the controller keyswitch is in Run mode or if the FactoryTalk Security settings deny this editing option. |
|---|---|

There are two ways to disable the Ethernet port:

- Disable the Ethernet Port on the FactoryTalk Linx Configuration Tab on page 192
- Disable the Ethernet Port with a MSG Instruction on page 195

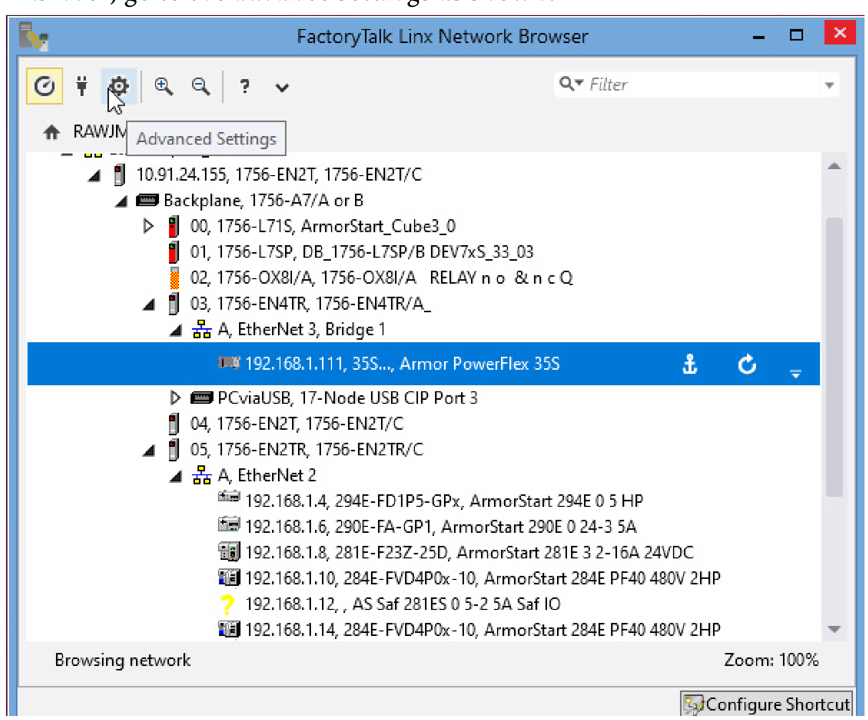
### Disable the Ethernet Port on the FactoryTalk Linx Configuration Tab

You can disable the Ethernet ports on the Armor PowerFlex drive using FactoryTalk Linx.

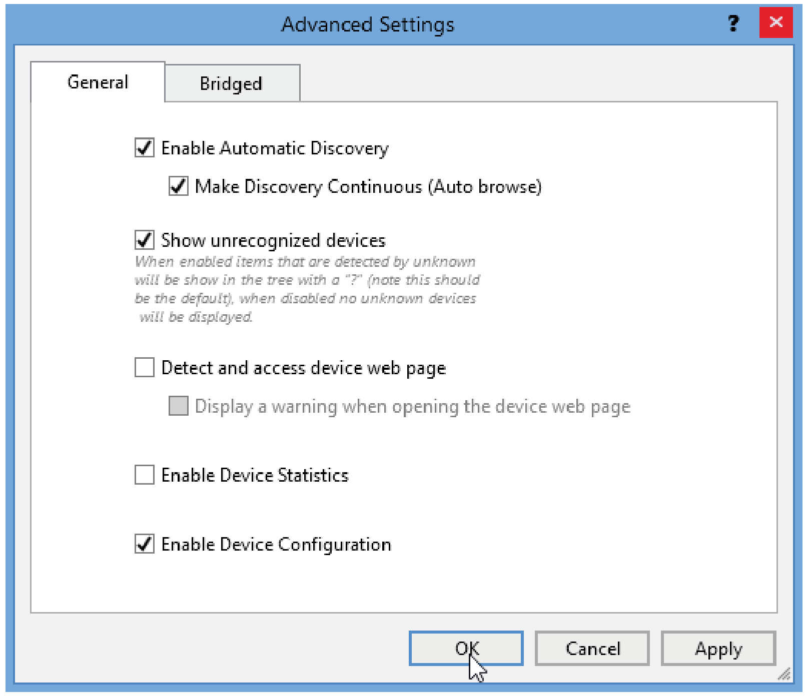
| IMPORTANT | Once a port is disabled, it cannot be used with FactoryTalk Linx. So if both ports are disabled, FactoryTalk Linx will not be able to communicate with the unit.<br>The Armor PowerFlex will have to be reset to factory default to enable communication again, see Reset to Out-of-Box State on page 89. |
|---|---|

Perform the following steps to disable a port of the Armor PowerFlex drive, using FactoryTalk Linx.

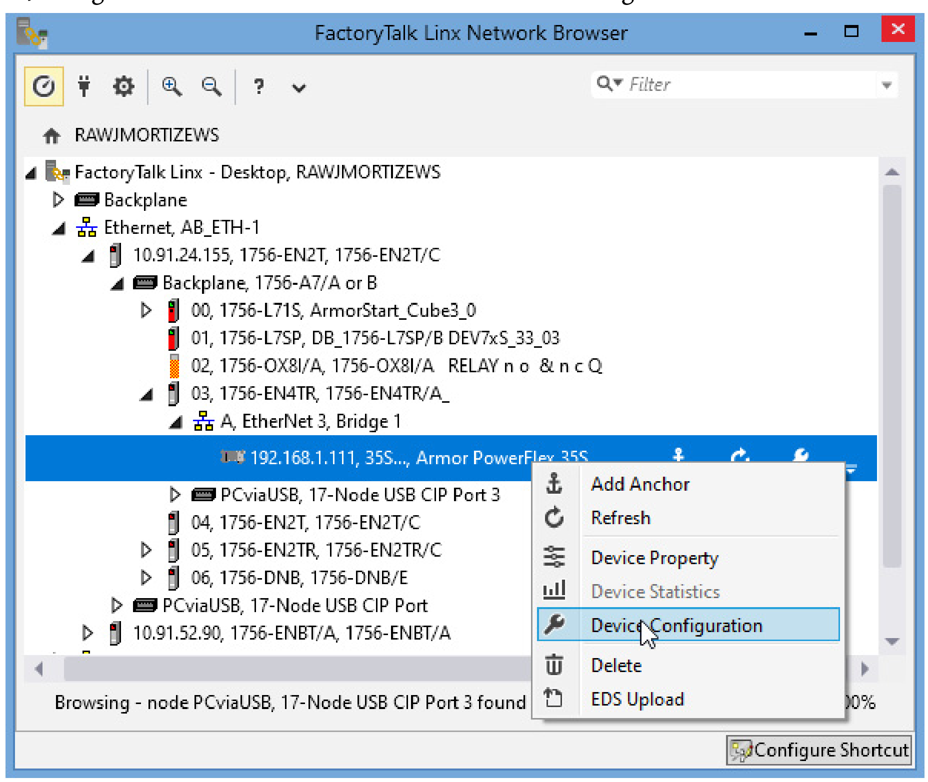
1. Launch the FactoryTalk Linx and create the appropriate EtherNet driver if needed.
2. Once you see the Armor PowerFlex IP Address listed under the EtherNet Driver, go to the advance settings as shown.



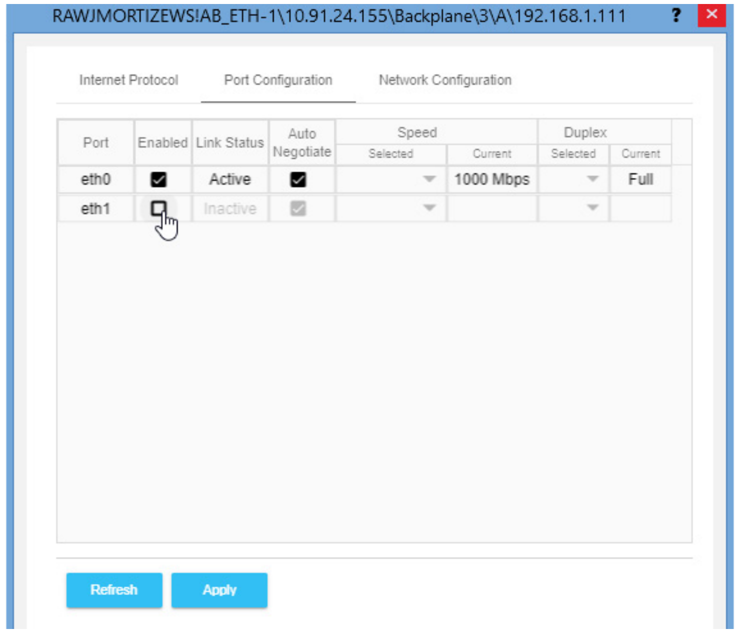
3. In Advanced Settings, check Enable Device Configuration under the General tab and click OK. This allows the IP Address to be changed using FactoryTalk Linx.




4. Right-click the device and choose Device Configuration.



5. Click on the Port Configuration tab.
6. Under the Enable column, uncheck the check box of the port that you want to disable.
7. Click Apply.




8. The port unchecked port is now disabled
9. To re-enable a port, repeat steps 1…7, but in step 6 check the check box of the port that you want to enable.

## Disable the Ethernet Port with a MSG Instruction

You can use a CIP Generic MSG to the drive, to disable one of the Ethernet ports. Follow these steps:

1. Add a MSG instruction to your program.

   This message only has to execute once, it does not need to execute with every program scan.

| | |
|---|---|
| **IMPORTANT** | You cannot add a MSG instruction to your program if the controller keyswitch is in Run mode, or if the FactoryTalk Security settings deny this editing option. |

2. In the Configuration tab, set the Message Type as CIP Generic.
3. Enter the remaining fields using the parameters in Table 78.

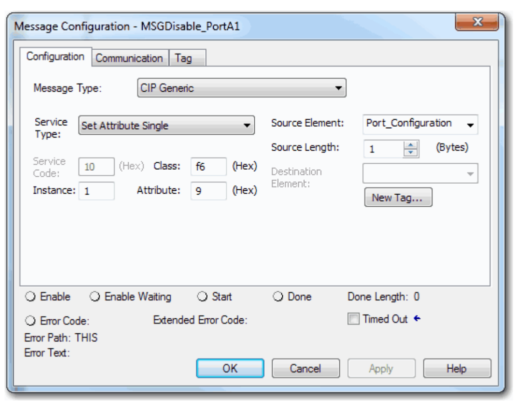
**Table 78 - Port Configuration Tab: MSG**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x10 | Set Attribute Single |
| Class | 0x00F6 | Motor Control Source |
| Instance | 1 | EtherNet Port 1 |
| | 2 | EtherNet Port 2 |
| Attribute | 9 | Admin |
| Data Type | USINT | 0 = Reserve<br>1 = Enable Interface<br>2 = Disable Interface |

| | |
|---|---|
| **IMPORTANT** | These values are stored to NVS memory in such a way that the MSG instruction is not required to execute each time the controller powers up. |

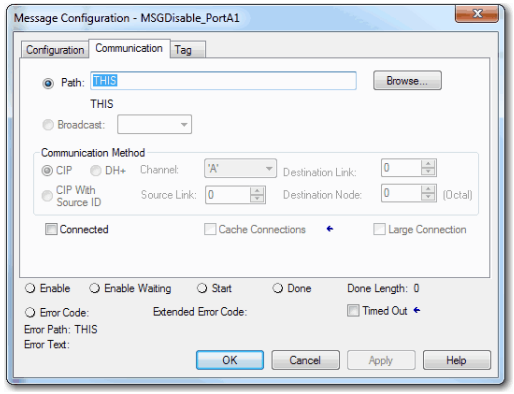
In this example, the controller tag is named Port_Configuration.

- Source Length - 1



4. Configure the Communication tab to use a Path of THIS. (THIS is the name of the Armor PowerFlex drive used in the example.)

| | |
|---|---|
| **IMPORTANT** | Messages to THIS must be unconnected messages. |




5. Before you enable the MSG instruction, make sure that the Source Element tag value is 2.

| | |
|---|---|
| **IMPORTANT** | You can re-enable an Ethernet port after it is disabled.<br>To re-enable the port, complete the steps that are described in this section. Before you enable the MSG instructions, however, make sure that the Source Element tag value is 1. |

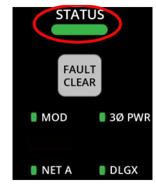
# Diagnostics, Status, and Troubleshooting

## View Status Indicators

The Armor PowerFlex drive has several groups of light-emitting diode (LED) status indicators, including system status, I/O status, EtherNet/IP status, power status, and keypad status, as described in this section.

**ATTENTION:** Status indicators are not reliable for safety functions. Use status indicators only for general diagnostics during commissioning or troubleshooting. Do not attempt to use status indicators to determine operational status.

### System Status Indicator

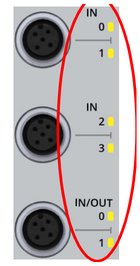



The system status LED (STATUS) indicates the overall state or status of the Armor PowerFlex drive. The STATUS LED operates the same for the Armor PowerFlex standard drive (35E) and the Armor PowerFlex safety drive (35S). See Table 79.

**Table 79 - STATUS LED**

| State | LED Indicator Status | Description |
|---|---|---|
| Drive is ready to run | Flashing green | Drive is ready to run but is not running, no faults or alarms |
| Drive is running | Steady green | Drive is running, no faults or alarms |
| Drive is not ready to run | Flashing amber | Drive is not ready to run, motor control cannot be started OR an alarm is present, device is not running |
| Drive is running with alarm | Steady amber | Drive is running, alarm is present |
| Fault is present | Flashing red | Fault is present, must be acknowledged by user before a motor control start can be accepted |
| Major (nonrecoverable) fault is present | Steady red | Drive has a major non-recoverable fault, power cycle or replace unit |
| Firmware update mode | Flashing green/red | Drive is in firmware update mode / firmware update in progress |

## I/O Status Indicators




The standard I/O LEDs consist of:

- IN0: input
- IN1: input
- IN2: input
- IN3: input
- IN/OUT0: configurable I/O
- IN/OUT1: configurable I/O

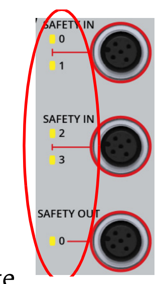
Table 80 and Table 81 describe the I/O status indicator state and status.

**Table 80 - Standard Input LEDs: IN0...IN3**

| State | LED Indicator Status | Description |
|---|---|---|
| Input off | Off | Input is off, no fault |
| Input on | Steady green | Input is on, no fault |
| Input fault | Steady red | Input is faulted |

**Table 81 - Configurable I/O LEDs: IN/OUT0...IN/OUT1**

| State | LED Indicator Status | Description |
|---|---|---|
| I/O off | Off | Input or output is off, no fault |
| Input on | Steady green | Input is on, no fault |
| Output on | Steady amber | Output is on, no fault |
| I/O fault | Steady red | I/O point is faulted |




The safety I/O LEDs consist of:

- SAFETY IN0: safety input
- SAFETY IN1: safety input
- SAFETY IN2: safety input
- SAFETY IN3: safety input
- SAFETY OUT0: safety output

Table 82 and Table 83 describe the safety I/O status indicator state and status.

**ATTENTION:** Do not use light-emitting diode (LED) status indicators on the safety I/O for safety operations. Do not use the colors as indication of safe or unsafe states.

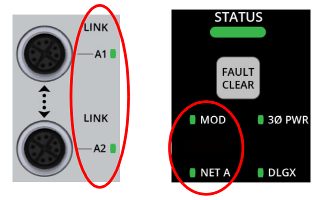
**Table 82 - Safety Input LEDs: SAFETY IN0...SAFETY IN3**

| State | LED Indicator Status | Description |
|---|---|---|
| Safety input off | Off | Input is off or not configured, no fault |
| Safety input on | Steady green | Input is on, no fault |
| Safety input fault | Steady red | Input is faulted, due to wiring or input circuit fault |
| Partner fault | Flashing red | Partner input circuit of a dual-input configuration is faulted |

**Table 83 - Safety Output LED: SAFETY OUT0**

| State | LED Indicator Status | Description |
|---|---|---|
| Safety output off | Off | Output is off or not configured, no fault |
| Safety output on | Steady green | Output is on, no fault |
| Safety output fault | Steady red | Output is faulted, due to wiring or output circuit fault |

## EtherNet/IP Status Indicators




The EtherNet/IP LEDs consist of:

- LINK A1: link activity
- LINK A2: link activity
- NET A: network status
- MOD: EtherNet/IP module status

Table 84, Table 85, and Table 86 describe the EtherNet/IP state and status.

**Table 84 - Ethernet Link Activity Status LEDs: LINK A1, LINK A2**

| State | LED Indicator Status | Description |
|---|---|---|
| No link | Off | No link |
| Link, no activity | Steady green | Link is established, no activity |
| Link, with activity | Flashing green | Link, with activity - flash rate is dependent on level of traffic on port, maximum flash rate of 100 ms on/100 ms off |

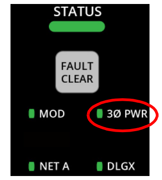
**Table 85 - Ethernet Network Status LED: NET A**

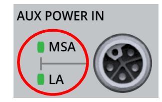
| State | LED Indicator Status | Description |
|---|---|---|
| Not powered, no IP address | Off | If the device does not have an IP address (or is powered Off), the network status indicator is steady Off. |
| Connected | Steady green | If the device has at least one established connection (even to the Message Router), the network status indicator is steady green. |
| No connections | Flashing green | If the device has no established connections, but has obtained an IP address, the network status indicator is flashing green. |
| Duplicate IP address | Steady red | If the device has detected that the IP address is already in use, the network status indicator is steady red. |
| Connection timeout | Flashing red | If one or more of the connections in which this device is the target has timed out, the network status indicator is flashing red. This indicator is turned Off only when all timeout connections are re-established or if the device is reset. |
| Self test | Flashing red/green | While the device is performing its power-up test, the network status indicator is flashing green/red. |

**Table 86 - Ethernet Module Status LED: MOD**

| State | LED Indicator Status | Description |
|---|---|---|
| No power | Off | If no power is supplied to the device, the module status indicator is steady Off. |
| Device operational | Steady green | If the device is operating correctly and the programmable controller is in Run mode, the module status indicator is steady green. |
| Standby | Flashing green | If the device has not been configured or the programmable controller is not in Run mode, the module status indicator is flashing green. |
| Unrecoverable major fault | Steady red | If the device has detected a nonrecoverable major fault, see Monitor Faults, Alarms, and Events. |
| Recoverable major fault | Flashing red | If the device has detected a recoverable major fault, the module status indicator is flashing red.<br>**Note:** An incorrect or inconsistent configuration is considered a minor fault. |
| Self test | Flashing red/green | While the device is performing its power-up test, the module status indicator is flashing green/red. |
| Waiting for TUNID or Configuring | Flashing red/green | For Armor PowerFlex safety drive (35S) , if there is no safety configuration and torque is not enabled via the hardwired inputs, or the safety configuration process is occurring, the module status indicator is flashing red/green. |

## Power Status Indicators




The power status LEDs consist of:

- 3Ø PWR: 3-phase AC power
- MSA: module sensor actuator indicates switched auxiliary/control 24V power (output power)
  - Module sensor actuator refers to external power for items (sensors, output devices) connected to the product. This supply powers the user output circuits in the product.
- LA: local actuator indicates unswitched auxiliary 24V power (sensor power)
  - Local actuator refers to local power for the module itself. This supply powers the logic and user input circuits in the product.

Table 87, Table 88, and Table 89 describe the power status indicator state and status.

**Table 87 - 3-phase Power LED: 3Ø PWR**

| State | LED Indicator Status | Description |
|---|---|---|
| 3-phase input power not present | Off | 3-phase AC input power is not present, motor output is not possible. |
| 3-phase input power present, drive On | Steady green | 3-phase AC input power is present, the local disconnect switch is On |
| 3-phase input power present, drive Off | Flashing green | 3-phase AC power is present and the local disconnect switch is Off |

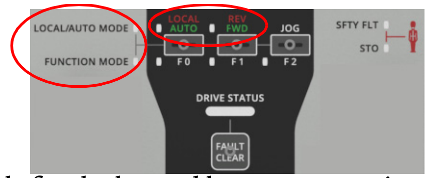
**Table 88 - Module Sensor Actuator - Switched Auxiliary/Control 24V Power (Output Power)**

| State | LED Indicator Status | Description |
|---|---|---|
| Switched 24V power not present | Off | Switched 24V input power not present, user outputs on the drive are not operational |
| Switched 24V power present | Steady green | Switched 24V input power is present and above the minimum required voltage |
| Switched 24V power present | Flashing red | Switched 24V input power is present but below the minimum required voltage |

**Table 89 - Local Actuator - Unswitched Auxiliary/Control 24V Power (Sensor Power)**

| State | LED Indicator Status | Description |
|---|---|---|
| Unswitched 24V power not present | Off | Unswitched 24V input power not present, drive is not operational |
| Unswitched 24V power present | Steady green | Unswitched 24V input power is present and within operating voltage range |
| Unswitched 24V power present | Flashing red | Unswitched 24V input power is present but not within operating voltage range |

## Keypad Status Indicators




The keypad LEDs consist of:

- LOCAL/AUTO MODE: The keypad LOCAL/AUTO mode LEDs indicate if the Local/Auto commands for the keypad buttons are active or not.
- FUNCTION MODE: The keypad Function mode LED indicates whether the keypad is in Function mode.
- LOCAL/AUTO: The keypad auto/local state LED indicates whether the keypad mode is auto mode, local mode, or another mode.
- FWD/REV: The keypad forward/reverse LED indicates the selected direction of motion and whether there is motion when in the local keypad mode.
- F0…F2: The keypad user function key LEDs (F0…F2) indicate that a keypad key is being pressed when the keypad mode is in user mode.

Table 90, Table 91, Table 92, Table 93, and Table 94 describe the keypad status indicator state and status.

**Table 90 - LOCAL/AUTO MODE**

| State | LED Indicator Status | Description |
|---|---|---|
| LOCAL/AUTO keypad mode is not available | Off | LOCAL/AUTO keypad mode is not available, keypad has been configured for user mode |
| LOCAL/AUTO keypad mode is available | Steady green | LOCAL/AUTO keypad mode is available |

**Table 91 - LOCAL/AUTO**

| State | LED Indicator Status | Description |
|---|---|---|
| Keypad is in another mode | Off | Keypad is in Function mode or it has been disabled |
| Keypad is in auto mode | Steady green | Keypad is in auto mode |
| Keypad is in local mode | Steady red | Keypad is in local mode |

**Table 92 - FWD/REV**

| State | LED Indicator Status | Description |
|---|---|---|
| Keypad mode is not local | Off | No Keypad control |
| Keypad mode is local | Steady green | Keypad mode is local, direction that is selected is forward, no motion |
| Keypad mode is local | Flashing green | Keypad mode is local, direction that is selected is forward, motion commanded (jogging, jog key pressed) |
| Keypad mode is local | Steady red | Keypad mode is local, direction that is selected is reverse, no motion |
| Keypad mode is local | Flashing red | Keypad mode is local, direction that is selected is reverse, motion commanded (jogging, jog key pressed) |

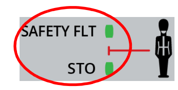
**Table 93 - FUNCTION MODE**

| State | LED Indicator Status | Description |
|---|---|---|
| Keypad mode is something other than Function mode | Off | Keypad is in Local/Auto mode |
| Unswitched 24V power present | Steady amber | Keypad has been configured for Function mode, local and auto modes are unavailable |

**Table 94 - Function Keys F0...F2**

| State | LED Indicator Status | Description |
|---|---|---|
| No key is being pressed OR keypad is not in Function mode | Off | Key is not being pressed in Function mode, or keypad mode is not user mode |
| Key is pressed while in Function mode | Steady amber | Key is being pressed while in Function mode |

## Safety Function Status Indicator




The safety function LEDs consist of:
- STO: Safe Torque Off
- SAFETY FAULT:

**Table 95 - STO**

| State | LED Indicator Status | Description |
|---|---|---|
| Torque disabled | Off | Torque is disabled (STO active = 1/Disable Torque).<br>Device may not be powered, check Module Status LED |
| Torque permitted | Steady green | The STO circuit is permitting torque<br>(Torque Disabled = 0/Torque Permitted) |
| Torque inhibited | Flashing green | Torque is enabled but the STO circuit is not permitting torque (STO Active = 0/Permit Torque, Torque Disabled = 1/Torque Disabled) |
| Circuit fault | Flashing red | The STO circuit is faulted |
| Nonrecoverable fault | Steady red | A nonrecoverable fault has occurred |

**Table 96 - SAFETY FLT**

| State | LED Indicator Status | Description |
|---|---|---|
| Normal operation | Steady green | Normal operation |
| Recoverable fault | Flashing red | A recoverable fault has occurred |
| Nonrecoverable fault | Steady red | A nonrecoverable fault has occurred |

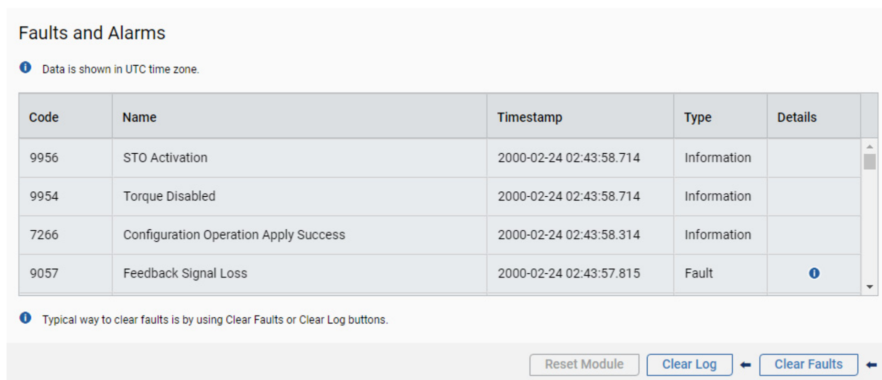
## Monitor Faults, Alarms, and Events

The Armor PowerFlex drive provides notification of critical faults, major faults, major alarms, and events.

**ATTENTION:** Do not attempt to defeat or override fault circuits. Determine the cause of the fault indication and correct it before an operation attempt. Failure to correct a control system or mechanical malfunction can result in personal injury and /or equipment damage due to uncontrolled machine system operation.

- When a critical fault occurs, all motor control operations stop. Motor power is immediately removed, which causes the attached motor to coast to a stop.
- A major fault stops the drive with a stop mode of coast.
- A major alarm notifies you of a condition that exists, but does not stop motor control operations, if the drive is already in a run condition. If the alarm occurs while the drive is in a stop condition, the alarm must be cleared for a run condition to be accepted. Alarms are cleared automatically when the condition that caused the alarm is no longer present for at least one second.
- An event occurs during normal operation of the product and can help you monitor status or troubleshoot problems.

The Armor PowerFlex drive's fault log, accessible from the Faults and Alarms page, displays the fault code, name of the fault, timestamp, and type of fault (Event, Alarm, Fault) and details about the fault.


Faults and Alarms

Data is shown in UTC time zone.

| Code | Name | Timestamp | Type | Details |
|---|---|---|---|---|
| 9956 | STO Activation | 2000-02-24 02:43:58.714 | Information | |
| 9954 | Torque Disabled | 2000-02-24 02:43:58.714 | Information | |
| 7266 | Configuration Operation Apply Success | 2000-02-24 02:43:58.314 | Information | |
| 9057 | Feedback Signal Loss | 2000-02-24 02:43:57.815 | Fault | |

Typical way to clear faults is by using Clear Faults or Clear Log buttons.



The log stores the 100 most recent entries in nonvolatile memory.

The Clear Faults button, clears unacknowledged faults. The Clear log button, clears the fault log data. The Reset Module button cycles power to the drive.

### Access Fault, Alarm, and Event Codes

This manual links to Armor PowerFlex AC Drive Fault Codes Reference Data, publication 35-RD002, for a list of fault codes; download the spreadsheets now for offline access.

## Condition Monitoring

The drive monitors the condition of the following physical components:

- Power supply
- Temperature

When these components operate outside their limits, a fault or alarm can be triggered. See Armor PowerFlex AC Drives Fault Codes Reference Data, publication 35-RD002.

You can use a message instruction to get status information about these physical components of the drive.

See Armor PowerFlex Drives Specifications Technical Data, publication 35-TD001 and the example in Power Supply on page 204.

### Power Supply

The voltage of internal and external power supplies is monitored and a fault occurs if they are outside the valid range (20.4 …26.4V):

- 0x04260001 Undervoltage, Hard
- 0x04260002 Overvoltage, Hard

You can use a message instruction to get the status of the internal or external power supplies (active or inactive), the nominal and measured voltage and more. For message instruction information, see Armor PowerFlex AC Drives CIP Objects and Attributes Reference Data, publication 35-RD001.

You can also use a message instruction to get the state of the front panel disconnect switch (on/off) used to interrupt 3-phase AC power to the drive.

| | | |
|---|---|---|
| **Service Code** | 0X0E | Get attribute single |
| **Class** | 0X0426 | Power supply object |
| **Instance** | 4 | 3-phase AC power (for motor) |
| **Data Type** | BOOL | — |
| **Attribute** | 8 | Physical switch state<br>0 = The physical switch is in the off position. Power is not being supplied to the end device.<br>1 = The physical switch is in the on position. Power is being supplied to the end device. |

### Temperature Sensor

The drive monitors the temperature of system and power boards, the IGBT heatsink, and the system processor. A fault (0x04230002 Overtemperature, Hard) occurs if the measured temperature of any of these components exceeds the predefined, fixed level at which damage may occur.

# Maintenance and Repair

| | |
|---|---|
| **IMPORTANT** | The functional safety part of the product does not need any maintenance (apart from proof testing, if applicable). For the functional safety part of the product, no spare parts are available and no repair is possible or intended by the user. In case of permanent fault, the device has to be taken out of order and replaced by another one. |

## Remove Power Before Servicing the Armor PowerFlex Drive

Be aware of the following precautions while servicing the Armor PowerFlex drive.

### Precautions

**ATTENTION:** Before replacing a component in a safety system, see Safety I/O Wiring on page 136.

**ATTENTION:** The service of energized industrial control equipment can be hazardous. Electrical shock, burns, or unintentional actuation of controlled industrial equipment can cause death or serious injury. For safety of maintenance personnel and others who can be exposed to electrical hazards associated with maintenance activities, follow the local safety-related work practices (for example, the NFPA 70E, Part II in the United States). Maintenance personnel must be trained in the safety practices, procedures, and requirements that pertain to their respective job assignments.

**ATTENTION:** Only qualified personnel familiar with adjustable frequency AC drives and associated machinery must plan or implement the installation, startup, and subsequent maintenance of the system. Failure to comply can result in personal injury and/or equipment damage.

**ATTENTION:** This drive contains electrostatic discharge (ESD) – sensitive parts and assemblies. Static control precautions are required during installation, test, service, or repair of this assembly. Component damage can result if ESD control procedures are not followed. If you are not familiar with static control procedures, see Guarding against Electrostatic Damage, publication 8000-4.5.2, or any other applicable ESD protection handbook.

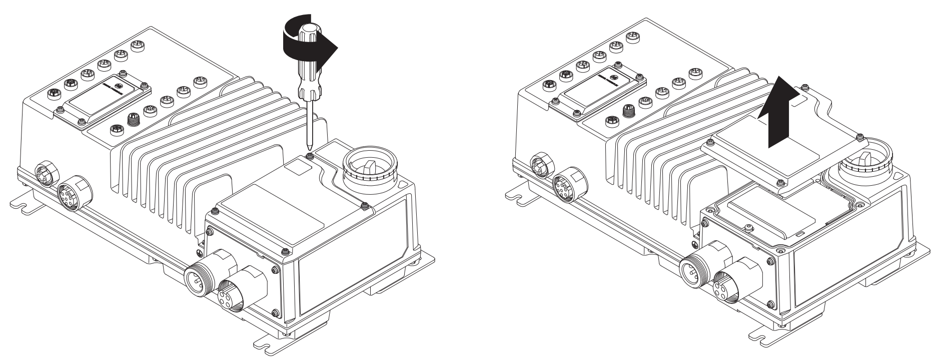
**ATTENTION:** The drive contains high-voltage capacitors. After removal of the main power supply, the capacitor discharge process can take 30 seconds to several minutes before a safe voltage is reached. Before working on the drive, or before servicing any device on the motor side, follow the procedure Test for Hazardous Voltage, starting on page 206, to verify that power is isolated and to verify that there are no hazardous voltages present. Use the test points under the power section door to confirm there are no hazardous AC line voltages (Test points: D1, D2, D3), and to confirm that the DC Bus capacitor bank voltage is at a safe level (Test points: DC+, DC-).
After confirming no hazardous voltages are present at the test points under the power section door, open the power section cover to access the terminal block. Measure the input power on the L1, L2, and L3 of the exposed terminal block to verify that the power has been removed and that no hazardous voltage is present.
Failure to verify that power is removed before working on the drive, or failure to verify that no hazardous voltages are present before working on the drive can result in personal injury or death.
Darkened display light-emitting diode (LED) status indicators are not an indication that capacitors have discharged to safe voltage levels.

**ATTENTION:** An incorrectly applied or installed drive can result in component damage or a reduction in product life. Wiring or application errors, such as undersized motor, incorrect or inadequate AC supply, or excessive ambient temperatures can result in malfunction of the system.

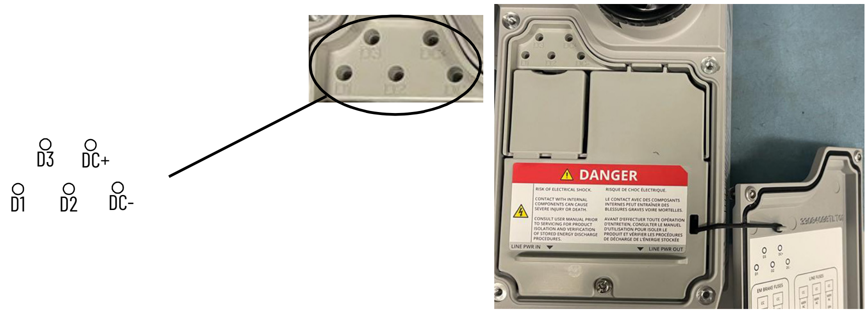
## Test for Hazardous Voltage

Before servicing the Armor PowerFlex drive or any device in the motor side (motor, motor cables, motor brake, and so on), you must follow these steps to remove power from the Armor PowerFlex, verify power is removed, and test for hazardous voltage:

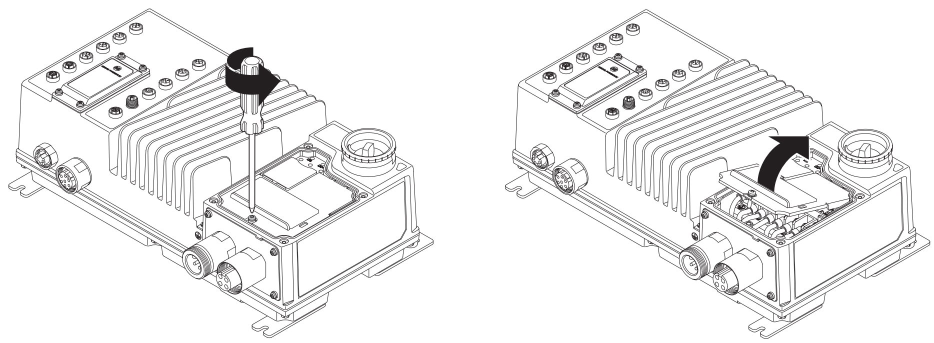
1. Remove power from the drive by removing the three-phase power using the isolating device upstream (system circuit breaker, for example). After removal of the main power supply, the capacitor discharge process can take 30 seconds to several minutes before a safe voltage is reached.
2. Loosen the screws to remove the power section door to gain access to the voltage test points: D1, D2, D3, DC-, and DC+.



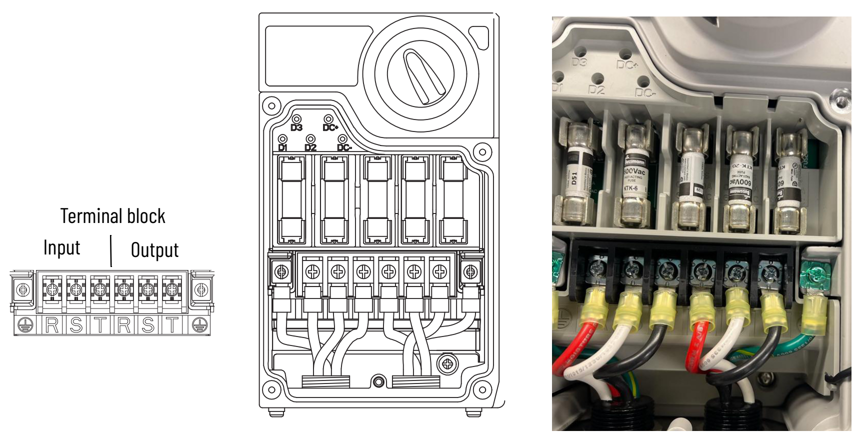
3. Measure the AC line voltage test points D1, D2, D3 (line-to-line and line-to-ground) to verify that main power has been disconnected.
4. Measure DC voltage across DC- and DC+ test points to verify that the DC bus has discharged to zero volts.




5. After verifying that there are no hazardous voltages present on test points: D1, D2, D3, DC-, or DC+, loosen the screws and remove the internal power section cover.



6. To verify that power has been removed and hazardous voltage is no longer present, take measurements on the exposed terminal block. Measure **input** power on L1, L2, and L3 (line-to-line and line-to-ground).




| Input | | | | Output | | | |
|---|---|---|---|---|---|---|---|
| Terminal ⏚ | Terminal R | Terminal S | Terminal T | Terminal R | Terminal S | Terminal T | Terminal ⏚ |
| ground | Line 1 | Line 2 | Line 3 | Line 1 | Line 2 | Line 3 | ground |

7. You can now proceed with Fuse Replacement or other service to the device.

# Fuse Replacement

The following fuses can be replaced on the Armor PowerFlex drive:

- Three 3-phase input line fuses
- Two EM brake fuses
- One fuse for Switched +24V power and one fuse for Unswitched +24V power

## 3-phase AC Power and EM Brake Fuse Replacement

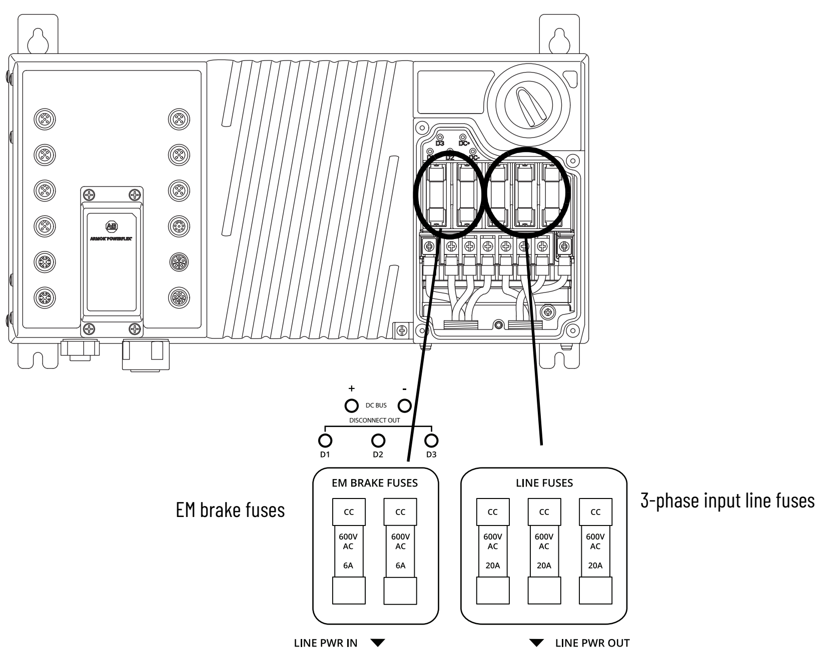
**Table 97 - 3-phase Input Power and EM Brake Fuse Specifications**

| Specification | 3-phase AC Line Power Fuses | EM Brake Fuses |
|---|---|---|
| Part No. | KTK-20 | KTK-6 |
| Description | 20 A, 600V AC, UL Listed Class CC, Std. 248-14 | 6 A, 600V AC, UL Listed Class CC, Std. 248-14 |
| Current | 20 A | 6 A |
| Interrupting Capacity | 100 kA rms | 100 kA rms |
| Voltage Rating | 600V AC | 600V AC |
| Manufacturer | Bussmann | Bussmann |
| Dimension mm (in.): | 38.1 (1.5) x 10.3 (0.41) | 38.1 (1.5) x 10.3 (0.41) |

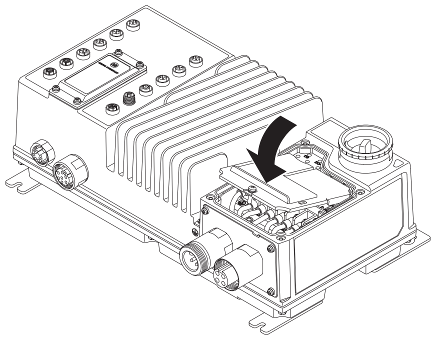
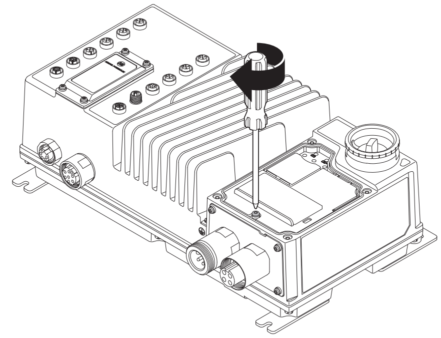
1. Loosen the screws and remove the power section door. See step 2 on page 206.
2. Loosen the screws and remove the internal power section cover. See step 5 on page 207.
3. Remove fuses from holding. We recommend using fuse puller FP-3 from Eaton/Bussmann.

When removing line power fuses, we recommend starting with the middle one, for ease of access.

4. Check each fuse with a multimeter to see if they are in good condition. If damaged, replaced the fuses.



5. Replace the internal power section cover. Tighten the screws. 1.37…1.57 N•m (12.1…13.9 lb•in).

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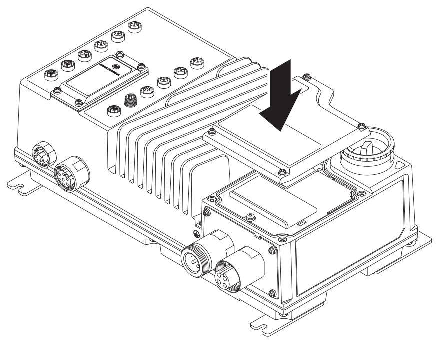
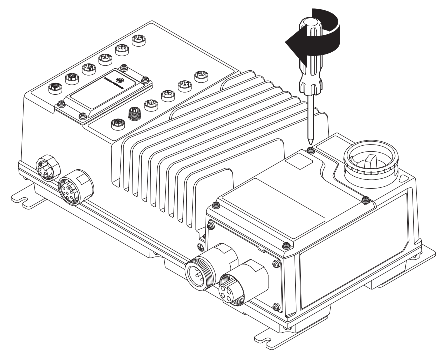
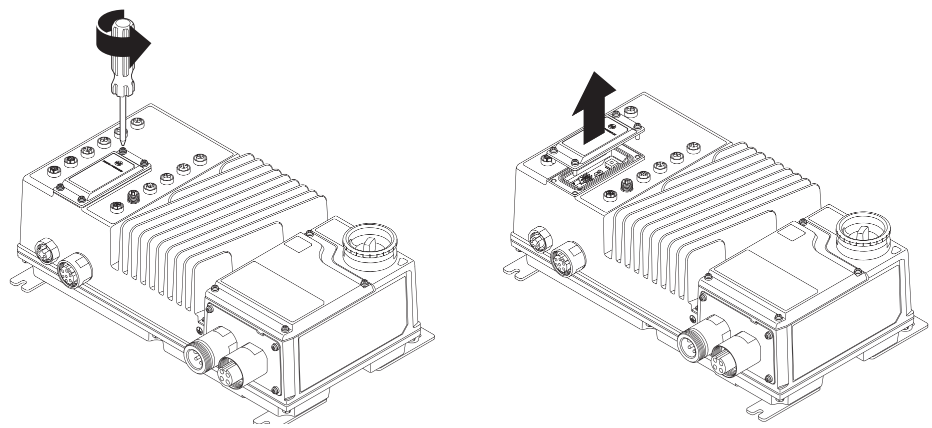



## Switched and Unswitched +24V DC Power Fuse Replacement

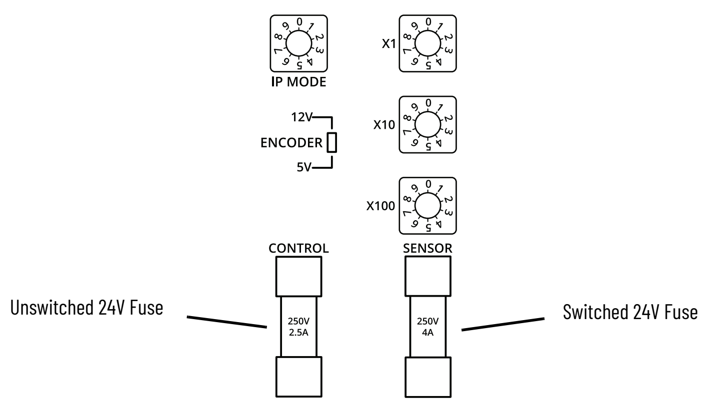
**Table 98 - 24V Fuse Specifications**

| Specification | Unswitched (Control) 24V DC Power Fuses | Switched (Sensor) 24V DC Power Fuses |
|---|---|---|
| Part No. | 21502.5MXP | 215004.MXP |
| Description | Fuse T C, 2.5 A, 250V, H CLIP | Fuse T C, 4 A, 250V, H CLIP |
| Current | 2.5 A | 4 A |
| Interrupting Capacity | 1500 A @ 250V AC | 1500 A @ 250V AC |
| Voltage Rating | 250V DC | 250V DC |
| Manufacturer | Littlefuse | Littlefuse |
| Dimension mm (in.): | 20 (0.78) x 5.2 (0.20) | 21.5 (0.84) x 5.5 (0.21) |

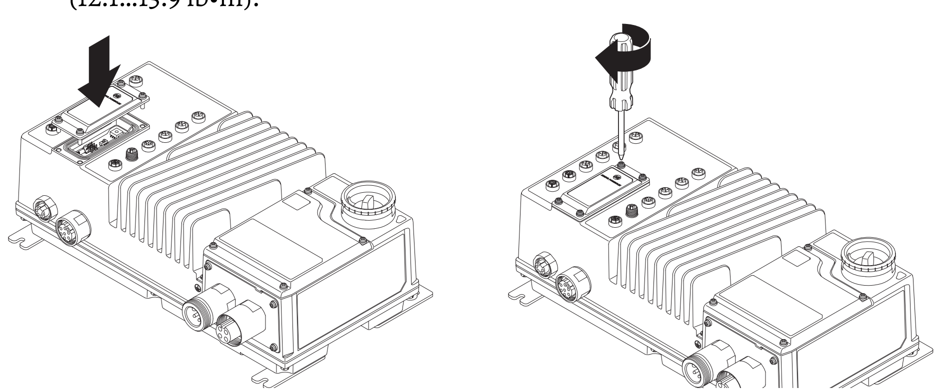
1. Loosen the screws and remove the logic section door screws.



2. Remove fuses from holding. We recommend using fuse puller FP-3 from Eaton/Bussmann.
3. Check each fuse with a multimeter to see if they are in good condition. If damaged, replaced the fuses.




4. Replace the logic section door. Tighten the screws. 1.37…1.57 N•m (12.1…13.9 lb•in).



# Integrated Safety Instruction Validation Checklist

| | |
|---|---|
| **IMPORTANT** | The validation tests in this appendix only apply to these integrated safety functions:<br>- Monitored Safe Stop 1 (SS1)<br>- Safely Limited Speed (SLS)<br>- Safely Limited Position (SLP)<br>- Safe Direction (SDI)<br>- Safety Feedback Interface (SFX)<br>- Safe Brake Control (SBC) |

Use this appendix to validate your integrated safety instructions. Each instruction has a checklist with test commands and results to verify for normal operation and abnormal operation scenarios.

For additional information on the safety instructions see the Drive Safety Chapter of GuardLogix Safety Application Instruction Set Reference Manual, publication 1756-RM095.

## Safe Stop 1

Use the Safe Stop 1 (SS1) instruction checklist in Table 99 to verify normal operation and the abnormal operation scenarios.

| | |
|---|---|
| **IMPORTANT** | Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.<br>When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.<br>Instruction operands must be verified for your safety ladder program. |

**Table 99 - SS1 Instruction Checklist**

| Test Type | Test Description | Test Status |
|---|---|---|
| Normal Operation | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine at the desired operating system speed. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SFX_Name*.ActualSpeed<br>• *SS1_Name*.SpeedLimit<br>• *SS1_Name*.DecelerationRamp<br>• *SS1_Name*.O1 | |
| | Initiate SS1 demand. | |
| | Make sure that the instruction output *SS1_Name*.O1 turns off without generating a fault and that the drive initiates an STO instruction.<br>• Verify that the STO instruction de-energizes the motor for a normal safe condition. | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify that the STO instruction remains de-energized for a normal safe condition<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped with the SS1 demand removed, initiate a Reset command of the STO and SS1 instructions.<br>• Verify that the STO instruction remains de-energized<br>• Verify proper machine status and safety application program status | |
| Abnormal Operation 1 | Change the actual motion deceleration rate within the motion task that is associated with this SS1 function so that it is slower than the calculated speed limit used by the SS1 instruction. | |
| | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine at the desired operating system speed. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SFX_Name*.ActualSpeed<br>• *SS1_Name*.SpeedLimit<br>• *SS1_Name*.DecelerationRamp<br>• *SS1_Name*.O1 | |
| | Initiate SS1 demand. | |
| | Make sure that the instruction generates a deceleration fault and that the drive initiates an STO instruction.<br>• Verify that the STO instruction de-energizes the motor for a normal safe condition | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify that the STO instruction remains de-energized for a normal safe condition<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped with the SS1 demand removed, initiate a Reset command of the STO and SS1 instructions.<br>• Verify that the STO instruction remains de-energized<br>• Verify proper machine status and safety application program status | |
| Abnormal Operation 2 | Change the motion deceleration rate within the motion task that is associated with this SS1 function so that the stop delay time is exceeded without triggering a deceleration fault. | |
| | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate machine at desired operating system speed. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SFX_Name*.ActualSpeed<br>• *SS1_Name*.SpeedLimit<br>• *SS1_Name*.DecelerationRamp<br>• *SS1_Name*.O1 | |
| | Initiate SS1 demand. | |
| | Make sure that the instruction generates a maximum time fault and that the drive initiates an STO instruction.<br>• Verify that the STO instruction de-energizes the motor for a normal safe condition | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify that the STO instruction remains de-energized for a normal safe condition<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped with the SS1 demand removed, initiate a Reset command of the STO and SS1 instructions.<br>• Verify that the STO instruction remains de-energized<br>• Verify proper machine status and safety application program status | |

## Safely-limited Speed

Use the Safety-limited Speed (SLS) instruction checklist in Table 100 to verify normal operation and the abnormal operation scenarios.

| | |
|---|---|
| **IMPORTANT** | Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.<br>When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.<br>Instruction operands must be verified for your safety ladder program. |

**Table 100 - SLS Instruction Checklist**

| Test Type | Test Description | Test Status |
|---|---|---|
| Normal Operation | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the desired speed range. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>*SFX_Name*.ActualSpeed<br>*SLS_Name*.SLSLimit<br>*SLS_Name*.ActiveLimit<br>*SLS_Name*.Output 1 | |
| | Initiate SLS demand. | |
| | Verify that the drive achieves the speed below the *SLS_Name*.ActiveLimit without asserting the *SLS_Name*.SLSLimit output. | |
| | While the system is in SLS monitoring state and with the sensor subsystems in a safe state, remove the SLS demand.<br>• Verify proper machine status and safety application program status | |
| | Resume normal machine operation.<br>• Verify proper machine status and safety application program status | |
| Abnormal Operation 1 | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the normal speed range. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>*SFX_Name*.ActualSpeed<br>*SLS_Name*.SLSLimit<br>*SLS_Name*.ActiveLimit<br>*SLS_Name*.Output 1 | |
| | Initiate SLS demand. | |
| | Verify that the drive achieves the speed below the *SLS_Name*.ActiveLimit without asserting the *SLS_Name*.SLSLimit output. | |
| | While the system is in the SLS monitoring state, initiate a motion command that violates the *SLS_Name*.ActiveLimit.<br>• Verify that the *SLS_Name*.SLSLimit output is asserted and the programmed stop action is initiated | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Reset command.<br>• Verify proper machine status and safety application program status | |

## Safely-limited Position

Use the Safety-limited Position (SLP) instruction checklist in Table 101 to verify normal operation and the abnormal operation scenarios.

| | |
|---|---|
| **IMPORTANT** | Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.<br>When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.<br>Instruction operands must be verified for your safety ladder program. |

**Table 101 - SLP Instruction Checklist**

| Test Type | Test Description | Test Status |
|---|---|---|
| Normal Operation | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the desired position range. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SFX_Name*.ActualPosition<br>• *SLP_Name*.SLPLimit<br>• *SLP_Name*.PositiveTravelLimit<br>• *SLP_Name*.NegativeTravelLimit<br>• *SLP_Name*.Output 1 | |
| | Initiate SLP demand. | |
| | Verify that the drive achieves and maintains a position between the *SLP_Name*.PositiveTravelLimit and the *SLP_Name*.NegativeTravelLimit without asserting the *SLP_Name*.SLPLimit output. | |
| | While the system is in SLP monitoring state and with the sensor subsystems in a safe state, remove the SLP demand.<br>• Verify proper machine status and safety application program status | |
| | Resume normal machine operation.<br>• Verify proper machine status and safety application program status | |
| Abnormal Operation 1 | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the desired position range. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SFX_Name*.ActualPosition<br>• *SLP_Name*.SLPLimit<br>• *SLP_Name*.PositiveTravelLimit<br>• *SLP_Name*.NegativeTravelLimit<br>• *SLP_Name*.Output 1 | |
| | Initiate SLP demand. | |
| | Verify that the drive achieves and maintains a position between the *SLP_Name*.PositiveTravelLimit and the *SLP_Name*.NegativeTravelLimit without asserting the *SLP_Name*.SLPLimit output. | |
| | While the system is in the SLP monitoring state, initiate a motion command that violates the *SLP_Name.PositiveTravelLimit*.<br>• Verify that *SLP_Name*.SLPLimit output is asserted and the programmed stop action is initiated | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Reset command.<br>• Verify proper machine status and safety application program status | |
| Abnormal Operation 2 | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the desired position range. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SFX_Name*.ActualPosition<br>• *SLP_Name*.SLPLimit<br>• *SLP_Name*.PositiveTravelLimit<br>• *SLP_Name*.NegativeTravelLimit<br>• *SLP_Name*.Output 1 | |
| | Initiate SLP demand. | |
| | Verify that the drive achieves and maintains a position between the *SLP_Name*.PositiveTravelLimit and the *SLP_Name*.NegativeTravelLimit without asserting the *SLP_Name*.SLPLimit output. | |
| | While the system is in the SLP monitoring state, initiate a motion command that violates the *SLP_Name.NegativeTravelLimit*.<br>• Verify that *SLP_Name*.SLPLimit output is asserted and the programmed stop action is initiated | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Reset command.<br>• Verify proper machine status and safety application program status | |

## Safe Direction

Use the Safe Direction (SDI) instruction checklist in Table 102 to verify normal operation and the abnormal operation scenarios.

| | |
|---|---|
| **IMPORTANT** | Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.<br>When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.<br>Instruction operands must be verified for your safety ladder program. |

**Table 102 - SDI Instruction Checklist**

| Test Type | Test Description | Test Status |
|---|---|---|
| Normal Operation | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the desired operating range. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SFX_Name*.ActualPosition<br>• *SDI_Name*.SDILimit<br>• *SDI_Name*.PositionWindow<br>• *SDI_Name*.Output 1 | |
| | Initiate SDI demand. | |
| | Verify that motion is in the intended direction and the *SDI_Name*.SDILimit output is not asserted. | |
| | While the system is in SDI monitoring state and with the sensor subsystems in a safe state, remove the SDI demand.<br>• Verify proper machine status and safety application program status | |
| | Resume normal machine operation.<br>• Verify proper machine status and safety application program status | |
| Abnormal Operation 1 | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the desired operating range. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SFX_Name*.ActualPosition<br>• *SDI_Name*.SDILimit<br>• *SDI_Name*.PositionWindow<br>• *SDI_Name*.Output 1 | |
| | Initiate SDI demand. | |
| | Verify that motion is in the intended direction and the *SDI_Name*.SDILimit output is not asserted. | |
| | While the system is in the SDI monitoring state, initiate a motion command that violates the *SDI_Name*.PositionWindow in the unintended direction.<br>• Verify that *SDI_Name*.SDILimit output is asserted and the programmed stop action is initiated | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Reset command.<br>• Verify proper machine status and safety application program status | |

## Safe Feedback Interface

Use the Safe Feedback Interface (SFX) instruction checklist in Table 103 to verify normal operation and the abnormal operation scenarios.

| | |
|---|---|
| **IMPORTANT** | Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.<br>When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.<br>Instruction operands must be verified for your safety ladder program. |

**Table 103 - SFX Instruction Checklist**

| Test Type | Test Description | Test Status |
|---|---|---|
| Normal Scaling Operation | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the normal operating range. | |
| | Set up a trend with the expected time scale and the following tags to graphically compare the motion position and speed from the Main task to the scaled position and speed in the Safety task.<br>• *Axis_Name*.ActualPosition<br>• *Axis_Name*.ActualSpeed<br>• *SFX_Name*.ActualPosition<br>• *SFX_Name*.ActualSpeed | |
| | Verify that the standard and safety position and speed are correlated as expected. | |
| Normal Homing Operation | Initiate a Start command. | |
| | Initiate a Homing procedure.<br>• Verify that the Home Position in the SFX instruction is set | |
| | Set up a trend with the expected time scale and the following tags to graphically compare the motion position and speed from the Main task to the scaled position and speed in the Safety task.<br>• *Axis_Name*.ActualPosition<br>• *SFX_Name*.ActualPosition | |
| | Verify that the standard and safety position are correlated as expected. | |
| Abnormal Operation 1 | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the normal operating range. | |
| | Set up a trend with the expected time scale and the following tags to graphically compare the motion position and speed from the Main task to the scaled position and speed in the Safety task.<br>• *Axis_Name*.ActualPosition<br>• *Axis_Name*.ActualSpeed<br>• *SFX_Name*.ActualPosition<br>• *SFX_Name*.ActualSpeed | |
| | Verify that the standard and safety position and speed are correlated as expected. | |
| | Disconnect the feedback between the motor/encoder and drive. | |
| | Verify the generation of a Fault Type: 100 Feedback Invalid by checking *Device_Name*.SI.PrimaryFeedbackValid tag. | |
| | Verify that the system fault action takes place as configured. | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Reset command.<br>• Verify proper machine status and safety application program status | |

**Table 103 - SFX Instruction Checklist (Continued)**

| Test Type | Test Description | Test Status |
|---|---|---|
| Abnormal Operation 2 | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Operate the machine within the normal operating range. | |
| | Set up a trend with the expected time scale and the following tags to graphically compare the motion position and speed from the Main task to the scaled position and speed in the Safety task.<br>• *Axis_Name*.ActualPosition<br>• *Axis_Name*.ActualSpeed<br>• *SFX_Name*.ActualPosition<br>• *SFX_Name*.ActualSpeed | |
| | Verify that the standard and safety position and speed are correlated as expected. | |
| | Disconnect the Ethernet cable between the controller and the drive. | |
| | Verify the generation of a Fault Type: 101 Connection Fault by checking the *Device_Name*.SI.ConnectionFaulted tag. | |
| | Verify that the system fault action takes place as configured | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Reset command.<br>• Verify proper machine status and safety application program status | |

## Safe Brake Control

Use the Safe Brake Control (SBC) instruction checklist in Table 104 to verify normal operation and the abnormal operation scenarios.

| IMPORTANT | Perform I/O verification and validation before validating your safety ladder program.<br>When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.<br>Instruction operands must be verified for your safety ladder program. |
|---|---|

**Table 104 - SBC Instruction Checklist**

| Test Type | Test Description | Test Status |
|---|---|---|
| Normal Operation | Verify that the brake feedback is properly wired to the input module as documented. | |
| | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SBC_Name*.BO1<br>• *SBC_Name*.BO2<br>• *SBC_Name*.TOR<br>• *Device_Name*.STOOutput | |
| | Initiate an SBC request and initiate the STO event.<br>• Verify the expected coordination of the STO output initiation and the *SBC_Name*.BO1 and *SBC_Name*.BO2 outputs<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Start command.<br>• Verify that the system remains de-energized for a normal safe condition<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Reset command.<br>• Verify that the system remains de-energized for a normal safe condition<br>• Verify proper machine status and safety application program status | |
| Abnormal Operation | Verify that brake feedback is properly wired to the input module as documented. | |
| | Initiate a Start command.<br>• Verify that the machine is in a normal machine run condition<br>• Verify proper machine status and safety application program status | |
| | Initiate machine function to make sure that the brake is released. | |
| | Set up a trend with expected time scale and the following tags to graphically capture this information:<br>• *SBC_Name*.BO1<br>• *SBC_Name*.BO2<br>• *SBC_Name*.TOR<br>• *Device_Name*:STOOutput | |
| | Remove brake feedback wires from the input module. | |
| | • Verify that the appropriate diagnostic code is generated<br>• Verify that the brake output *SBC_Name*.BO1 and *SBC_Name*.BO2 bits clear<br>• Verify the external brake engagement | |
| | While the system is stopped with the sensor subsystems in a safe state, initiate a Start command.<br>• Verify proper machine status and safety application program status | |
| | While the system is stopped, initiate a Reset command.<br>• Verify proper machine status and safety application program status | |

# Configure a Message Instruction

## Overview

A message instruction (MSG) is used to transfer data that does not require continuous updates. You can use it to configure and monitor the parameters/attributes of a dependent device on the network.

| | |
|---|---|
| **IMPORTANT** | A message instruction must not be used for any safety-related function. |

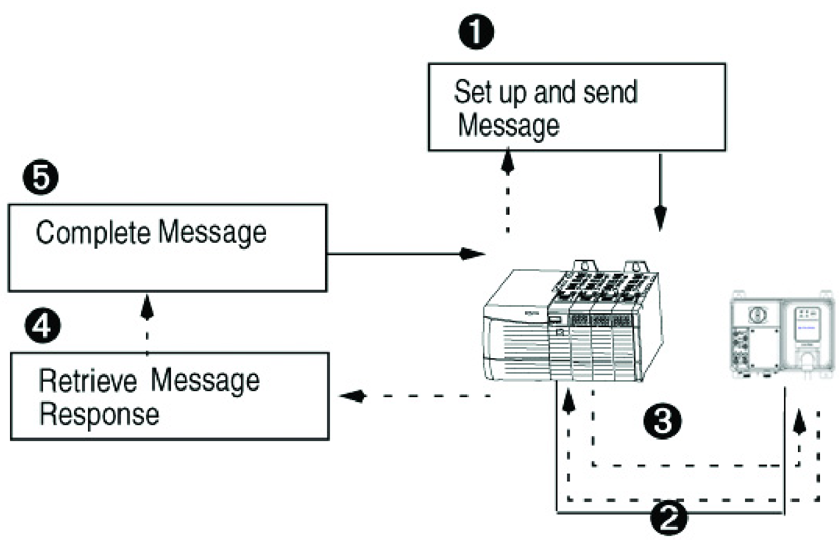
Before you can configure an MSG instruction, you must create a tag with the MESSAGE data type to use in your logic program.

The MSG (message) instruction handles all messaging that is initiated by a Logix Designer program. It automatically creates and manages TCP connections and CIP encapsulation sessions.

For details on how to use MSG instructions, see Logix 5000 Controllers Messages Programming Manual, publication 1756-PM012.

## Message Process

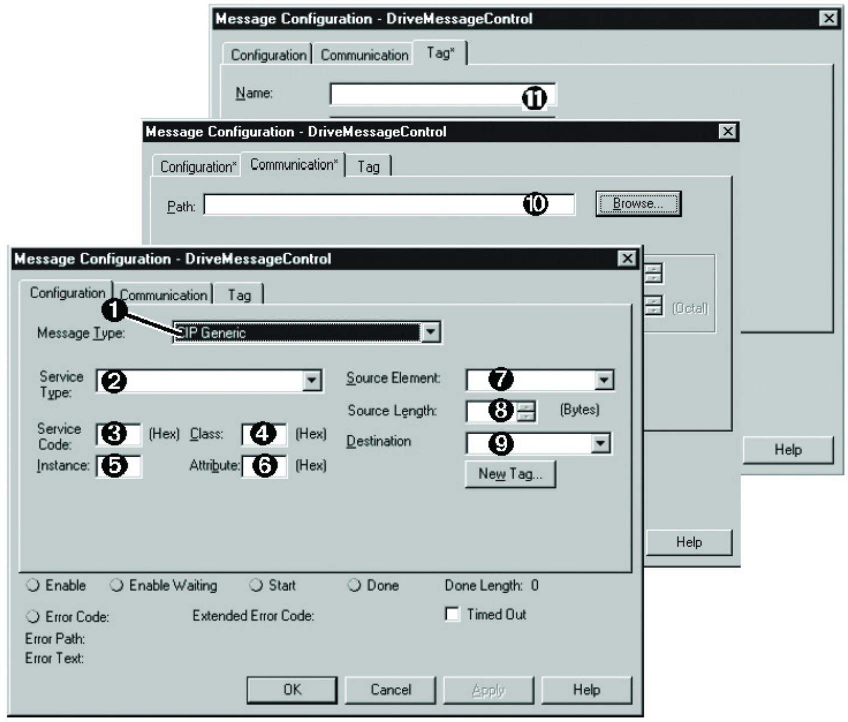
**Figure 81 - Message Process**




| Box | Description |
|---|---|
| 1 | Format the required data and configure the ladder logic program to send a Message Request to the scanner or bridge module (download). |
| 2 | The scanner or bridge module transmits the Message Request to the dependent device over the EtherNet/IP network. |
| 3 | The dependent device transmits the Message Response back to the scanner. The data is stored in the scanner buffer. |
| 4 | The controller retrieves the Message Response from the buffer of the scanner (upload). |
| 5 | The Message is complete. |

The details of each step vary depending on the controller. See the product documentation for your controller.

**Figure 82 - ControlLogix Message Format in Studio 5000**




For supported classes, instances, and attributes, see Armor PowerFlex AC Drives CIP Objects and Attributes Reference Data, publication 35-RD001.

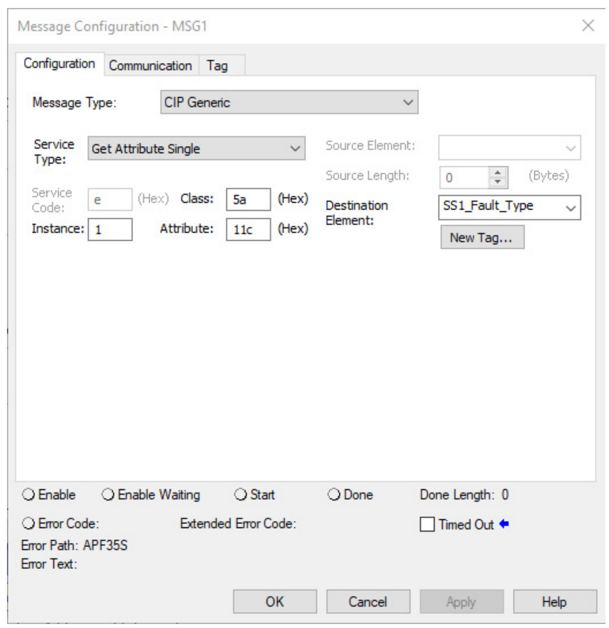
| Box | Description |
|---|---|
| 1 | **Message Type**<br>The message type is usually CIP Generic. |
| 2 | **Service Type**<br>The service type indicates the service (for example, Get Attribute Single or Set Attribute Single) that you want to perform. |
| 3 | **Service Code**<br>The service code is the code for the requested EtherNet/IP service. This value changes based on the Service Type that has been selected. In most cases, this is a read-only box.<br>If you select "Custom" in the Service Type box, then you must specify a service code in this box (for example, 4B for a Get Attributes Scattered service or 4C for a Set Attributes Scattered service). |
| 4 | **Class**<br>The class is an EtherNet/IP class. |
| 5 | **Instance**<br>The instance is an instance (or object) of an EtherNet/IP class. |
| 6 | **Attribute**<br>The attribute is a class or instance attribute. |
| 7 | **Source Element**<br>This box contains the name of the tag for any service data to be sent from the scanner or bridge to the module and drive. |
| 8 | **Source Length**<br>This box contains the number of bytes of service data to be sent in the message. |
| 9 | **Destination**<br>This box contains the name of the tag that receives service response data from the module and drive. |
| 10 | **Path**<br>The path is the route that the message follow.s<br>**Note:** Click **Browse** to find the path or type in the name of a module that you previously mapped. |
| 11 | **Name**<br>The name for the message. |

## Example: Read SS1 Fault Type

In the drive module, the connection to the safety instance or instances is controlled by a safety supervisor. The supervisor status is read by the safety controller through the Safety Input Assembly or by an explicit message.

**Table 105 - Safe Stop 1 Fault Type: MSG**

| Parameter | Value | Description |
|---|---|---|
| Service Code | 0x0E | Get attribute single |
| Class | 0x5A | Safety Stop Functions Object |
| Instance | 1 | |
| Attribute | 0x11C | SS1 Fault Type |
| Data Type | USINT | Unsigned short integer |

# Notes:

# 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 |

## Documentation Feedback

Your comments help us serve your documentation needs better. If you have any suggestions on how to improve our content, complete the form at rok.auto/docfeedback.

## 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.



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