XS/SC26-2 Safety Controller

Instruction Manual

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174868

Contents

1 About This Document

1.1 Important . . . Read This Before Proceeding!

It is the responsibility of the machine designer, controls engineer, machine builder, machine operator, and/or maintenance personnel or electrician to apply and maintain this device in full compliance with all applicable regulations and standards. The device can provide the required safeguarding function only if it is properly installed, properly operated, and properly maintained. This manual attempts to provide complete installation, operation, and maintenance instruction. *Reading the manual in its entirety is highly recommended.* Please direct any questions regarding the application or use of the device to Banner Engineering.

For more information regarding U.S. and international institutions that provide safeguarding application and safeguarding device performance standards, see *Standards and Regulations* on page 124.

⚠️ WARNING: User Responsibility

The user is responsible to:

- Carefully read, understand, and comply with all instructions for this device.
- Perform a risk assessment that includes the specific machine guarding application. Guidance on a compliant methodology can be found in ISO 12100 or ANSI B11.0.
- Determine what safeguarding devices and methods are appropriate per the results of the risk assessment and implement per all applicable local, state, and national codes and regulations. See ISO 13849-1, ANSI B11.19, and/or other appropriate standards.
- Verify that the entire safeguarding system (including input devices, control systems, and output devices) is properly configured and installed, operational, and working as intended for the application.
- Periodically re-verify, as needed, that the entire safeguarding system is working as intended for the application.

Failure to follow any of these **responsibilities** may **potentially** create a dangerous **condition** that may lead to serious injury or death.

1.1.1 Use of Warnings and **Cautions**

The precautions and statements used throughout this document are indicated by alert symbols and must be followed for the safe use of the XS/SC26-2 Safety Controllers. Failure to follow all precautions and alerts may result in unsafe use or operation. The following signal words and alert symbols are defined as follows:

Signal Word	Definition	Symbol
⚠️ **WARNING**	Warnings refer to potentially hazardous situations which, if not avoided, could result in death or serious injury.	⚠️
⚠️ **CAUTION**	**Cautions** refer to potentially hazardous situations which, if not avoided, could result in minor or moderate injury.	⚠️

These statements are intended to inform the machine designer and manufacturer, the end user, and maintenance personnel, how to avoid misapplication and effectively apply the XS/SC26-2 Safety Controllers to meet the various safeguarding application requirements. These individuals are responsible to read and abide by these statements.

1.2 EU **Declaration** of Conformity (DoC)

Banner Engineering Corp. herewith declares that the SC26-2 Programmable Safety Controller, XS26-2 Programmable Safety Controller, XS2so and XS4so Solid-State Safety Output Modules, XS8si and XS16si Safety Input Modules, XS1ro and XS2ro Safety Relay Modules is in conformity with the provisions of the Machinery Directive 2006/42/EC and EMC Directive 2004/108/EC and all essential health and safety requirements have been met.

Representative in EU: Peter Mertens, Managing Director Banner Engineering Europe. Address: Park Lane, Culliganlaan 2F, 1831 Diegem, Belgium.

1.3 Banner Engineering Corp. Limited Warranty

Banner Engineering Corp. warrants its products to be free from defects in material and workmanship for one year following the date of shipment. Banner Engineering Corp. will repair or replace, free of charge, any product of its manufacture which, at the time it is returned to the factory, is found to have been defective during the warranty period. This warranty does not cover damage or liability for misuse, abuse, or the improper application or installation of the Banner product.

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Banner Engineering Corp. reserves the right to change, modify or improve the design of the product without assuming any obligations or liabilities relating to any product previously manufactured by Banner Engineering Corp. Any misuse, abuse, or improper application or installation of this product or use of the product for personal protection applications when the product is identified as not intended for such purposes will void the product warranty. Any modifications to this product without prior express approval by Banner Engineering Corp will void the product warranties. All specifications published in this document are subject to change; Banner reserves the right to modify product specifications or update documentation at any time. Specifications and product information in English supersede that which is provided in any other language. For the most recent version of any documentation, refer to: www.bannerengineering.com.

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2 Overview

The Banner SC26-2 Programmable Safety Controller, XS26-2 Programmable Safety Controller, XS2so and XS4so Solid-State Safety Output Modules, XS8si and XS16si Safety Input Modules, XS1ro and XS2ro Safety Relay Modules are easy-to-use, configurable, and expandable modules (XS26-2xx models) designed to monitor multiple safety and non-safety input devices, providing safe stop and start functions for machines with hazardous motion. The Safety Controller can replace multiple safety relay modules in applications that include such safety input devices as E-stop buttons, interlocking gate switches, safety light curtains, two-hand controls, safety mats, and other safeguarding devices. The SC26-2 Programmable Safety Controller, XS26-2 Programmable Safety Controller, XS2so and XS4so Solid-State Safety Output Modules, XS8si and XS16si Safety Input Modules, XS1ro and XS2ro Safety Relay Modules may also be used in place of larger and more complex safety PLCs with the use of additional input and/or output expansion modules.

Based on the easy-to-learn SC22-3 Safety Controller software, the next generation PC Interface for the XS/SC26-2 controllers introduces greater flexibility with the addition of the Boolean Logic Blocks and fully configurable safety Function Blocks. This free, downloadable software is ready to solve the machine safety challenges before purchasing any hardware.

The following terms are used in this manual:

SC26-2 Programmable Safety Controller, XS26-2 Programmable Safety Controller, XS2so and XS4so Solid-State Safety Output Modules, XS8si and XS16si Safety Input Modules, XS1ro and XS2ro Safety Relay Modules - formal name of the product line
Safety Controller - an abbreviated version referring to the entire XS/SC26-2 Safety Controller system
Expandable Safety Controller - refers to expandable models
Base Controller - refers to the main module in the XS/SC26-2 Safety Controller System

2.1 Applications

The Safety Controller can be used wherever safety modules are used. The Safety Controller is well suited to address many types of applications, including, but not limited to:

- Two-hand control with mute function
- Robot weld/processing cells with dual-zone muting
- Material-handling operations that require multiple inputs and bypass functions
- Manually loaded rotary loading stations
- Multiple two-hand-control station applications
- Lean manufacturing stations
- Dynamic monitoring of single- or dual-solenoid valves or press safety valves
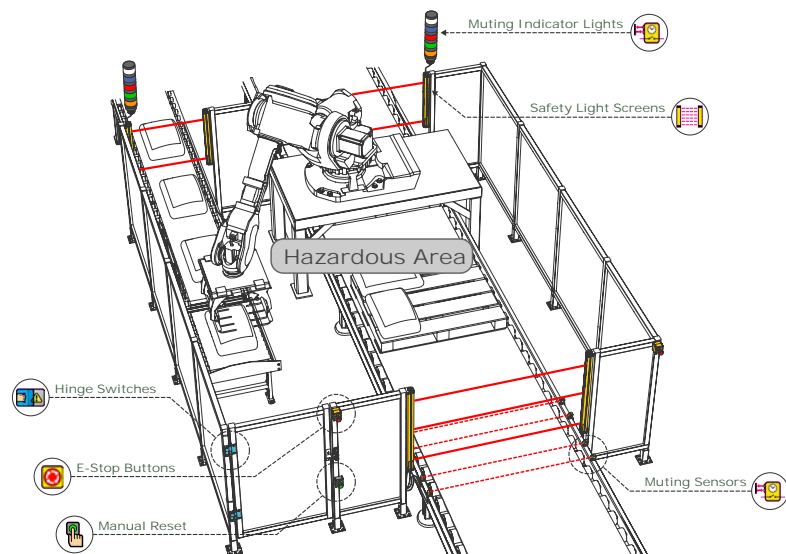
Figure 1. Sample Application - Robotic Cell

2.2 Design and **Testing**

The SC26-2 Programmable Safety Controller, XS26-2 Programmable Safety Controller, XS2so and XS4so Solid-State Safety Output Modules, XS8si and XS16si Safety Input Modules, XS1ro and XS2ro Safety Relay Modules are designed for up to Category 4 PL e (ISO 13849-1) and Safety Integrity Level 3 (IEC 61508 and IEC 62061) safeguarding applications. It has been extensively tested to ensure that it meets these standards as well as IEC 61131-2 and UL 61131-2 product performance requirements. The Safety Controller incorporates:

- Redundant microcontrollers
- Redundant input signal detection circuitry
- Redundant safety output control circuitry

The safety circuit performance of a specific safety or safeguarding application is determined by the devices used and their interconnection to the Safety Controller.

2.3 Interface

Onboard Interface	Personal Computer (PC) Interface
• Displays configuration summary, including terminal assignments and network settings • Provides access to fault diagnostics • Allows reading and writing the configuration file from and to the SC-XM2 drive See *Onboard Interface* on page 74 for details.	• Used to configure the Safety Controller • Automatically generates wiring and ladder logic diagrams as the configuration progresses • Allows testing of the configuration using Simulation Mode • Allows reading and writing the configuration file from and to the Safety Controller and the SC-XM2 drive See *PC Interface Overview* on page 18 for details.

2.4 USB **Connections**

The micro USB port on the Base Controller is used to connect to the PC (via the SC-USB2 cable) and the SC-XM2 drive to read and write configurations created with the PC Interface.

⚠️ CAUTION: **Potential** for Unintended Ground Return Path

The USB interface is implemented in an industry standard way and is not isolated from the 24 V supply.

The USB cable makes it possible for the computer and safety controller to become part of an unintended ground return path for other connected equipment. A large current could damage the PC and/or the safety controller. To minimize this possibility, Banner recommends that the USB cable is the only cable connected to the PC. This includes disconnecting the AC power supply to a laptop whenever possible.

The USB interface is intended for downloading configurations and temporary monitoring or troubleshooting. It is not designed for continuous use.

2.5 Ethernet **Connections**

Ethernet connections are made using an Ethernet cable connected from the Ethernet port of the Base Safety Controller (Ethernet models only) to a network switch or to the control or monitoring device. The Safety Controller supports either the standard or crossover-style cables. A shielded cable may be needed in high-noise environments.

2.6 **Configuring** the Safety Controller

The Safety Controller is configured using the PC Interface. The configuration process comprises three main steps:

1. Define the safeguarding application (risk assessment).
   - Determine the required devices
   - Determine the required level of safety
2. Build the configuration.
   - Assign the configuration name, file name, date, and author name
   - Add safety and non-safety input devices, choose circuit connections and other attributes
   - Add Logic Blocks
   - Add Function Blocks
   - Connect inputs and outputs to Function and Logic Blocks
   - Adjust I/O and Function Blocks' parameters

- Set optional Safety Output On- or Off-time delays
- Assign status output signals, if needed
- Assign virtual outputs, if using Ethernet (Ethernet models only)
3. Confirm the configuration on the Safety Controller.

2.6.1 Using FID 1 and FID 2 Devices

Over time, Banner adds new features to some devices. The Feature ID (FID) identifies the set of features and functions included in a particular model. Generally, an increasing FID number corresponds to an increasing feature set. A configuration using a higher numbered FID feature is not supported by a Controller of a lower FID.

FID 1 and FID 2 XS26 Base Modules can be used in the same application, however steps must be taken to ensure compatibility. See the side label on the module (*Figure 2* on page 9) or query the Module Information of the Base Module to determine whether a particular device is FID 1 or FID 2. PROFINET, virtual non-safety inputs, delay blocks, and some virtual status outputs are not compatible with FID 1 devices. In order to have one configuration file that applies to both FID 1 and FID 2 devices, create configurations without using these features. Confirm all configurations after loading to ensure that they are correct.
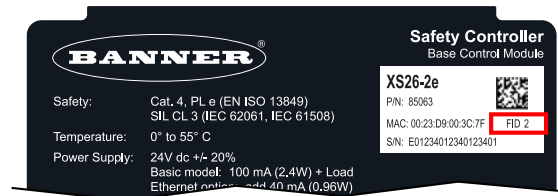
Figure 2. Example Label

2.7 Input and Output Connections

2.7.1 Safety and Non-Safety Input Devices

The Base Controller has 26 input terminals that can be used to monitor either safety or non-safety devices; these devices may incorporate either solid-state or contact-based outputs. Some of the input terminals can be configured to either source 24 V dc for monitoring contacts or to signal the status of an input or an output. The function of each input circuit depends on the type of the device connected; this function is established during the controller configuration.

The FID 2 Base Controller also supports non-safety virtual inputs.

The expansion modules XS8si and XS16si add additional inputs to the Safety Controller System.

Contact Banner Engineering for additional information about connecting other devices not described in this manual.

2.7.2 Safety Outputs

The Safety Outputs are designed to control Final Switching Devices (FSDs) and Machine Primary Control Elements (MPCEs) that are the last elements (in time) to control the dangerous motion. These control elements include relays, contactors, solenoid valves, motor controls, and other devices that typically incorporate force-guided (mechanically-linked) monitoring contacts, or electrical signals needed for external device monitoring. These features are typically used to detect external device failures.

The Safety Controller has two independently controlled and redundant solid-state Safety Outputs (terminals SO1a & SO1b, and SO2a & SO2b). The controller's self-checking algorithm ensures that the outputs turn On and Off at the appropriate times, in response to the assigned input signals.

Each redundant solid-state Safety Output is designed to work either in pairs or as two individual outputs. When controlled in pairs, the Safety Outputs are suitable for Category 4 applications; when acting independently, they are suitable for applications up to Category 3 when appropriate fault exclusion has been employed (see *Single-channel Control* in *Safety (Protective) Stop Circuits* on page 103 and *Safety Circuit Integrity and ISO 13849-1 Safety Circuit Principles* on page 77). See *Safety Outputs* on page 95 for more information about hookup, solid-state and safety relay outputs, external device monitoring, single/dual-channel Safety Stop Circuits, and configuring Safety Outputs.

Additional solid-state or safety relay outputs can be added to expandable models (XS26-2xx) of the Base Controller by incorporating expansion output modules (XS2so, XS4so, XS1ro, and XS2ro). Up to eight expansion modules, in any combination of input or output modules, can be added.

The Safety Outputs can be controlled by input devices with both automatic and manual reset operation.
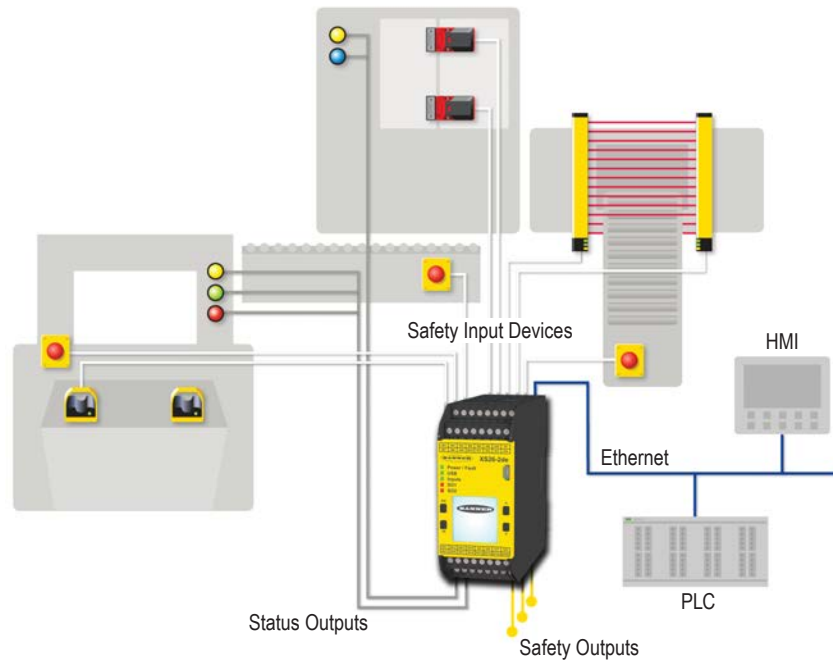
Figure 3. Safety Outputs (example application)

Functional Stops according to IEC 60204-1 and ANSI NFPA79

The Controller is capable of performing two functional stop types:
- Category 0: an uncontrolled stop with the immediate removal of power from the guarded machine
- Category 1: a controlled stop with a delay before power is removed from the guarded machine

Delayed stops can be used in applications where machines need power for a braking mechanism to stop the hazardous motion.

2.7.3 Status Outputs and Virtual Status Outputs

The Base Controller has eight convertible I/Os (labeled IOx) that can be used as Status Outputs which have the capability to send non-safety status signals to devices such as programmable logic controllers (PLCs) or indicator lights. In addition, any unused Safety Output terminals may be configured to perform a Status Output function with the benefit of higher current capacity (see *Specifications* on page 12 for more information). The Status Output signal convention can be configured to be 24 V dc or 0 V dc. See *Status Output Signal Conventions* on page 106 for information on the specific functions of a Status Output.

Ethernet models, using the PC Interface, can be configured for up to 64 Virtual Status Outputs on FID 1 Base Controllers and up to 256 virtual status outputs on FID 2 Base Controllers. These outputs can communicate the same information as the status outputs over the network. See *Virtual Status Outputs* on page 107 for more information.

> ⚠️ WARNING: Status Outputs and Virtual Status Outputs
>
> Status Outputs and Virtual Status Outputs are not safety outputs and can fail in either the On or the Off state. They must never be used to control any **safety-critical applications.** If a Status Output or a Virtual Status Output is used to control a **safety-critical application,** a failure to danger is possible and may lead to serious injury or death.

2.8 Internal Logic

The Safety Controller's internal logic is designed so that a Safety Output can turn On only if all the controlling safety input device signals and the Controller's self-check signals are in the Run state and report that there is no fault condition.

The Safety Controller configuration software uses both Logic and Safety Function blocks for simple and more advanced applications.

Logic Blocks are based on Boolean (True or False) logic laws. The following Logic Blocks are available:
- NOT
- AND
- OR
- NAND
- NOR

- XOR
- Flip Flop (Set priority and Reset priority)

See *Logic Blocks* on page 26 for more information.

Function Blocks are pre-programmed blocks with built-in logic which provide various attribute selections to serve both common and complex application needs. The following Function Blocks are available:

- Bypass Block
- Enabling Device Block
- Latch Reset Block
- Muting Block
- THC (Two-Hand Control) Block
- Delay Block (FID 2 only)

See *Function Blocks* on page 27 for more information.

2.9 Password Overview

A password is required to confirm and save the configuration to the device and to access the Password Manager via the PC Interface. See *Password Manager* on page 59 for more information.

2.10 **Confirming** a **Configuration**

Confirmation is a verification process where the Safety Controller analyzes the configuration generated by the PC Interface for logical integrity and completeness. The user must review and approve the results before the configuration can be saved and used by the device. Once confirmed, the configuration can be sent to a Safety Controller or saved on a PC or an SC-XM2 drive.

⚠️ WARNING: After confirming the configuration, the Safety Controller operation must be fully tested (commissioned) before it can be used to control any hazards. Failure to follow the commissioning process may lead to serious injury or death.

3 **Specifications** and Requirements

3.1 **Specifications**

Base Controller and Expansion Modules

Mechanical Stress
Shock: 15 *g* for 11 ms, half sine, 18 shocks total (per IEC 61131-2)
Vibration: 3.5 mm occasional / 1.75 mm continuous at 5 Hz to 9 Hz, 1.0 *g* occasional and 0.5 *g* continuous at 9 Hz to 150 Hz: all at 10 sweep cycles per axis (per IEC 61131-2)

Safety
Category 4, PL e (EN ISO 13849)
SIL CL 3 (IEC 62061, IEC 61508)

Product Performance Standards
See *Standards and Regulations* on page 124 for a list of industry applicable U.S. and international standards

EMC
Meets or exceeds all EMC requirements in IEC 61131-2, IEC 62061 Annex E, Table E.1 (increased immunity levels), IEC 61326-1:2006, and IEC61326-3-1:2008

Operating Conditions
Temperature: 0 °C to +55 °C (+32 °F to +131 °F)
Storage Temperature: –30 °C to +80 °C (–34 °F to +176 °F)

Environmental **Rating**
NEMA 1 (IEC IP20), for use inside NEMA 3 (IEC IP54) or better enclosure

Removable Screw Terminals
Wire size: 24 to 12 AWG (0.2 to 3.31 mm²)
Wire strip length: 7 to 8 mm (0.275 in to 0.315 in)
Tightening torque: 0.565 N·m (5.0 in-lb)

Removable Clamp Terminals
Important: Clamp terminals are designed for 1 wire only. If more than 1 wire is connected to a terminal, a wire could loosen or become completely disconnected from the terminal, causing a short.
Wire size: 24 to 16 AWG (0.20 to 1.31 mm²)
Wire strip length: 8.00 mm (0.315 in)

☞ Important: The Safety Controller and all solid state output expansion modules should be connected only to a SELV (Safety Extra-Low Voltage), for circuits without earth ground or a PELV (Protected Extra-Low Voltage), for circuits with earth ground power supply.

XS26-2 and SC26-2 Base Safety Controller Modules

Power
24 V dc ± 20% (incl. ripple), 100 mA no load
Ethernet models: add 40 mA
Display models: add 20 mA
Expandable models: 3.6 A max. bus load

Network Interface (Ethernet models only)
Ethernet 10/100 Base-T/TX, RJ45 modular connector
Selectable auto negotiate or manual rate and duplex
Auto MDI/MDIX (auto cross)
Protocols: EtherNet/IP (with PCCC), Modbus/TCP, and PROFINET (FID 2 only)
Data: 64 configurable virtual Status Outputs on FID 1 Base Controllers or 256 virtual Status Outputs on FID 2 Base Controllers; fault diagnostic codes and messages; access to fault log

Convertible I/O
Sourcing current: 80 mA maximum (overcurrent protected)

Test Pulse
Width: 200 μs max.
Rate: 200 ms typical

Output **Protection**
All solid-state outputs (safety and non-safety) are protected from shorts to 0 V or +24 V, including overcurrent conditions

Safety **Ratings**
PFH [1/h]: 1.05×10^{-9}
Proof Test Interval: 20 years

Certifications

Safety Inputs (and **Convertible** I/O when used as inputs)
Input On threshold: > 15 V dc (guaranteed on), 30 V dc max.
Input **Off** threshold: < 5 V dc and < 2 mA, –3 V dc min.
Input On current: 5 mA typical at 24 V dc, 50 mA peak contact cleaning current at 24 V dc
Input lead resistance: 300 Ω max. (150 Ω per lead)
Input requirements for a 4-wire Safety Mat:
· Max. capacity between plates: 0.22 μF
· Max. capacity between bottom plate and ground: 0.22 μF
· Max. resistance between the 2 input terminals of one plate: 20 Ω

Solid State Safety Outputs
0.5 A max. at 24 V dc (1.0 V dc max. drop), 1 A max. inrush
Output OFF threshold: 1.7 V dc typical (2.0 V dc max.)
Output leakage current: 50 μA max. with open 0 V
Load: 0.1 μF max., 1 H max., 10 Ω max. per lead

Response and Recovery Times
Input to Output Response Time (Input Stop to Output **Off**): see the Configuration Summary in the PC Interface, as it can vary
Input Recovery Time (Stop to Run): 250 ms typical, 400 ms max.
Output xA to Output xB turn On **differential** (used as a pair, not split): 6 to 14 ms typical, ±25 ms max.
Output X to Output Y turn on **Differential** (same input, same delay, any module): 3 scan times +25 ms max.
Virtual Input (Mute Enable and **On/Off**) Timing (FID 2 only): RPI + 200 ms typical
Virtual Input (Manual Reset and Cancel Delay) Timing (FID 2 only): see *Virtual Non-Safety Input Devices (FID 2 Only)* on page 93 for details

XS2so and XS4so Solid-State Safety Output Modules

Solid State Safety Outputs
XS2so: 0.75 A max. at 24 V dc (1.0 V dc max drop)
XS4so: 0.5 A max. at 24 V dc (1.0 V dc max drop)
Inrush: 2 A max.
Output **Off** threshold: 1.7 V dc typical (2.0 V dc max.)
Output leakage current: 50 µA max. with open 0 V
Load: 0.1 µF max., 1 H max., 10 Ω max. per lead

Safety **Ratings**
PFH [1/h]: 5.8×10^{-10}
Proof Test Interval: 20 years

Certifications

CE
c UL us LISTED Industrial Control Equipment1 3NVF
UL LISTED Programmable Safety Controller 3NBN

External Power
XS2so: 24 V dc ± 20% (including ripple); 0.075 A no load, 3.075 A max. load
XS4so: 24 V dc ± 20% (including ripple); 0.1 A no load, 4.1 A max. load
Maximum Power-up Delay: 5 seconds after the Base Controller
Limited **Isolation:** ±30 V dc max. referenced to 0 V on the Base Controller

Bus Power
0.02 A

Test Pulse
Width: 200 µs max.
Rate: 200 ms typical

Output **Protection**
All solid-state outputs (safety and non-safety) are protected from shorts to 0 V or +24 V, including overcurrent conditions

XS8si and XS16si Safety Input Modules

Convertible I/O
Sourcing current: 80 mA maximum at 55 °C (131 °F) operating ambient temperature (overcurrent protected)

Bus Power
XS8si: 0.07 A no load, 0.23 A max. load
XS16si: 0.09 A no load, 0.41 A max. load

Safety **Ratings**
PFH [1/h]: 4×10^{-10}
Proof Test Interval: 20 years

Certifications

CE
c UL us LISTED Industrial Control Equipment1 3NVF
UL LISTED Programmable Safety Controller 3NBN

Safety Inputs (and **Convertible** I/O when used as inputs)
Input On threshold: > 15 V dc (guaranteed on), 30 V dc max.
Input **Off** threshold: < 5 V dc and < 2 mA, −3 V dc min.
Input On current: 5 mA typical at 24 V dc, 50 mA peak contact cleaning current at 24 V dc
Input lead resistance: 300 Ω max. (150 Ω per lead)
Input requirements for a 4-wire Safety Mat:
· Max. capacity between plates: 0.22 µF
· Max. capacity between bottom plate and ground: 0.22 µF
· Max. resistance between the 2 input terminals of one plate: 20 Ω

Output **Protection**
The convertible inputs are protected from shorts to 0 V or +24 V, including overcurrent conditions

XS1ro and XS2ro Safety Relay Modules

Bus Power
XS1ro 0.125 A (outputs On)
XS2ro 0.15 A (outputs On)

Maximum Power
2000 VA, 240 W

Electrical Life
50,000 cycles at full resistive load

Overvoltage Category
III

Pollution Degree
2

Mechanical Life
40,000,000 cycles
Note: Transient suppression is recommended when switching inductive loads. Install suppressors across load. Never install suppressors across output contacts.

Safety **Ratings**
PFH [1/h]: 7.6×10^{-10}
Proof Test Interval: 20 years

Certifications

CE
c UL us LISTED Industrial Control Equipment1 3NVF
UL LISTED Programmable Safety Controller 3NBN

Contact **Rating**
UL/NEMA:
- N.O. Contacts: 6 A 250 V ac/24 V dc resistive; B300/Q300 pilot duty
- N.C. Contacts: 2.5 A 150 V ac/24 V dc resistive; Q300 pilot duty

IEC 60947-5-1:
- N.O. Contacts: 6 A 250 V ac/dc continuous; AC 15: 3 A 250 V; DC13: 1 A 24 V/4 A 24 V 0.1 Hz
- N.C. Contacts: 2.5 A 150 V ac/dc continuous; AC 15: 1 A 150 V; DC13: 1 A 24 V/4 A 24 V 0.1 Hz

Contact **Ratings** to preserve 5 µm AgNi gold **plating**

	Minimum	Maximum
Voltage	100 mV ac/dc	60 V ac/dc
Current	1 mA	300 mA
Power	1 mW (1 mVA)	7 W (7 VA)

3.2 Dimensions

All measurements are listed in millimeters [inches], unless noted otherwise.
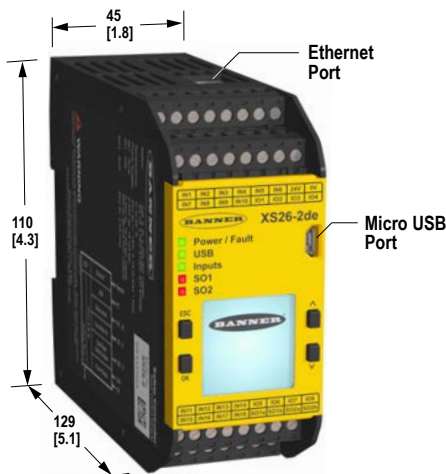
Figure 4. Base Module Dimensions
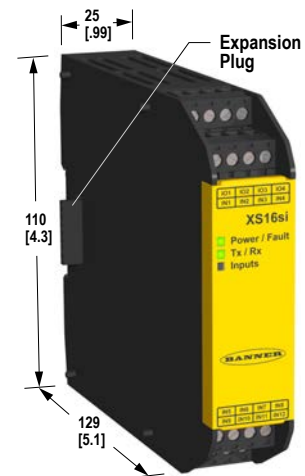
Figure 5. Expansion Module Dimensions

3.3 PC Requirements

Operating system:	Microsoft Windows XP Service Pack 3, Windows Vista, Windows 7, Windows 8 (except Windows RT), or Windows 10[1]
System type:	32-bit, 64-bit
Hard drive space:	80 MB (plus up to 280 MB for Microsoft .NET 4.0, if not already installed)
Memory (RAM):	512 MB minimum, 1 GB+ recommended
Processor:	1 GHz minimum, 2 GHz+ recommended
Screen resolution:	1024 × 768 full color minimum, 1650 × 1050 full color recommended
Third-party software:	Microsoft .NET 4.0 (included with installer), PDF Viewer (such as Adobe Acrobat)
USB port:	USB 2.0 (not required to build configurations)

☞ Important: Administrative rights are required to install the Safety Controller drivers (needed for communication with the controller).

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[1] Windows is a registered trademark of Microsoft Corporation in the United States and/or other countries.

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4 PC Interface

The XS26-2 Expandable Safety Controller PC Interface is a software application with real-time display and diagnostic tools that are used to:

- Design and edit configurations
- Test a configuration in Simulation Mode
- Write a configuration to the Safety Controller
- Read the current configuration from the Safety Controller
- Display the real-time information, such as device statuses
- Display the fault information

The PC Interface uses icons and circuit symbols to assist in making appropriate input device and property selections. As the various device properties and I/O control relationships are established on the **Functional** View, the program automatically builds the corresponding wiring and ladder logic diagrams.

See *Creating a Configuration* on page 19 for the configuration design process. See *Sample Configuration* on page 70 for a sample configuration design process.

See *Wiring Diagram* on page 61 to connect the devices, and *Ladder Logic* on page 62 for the ladder logic rendering of the configuration.

See *Live Mode* on page 67 for the Safety Controller Run-time information.

4.1 Installation

The XS26-2 Expandable Safety Controller PC Interface can be downloaded from *www.bannerengineering.com/xs26*.

☞ Important: Administrative rights are required to install the Safety Controller drivers (needed for communication with the controller).

To install the **software** from the Banner Engineering website:

1. Download the latest version of the software from *www.bannerengineering.com/xs26*.
2. Navigate to and open the downloaded file.
3. Click Next to begin the installation process.
4. Confirm the software destination and availability for users and click Next.
5. Click Next to install the software.
6. Depending on your system settings, a popup window may appear prompting to allow XS26-2 Expandable Safety Controller to make changes to your computer. Click Yes.
7. Click Close to exit the installer.

Open XS26-2 Expandable Safety Controller from the Desktop or the Start Menu.

4.2 Abbreviations

Abbreviation[2]	Description
AVM	Adjustable Valve Monitoring input node of the Safety Outputs
AVMx	Adjustable Valve Monitoring input
BP	Bypass input node of the Bypass Blocks and Muting Blocks
BPx	Bypass Switch input
CD	Cancel Delay input node of the Safety Outputs
CDx	Cancel Delay input
ED	Enabling Device input node of the Enabling Device Blocks
EDx	Enabling Device input
EDM	External Device Monitoring input node of the Safety Outputs
EDMx	External Device Monitoring input
ES	Emergency Stop input node of the Enabling Device Blocks
ESx	Emergency Stop input
FID	Feature identification

---

[2] The "x" suffix denotes the automatically assigned number.

Abbreviation[2]	Description
FR	Fault Reset input node of the Safety Outputs
GSx	Gate Switch input
JOG	Jog Input node of the Enabling Device Blocks
IN	Normal Input node of function blocks and Safety Output blocks
LR	Latch Reset input node of the Latch Reset Block and the Safety Outputs
ME	Mute Enable input node of the Muting Blocks and Two-Hand Control Blocks
MEx	Mute Enable input
MP1	First Muting Sensor Pair input node in Muting Blocks and Two-Hand Control Blocks
MP2	Second Muting Sensor Pair input node (Muting Blocks only)
Mx	Base Controller and Expansion modules (in the order displayed on the Equipment view)
MRx	Manual Reset input
MSPx	Muting Sensor Pair input
ONx	On-Off input
OSx	Optical Sensor input
PSx	Protective Stop input
RE	Reset Enable input node of the Latch Reset Blocks and the Safety Outputs
ROx	Relay Output
RPI	Requested Packet Interval
RPx	Rope Pull input
RST	Reset node of the SR-Flip-Flop, RS-Flip-Flop, Latch Reset Blocks, and Enabling Device Blocks
SET	Set node of the SR- and RS-Flip-Flop Blocks
SMx	Safety Mat input
SOx	Safety Output
STATx	Status Output
TC	Two-Hand Control input node of the Two-Hand Control Blocks
TCx	Two-Hand Control input

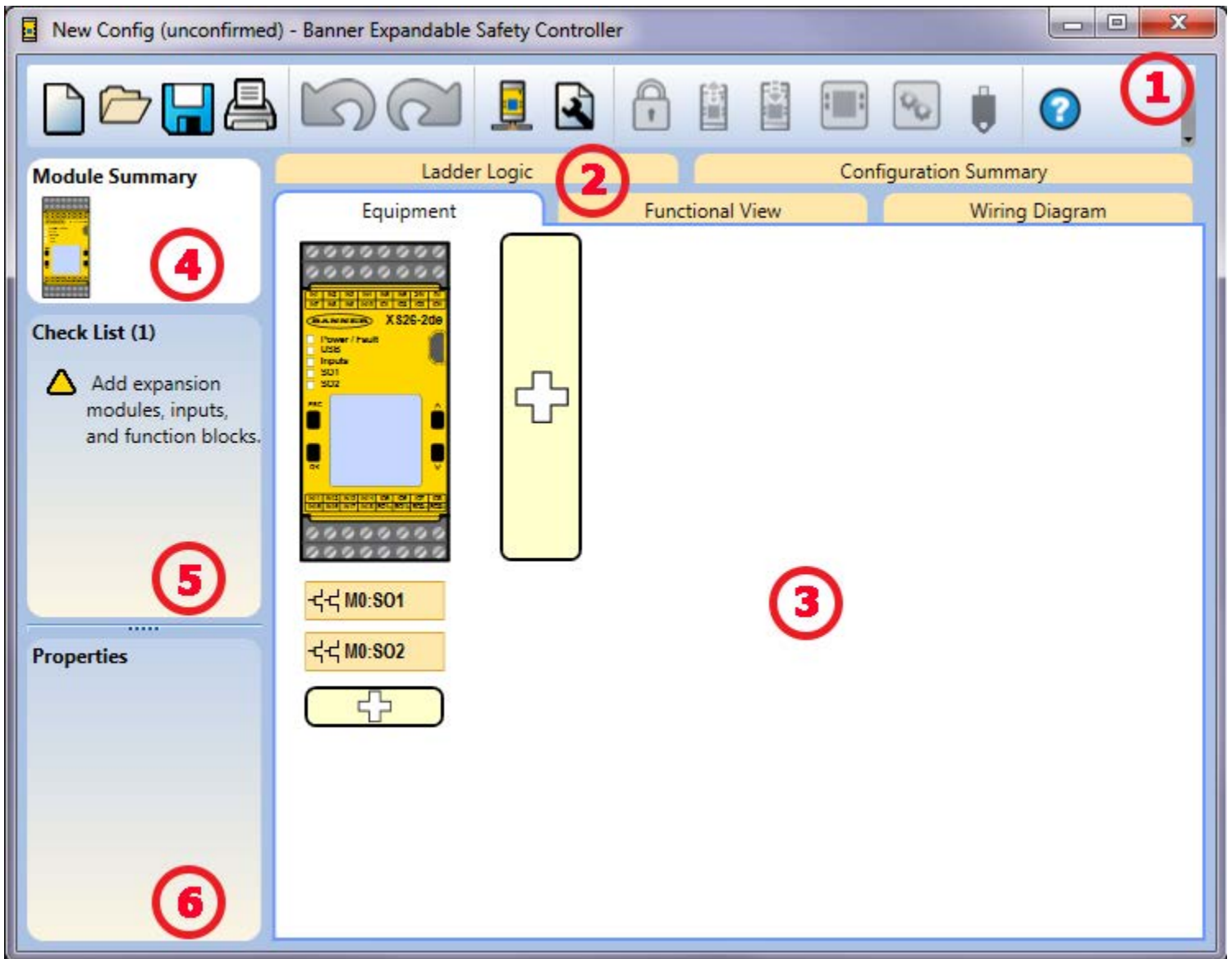[2] The "x" suffix denotes the automatically assigned number.

4.3 PC Interface Overview

Figure 6. XS26-2 Expandable Safety Controller PC Interface

(1) Navigation Toolbar

Starts a New Project or opens a Recent project and Sample Configurations

Opens an existing project

Saves (or Saves As) the project to the user-defined location

Prints a customizable Configuration Summary

Reverts up to ten previous actions

Re-applies up to ten previously reverted actions

Displays Network Settings

Displays Project Settings

Opens Password Manager

Reads the data, such as Fault Log, Configuration, Network Settings, and Device Information from the Safety Controller

Writes the data, such as Configuration and/or Network Settings to the Safety Controller

Makes the Live Mode view available

Makes the Simulation Mode view available

Indicates SC-XM2 drive connection

Opens the Help options
- Help— opens Help topics
- About—displays PC Interface version number and user responsibilities warning
- Release Notes—displays the release notes for each version of the software
- Icons—switches between US- and European-style icons
- Support **Information**—describes how to request help from the Banner Advanced Technical Support Group
- Language—selects the PC interface language options

(2) Tabs for Worksheets and Diagrams

Equipment—displays an editable view of all connected equipment

Functional View—provides editable iconic representation of the control logic

Wiring Diagram—displays the I/O device wiring detail for the use by the installer

Ladder Logic—displays a symbolic representation of the Controller's safeguarding logic for the use by the machine designer or controls engineer

Industrial Ethernet (when enabled)—displays editable network configuration options

Configuration Summary—displays a detailed configuration summary

Live Mode (when enabled)—displays the live mode data, including current faults

Simulation Mode (when enabled)—displays the simulation mode data

(3) Selected View

Displays the view corresponding to the selected tab (Equipment view shown)

(4) Module Summary

Displays the Base Controller and any connected modules

(5) Check List

Provides action items to configure the system and correct any errors to successfully complete the configuration

(6) **Properties**

Displays the properties of the selected device, function block, or connection (properties cannot be edited in this view; click Edit below to make changes)

Delete—deletes the selected item

Edit—displays the configuration options for the selected device or function block

See *PC Interface - Troubleshooting* on page 115 for issues related to the PC Interface functionality.

4.4 **Creating** a **Configuration**

The following steps are required to complete and confirm (write to controller) the configuration:

1. Install XS26-2 Expandable Safety Controller software. See *Installation* on page 16.
2. Become familiar with the PC Interface options. See *PC Interface Overview* on page 18.
3. Start a new project by clicking New Project/Recent Files.
4. Define the Project **Settings**. See *Project Settings* on page 20.
5. Customize the Base Controller module and add Expansion Modules (if used)(see *Equipment* on page 21).
6. Add Safety Input devices, Non-Safety Input devices, and Status Outputs. See *Adding Inputs and Status Outputs* on page 22.

7. Design the control logic. See *Designing the Control Logic* on page 49.
8. If used, configure the network settings. See *Network Settings: Modbus/TCP, Ethernet/IP, PCCC* on page 50 or *Network Settings: PROFINET (FID 2 Only)* on page 51.
9. Save and confirm the configuration. See *Saving and Confirming a Configuration* on page 59.

The following steps are optional and may be used to aid with the system installation:
- Modify the configuration access rights. See *Password Manager* on page 59.
- View the **Configuration** Summary for the detailed device information and response times. See *Configuration Summary* on page 57.
- Print the configuration views, including the **Configuration** Summary and Network **Settings**. See *Print Options* on page 58
- Test the configuration using Simulation Mode. See *Simulation Mode* on page 63.

4.5 Project **Settings**

Figure 7. Project Settings

Each configuration has an option to include additional project information for easier differentiation between multiple configurations. To enter this information click Project **Settings**.

Configuration Name

Name of the configuration; displayed on the controller (models with display); different from file name.

Project

Project name; useful for distinguishing between various application areas.

Author

Person designing the configuration.

Notes

Supplemental information for this configuration or project.

Project Date

Date pertaining to the project.

4.6 Equipment
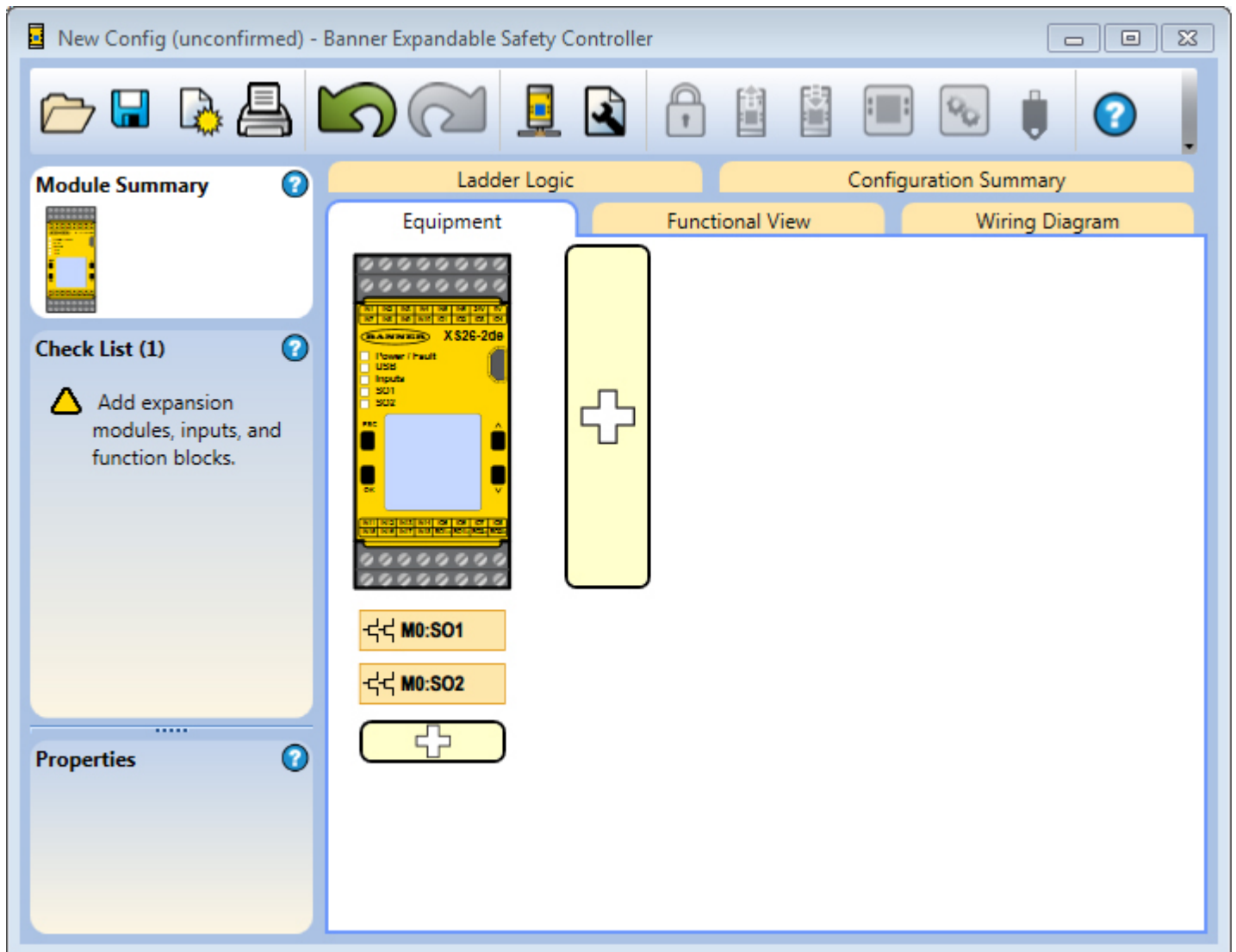
Figure 8. Equipment

The Equipment view is used to select the base model, add the expansion modules (input and output), and add input devices and status outputs. Add the expansion modules by clicking ⊹ to the right of the Base Controller module.

The Base Controller module can be customized by either double-clicking the module or selecting it and clicking Edit under the **Properties** table on the left and selecting the appropriate Controller features (display, Ethernet, expandability). The properties of Safety and Non-Safety inputs, Status Outputs, Logic Blocks, and Function Blocks are also configured by either double-clicking the block or selecting it and clicking Edit under the **Properties** table. Clicking the block the second time de-selects it.
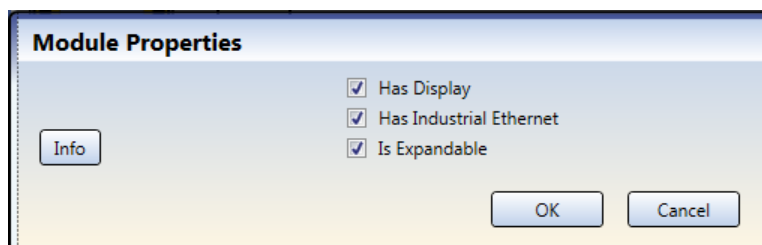
Figure 9. Module Properties

4.7 Adding Inputs and Status Outputs

Safety and Non-Safety Inputs can be added from either the Equipment view or the **Functional** View. Status Outputs can be added from the Equipment view only. When inputs are added on the Equipment view, they are automatically placed in the **Functional** View. All inputs and Logic and **Function** Blocks can be moved around on the **Functional** View. The Safety Outputs are statically positioned on the right side.

4.7.1 Adding Safety and Non-Safety Inputs

1. On the Equipment view, click 🞣 below the module which will have the input device connected (the module and terminals can be changed from the input device **Properties** window) or any of the placeholders on the **Functional** View.

   ➡ Note: Virtual Non-Safety Inputs are available only from the **Functional** View.

2. Click Safety Input or Non-Safety Input to add input devices:

Figure 10. Safety Inputs (Virtual Non-Safety Inputs available only from the Functional View)
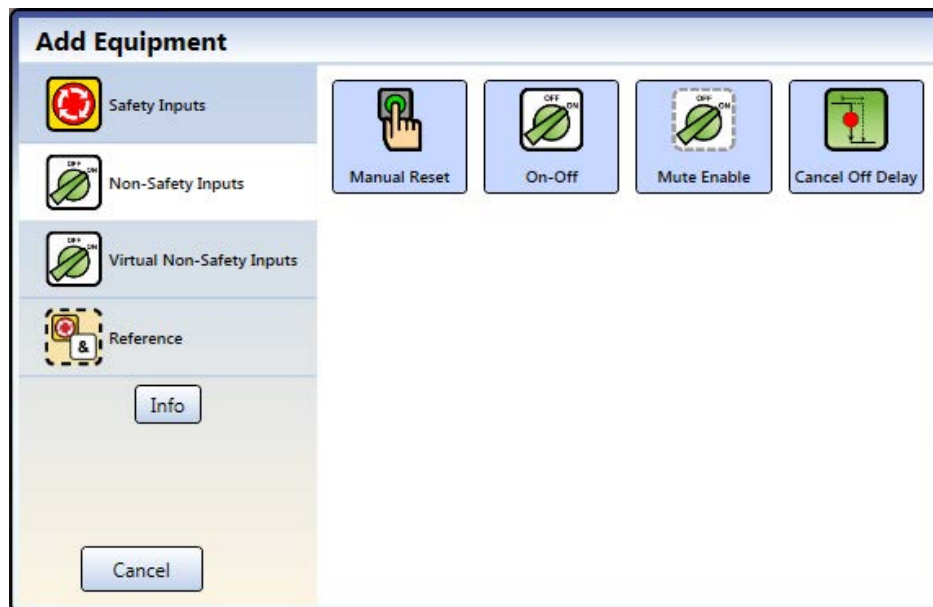
Figure 11. Non-Safety Inputs (Virtual Non-Safety Inputs available only from the Functional View)

3. Select appropriate device settings:

Basic settings:
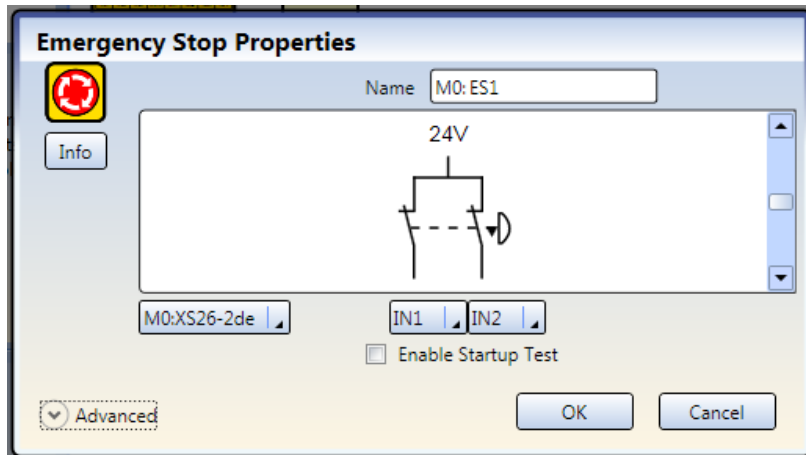
Figure 12. Basic Safety Input Settings

- *Name*—input device name; generated automatically and can be changed by the user
- *Circuit Type*—the circuit and signal convention options appropriate for the selected input device
- *Module*—the module to which the input device is connected
- *I/O Terminals*—the assignment of input terminals for the selected device on the selected module
- *Enable Startup Test* (where applicable)—an optional precautionary safety input device test required after each power-up
- *Reset Options* (where applicable)—various reset options such as Manual Power Up, System Reset, and Reset Track Input Group

Advanced settings (where applicable):
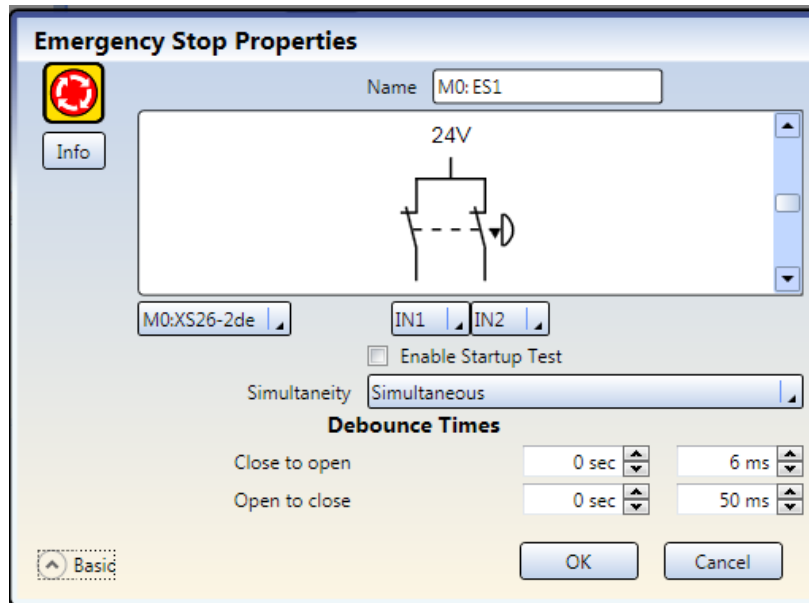
Figure 13. Advanced Safety Input Settings

- *Simultaneity* (where applicable)—Simultaneous or Concurrent (see *Glossary* on page 125 for definitions)
- *Debounce Times*—the signal state transition time
- *Monitored/Non-Monitored* (where applicable)

4.7.2 Adding Status Outputs

1. On the Equipment view, click ⊞ below the module which will have the status monitoring.

2. Click Status Outputs to add status monitoring[3].
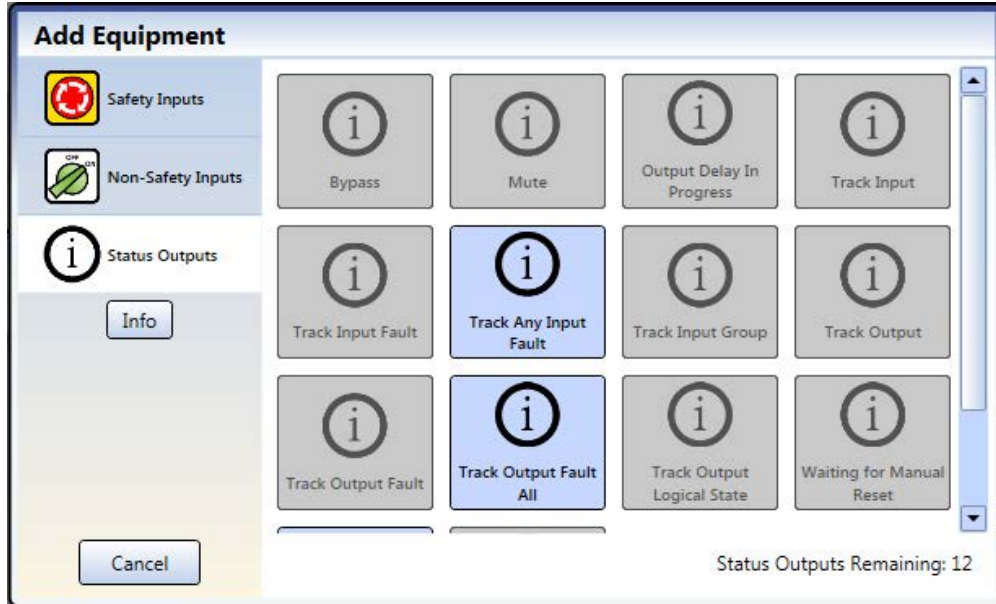
Figure 14. Status Outputs

3. Select appropriate Status Output settings:
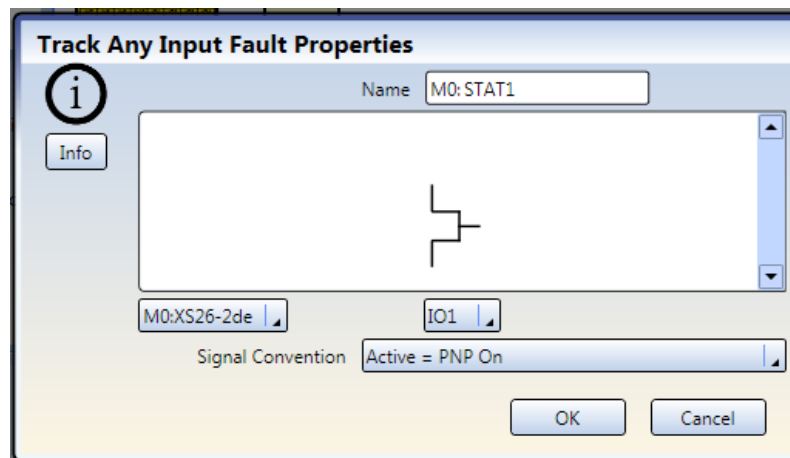
Figure 15. Status Output Properties

- *Name*
- *Module*
- *I/O (where applicable)*
- *Terminal*
- *Input or Output (where applicable)*
- *Signal Convention*

---

[3] Status outputs can be configured when the state of an input device or an output needs to be communicated. The IOx terminals are used for these status signals.

4.8 **Functional** View
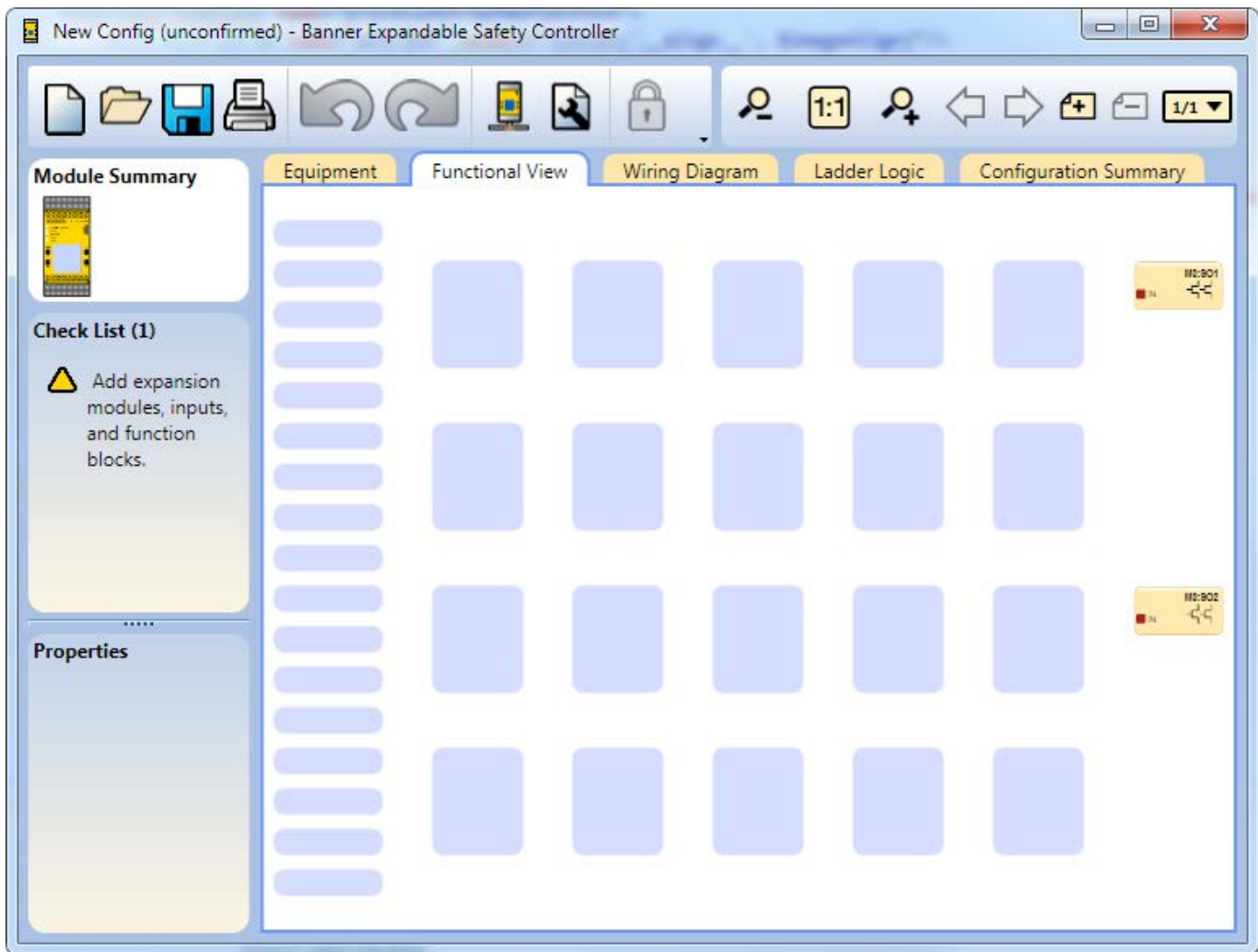
Figure 16. Functional View

The **Functional** View is used to create the control logic. The left column of the **Functional** View is used for Safety and Non-Safety Inputs; the middle area is used for Logic and Function Blocks and the right column is reserved for Safety Outputs. Safety and Non-Safety Inputs can be moved between the left and middle areas. Function and Logic Blocks can only be moved within the middle area. Outputs are placed statically by the program and cannot be moved. Reference blocks of any type can be placed anywhere within the left and middle areas.

☞ Important: The XS26-2 Expandable Safety Controller PC Interface is designed to assist in creating a valid configuration, however, the user is responsible for verifying the integrity, safety, and functionality of the configuration by following the *Commissioning Checkout Procedure* on page 108.

On the **Functional** View you can:
- Customize the look of the diagram by repositioning inputs, Function Blocks, and Logic blocks
- Undo and Redo up to 10 most recent actions
- Add additional pages for larger configurations using the page navigation toolbar (see *Figure 17* on page 25)
- Zoom in and out of the diagram view, or automatically adjust it to the best ratio for the current window size (see *Figure 17* on page 25)

Figure 17. Page Navigation and Diagram Size toolbar

- Navigate between pages by clicking the left and right arrows within the page navigation area in the top right corner of the PC Interface
- Modify properties of all blocks by either double-clicking a block or by selecting a block and clicking Edit under the **Properties** table

- Delete any block or connection by selecting the item and then either hitting the Delete key on your keyboard or clicking Delete under the **Properties** table

> Note: There is no confirmation of the object deletion. You may undo the deletion by clicking Undo.

By default all inputs added on the Equipment view are placed on the **Functional** View to the first available placeholder in the left column. There are two ways to move signals from one page to another. To do so, perform one of the following steps:

1. Add a Reference to the block located on a different page—click any of the empty placeholders in the middle area, select Reference and select the block that is on the next page. Only blocks from other pages can be added as a Reference.
2. Re-assign page—on the page where you want to keep the configuration, move one of the blocks to any of the placeholders in the middle area. Go to the page which contains the block that needs to be moved. Select the block and change the page assignment below the **Properties** table.

4.8.1 Logic Blocks

Logic Blocks are used to create Boolean (True or False) functional relationships between inputs, outputs, and other logic and function blocks. Logic Blocks accept appropriate safety inputs, non-safety inputs, or safety outputs as an input. The state of the output reflects the Boolean logic result of the combination of the states of its inputs (1 = On, 0 = Off, x = do not care) .

> ⚠️ CAUTION: Inverted Logic
>
> It is not recommended to use Inverted Logic configurations in safety applications where a hazardous situation can occur.

Signal states can be inverted by the use of NOT, NAND, and NOR logic blocks, or by selecting "Invert Output" or "Invert Input Source" check boxes (where available). On a Logic Block input, inverted logic treats a Stop state (0 or Off) as a "1" (True or On) and cause an output to turn On, assuming all inputs are satisfied. Similarly, the inverted logic causes the inverse function of an output when the block becomes "True" (output turns from On to Off). Because of certain failure modes that would result in loss of signal, such as broken wiring, short to GND/0 V, loss of safeguarding device supply power, etc., inverted logic is not typically used in safety applications. A hazardous situation can occur by the loss of a stop signal on a safety input, resulting in a safety output turning On.

AND

(US)   & (EU)

The output value is based on the logical AND of 2 to 5 inputs.

Output is On when all inputs are On.

Input 1	Input 2	Output
0	x	0
x	0	0
1	1	1

OR

(US)   ≥1 (EU)

The output value is based on the logical OR of 2 to 5 inputs.

Output is On when at least one input is On.

Input 1	Input 2	Output
0	0	0
1	x	1
x	1	1

NAND

(US)   & (EU)

The output value is based on inverting the logical AND of 2 to 5 inputs.

Output is Off when all inputs are On.

Input 1	Input 2	Output
0	x	1
x	0	1
1	1	0

NOR

(US)   (EU)
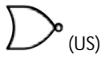
The output value is based on inverting the logical OR of 2 to 5 inputs.

Output is On when all inputs are Off.

Input 1	Input 2	Output
0	0	1
1	x	0
x	1	0

XOR

(US)   (EU)
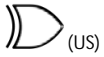
The output value is an exclusive OR of 2 to 5 inputs.

Output is On when only one (exclusive) input is On.

Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	0

NOT

(US)   (EU)
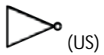
Output is the opposite of the input.

Input	Output
0	1
1	0

RS Flip-Flop

RS

This block is Reset Dominant (Reset has priority if both inputs are On).

Input 1 (Set)	Input 2 (Reset)	Output
0	0	Value remains the same
0	1	0 (Reset)
1	0	1 (Set)
1	1	0 (Reset has priority)

SR Flip-Flop

SR

This block is Set Dominant (Set has priority if both inputs are On).

Input 1 (Set)	Input 2 (Reset)	Output
0	0	Value remains the same
0	1	0 (Reset)
1	0	1 (Set)
1	1	1 (Set has priority)

4.8.2 Function Blocks

Function Blocks provide built-in functionality for most common applications in one block. While it is possible to design a configuration without any function blocks, using the Function Blocks offers substantial efficiency, ease of use, and improved functionality.

Most Function Blocks expect the corresponding safety input device to be connected to it. The Check List on the left creates a notification if any required connections are missing. Depending on the application, some Function Blocks may be connected to other Function Blocks and/or Logic Blocks.

Dual-channel safety input devices have two separate signal lines. Dual-channel signals for some devices are both positive (+24 V dc) when the device is in the Run state. Other devices may have a complementary circuit structure where one channel is at 24 V dc and the other is at 0 V dc when the device is in the Run state. This manual uses the Run state/Stop state convention instead of referring to a safety input device as being On (24 V dc) or Off (0 V dc).

Bypass Block

Default Nodes	**Additional** Nodes	Notes
IN BP	-	When the BP node is inactive, the safety signal simply passes through the Bypass Block. When the BP node is active, the output of the block is On regardless of the state of the IN node (if the Output turns **Off** when both inputs (IN&BP) are On checkbox is clear). The Bypass Block output turns Off when the bypass timer expires.

**Bypass
Function Block**
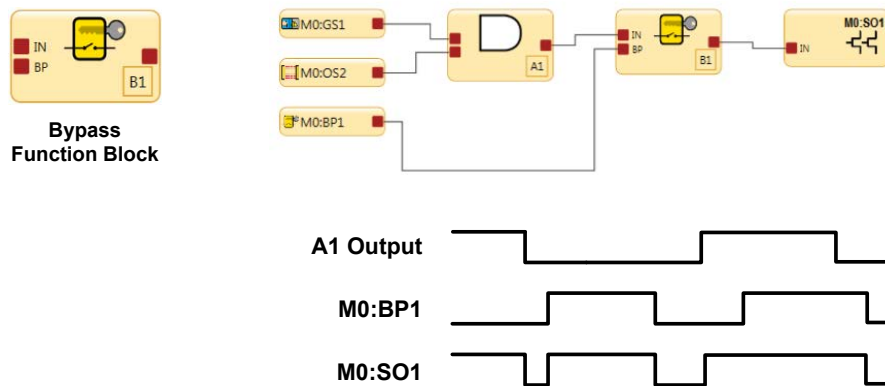
Figure 18. Timing Diagram—Bypass Block

Bypass Time Limit—a bypass function time limit must be established to limit how long the safety input device bypass is active. The time limit can be adjusted from 1 second to 12 hours and cannot be disabled. Only one time limit can be set, and this limit will apply to all safety devices that are bypassed. At the end of the time limit, the safety output control authority is transferred back to the bypassed safety input devices.

Two-Hand Control Bypassing—the Safety Controller issues a Stop signal if a Two-Hand Control input is actuated while the input is being bypassed. This ensures that the operator does not mistakenly assume that the Two-Hand Control is functional; unaware that the Two-Hand Control is bypassed and no longer providing the safeguarding function.

Lockout/Tagout

Hazardous energy (lockout/tagout) must be controlled in machine maintenance and servicing situations in which the unexpected energization, start up, or release of stored energy could cause injury. Refer to OSHA 29CFR 1910.147, ANSI 2244.1, ISO 14118 , ISO 12100 or other relevant standards to ensure that bypassing a safeguarding device does not conflict with the requirements that are contained within the standards.

⚠️ WARNING: Limit Use of Bypass **Function**

The Bypass **function** is not intended for **production** purposes; it is to be used only for temporary or **intermittent actions,** such as to clear the **defined** area of a safety light screen if material becomes "stuck". When Bypass is used, it is the user's responsibility to install and use it according to relevant standards (such as ANSI NFPA79 or IEC/EN60204-1).

Safe Working Procedures and Training

Safe work procedures provide the means for individuals to control exposure to hazards through the use of written procedures for specific tasks and the associated hazards. The user must also address the possibility that an individual could bypass the safeguarding device and then either fail to reinstate the safeguarding or fail to notify other personnel of the bypassed condition of the safeguarding device; both cases could result in an unsafe condition. One possible method to prevent this is to develop a safe work procedure and ensure personnel are trained and correctly follow the procedure.

Enabling Device Block

Default Nodes	**Additional** Nodes	Notes
ED IN RST	ES JOG	An Enabling Device Block must be connected directly to an Output Block. This method assures that the final control of the outputs is given to the operator holding the Enabling Device. Use the ES node for safety signals that should not be bypassed by the ED node. If no other inputs of the function block are configured, using an Enabling Device function block is not required.

**Enabling Device
Function Block**
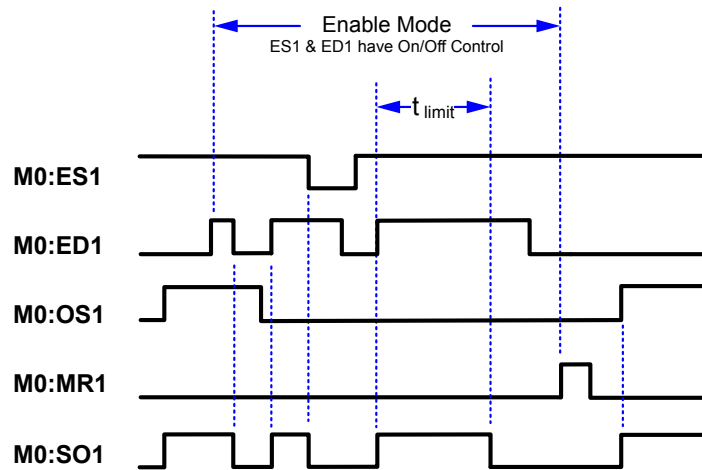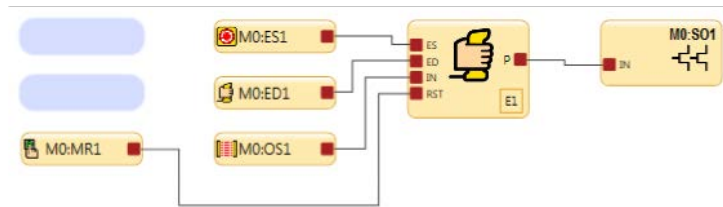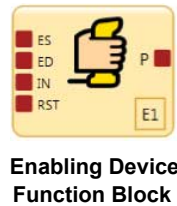
Figure 19. Timing Diagram—Enabling Device, Simple Configuration
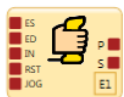
**Enabling Device Primary &
Secondary Output Control**
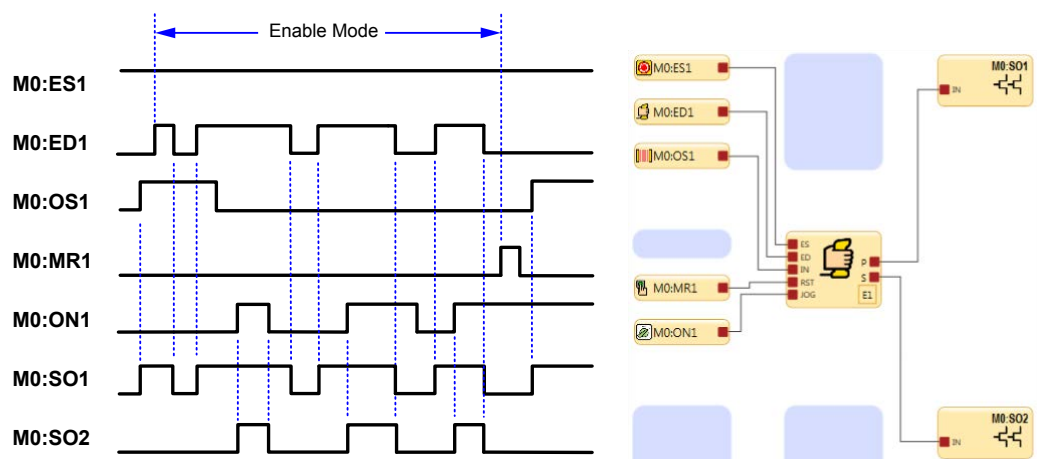
E1 enabling mode starts when the Enabling Device ED1 is switched to the Run state.
ED1 and ES input devices have On/Off control authority while in Enable mode.
When MR1 is used to perform a reset, the normal Run mode is re-established and OS1 and ES1
have the On/Off control authority.

Figure 20. Timing Diagram—Enabling Device

To exit the Enable mode, the enabling device must be in the Off state, and an Enabling Device Block reset must be performed.

The enabling device **time** limit may be adjusted between 1 second and 30 minutes and cannot be disabled. When the time limit expires, the associated safety outputs turn Off. To start a new Enable mode cycle, with the time limit reset to its original value, the enabling device must switch from On to Off, and then back to On.

All On- and Off-delay time limits associated with the safety outputs that are controlled by the enabling device function are followed during the Enable mode.

Latch Reset Block

Default Nodes	**Additional** Nodes	Notes
IN LR	RE	The RE (Reset Enable) node can be used to enable or disable the Latch Reset function. If the input devices connected to the IN node are all in the Run state and RE input signal is high, the LR function block can be manually reset to have its output turn On. See *Figure 21* on page 30 with Reference Signal SO2 connected to the RE node.

**Latch Reset
Function Block**
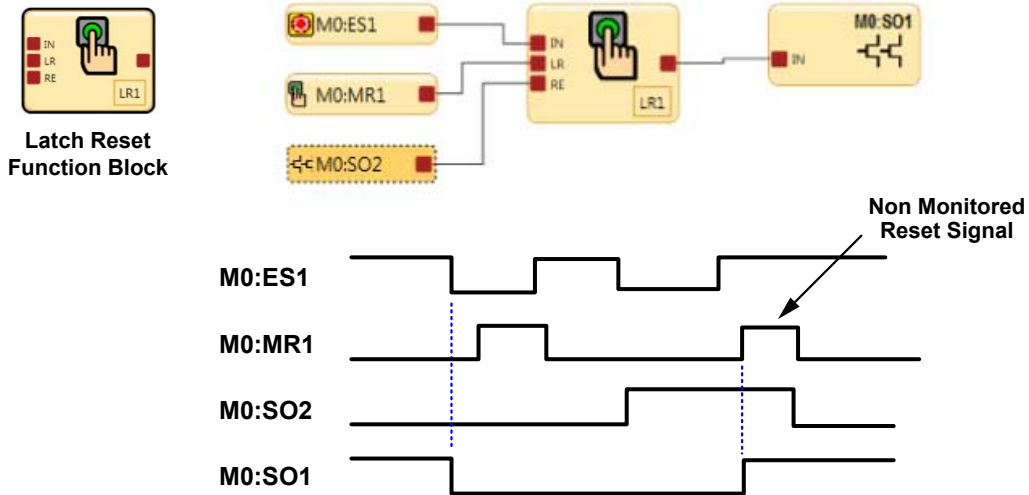
The Latch Reset function block LR1 will turn its output and the safety output SO1 Off when the E-Stop button changes to the Stop state.
The latch off condition can be reset when the Reset Enable RE of LR1 detects that the SO2 reference signal is in the Run state & MR1 is used to perform a reset.

Figure 21. Timing Diagram—Latch Reset Block

Figure 22. Timing Diagram—Latch Reset Block, Monitored/Non-Monitored Reset
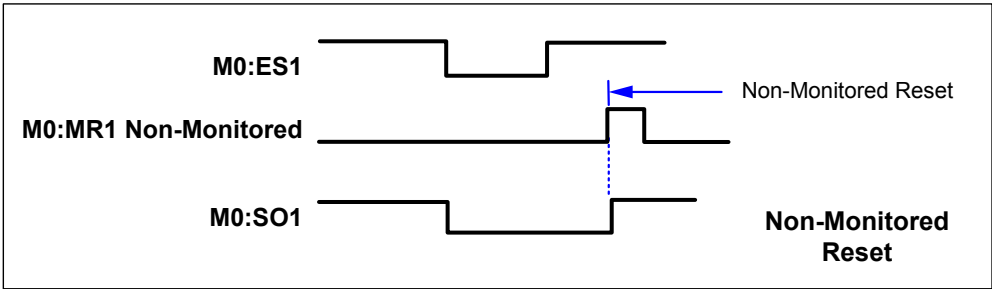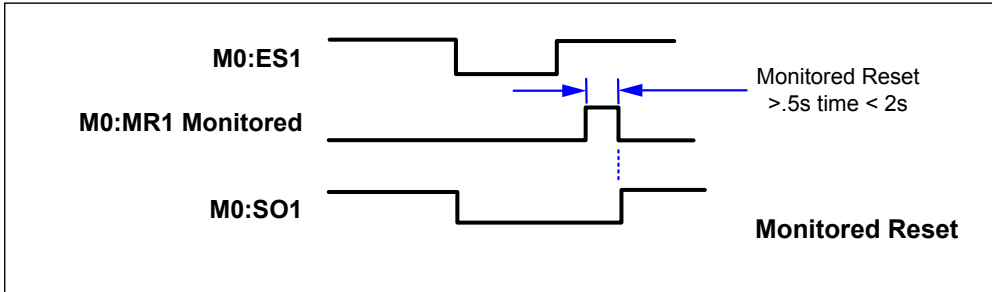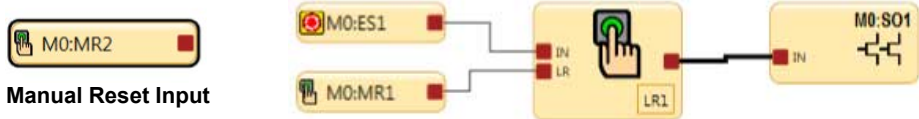
The Manual Reset input device can be configured for one of two types of reset signals: Monitored & Non-Monitored

Reference Signals

A Reference Signal is used to:
- Control an output based on the state of another output
- Represent the state of an output, input, safety function or logic block on another page.
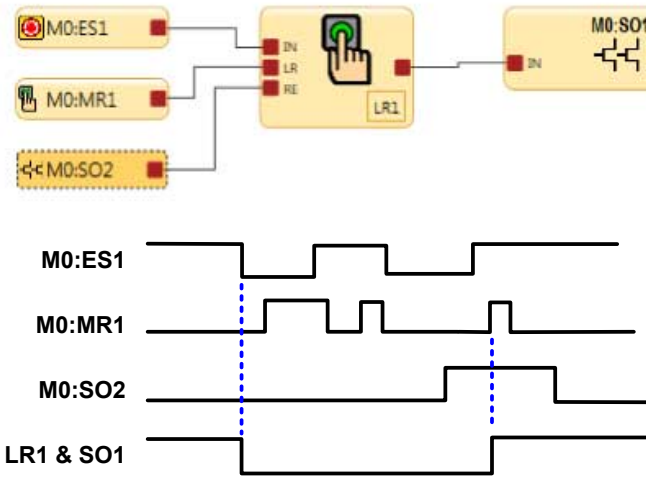
When output SO2 is On, the SO2 reference signal state is On or High. The function block above shows reference signal SO2 connected to the Reset Enable node RE of Latch Reset Block LR1.

LR1 can only be reset (turned On) when ES1 is in the Run state and SO2 is On.

See *Reference Signals* on page 73 for use of referenced Safety Outputs.

Figure 23. Timing Diagram—Latch Reset Block and Referenced Safety Output

In the figure below, reference signal A3 is on page 1 of the function block diagram and the A3 AND block is on page 2. The output node on the A3 AND block can also be used on page 2 for other safety control logic.

Reference Signals

Reference signal A3 on page 1

AND logic block A3 on page 2
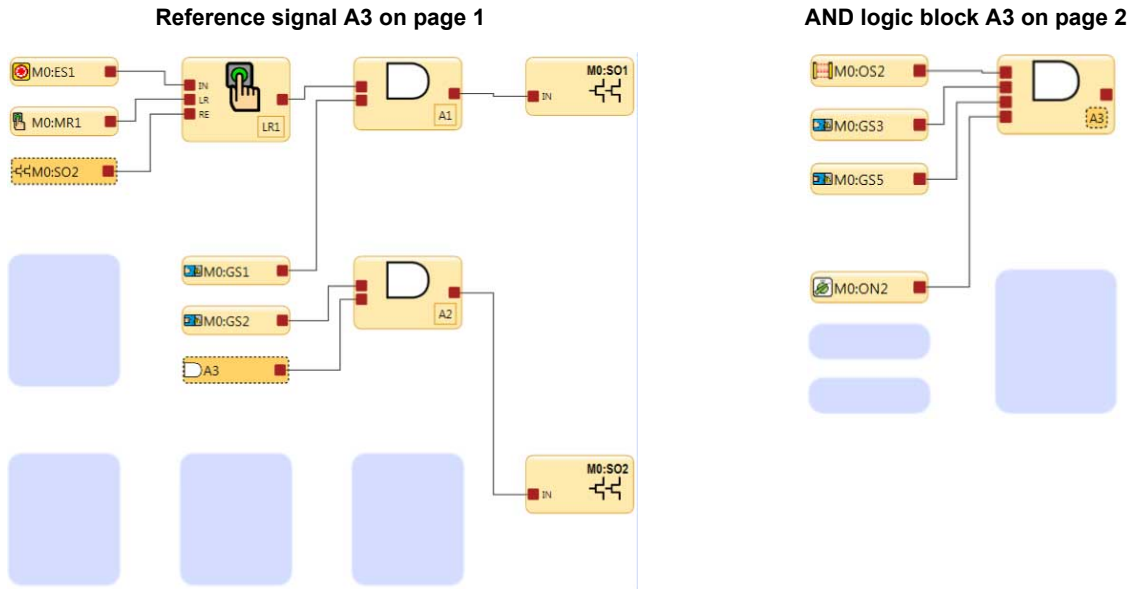
Figure 24. Latch Reset and Referenced Safety Output and AND block

Latch Reset Mute Function
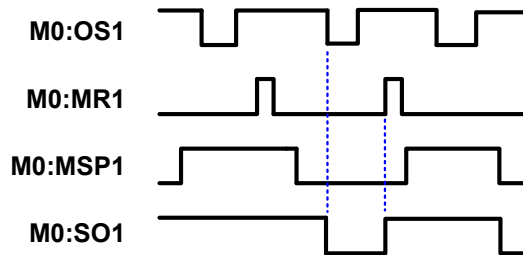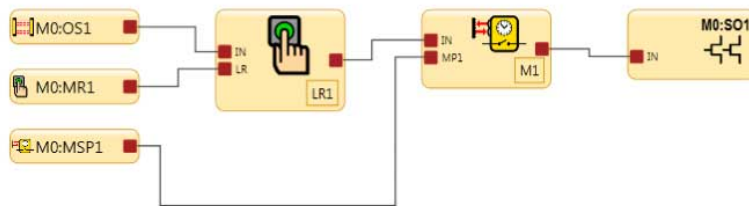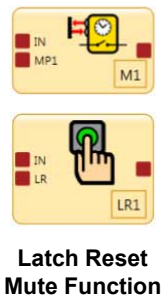
When a safeguarding device OS1 transitions to a Stop state in a valid muting cycle, the latch reset function block will latch and require a reset signal to keep SO1 on after muting ends.
If OS1 switches to the Stop state in a valid muting cycle and no reset signal is seen, SO1 turns off after muting ends.

Figure 25. Timing Diagram—Latch Reset Block and Muting Block

Manual Reset Input

The Manual Reset input may be configured to perform any combination of the following (see *Adding Inputs and Status Outputs* on page 22):

Reset of Safety Inputs

Sets the output of the Latch Reset Block(s) to a Run state from a Latched state when the IN node is in a Run state

Reset of Safety Outputs

Sets the Output to On if the Output Block configured for Latch Reset is On.

Exceptions:

- A Safety Output cannot be configured to use a Manual Reset when associated with a Two Hand Control input or an Enabling Device Function Block.

System Reset

Sets the System to a Run state from a Lockout state due to a system fault. Possible scenarios when System Reset is needed include:
- Signals are detected on unused terminal pins
- Configuration Mode timeout
- Exiting Configuration Mode
- Internal faults

Output Fault Reset

Clears the fault and allows the output to turn back On if the cause of the fault has been removed. Possible scenarios when an Output Fault Reset is needed include:
- Output faults
- EDM or AVM faults

Manual Reset on Power-Up

Allows various Latch Reset Blocks and/or Output Blocks to be controlled by a single reset input after the power up.

Enable Mode Exit

A reset is required to exit the Enable Mode.

Track Input Group Reset

Resets the Status Output function Track Input Group and the Virtual Status Output function Track Input Group

The reset switch must be mounted at a **location** that complies with the warning below. A key-actuated reset switch provides some operator or supervisory control, as the key can be removed from the switch and taken into the guarded area. However, this does not prevent from any unauthorized or inadvertent resets due to spare keys being in the possession of others, or additional personnel entering the guarded area unnoticed (a pass-through hazard).

WARNING: Reset Switch **Location**

All reset switches must be accessible only from outside, and in full view of, the hazardous area. Reset switches must also be out of reach from within the safeguarded space, and must be protected against unauthorized or inadvertent **operation** (for example, through the use of rings or guards). If any areas are not visible from the reset switch(es), additional means of safeguarding must be provided. Failure to do so may result in serious bodily injury or death.

Important: Resetting a safeguard must not initiate hazardous motion. Safe work procedures require a start-up procedure to be followed and the individual performing the reset to verify that the entire hazardous area is clear of all personnel before each reset of the safeguard is performed. If any area cannot be observed from the reset switch location, additional supplemental safeguarding must be used: at a minimum, visual and audible warnings of the machine start-up.

Note: **Automatic** Reset sets an output to return to an On state without action by an individual once the input device(s) changes to the Run state and all other logic blocks are in their Run state. Also known as "Trip mode," automatic reset is typically used in applications in which the individual is continually being sensed by the safety input device.

WARNING: **Automatic** Power Up

On power up, the Safety Outputs and Latch Reset Blocks configured for automatic power up will turn their outputs On if all associated inputs are in the Run state. If manual reset is required, configure outputs for a manual power mode.

Automatic and Manual Reset Inputs Mapped to the Same Safety Output

By default, Safety Outputs are configured for the automatic reset (trip mode). They can be configured as a Latch Reset using the Solid State Output Properties attribute of the Safety Output (see *Function Blocks* on page 27).

Safety Input Devices operate as automatic reset unless a Latch Reset Block is added. If a Latch Reset Block is added in line with an output configured for Latch Reset mode, the same or different Manual Reset Input Device(s) may be used to reset the Latch Reset Block and the Safety Output latch. If the same Manual Reset Input Device is used for both, and all inputs are in their Run state, a single reset action will unlatch the function block and the output block. If different Manual Reset Input Devices are used, the reset associated with the Safety Output must be the last one activated. This can be used to force a sequenced reset routine, which can be used to reduce or eliminate pass-through hazards in perimeter guarding applications (see *Safety Input Device Properties* on page 78).

If the controlling inputs to a Latch Reset Block or a Safety Output Block are not in the Run state, the reset for that block will be ignored.

Reset Signal Requirements

Reset Input devices can be configured for monitored or non-monitored operation, as follows:

Monitored reset: Requires the reset signal to transition from low (0 V dc) to high (24 V dc) and then back to low. The high state duration must be 0.5 to 2 seconds. This is called a trailing edge event.

Non-monitored reset: Requires only that the reset signal transitions from low (0 V dc) to high (24 V dc) and stays high for at least 0.5. After the reset, the reset signal can be either high or low. This is called a leading-edge event.

Muting Block

Default Nodes	Additional Nodes	Notes
IN MP1 MP2	ME BP	Muting Sensor Pair input blocks must be connected directly to the Muting function block.
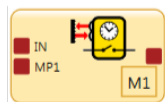
Mute Function Block

There are five Mute Function types listed below. The following timing diagrams show the function detail and sensor/safeguarding state change order for each mute function type.

 One Way - 1 Mute Sensor Pair

 Two Way - 1 Mute Sensor Pair

 One Way - 2 Mute Sensor Pair

 Two Way - 2 Mute Sensor Pair

 Two Way - 1 Mute Sensor Pair
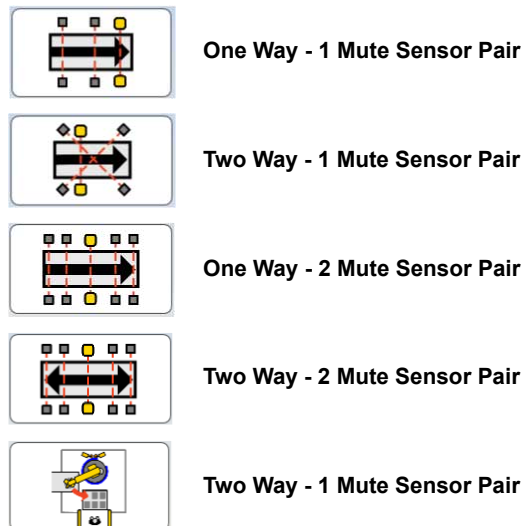
Figure 26. Muting Block—Function Types
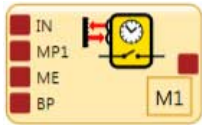
There are 2 types of Mute Bypass:
▪ Mute Dependent Override
▪ Bypass (normal)

In the Mute Block Properties menu in the Advanced settings, if the Bypass check box is checked, the option to select a Bypass or a Mute Dependent Override is possible.

The Mute Dependent Override is used to temporarily restart an incomplete mute cycle (for example after the mute time limit expires). In this case, one or more mute sensors must be activated while the safeguard is in the Stop state.

The normal Bypass is used to temporarily bypass the safeguarding device to keep on or turn on the output of the function block.
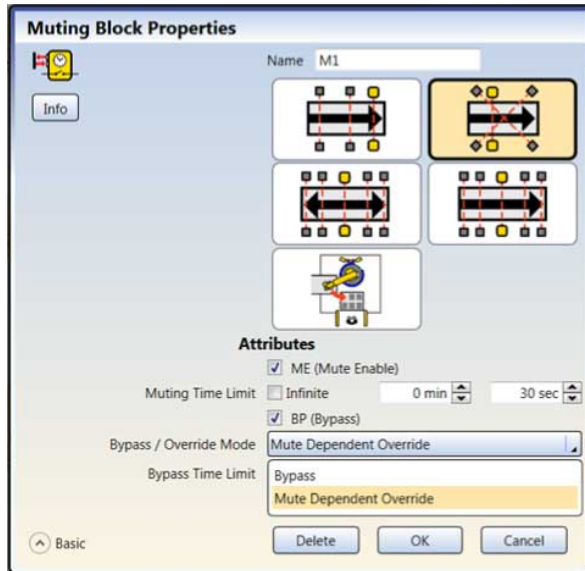
Figure 27. Muting Block—Bypass/Override Mode Options
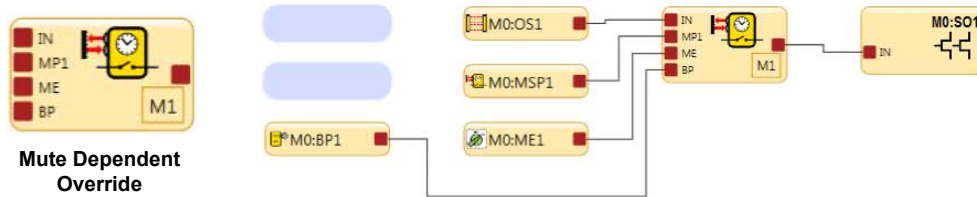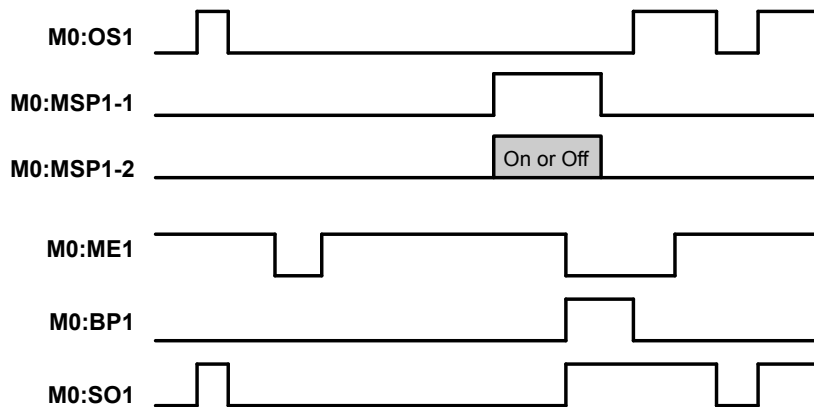
Figure 28. Mute-Dependent Override
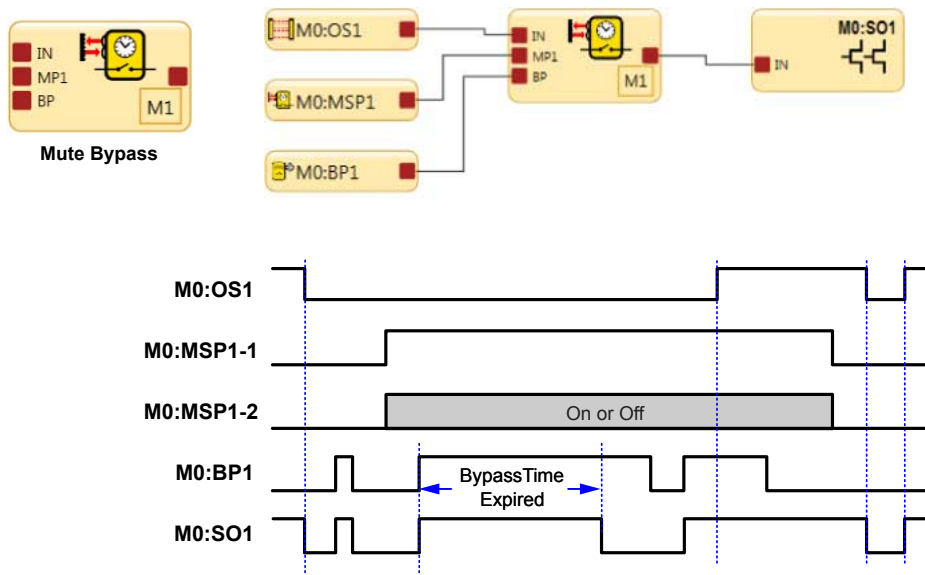
Figure 29. Mute Bypass
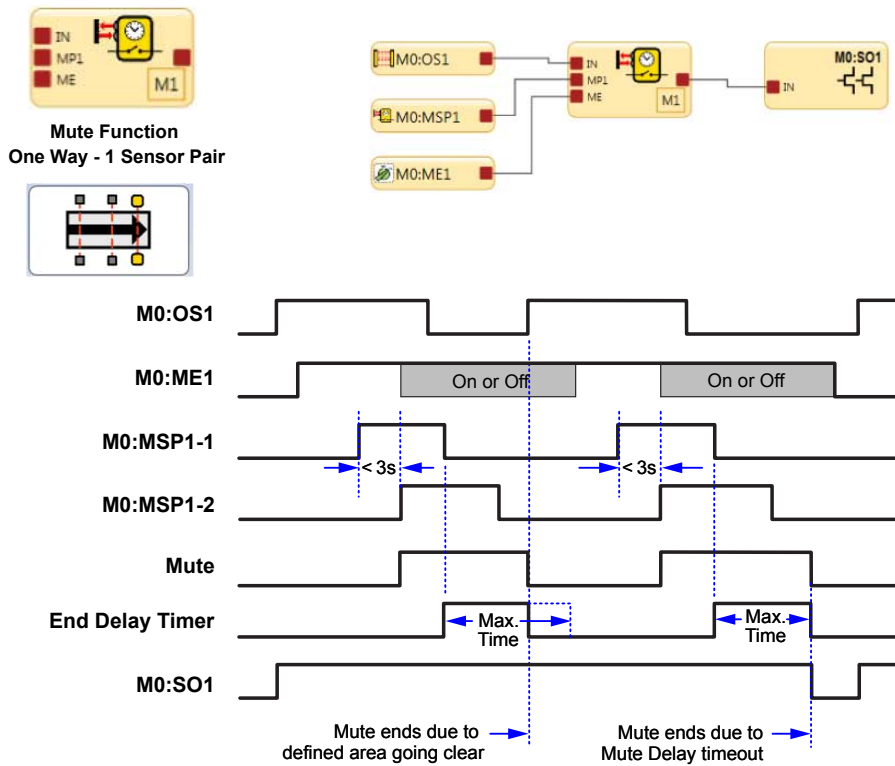
Note: MO:OS1 must be blocked before either MSP1-1 or MSP1-2 clears.

Figure 30. Timing Diagram—One-Way Muting Block, One Muting Sensor Pair

**Mute Function
One Way - 2 Sensor Pair**
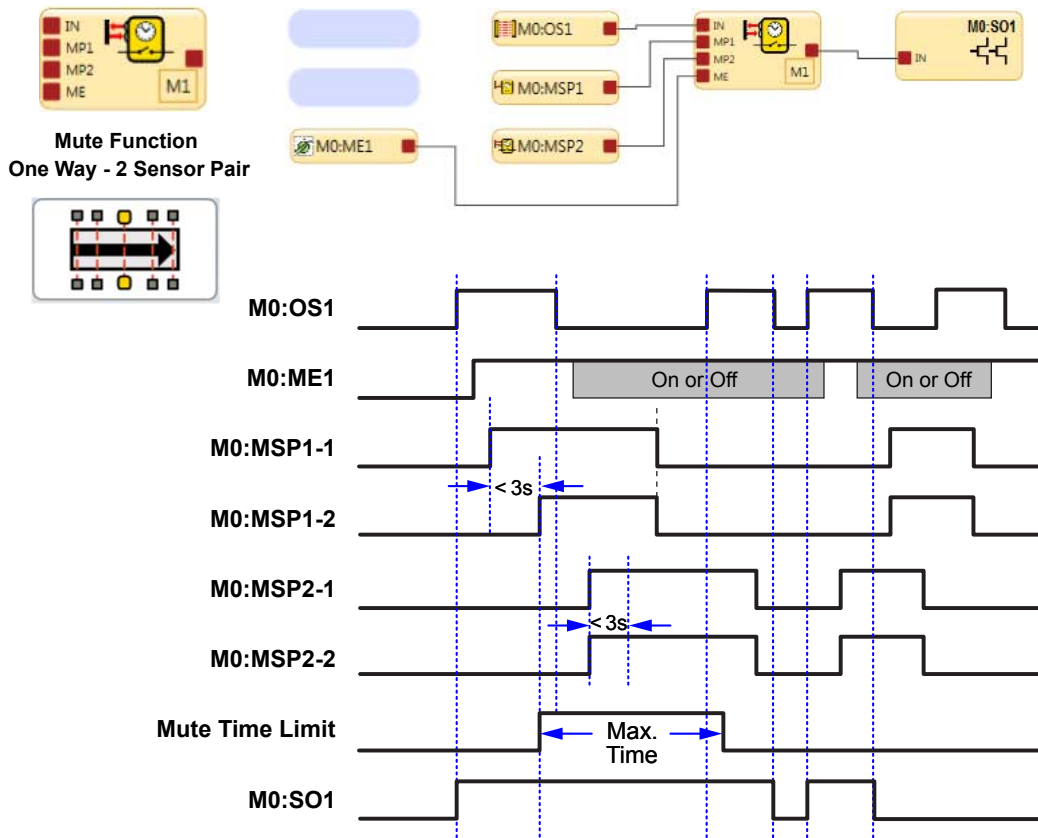
Figure 31. Timing Diagram—One-Way Muting Block, Two Muting Sensor Pairs

**Mute Function
Two Way - 1 Sensor Pair**
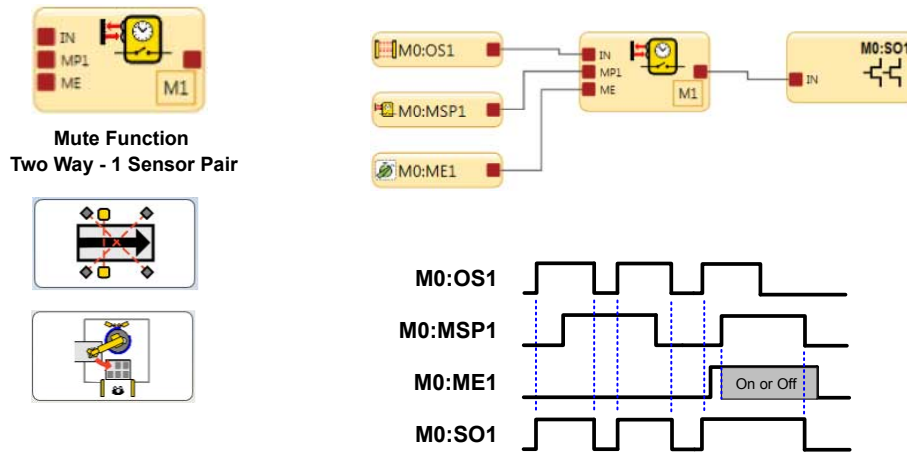
Figure 32. Timing Diagram—Two-Way Muting Block, One Muting Sensor Pair
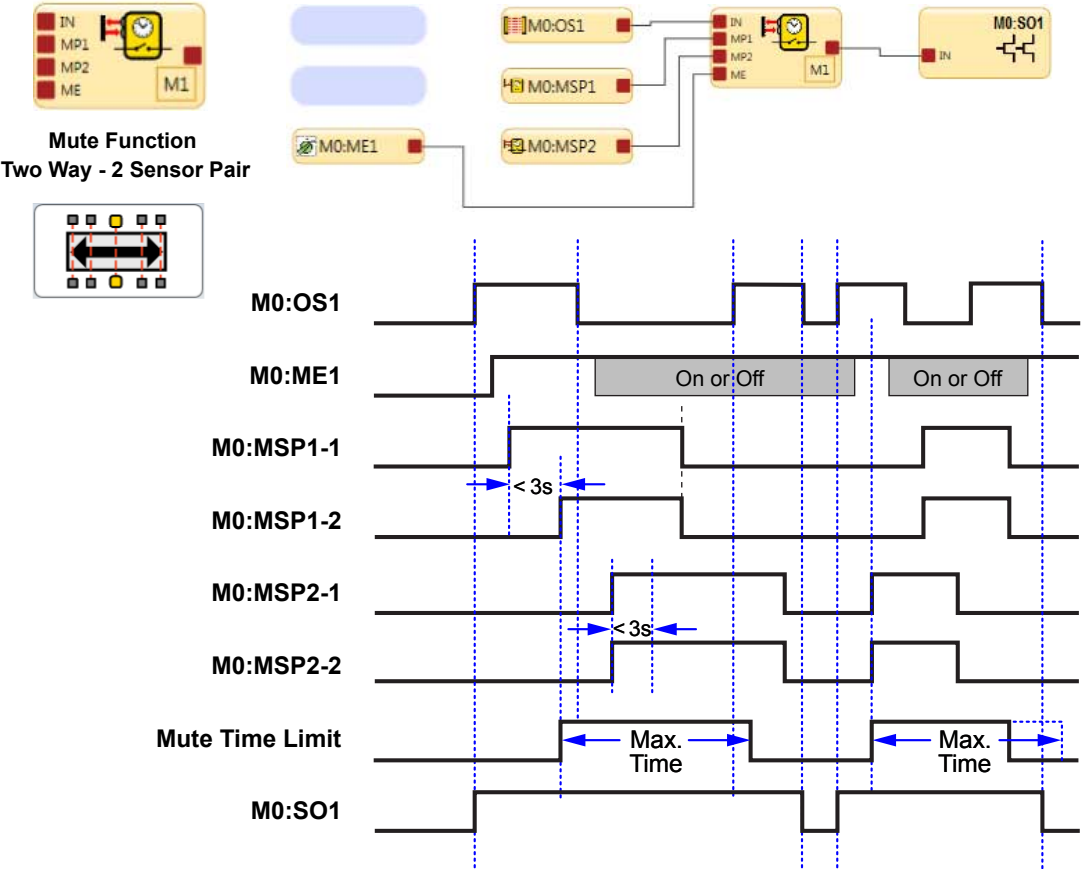
Figure 33. Timing Diagram—Two-Way Muting Block, Two Muting Sensor Pairs

⚠ WARNING   **E-Stop Button control authority when using the Mute function**

Improper E-Stop Control
NOT RECOMMENDED
The configuration top right shows OS1 and E-Stop button ES1 with a Latch Reset LR1 connected to a mute function via the AND function. In this case both ES1 and OS1 will be muted.

If there is an active mute cycle in progress and the E-Stop button is pressed (switched to the Stop state), SO1 will not turn Off. This will result in a loss of safety control and may lead to a potential hazardous condition.
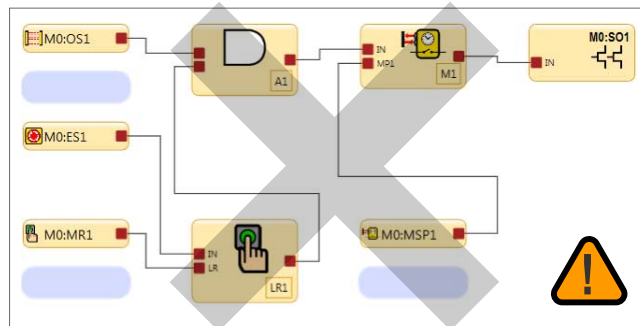
Proper E-Stop Control
The configuration to the right shows OS1 connected directly to the Mute block M1. M1 and ES1 are both inputs to AND A1. In this case both M1 and ES1 control SO1.

If there is a an active mute cycle in progress and the E-Stop button is pressed (switched to the Stop state), SO1 will turn Off.
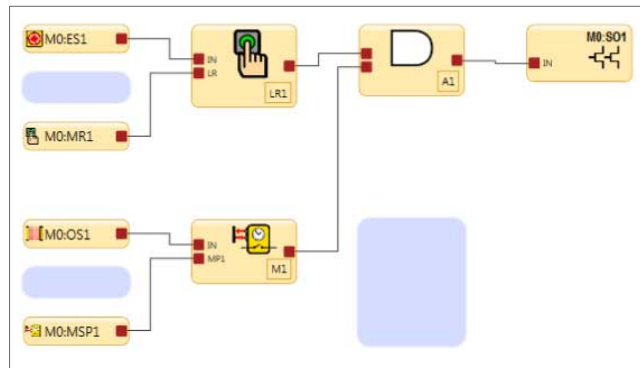
Figure 34. Emergency Stop and Mute Function

E-stop buttons, rope pulls, enabling devices, external device monitoring, and bypass switches are non-mutable devices or functions.

To mute the primary safeguard appropriately, the design of a muting system must:

1. Identify the non-hazardous portion of the machine cycle
2. Involve the selection of the proper muting devices
3. Include proper mounting and installation of those devices

> ⚠ WARNING: Mute and Bypass
>
> Mute and Bypass **operations** must be done in a way that minimizes personnel risk. Implement the following when creating mute and bypass applications:
>
> • Guard against unintended stop signal suspension by using one or more diverse-redundant mute sensor pairs or a dual channel key-secured bypass switch.
> • Set reasonable **time** limits (no longer than needed) for the mute and bypass functions.
>
> Failure to follow these rules could lead to an unsafe **condition** that may result in serious injury or death.

The Safety Controller can monitor and respond to redundant signals that initiate the mute. The mute then suspends the safeguarding function by ignoring the state of the input device to which the muting function has been assigned. This allows an object or person to pass through the defined area of a safety light screen without generating a stop command. This should not be confused with blanking, which disables one or more beams in a safety light screen resulting in larger resolution.

The mute function may be triggered by a variety of external devices. This feature provides a variety of options to design the system to meet he requirements of a specific application.

A pair of muting devices must be triggered simultaneously (within 3 seconds of one another). This reduces the chance of common mode failures or defeat. Directional muting, in which sensor pair 1 is required to be blocked first, also may reduce the possibility of defeat.

At least two mute sensors are required for each muting operation. The muting typically occurs 100 ms after the second mute sensor input has been satisfied. One or two pairs of mute sensors can be mapped to one or more safety input devices so that their assigned safety outputs can remain On to complete the operation.

⚠️ WARNING: **Muting Limitations**

Muting is allowed only during the non-hazardous portion of the machine cycle.

A muting application must be designed so that no single component failure can prevent the stop command or allow subsequent machine cycles until the failure is corrected.

⚠️ WARNING: Mute Inputs Must Be Redundant

It is not acceptable to use a single switch, device, or relay with two N.O. contacts for the mute inputs. This single device, with multiple outputs, may fail so that the System is muted at an inappropriate time. This may result in a hazardous **situation.**

Optional Muting Attributes

The Muting Sensor Pair Input and the Muting Block have several optional functions that can be used to minimize an unauthorized manipulation and the possibility of an unintended mute cycle.

Mute Enable (ME)

The Mute Enable input is a non-safety-rated input. When the input is closed, or active for virtual input, the Safety Controller allows a mute condition to occur; opening this input while the System is muted will have no effect.

Typical uses for Mute Enable include:
- Allowing the machine control logic to create a period of time for muting to begin
- Inhibiting muting from occurring
- Reducing the chance of unauthorized or unintended bypass or defeat of the safety system

The optional Mute Enable function may be configured to ensure that a mute function is permitted only at the appropriate time. If a Mute Enable input device has been mapped to a Muting Block, the safety input device can be muted only if the mute enable switch is in the enable (24V dc) state, or active state for virtual input, at the time the mute cycle is started. A mute enable input device can be mapped to one or more Muting Blocks.
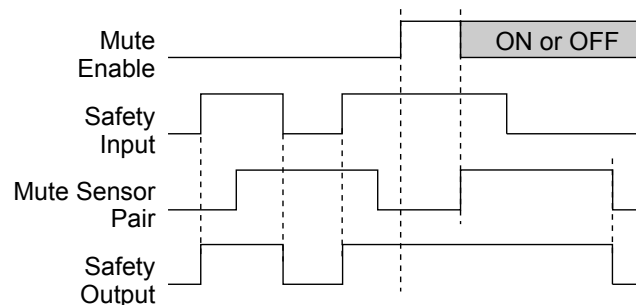
Figure 35. Timing logic—One mute sensor pair with mute enable

Simultaneity Timer Reset Function

The Mute Enable input can also be used to reset the simultaneity timer of the mute sensor inputs. If one input is active for longer than three seconds before the second input becomes active, the simultaneity timer prevents a mute cycle from occurring. This could be due to a normal stoppage of an assembly line that may result in blocking one mute device and the simultaneity time running out.

If the ME input is cycled (closed-open-closed or active-inactive-active for virtual input) while one mute input is active, the simultaneity timer is reset, and if the second mute input becomes active within three seconds, a normal mute cycle begins. The function can reset the timer only once per mute cycle (all mute inputs M1-M4 must open before another reset can occur).

Bypass

An optional Bypass/Override Mode may be enabled by checking the BP (Bypass) box in the **Muting** Block properties window. There are two available Bypass/Override Modes—Bypass and Mute Dependent Override. The Bypass mode is used to temporarily bypass the safeguarding device to keep on or turn on the output of the function block. The Mute Dependent Override mode is used to manually override an incomplete mute cycle (for example after the mute time limit expires). In this case, one or more mute sensors must be activated while the safeguard is in the Stop state to initiate the override.

Mute Lamp Output (ML)

Depending on a risk assessment and relevant standards, some applications require that a lamp (or other means) be used to indicate when the safety device, such as a light screen, is muted. The Safety Controller provides a signal that the protective function is suspended through the Mute status output.

☞ Important: Mute Status **Indication**

Indication that the safety device is muted must be provided and be readily observable from the location of the muted safety device. Operation of the indicator may need to be verified by the operator at suitable intervals.

Muting Time Limit

The muting time limit allows the user to select a maximum period of time that muting is allowed to occur. This feature hinders the intentional defeat of the muting devices to initiate an inappropriate mute. It is also useful for detecting a common mode failure that would affect all mute devices in the application. The time limit can be adjusted from 1 second to 30 minutes. The mute time limit may also be set to **Infinite** (disabled).

The timer begins when the second muting device makes the simultaneity requirement (within 3 seconds of the first device). After the timer expires, the mute ends despite what the signals from the mute devices indicate. If the input device being muted is in an Off state, the corresponding Muting Block output turns off.

⚠ WARNING: **Muting** Time Limit

An infinite time for the Muting Time Limit should be selected only if the possibility of an inappropriate or unintended mute cycle is minimized, as determined, and allowed by the machine's risk assessment. The user is responsible to make sure that this does not create a hazardous situation.

Mute **Off-Delay** Time

A delay time may be established to extend the Mute state up to the selected time (1, 2, 3, 4, or 5 seconds) after the Mute Sensor Pair is no longer signaling a muted condition. Off-delay is typically used for Safety Light Screen/Grid workcell "Exit Only" applications with mute sensors are located only on one side of the defined area. The Muting Block output will remain On for up to 5 seconds after the first mute device is cleared, or until the muted Safety Input device (Mute Block In) returns to a Run state, whichever comes first.

Mute on Power-Up

This function initiates a mute cycle after power is applied to the Safety Controller. If selected, the Mute on Power-Up function will initiate a mute when:
- The Mute Enable input is On (if configured)
- The safety device inputs are active (in Run mode)
- Mute sensors M1-M2 (or M3-M4, if used, but not all four) are closed

If Auto Power-Up is configured, the Controller allows approximately 2 seconds for the input devices to become active to accommodate systems that may not be immediately active at power-up.

If Manual Power-Up is configured and all other conditions are satisfied, the first valid Power-Up Reset after the muted safety inputs are active (Run state or closed) will result in a mute cycle. The Mute On Power-up function should be used only if safety can be assured when the mute cycle is expected, and the use of this function is the result of a risk assessment and is required by that particular machine operation.

⚠ WARNING: The Mute on Power-Up should be used only in applications where:
- Muting the System (MP1 and MP2 closed) when power is applied is required
- Using it does not, in any situation, expose personnel to hazard

Mute Sensor Pair Debounce Times

The input debounce times, accessible under the Advanced settings in the Mute Sensor Pair properties window, may be used to extend a mute cycle after a mute sensor signal is removed. By configuring the close-to-open debounce time, the mute cycle may be extended up to 1.5 seconds (1500 ms) to allow the Safety Input Device to turn On. The start of the mute cycle can also be delayed by configuring the open-to-close debounce time.

Muting Function Requirements

The beginning and the end of a mute cycle is triggered by signals from a pair of muting devices. The muting device circuit options are configurable and shown in the Mute Sensor Pair **Properties** window. A proper mute signal occurs when both channels of the mute device change to the Mute Active states while the muted safeguard is in the Run state.

The Controller monitors the mute devices to verify that their outputs turn ON within 3 seconds of each other. If the inputs do not meet this simultaneity requirement, a mute condition cannot occur.

Several types and combinations of mute devices can be used, including, but not limited to photoelectric sensors, inductive proximity sensors, limit switches, positive-driven safety switches, and whisker switches.

Corner Mirrors, Optical Safety Systems, and Muting

Mirrors are typically used with safety light screens and single-/multiple-beam safety systems to guard multiple sides of a hazardous area. If the safety light screen is muted, the safeguarding function is suspended on all sides. It must not be possible for an individual to enter the guarded area without being detected and a stop command issued to the machine control. This supplemental safeguarding is normally provided by an additional device(s) that remains active while the Primary Safeguard is muted. Therefore, mirrors are typically not allowed for muting applications.

Multiple Presence-Sensing Safety Devices

Muting multiple presence-sensing safety devices (PSSDs) or a PSSD with multiple sensing fields is not recommended unless it is not possible for an individual to enter the guarded area without being detected and a stop command issued to the machine control. As with the use of corner mirrors (see *Corner Mirrors, Optical Safety Systems, and Muting* on page 42), if multiple sensing fields are muted, the possibility exists that personnel could move through a muted area or access point to enter the safeguarded area without being detected.

For example, in an entry/exit application where a pallet initiates the mute cycle by entering a cell, if both the entry and the exit PSSDs are muted, it may be possible for an individual to access the guarded area through the "exit" of the cell. An appropriate solution would be to mute the entry and the exit with separate safeguarding devices.

> ⚠️ WARNING: Guarding **Multiple** Areas
>
> Do not safeguard **multiple** areas with mirrors or **multiple** sensing **fields,** if personnel can enter the hazardous area while the System is muted, and not be detected by supplemental safeguarding that will issue a stop command to the machine.

Two-Hand Control Block

Default Nodes	**Additional** Nodes	Notes
TC (up to 4 TC nodes)	IN MP1 ME	Two-Hand Control inputs must connect either directly to a Two-Hand Control Block or indirectly through a Bypass Block connected to a Two-Hand Control Block. It is not possible to use a Two-Hand Control input without a Two-Hand Control Block.

Two-Hand Control Function Block
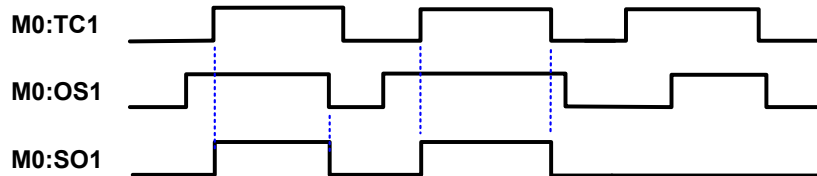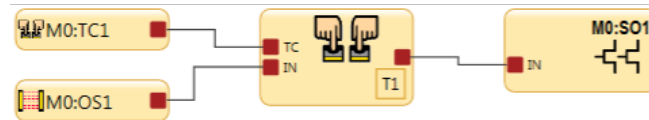
Either the TC1 input or the OS1 input has turn Off authority.
OS1 needs to be in the Run state before TC1 can turn the output of T1 & SO1 On.

Figure 36. Timing Diagram—Two-Hand Control Block
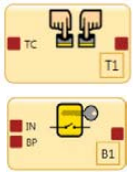
Two-Hand Control & Bypass Function Blocks
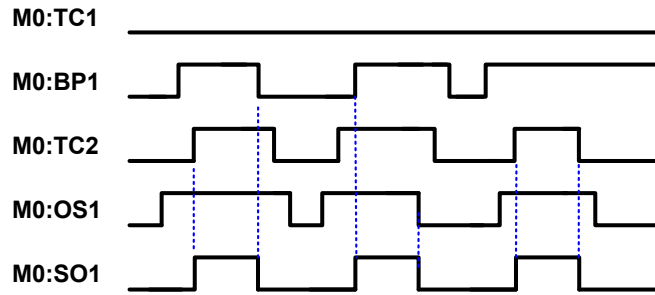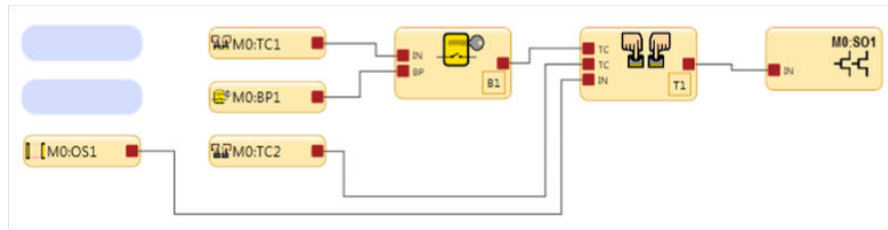
The Two-Hand Control actuators TC2 and the Bypass Switch BP1 need to be in the Run state and need to be the last devices in time to transition to the Run state for the TC1 function block to turn On.

Figure 37. Timing Diagram—Two-Hand Control Block and Bypass Blocks
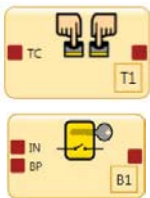
Two-Hand Control & Bypass Function Blocks
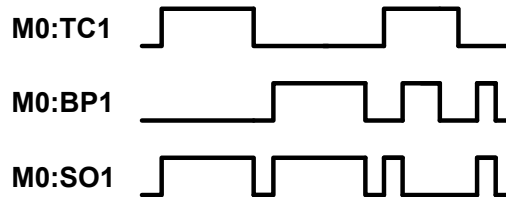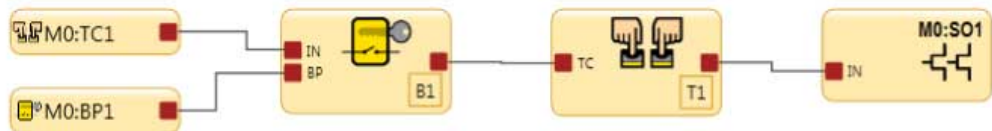
If both TC1 actuators and the BP1 Bypass switch active at the same time, the B1 Bypass function block output and the Two-Hand Control function block output turn Off.
The outputs for B1 and T1 will only turn On when either the TC1 actuators or the BP1 switch are in the Run state.

Figure 38. Timing Diagram—Two-Hand Control Block and Bypass Blocks with 1 Two-Hand Control Input

**Two-Hand Control &
Bypass Function Blocks**
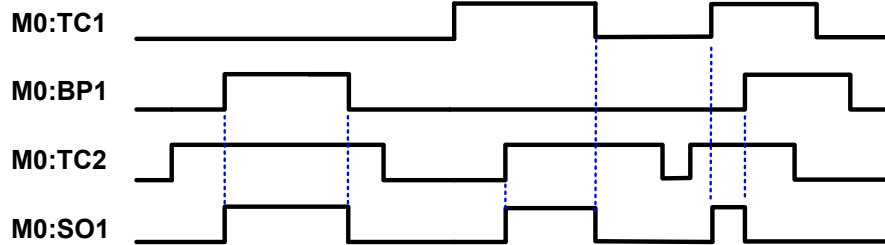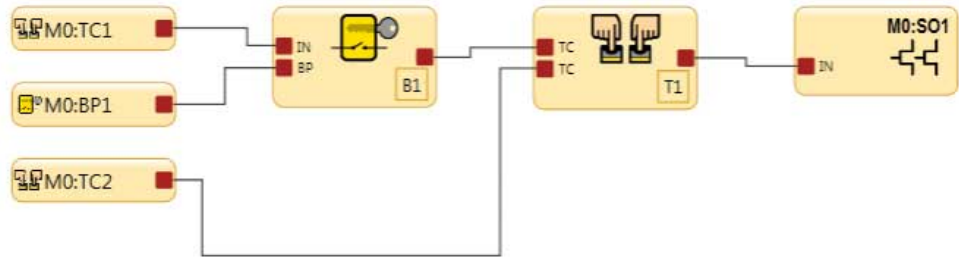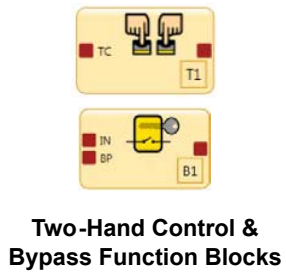
The Bypass function can be used with the TC2 actuators to turn the Safety Output On.

When the TC1 actuators are not bypassed they must be used along with the TC2 actuators to turn the Safety Output On. If the TC1 actuators and the Bypass switch are both in the Run state, TI and SO1 cannot be turned On or will turn Off.

Figure 39. Timing Diagram—Two-Hand Control Block and Bypass Blocks with 2 Two-Hand Control Inputs
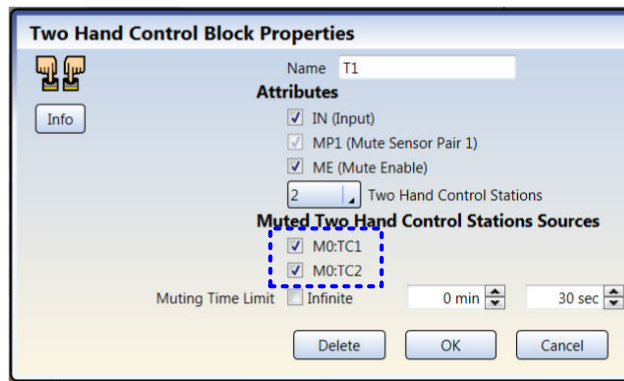
To configure the Two-Hand Control mute option, the TC actuators first need to be connected to the Two-Hand Control function block in the Function View. Check boxes (blue square above) in the Properties menu will display the names of all TC actuator input devices. Only those THC station boxes that are checked will be muted.

Figure 40. Two-Hand Control Muting Options

**Two Hand Control
with Muting**
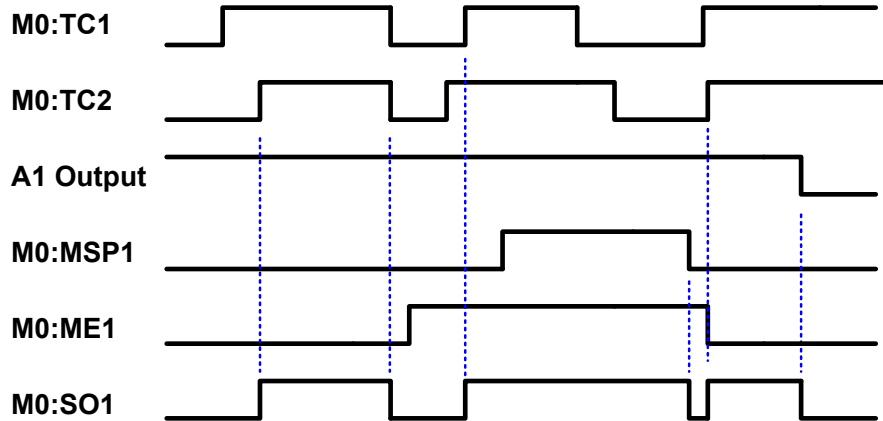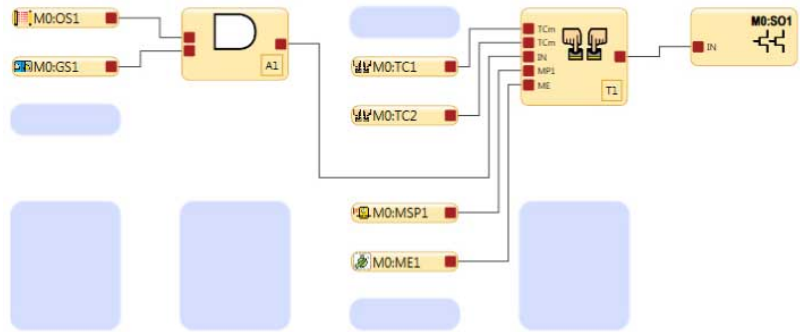
Actuators TC1 and TC2 can initiate a two-hand cycle if the mute enable ME1 is not active.
ME1 must be active for the MSP1 mute sensors to keep the SO On after the TC1 and TC2 actuators are in the Stop state.

Figure 41. Timing Diagram—Two-Hand Control Block with Muting

Two-Hand Control **Activation** on Power-Up **Protection.** The Controller's two-hand control logic does not permit the assigned safety output to turn On when power is initially supplied while the THC actuators are in their Run state. The THC actuators must change to their Stop state and return to the Run state before the Safety Output can turn On. A Safety Output associated with a Two-Hand Control device will not have a manual reset option.

Delay Block (FID 2 Only)

The Delay Block allows a user-configurable ON or OFF delay on a maximum of 5 minutes, in 1 ms increments.

Default Nodes	**Additional** Nodes	Notes
IN	-	Depending on the selection, a signal/state transition on the input node will be delayed by the output delay time by either holding the output OFF (ON Delay) or holding the output ON (OFF Delay) after a signal transition.

Note: The actual delay time of a delay function block or a safety output with a delay can be up to 1 scan time longer than the delay setting. Multiple delay blocks or delay outputs in series will increase the final delay time by up to 1 scan for each delay function. For example, three 100 ms off delay function blocks in series and a scan time of 15 ms may result in an actual delay time of up to 345 ms (300 ms + 45 ms).

The Cancel Delay Node is a configurable node if Off Delay is selected.
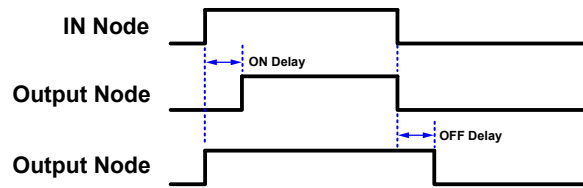
Figure 42. Delay Block Timing Diagram

⚠️ CAUTION: Delay **time effect** on response **time**

The off delay time may significantly increase the safety control response time. This will impact the positioning of safeguards whose installation is determined by the safety (minimum) distance formulas or are otherwise influenced by the amount of time to reach a non-hazardous state. The installation of safeguards must account for the increase in response time.

Note: The response time provided on the Configuration Summary is a maximum time that can change depending on the use of delay blocks and other logic blocks (such as OR functions). It is the user's responsibility to determine, verify, and incorporate the appropriate response time.
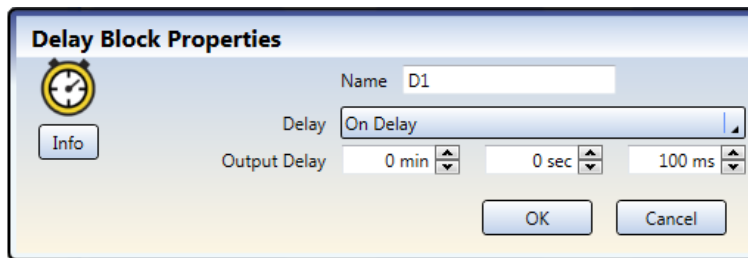
Figure 43. Delay Block Properties

The Delay Block **Properties** window allows the user to configure the following:

Name

The input designation.

Safety Output Delay

- None
- **Off** Delay
- On Delay

Output Delay

Available when the Safety Output Delay is set to either Off Delay or On Delay

Delay time: 0 to 5 minutes, in 1 ms increments.

Cancel Type

Available when the Safety Output Delay is set to Off Delay.

- Do Not Cancel
- Control Input
- Cancel Delay Node

End Logic

Available when the Cancel Type is set to Cancel Delay Node.

- Keep Output On
- Turn Output Off

4.8.3 Error Codes

The following table lists error codes that are encountered when attempting to make an invalid connection between blocks on the **Functional** View.

PC Interface Code	Error
A.1	This connection creates a loop.
A.2	A connection from this block already exists.

PC Interface Code	Error
A.3	Connecting a block to itself is not allowed.
B.2	This Bypass Block is connected to a Two-Hand Control Block. You can connect only a Two-Hand Control input to the IN node.
B.3	This Bypass Block is already connected to another block.
B.4	This Bypass Block is connected to the TC node of a Two-Hand Control Block and cannot be connected to any other blocks.
B.5	Cannot connect Two-Hand Control Block to the IN node of this Bypass Block because it has the "Output turns Off when both inputs (IN and BP) are On" option enabled.
B.6	The IN node of a Bypass Block cannot be connected to Emergency Stop and Rope Pull inputs.
B.7	The IN node of a Bypass Block cannot be connected to Emergency Stop and Rope Pull inputs via other blocks.
C.1	Only a Cancel Off Delay input can be connected to the CD node.
C.2	A Cancel Off Delay input can be connected only to the CD node of a Safety Output.
D.1	This External Device Monitoring input is configured for a Dual-Channel 2 Terminal circuit and can be connected only to the EDM node of a Safety Output.
E1	The Enabling Device Block output nodes (P or S) can be connected only to the IN node of a Safety Output.
E.2	The IN node of an Enabling Device Block cannot be connected to Emergency Stop and Rope Pull inputs.
E.3	The ED node of an Enabling Device Block can be connected only to an Enabling Device input.
E.4	The ED node of an Enabling Device Block cannot be connected to Emergency Stop and Rope Pull inputs via other blocks.
E.5	An Enabling Device Block that has a Two-Hand Control input connected to the IN node cannot be connected to a Safety Output that has *Safety Output Delay* set to "Off Delay".
E.6	The secondary output node S of an Enabling Device Block can be connected only to the IN node of a Safety Output.
F.1	Emergency Stop and Rope Pull inputs cannot be muted.
F.2	Emergency Stop and Rope Pull inputs cannot be connected to a Latch Reset Block that is connected to a Muting Block.
F.3	A Latch Reset Block that is connected to an Emergency Stop or a Rope Pull input cannot be connected to a Muting Block.
G.1	Only a Manual Reset input can be connected to the FR node of a Safety Output.
G.2	Only a Manual Reset input can be connected to the LR node of a Latch Reset Block or Safety Output.
G.3	Only a Manual Reset input can be connected to the RST node of an Enabling Device Block.
G.4	A Manual Reset input can be connected only to LR and FR nodes of a Safety Output, an LR node of a Latch Reset Block, an RST node of an Enabling Device Block, and SET and RST nodes of the Flip-Flop Blocks.
H.1	This Latch Reset Block is already connected to another function block.
H.2	This Latch Reset Block cannot be connected to any other input nodes.
I.1	Only Muting Sensor Pair, Optical Sensor, Gate Switch, Safety Mat, or Protective Stop inputs can be connected to the MP1 and MP2 nodes of a Muting Block or to the MP1 node of a Two-Hand Control Block.
I.2	The MP1 and MP2 nodes of a Muting Block and the MP1 node of a Two-Hand Control Block can be connected to inputs that are using only Dual-Channel circuits.
I.3	A Muting Sensor Pair input can be connected only to MP1 and MP2 nodes of a Muting Block or the MP1 node of a Two-Hand Control Block.
J.1	A Two-Hand Control Block can be connected only to an Enabling Device Block (IN node) or a Safety Output (IN node).
J.3	Only Two-Hand Control inputs or Bypass Blocks with Two-Hand Control inputs connected to them can be connected to the TC node of a Two-Hand Control Block.
K.1	A Two-Hand Control input can be connected only to a Two-Hand Control Block (TC node) or Bypass Block (IN node).
K.2	A Safety Output that has *Safety Output Delay* set to "Off Delay" cannot be connected to a Two-Hand Control Block.
K.3	A Safety Output that has *Safety Output Delay* set to "Off Delay" cannot be connected to a Two-Hand Control Block via an Enabling Device Block.
L.1	This Safety Output is disabled because a Status Output is using its terminals.
L.2	The IN node of a Safety Output cannot be connected to External Device Monitoring, Adjustable Valve Monitor, Mute Sensor Pair, Bypass Switch, Manual Reset, Mute Enable, or Cancel Off Delay inputs.
L.3	A Safety Output block that has *LR (Latch Reset)* function enabled cannot be connected to Two-Hand Control Blocks or Enabling Device Blocks.
L.4	A Safety Output block that has *Power up Mode* set to "Manual Reset" cannot be connected to Two-Hand Control Blocks or Enabling Device Blocks.

4.9 Designing the Control Logic

To design the control logic:

1. Add the desired Safety and Non-Safety Inputs:

   - On the Equipment view: click ✛ under the module to which the input will be connected (the module can be changed in the input **Properties** window)
   - On the **Functional** View: click any of the empty placeholders in the left column

   See *Adding Inputs and Status Outputs* on page 22 for more information and device properties.

2. Add Logic and/or **Function** Blocks (see *Logic Blocks* on page 26 and *Function Blocks* on page 27) by clicking any of the empty placeholders in the middle area.

   > Note: The response time of the Safety Outputs can increase if a large number of blocks are added to the configuration. Use the function and logic blocks efficiently to achieve the optimum response time.

3. Create the appropriate connections between added inputs, **Function** and Logic Blocks, and Safety Outputs.

   > Note: The Check List on the left displays connections that are required for a valid configuration and all items must be completed. The controller will not accept an invalid configuration.

   > Tip: To aid with creating a valid configuration, the program displays helpful tooltips if you attempt to make an invalid connection.

4.10 Industrial Ethernet

Figure 44. Industrial Ethernet view

The Industrial Ethernet view of the PC Interface allows configuration of the Virtual Status Outputs, which offer the same functionality as Status Outputs (added on the Equipment view) over the network (see *Status Output Signal Conventions* on page 106 and *Status Output Functionality* on page 106 for detailed information). Up to 64 Virtual Status Outputs can be added for any configuration using Modbus/TCP, EtherNet/IP Input Assemblies, EtherNet/IP Explicit Messages, and PCCC protocols on FID 1 Base Controllers and up to 256 virtual Status Outputs can be added on FID 2 Base Controllers. FID 2 Base Controllers can also use PROFINET.

To access the Industrial Ethernet view:

1. Click Network **Settings**.
2. Select Enable Network Interface.
3. Adjust any settings, if necessary (see *Network Settings: Modbus/TCP, Ethernet/IP, PCCC* on page 50 or *Network Settings: PROFINET (FID 2 Only)* on page 51).
4. Click OK.

Use the Auto **Configure** function, located on the Industrial Ethernet view of the PC Interface, to automatically configure the Virtual

Status Outputs to a set of commonly used functions, based on the current configuration. Click ⊹ in the **Function** column next to any of the VOx cells to add a Virtual Status Output manually. Functions of all Virtual Status Outputs can be modified by clicking on the button that contains the name of the function of the Virtual Status Output or by clicking Edit under the **Properties** table when VOx is selected.

4.10.1 Network **Settings**

Network **Settings:** Modbus/TCP, Ethernet/IP, PCCC
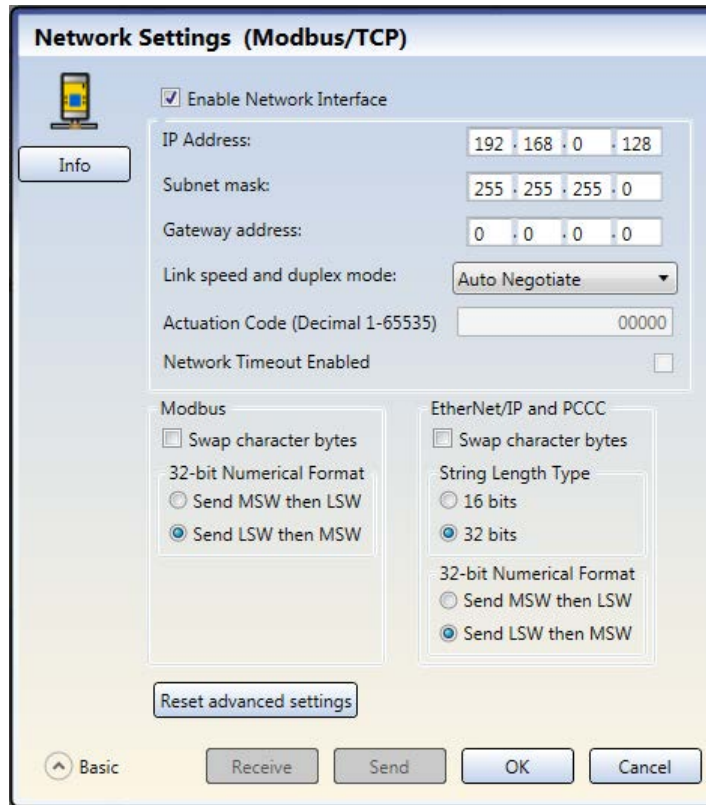
Figure 45. Network Settings

Click Network **Settings** on the PC Interface to open the Network Settings window. In the case of a Modbus/TCP connection, the default TCP port used is 502, by specification. This value is not shown in the Network **Settings** window.

Table 1: Default Network Settings

Setting Name	Factory Default Value
IP Address	192.168.0.128
Subnet Mask	255.255.255.0
Gateway Address	0.0.0.0
Link Speed and Duplex Mode	Auto Negotiate

The Advanced option allows further configuration of Modbus/TCP and EtherNet/IP settings, such as Swap character bytes, MSW and LSW sending precedence, and String Length Type (EtherNet/IP and PCCC).

Click Send to write the network settings to the controller. Network settings are sent separately from the configuration settings.

Click Network Timeout Enabled to have any configured Virtual On/Off or Virtual Mute Enable become inactive in the event of a network timeout condition. The network timeout time is fixed at 5 seconds.

Network Settings: PROFINET (FID 2 Only)

Click Network Settings on the PC Interface to open the Network Settings window.
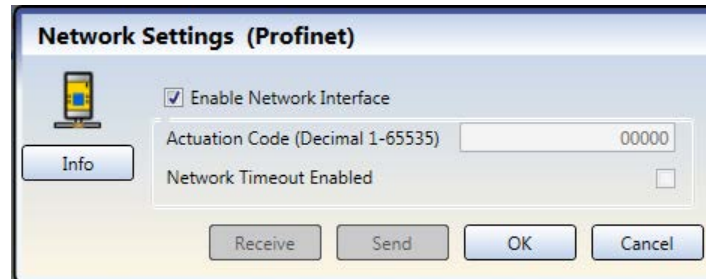
Figure 46. Network Settings—PROFINET

Click Send to write the network settings to the controller. Network settings are sent separately from the configuration settings.

Click Network Timeout Enabled to have all configured Virtual On/Off or Virtual Mute Enable become inactive in the event of a network timeout condition. The network timeout time is fixed at 5 seconds.

4.10.2 EtherNet/IP Assembly Objects

Note: The EDS file is available for download at *www.bannerengineering.com.*

Input (T->O) Assembly Objects

Instance ID	Data Length (16-bit words)	Description
100 (0x64)	8	Used to access the basic information about the Virtual Status Outputs 1 - 64.
101 (0x65)	104	Used to access the advanced information (including the basic information) about the Virtual Status Outputs
102 (0x66)	150	Used to access the fault log information and provides no Virtual Status Output information
103 (0x67)	35	Used to access the basic information about Virtual Status Outputs 1 - 256 and feedback information about Virtual Reset and Virtual Cancel Delay inputs. Available on FID 2 Base Controllers.

Output (O->T) Assembly Object

Instance ID	Data Length (16-bit words)	Description
112 (0x70)	2	Reserved
113 (0x70)	11	Used to control Virtual Inputs (On/Off, Mute Enable, Reset, Cancel Delay). Available on FID 2 Base Controllers.

Configuration Assembly Object

The Configuration Assembly Object is not implemented. However, some EtherNet/IP clients require one. If this is the case, use Instance ID 128 (0x80) with a data length of 0.

Set the Data Type of the communication format to INT.

Set the RPI (requested packet interval) to a minimum of 150.

4.10.3 Industrial Ethernet - Table Row and Column Descriptions

The following are table row and column descriptions (listed in alphanumeric order) for the register maps found in Industrial Ethernet view of the PC Interface and *Fault Log Support Tables* on page 53.

Table 2: Data Types

Data Type	Description
UINT	Unsigned integer—16 bits
UDINT	Unsigned double integer—32 bits
Word	Bit string—16 bits
Dword	Bit string—32 bits
String	Two ASCII characters per Word (see protocol-based String information below)
Octet	Reads as each byte translated to decimal separated by a dot
Hex	Reads as each nibble translated to hex, paired, and then separated by a space
Byte	Bit string—8 bits

Byte:Bit

Indicates the byte offset followed by the specific bit.

Fault Flag

If the particular input or output being tracked causes a lockout, a flag associated with that virtual output will be set to 1. In Modbus/TCP, this can be read as a discrete input, input register, or holding register.

Fault Index

If the Fault Flag bit is set for a virtual output, the Fault Index will contain a number, which translates to a Fault Code. For example, a Fault Index 41, can contain a number 201, which translates to the Fault Code 2.1; the number 412 would translate to the Fault Code 4.12 (see *Fault Code Table* on page 118 for more information).

Function

The function that determines the state of that virtual output.

Operating Mode

Operating Mode Value	Description
1 (0x01)	Normal Operating Mode (including I/O faults, if present)
2 (0x02)	Configuration Mode
4 (0x04)	System Lockout
65 (0x41)	Waiting For System Reset/Exiting Configuration Mode
129 (0x81)	Entering Configuration Mode

Reg:Bit

Indicates the offset from 30000 or 40000 followed by the specific bit in the register.

Reserved

Registers that are reserved for internal use.

Seconds Since boot

The time in seconds since power was applied to the Safety Controller. May be used in conjunction with the Timestamp in the Fault Log and a real time clock reference to establish the time when a fault occurred.

String (EtherNet/IP and PCCC Protocol)

The default format EtherNet/IP string format has a 32 bit length preceding the string (suitable for ControlLogix). When configuring the Network Settings using the PC Interface, you can change this setting to a 16 bit length which corresponds to the standard CIP "String" under the Advanced menu. However, when reading an Input Assembly that includes a string with a 16 bit length, the string length will be preceded by an extra 16 bit word (0x0000).

The string itself is packed ASCII (2 characters per word). In some systems, the character order may appear reversed or out of order. For example, the word "System" may read out as "yStsme". Use "*Swap character bytes*" option under the Advanced menu in the Network Settings window to swap characters so words read correctly.

String (Modbus/TCP Protocol)

The string format is packed ASCII (2 characters per word). In some systems, the character order may appear reversed or out of order. For example, the word "System" may read out as "yStsme". Use "*Swap character bytes*" option under the Advanced menu in the Network Settings window to swap characters so words read correctly.

While the string length is provided, it is usually not required for Modbus/TCP systems. If string length is used for Modbus/TCP, the length format corresponds to the settings used for EtherNet/IP.

Timestamp

The time, in seconds, when the fault occurred since power up.

Virtual Status Output

The reference designator associated with a particular Virtual Status Output, for example, VO10 is Virtual Status Output 10.

VO Status

This identifies the location of a bit indicating the status of a Virtual Status Output. In the case of Modbus/TCP, the state of the Virtual Status Output can be read as a discrete input, as part of an input register, or holding register. The register given is the offset from 30000 or 40000 followed by the bit location within the register.

4.10.4 Fault Log Support Tables

Modbus/TCP 3X/4X

Fault Log	Type	Length (Words)	Starting Register
Fault log entry 1 (most recent)	See Fault Log Entry table below	15	233
Fault log entry 2		15	248
Fault log entry 3		15	263
Fault log entry 4		15	278
Fault log entry 5		15	293
Fault log entry 6		15	308
Fault log entry 7		15	323
Fault log entry 8		15	338
Fault log entry 9		15	353
Fault log entry 10 (oldest)		15	368

Fault Log Entry	Type	Length (Words)
Timestamp	UDINT	2
Name Length	DWORD	2
Name String	String	6
Error Code	WORD	1
Advanced Error Code	WORD	1
Error Message Index	WORD	1
Reserved	WORD	2

System Information	Type	Length (Words)	Starting Register
Seconds since boot	UDINT	2	383
Operating mode	WORD	1	385
LengthOfConfigName	DWORD	2	386
ConfigName	String	8	388
Config CRC	WORD	2	396

PCCC

Fault Log	Type	Length (Words)	Starting Register
Fault log entry 1 (most recent)	See Fault Log Entry table below	15	232
Fault log entry 2		15	247
Fault log entry 3		15	262
Fault log entry 4		15	277
Fault log entry 5		15	292

Fault Log	Type	Length (Words)	**Starting** Register
Fault log entry 6		15	307
Fault log entry 7		15	322
Fault log entry 8		15	337
Fault log entry 9		15	352
Fault log entry 10 (oldest)		15	367

Fault Log Entry	Type	Length (Words)	**Starting** Register
Timestamp	UDINT	2	Offset: 0
Name Length	DWORD	2	Offset: 2
Name String	String	6	Offset: 4
Error Code	WORD	1	Offset: 10
Advanced Error Code	WORD	1	Offset: 11
Error Message Index	WORD	1	Offset: 12
Reserved	WORD	2	Offset: 13

System **Information**	Type	Length (Words)	**Starting** Register
Seconds since boot	UDINT	2	382
Operating mode	WORD	1	384
LengthOfConfigName	DWORD	2	385
ConfigName	String	8	387
Config CRC	WORD	2	395

EtherNet/IP Explicit Messages

Fault Log	Type	Length (Words)	Class 0x71 Instance 1 **Attribute**
Fault log entry 1 (most recent)		15	1
Fault log entry 2		15	2
Fault log entry 3		15	3
Fault log entry 4		15	4
Fault log entry 5		15	5
Fault log entry 6	See Fault Log Entry table below	15	6
Fault log entry 7		15	7
Fault log entry 8		15	8
Fault log entry 9		15	9
Fault log entry 10 (oldest)		15	10

Fault Log Entry	Type	Length (Words)
Timestamp	UDINT	2
Name Length	DWORD	2
Name String	String	6
Error Code	WORD	1
Advanced Error Code	WORD	1
Error Message Index	WORD	1
Reserved	WORD	2

System **Information**	Type	Length (Words)	Class 0x72 Instance 1 **Attribute**
Seconds since boot	UDINT	2	1
Operating mode	WORD	1	2
LengthOfConfigName	DWORD	2	3
ConfigName	String	8	3
Config CRC	WORD	2	4

EtherNet/IP Input Assembly

Class 4, Instance 102, Attribute 3

Fault Log	Timestamp	Name Length	Name String	Error Code	Adv. Error Code	Error Msg. Index	Reserved
Fault log entry 1 (most recent)	0	2	4	10	11	12	13
Fault log entry 2	15	17	19	25	26	27	28
Fault log entry 3	30	32	34	40	41	42	43
Fault log entry 4	45	47	49	55	56	57	58
Fault log entry 5	60	62	64	70	71	72	73
Fault log entry 6	75	77	79	85	86	87	88
Fault log entry 7	90	92	94	100	101	102	103
Fault log entry 8	105	107	109	115	116	117	118
Fault log entry 9	120	122	124	130	131	132	133
Fault log entry 10 (oldest)	135	137	139	145	146	147	148
	UDINT	DWORD	String	WORD	WORD	WORD	WORD

Retrieving Current Fault **Information**

Follow the steps below to retrieve information via network communications about a fault that currently exists:

1. Read the *Fault Index* location to retrieve the fault index value.
2. Find the index value in the *Fault Code Table* on page 118 to access a fault description and steps to resolve the fault.

PROFINET Slots (FID 2 Only)

PROFINET real time data is sent and received via slots.

> Note: The GSDML file is available for download at *http://www.bannerengineering.com*.

The function of slots 1 to 17 is fixed and always active. The user-selectable data is 4 bytes. Slots 1 to 12 are for virtual status outputs. Slots 13 to 17 are for virtual non-safety inputs. Slots 18 and 19 have selectable module data. Use the TIA portal to activate the data for slots 18 and 19.

Slot 18: Fault Log **Buffer**

Fault Log	Type	Length (Words)
Fault log entry 1 (most recent)	See Fault Log Entry table below	15
Fault log entry 2		15
Fault log entry 3		15
Fault log entry 4		15

Fault Log	Type	Length (Words)
Fault log entry 5		15
Fault log entry 6		15
Fault log entry 7		15
Fault log entry 8		15
Fault log entry 9		15
Fault log entry 10 (oldest)		15

Fault Log Entry	Type	Length (Words)
Timestamp	UDINT	2
Name Length	DWORD	2
Name String	String	6
Error Code	WORD	1
Advanced Error Code	WORD	1
Error Message Index	WORD	1
Reserved	WORD	2

Slot 19: System **Information Buffer**

System **Information**	Type	Length (Words)
Seconds since boot	UDINT	2
Operating mode	WORD	1
LengthOfConfigName	DWORD	2
ConfigName	String	8
Config CRC	WORD	2

4.11 **Configuration** Summary
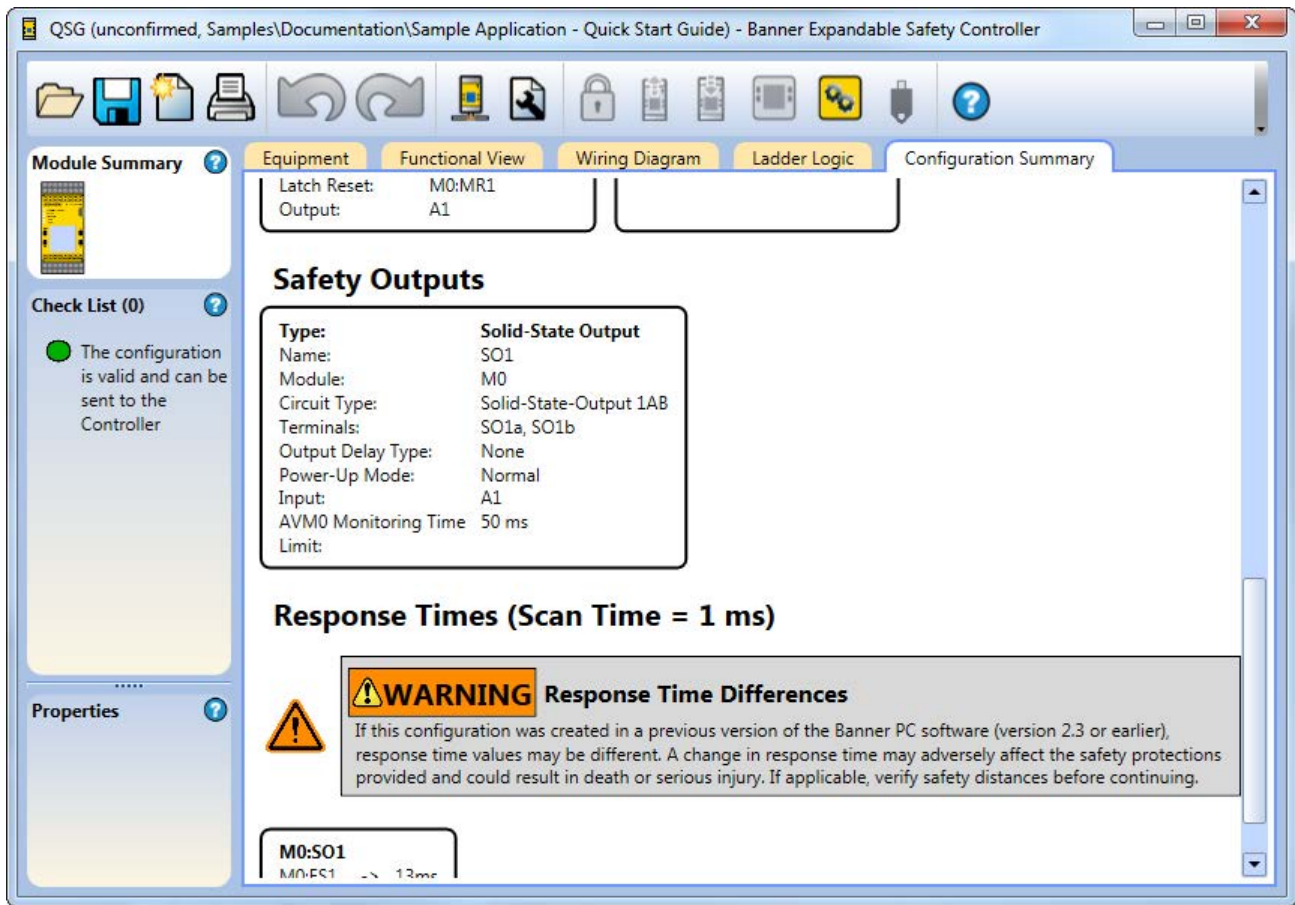
Figure 47. Configuration Summary

The **Configuration** Summary view displays the detailed information about all configured inputs, Function and Logic Blocks, Safety Outputs, Status Outputs, and the related Response Times in a text format.

4.12 Print **Options**
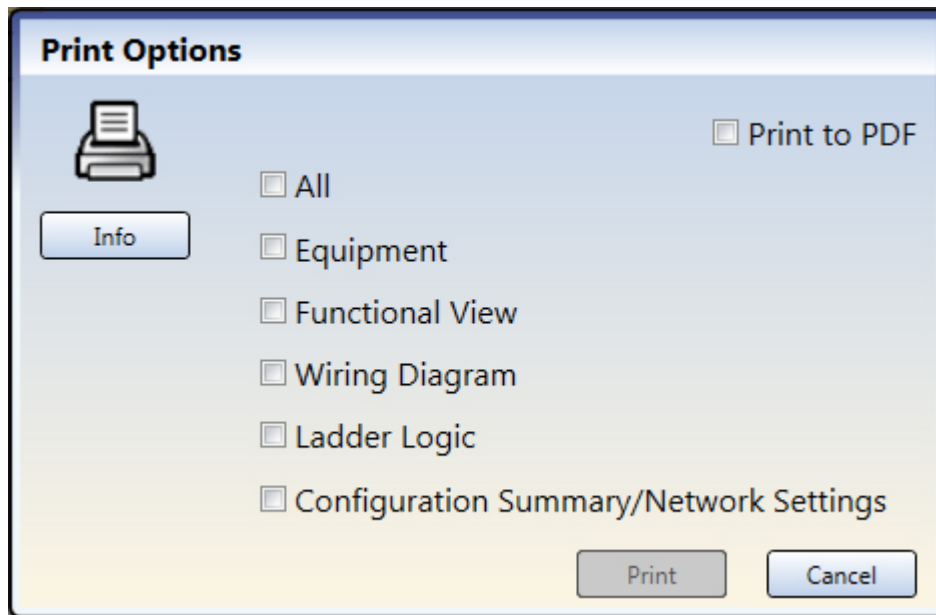
Figure 48. Print Options

The PC Interface provides several options to print the configuration. Click Print on the toolbar to access the Print **Options**.

The following print choices are available:
- All—prints all views, including Network Settings (in Ethernet-enabled versions)
- Equipment—prints Equipment tab
- **Functional** View—prints Functional View tab
- Wiring Diagram—prints Wiring Diagram tab
- Ladder Logic—prints Ladder Logic tab
- Industrial Ethernet—prints Industrial Ethernet tab
- **Configuration** Summary/Network **Settings**—prints Configuration Summary and Network Settings (when available)

Printing Options:
- Print to PDF—prints the selection to a PDF file stored in a user-defined location
- Print—opens the default Windows Print dialog and sends the selection to the user-defined printer

4.13 Password Manager
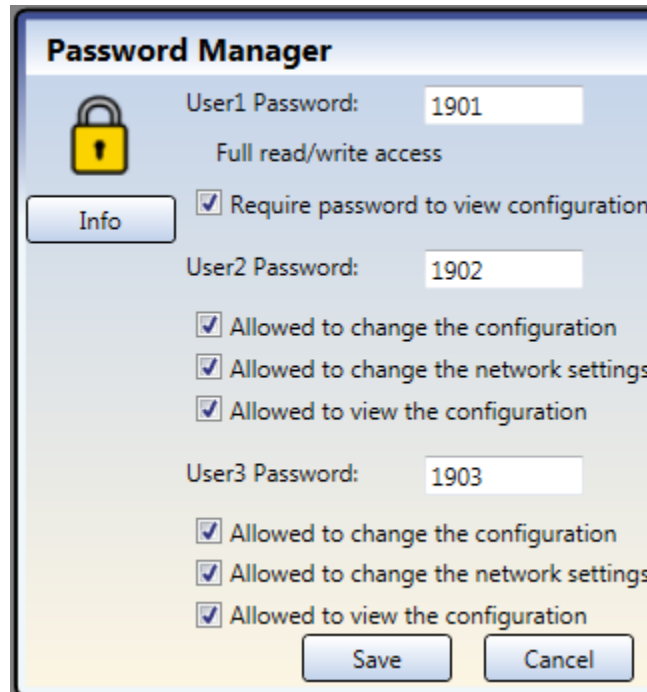
Figure 49. Password Manager

Click Password Manager on the PC Interface toolbar to edit the configuration access rights. The Safety Controller stores up to three user passwords to manage different levels of access to the configuration settings. The password for User1 provides full read/write access and the ability to set access levels for User2 and User3 (user names cannot be changed). Basic information, such as network settings, wiring diagrams, and diagnostic information, is accessible without a password. A configuration stored on a PC or an SC-XM2 drive is not password-protected. If desired, a password requirement for User2 and User3 may be set to change the network settings, view the configuration, and change the configuration. "Allowed to view the configuration" option for User2 and User3 is available when "Require password to view configuration" for User1 is checked.

> Note: The default passwords for devices with firmware version 1.5 and later for User1, User2, and User3, are 1901, 1902, and 1903, respectively. The default passwords for devices with firmware version 1.4 and earlier are 0000, 1111, and 2222. It is highly recommended to change the default passwords to new values.

4.14 Saving and **Confirming** a **Configuration**

Saving a **Configuration:**

1. Click Save.
2. Select Save As.
3. Navigate to the folder where you wish to save the configuration.
4. Name the file (may be the same or different from the configuration name).
5. Click Save.

Confirming a **Configuration** (the Controller must be powered up and connected to the PC via the SC-USB2 cable):

1. Click Write **Configuration** to Controller.
2. Enter the password (default password is 1901).
3. Click **Continue** to enter the configuration mode.
4. After the Reading **Configuration** from the Controller process is completed, the **Confirm Configuration** screen opens. Verify that the configuration is correct.
5. Scroll to the end of the configuration and click **Confirm**.
6. After the **Writing Configuration** To Controller process is completed, click Close.

> Note: Network settings are sent separately from the configuration settings. Click Send from the Network **Settings** window to write the network settings to the controller.

7. Reset the Safety Controller for the changes to take effect.

4.15 Viewing and **Importing** Controller Data

The XS26-2 Expandable Safety Controller PC Interface allows viewing or copying current Controller data, such as model number and firmware version, configuration and network settings, and wiring diagram.

Viewing System and Network **Settings** Snapshot
Click Read from Controller on the PC Interface toolbar. The current Controller settings are displayed:
- Configuration Name
- Configuration CRC
- Date Confirmed
- Time confirmed
- Author
- Project Name
- IP Address
- Subnet mask
- Gateway address
- Link speed and duplex mode
- MAC ID
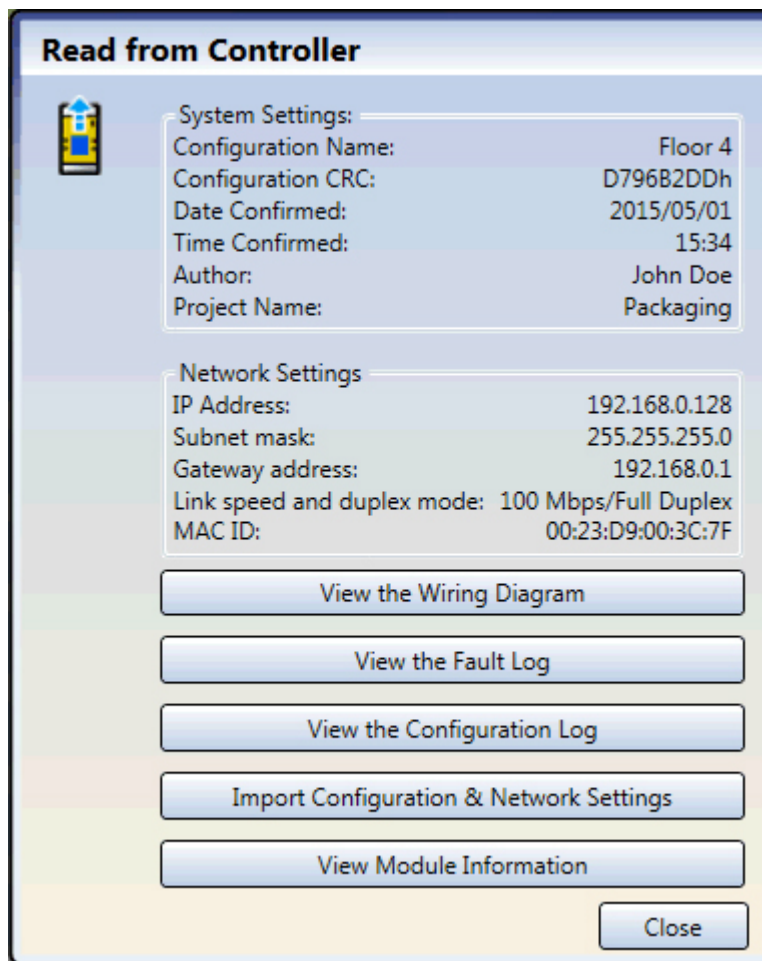
Figure 50. Viewing System and Network Settings Snapshot

Viewing and **Importing** Controller Data
Click Read from Controller to view:
- Wiring Diagram (removes all other tabs and worksheets from the PC Interface and displays only Wiring Diagram and Equipment views)
- Fault Log—history of the last 10 faults.

> Note: Fault Log numbering increases up to 4,294,967,295 unless the Controller power cycle is performed, in which case the numbering is reset to start at 1. Clearing the Fault Log (either via the PC Interface or the Onboard Interface) removes the log history but retains the numbering.

- **Configuration** Log—history of up to 10 most recent configurations (only the current configuration can be viewed or imported)
- Module **Information**

Click Import **Configuration** & Network **Settings** to access the current Controller configuration and network settings (depends on user access rights, see *Password Manager* on page 59).

4.16 Wiring Diagram
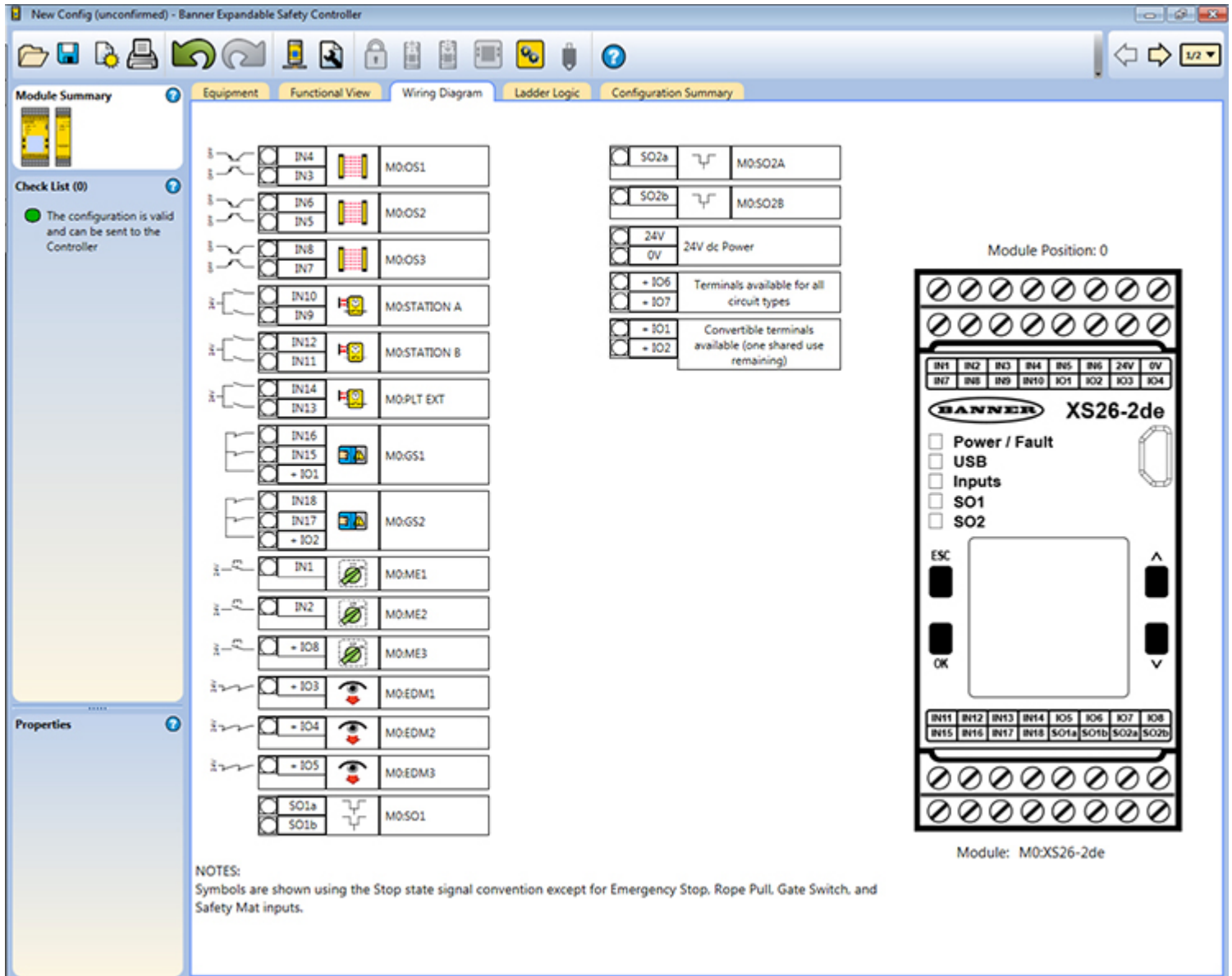
Figure 51. Wiring Diagram

The Wiring Diagram view shows the terminal assignments and the electrical circuits for the safety and non-safety inputs, Safety Outputs, and status outputs, and any terminals that are still available for the selected module. Use the wiring diagram as a guide to physically connect the devices. Navigate between modules using the Page Navigation toolbar at the top right corner of the PC Interface.

4.17 Ladder Logic
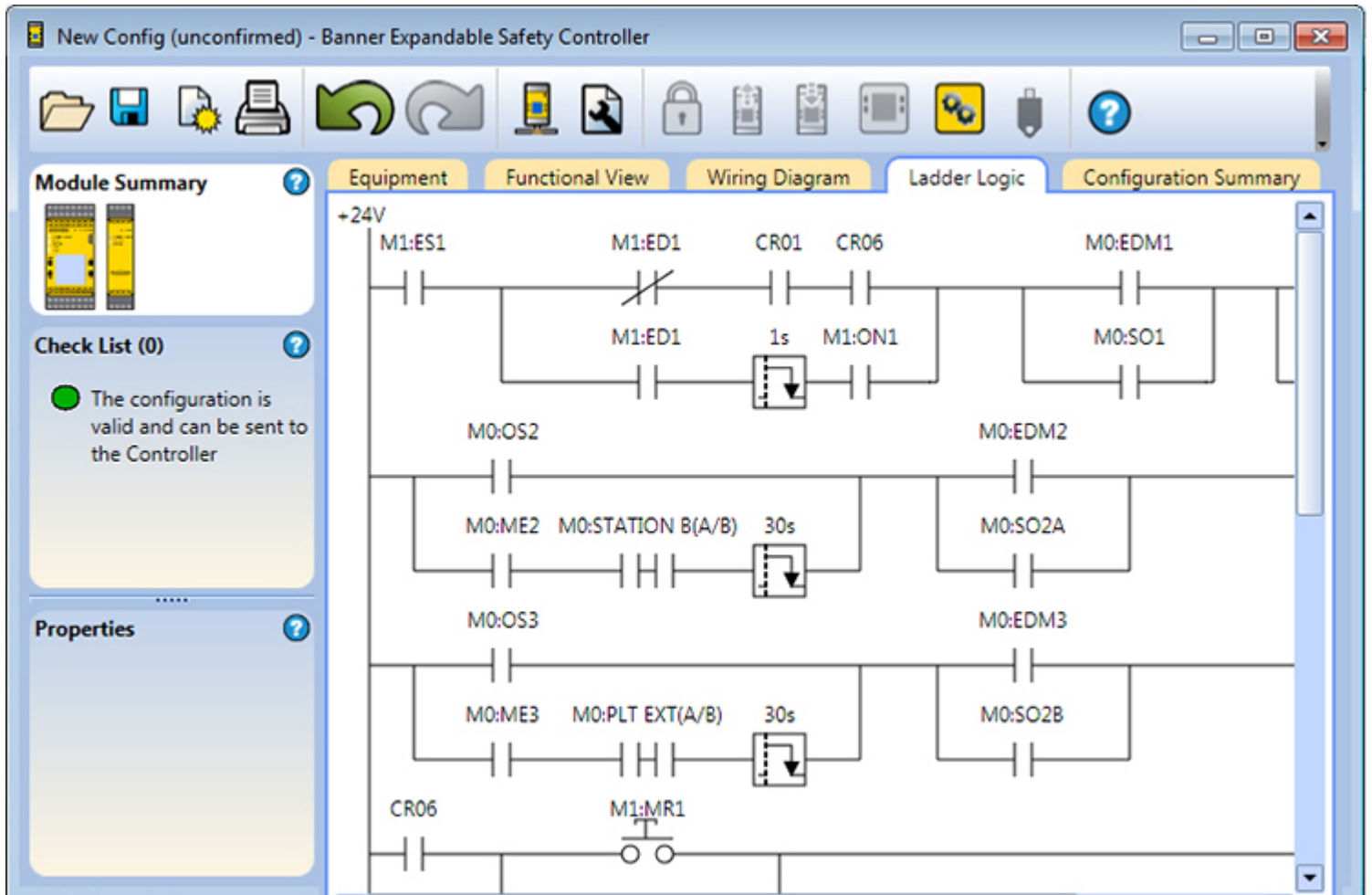
Figure 52. Ladder Logic

The Ladder Logic view displays a simplified relay logic rendering of the configuration.

4.18 **Simulation** Mode
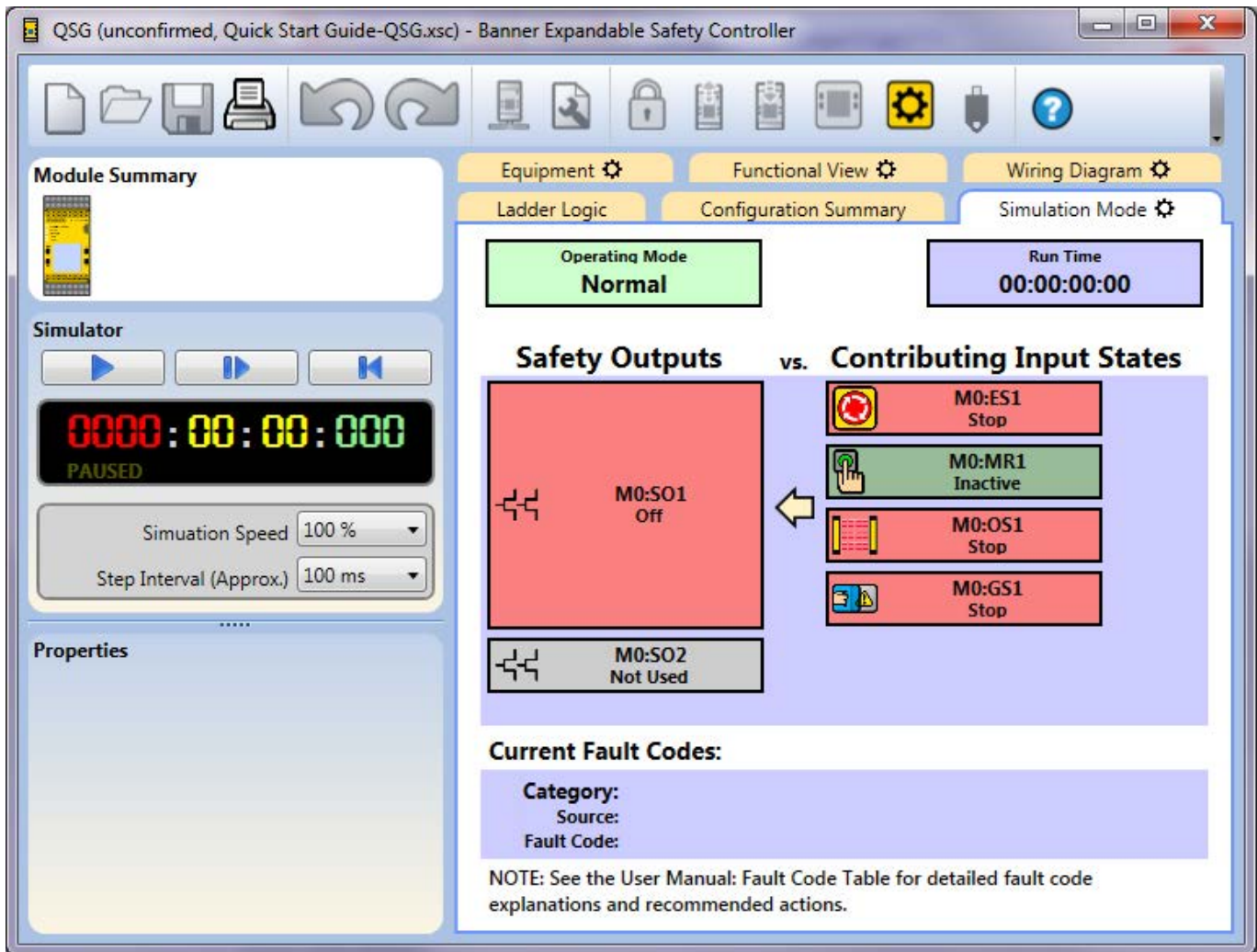
Figure 53. Simulation Mode

The **Simulation** Mode view becomes accessible when **Simulation** Mode is clicked on the toolbar. Simulation Mode options become available on the left side of the screen. The Simulation Mode tab contains view only information; you cannot click on the output or input items in this view.

[Play/Pause]	Starts the simulation time running at the specified simulation speed or temporarily stops the simulation time
[Single Step]	Advances the simulation time at the specified step interval
[Reset]	Resets the timer to zero and the equipment to the initial stop state
[Timer]	Displays elapsed time in hours, minutes, seconds, and thousandths of a second
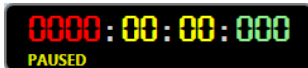
Simulation Speed—Sets the speed of the simulation.
- 1%
- 10%
- 100% (default speed)
- 500%
- 2,000%

Step Interval—Sets the amount of time that the Single Step button advances when pressed. The amount of time is based on the size of the configuration.

Press Play to begin the simulation. The timer runs and gears spin to indicate that the simulation is running. The **Functional**, Equipment, and Wiring Diagram views update, providing visual **representation** of the simulated device states as well as allowing **testing** of the **configuration**. Click on the items to be tested; their color and state change accordingly. Red indicates the stop or off state. Green indicates the run or on state. Yellow indicates a fault state. Orange indicates that the input was turned on before the **initial** start of the **simulation**. Due to a start-up off test requirement, the input must be seen as **off** before it can be recognized as on.
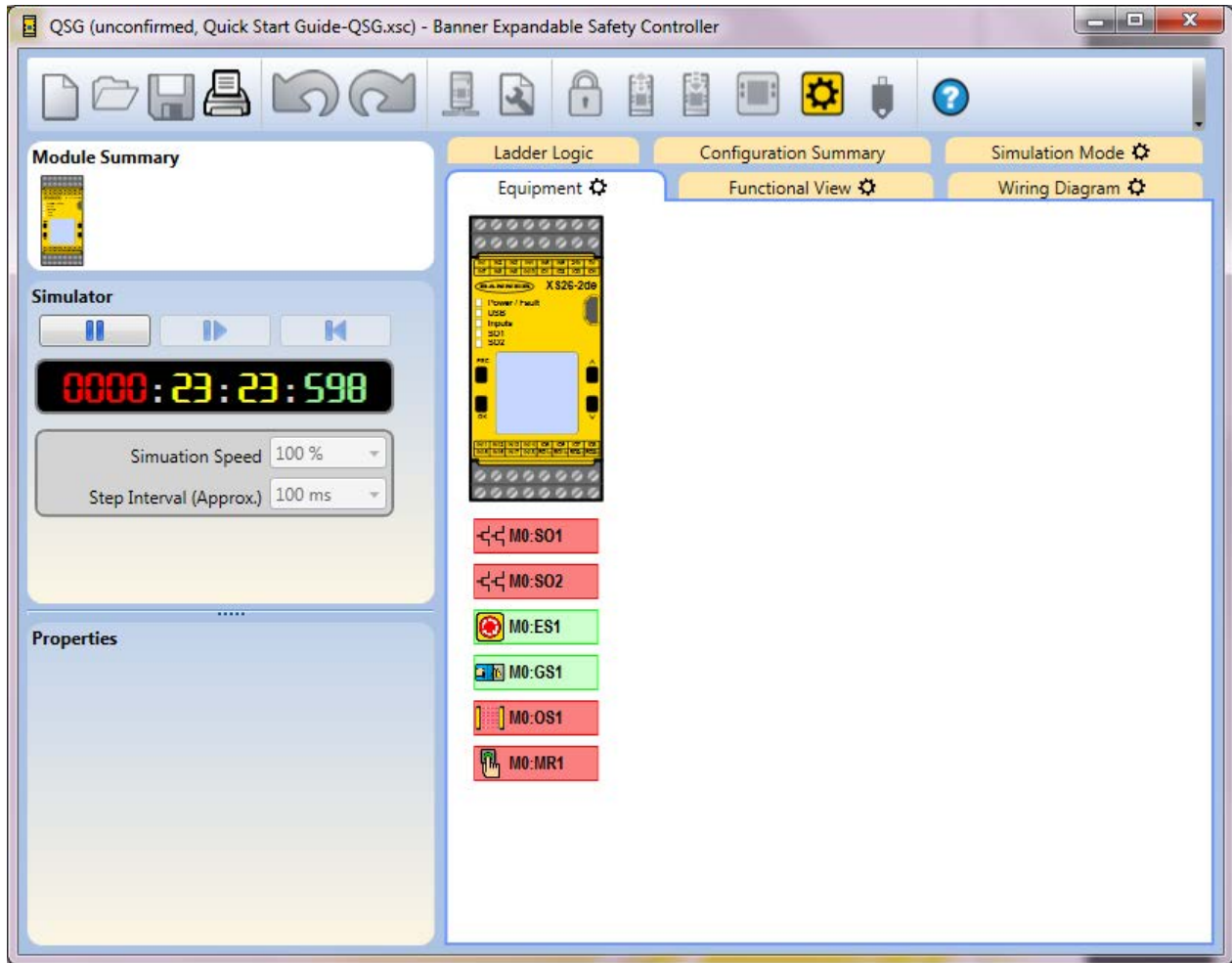
Figure 54. Simulation Mode—Equipment View
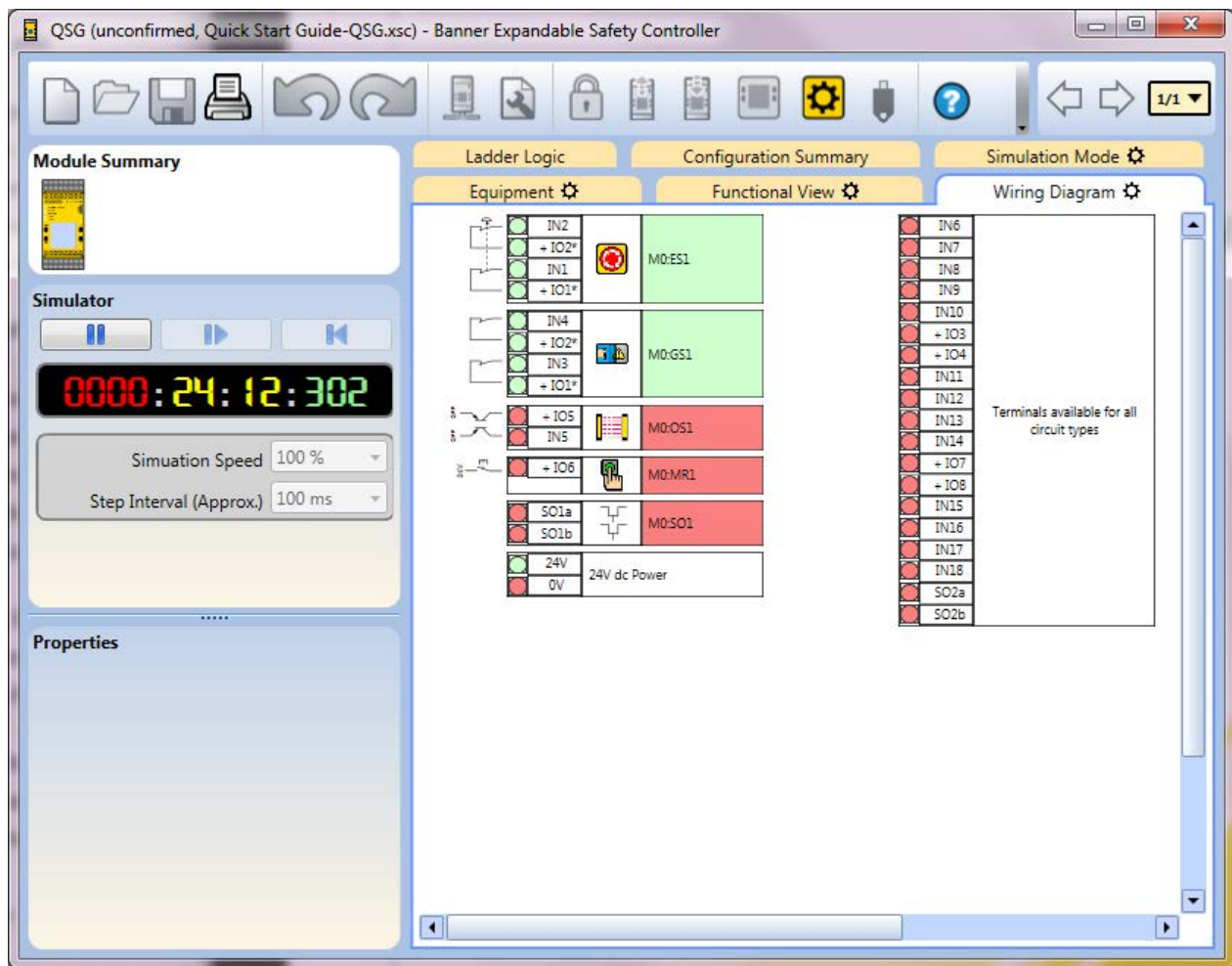
Figure 55. Simulation Mode—Wiring Diagram View
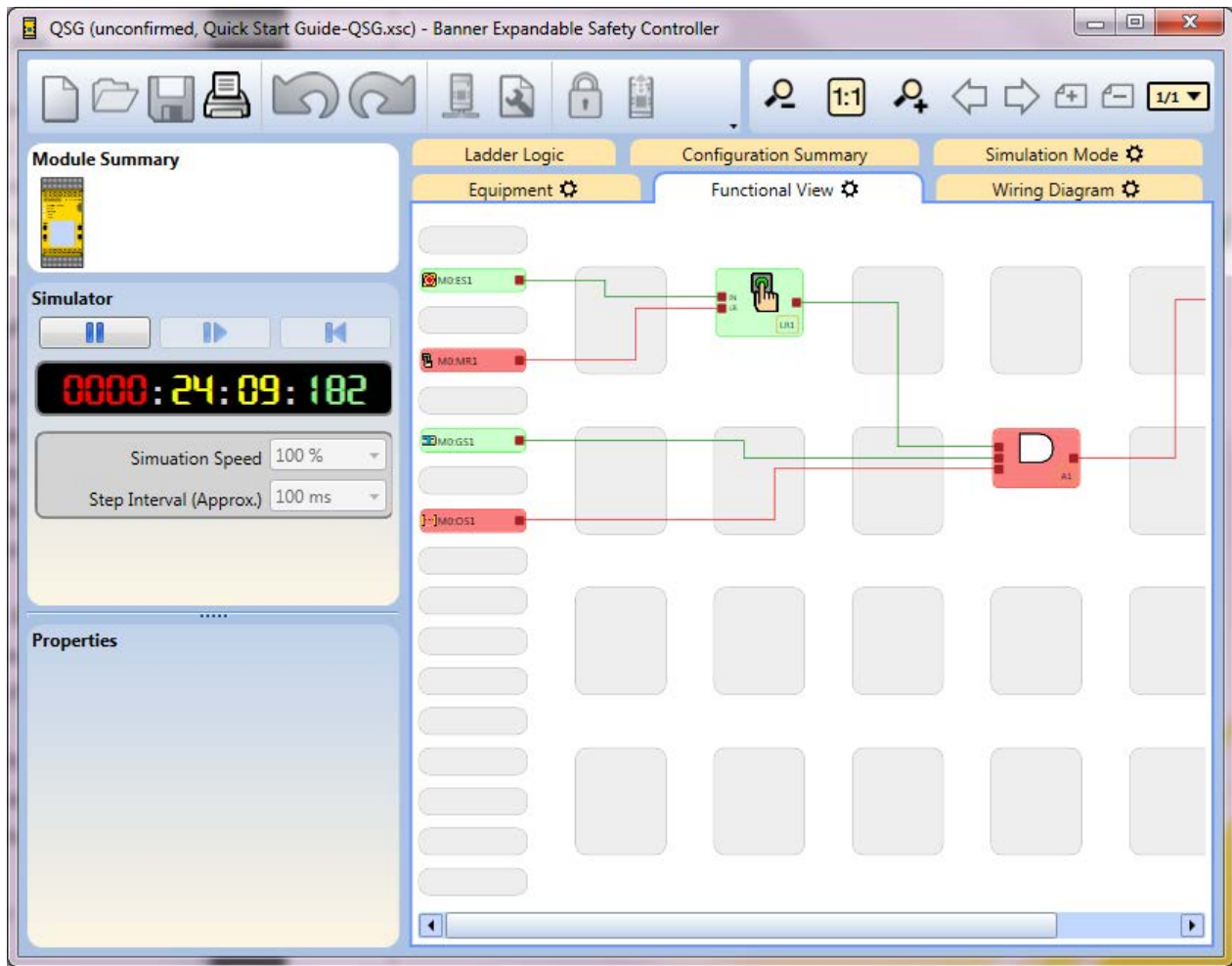
Figure 56. Simulation Mode—Functional View

4.18.1 Timed **Action** Mode

While in Simulation Mode and on the **Functional** View, certain elements which are in delay action modes are indicated in purple. The progress bar shows the countdown of the associated timer for that element.

The following figures show the different element states:
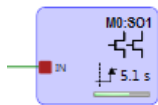
Figure 57. Safety output in Delay Off Timing mode
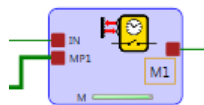
Figure 58. Muting Block in Timed Muting mode
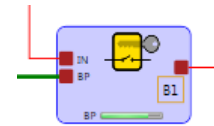
Figure 59. Bypass Block in Timed Bypass mode

Note: The M next to the progress bar indicates Timer Muting.
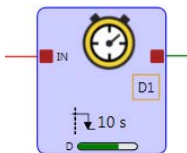
Figure 60. Delay Block—FID 2 Base Controllers only

4.19 Live Mode
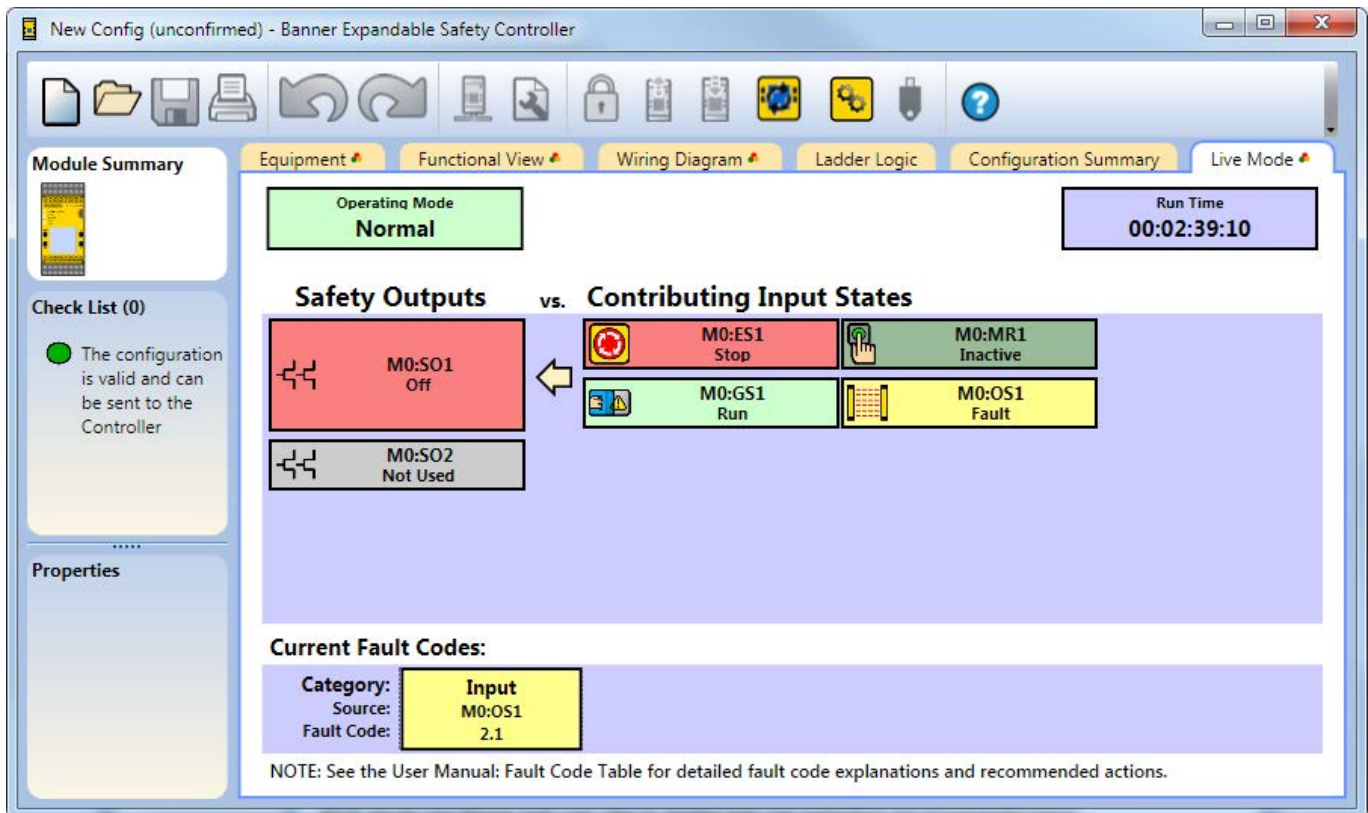
Figure 61. Run Time—Live Mode view

The Live Mode view becomes accessible when Live Mode is clicked on the toolbar. Enabling Live Mode disables configuration modification on all other views. The Live Mode view provides additional device and fault information, including a fault code (see *Fault Code Table* on page 118 for the description and possible remedies). The Run-time data is also updated on the **Functional** View, Equipment, and Wiring Diagram views providing the visual representation of the device states. See *Figure 65* on page 69 for the differences between Live Mode view and all other views.
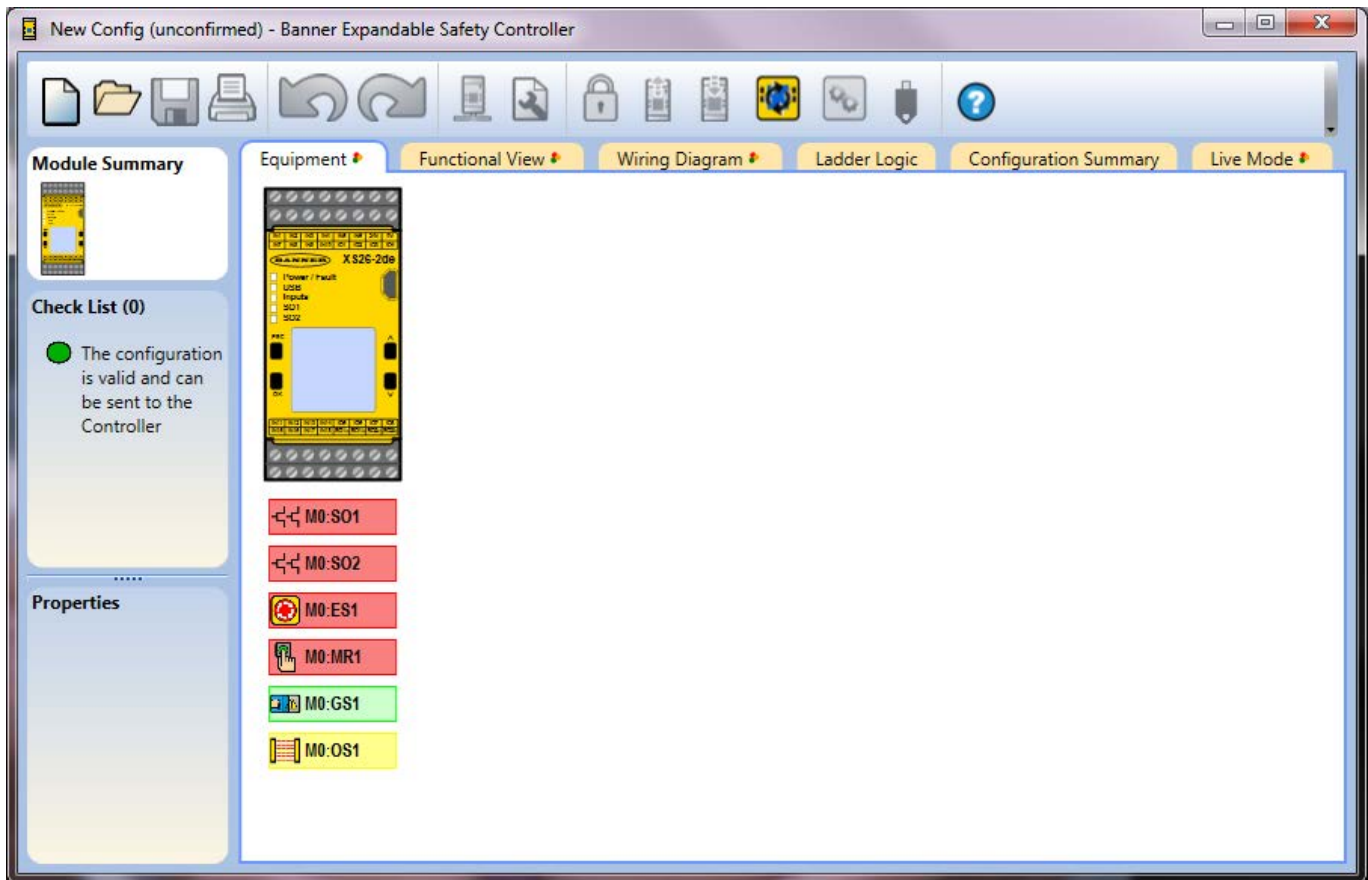
Figure 62. Run Time—Equipment view
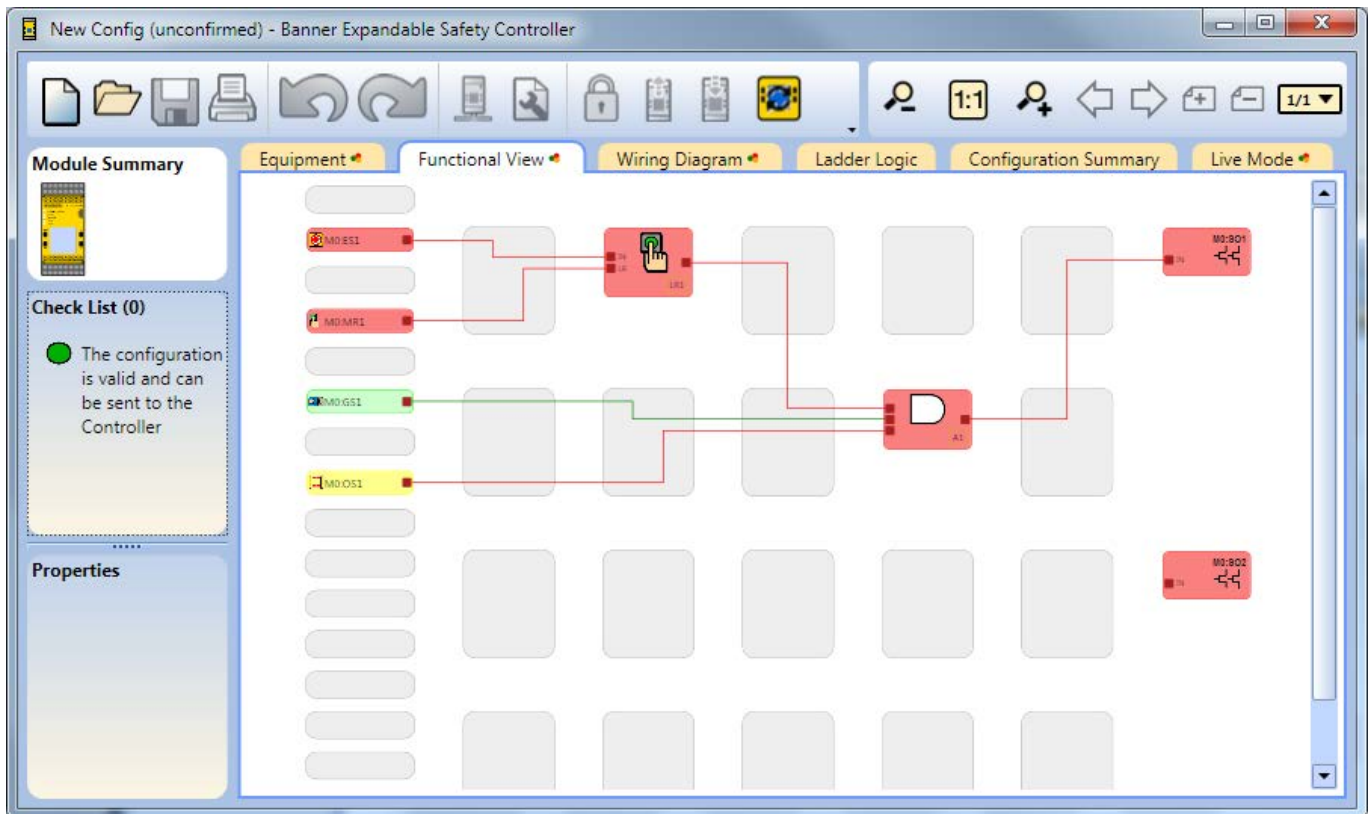
*Figure 63. Run Time—**Functional** View*
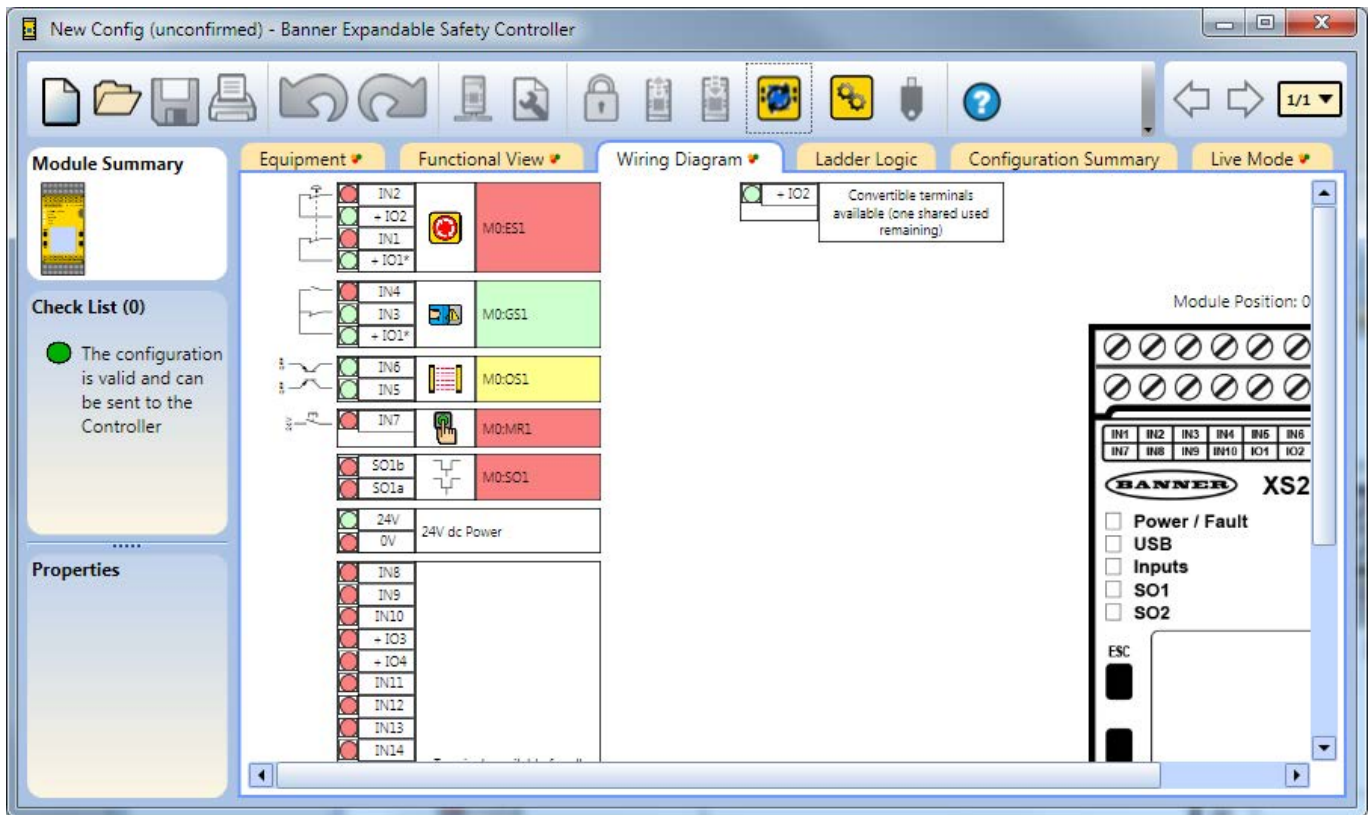
Figure 64. Run Time—Wiring Diagram view

The table below shows the **differences** in the display method of the device statuses between the Live Mode view and all other views.

Live Mode	Equipment	Functional View	Wiring Diagram
Bypassed			
Fault			
Inactive			
Muted			
Not Used			
Off			
Off-Delay			
On-Delay			
Ready			
Run			
Stop			

Figure 65. View-based device state color representation

4.20 Sample **Configuration**
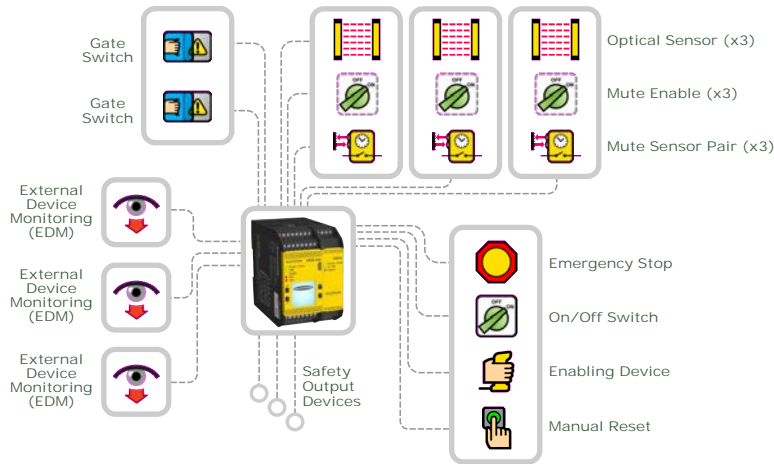
Figure 66. Sample Configuration Schematic

The PC Interface provides several Sample **Configurations** that demonstrate various **applications** of the Safety Controller. To access these **configurations,** click New Project/Recent Files and then click Sample Projects. This **section** describes designing a sample **configuration** for a **robotic palletizer application** that **utilizes** an XS26-2 Safety Controller, XS8si Safety Input Module, three **optical** sensors (**muting** is added via the **software),** two interlock switches, a manual reset, and an Emergency Stop.

To design the **configuration** for this **application:**

1. Click New Project/Recent Files and then click New Project.
2. **Define** project **settings.** See *Project Settings* on page 20.
3. Select Base Controller model. See *Equipment* on page 21 (for this **configuration,** only the Is Expandable box is required to be checked).
4. Add the expansion module XS8si by clicking on ⊞ to the right of the Base Controller module.

    a. Click Input Modules.
    b. Select XS8si.

5. Add the following inputs, leaving the default **settings:**

Input	Quantity	Type	Module	Terminals	Circuit
Emergency Stop	1	Safety Input	XS8si	IO1, IN1, IN2	Dual Channel 3 terminal
Enabling Device	1	Safety Input	XS8si	IO1, IN3, IN4	Dual Channel 3 terminal
External Device Monitoring	3	Safety Input	Base	1. IO3 2. IO4 3. IO5	Single-Channel 1 terminal
Gate Switch	2	Safety Input	Base	1. IO1, IN15, IN16 2. IO2, IN17, IN18	Dual Channel 3 terminal
Manual Reset	1	Non-Safety Input	XS8si	IN6	Single-Channel 1 terminal
Muting Sensor Pair	3	Safety Input	Base	1. IN9, IN10 2. IN11, IN12 3. IN13, IN14	Dual-Channel 2 terminal
Mute Enable	3	Non-Safety Input	Base	1. IN1 2. IN2 3. IO8	Single Channel 1 terminal
On-Off	1	Non-Safety Input	XS8si	IN5	Since-Channel 1 terminal
Optical Sensor	3	Safety Input	Base	1. IN3, IN4 2. IN5, IN6 3. IN7, IN8	Dual-Channel PNP

6. Go to the **Functional** View.

> Tip: You may notice that not all inputs are placed on Page 1. There are two solutions to keep the configuration on one page. Perform one of the following steps:
>
> 1. Add a Reference to the block located on a different page—click any of the empty placeholders in the middle area, select Reference and select the block that is on the next page. Only blocks from other pages can be added as a Reference.
> 2. Re-assign page—by default all inputs added on the Equipment view are placed on the **Functional** View to the first available placeholder in the left column. However, inputs can be moved to any location in the middle area. Move one of the blocks to any of the placeholders in the middle area. Go to the page which contains the block that needs to be moved. Select the block and change the page assignment below the **Properties** table.

7. Split M0:SO2:
    a. Double-click M0:SO2 or select it and click Edit under the **Properties** table.
    b. Click Split.
8. Add the following **Function** Blocks by clicking on any of the empty placeholders in the middle area of the **Functional** View (see *Function Blocks* on page 27 for more information):
    - **Muting** Block x 3 (**Muting** Mode: One Pair, ME (Mute Enable): Checked)
    - Enabling Device Block (ES: Checked, JOG (Jog): Checked)
9. Add the following Logic Blocks by clicking on any of the empty placeholders in the middle area of the **Functional** View (see *Logic Blocks* on page 26 for more information):
    - AND with 2 input nodes
    - AND with 4 input nodes
10. Connect the following to each **Muting** Block:
    - 1 x **Optical** Sensor (IN node)
    - 1 x Mute Sensor Pair (MP1 node)
    - 1 x Mute Enable (ME node)
11. Connect Gate Switch x 2 to the AND block with 2 nodes.
12. Connect **Muting** Block x 3, and AND block with 2 nodes to the AND block with 4 nodes.
13. Connect one of the **Muting** Blocks to one of the split safety outputs (M0:SO2A or M0:SO2B) and one to the other split safety output.
14. Connect the following to the Enabling Device Block:
    - Emergency Stop (ES node)
    - Enabling Device (ED node)
    - AND block with four input nodes (IN node)
    - Manual Reset (RST node)
    - **On-Off** (JOG node)
15. Connect Enabling Device Block to the remaining Safety Output (M0:SO1).
16. Enable *EDM (External Device Monitoring)* in each of the Safety Output **Properties** windows.
17. Connect 1x External Device Monitoring input to each of the Safety Outputs.

The Sample Configuration is complete.

> Note: At this point you may want to reposition the blocks in the **Functional** View for a better configuration flow (see *Figure 67* on page 72).
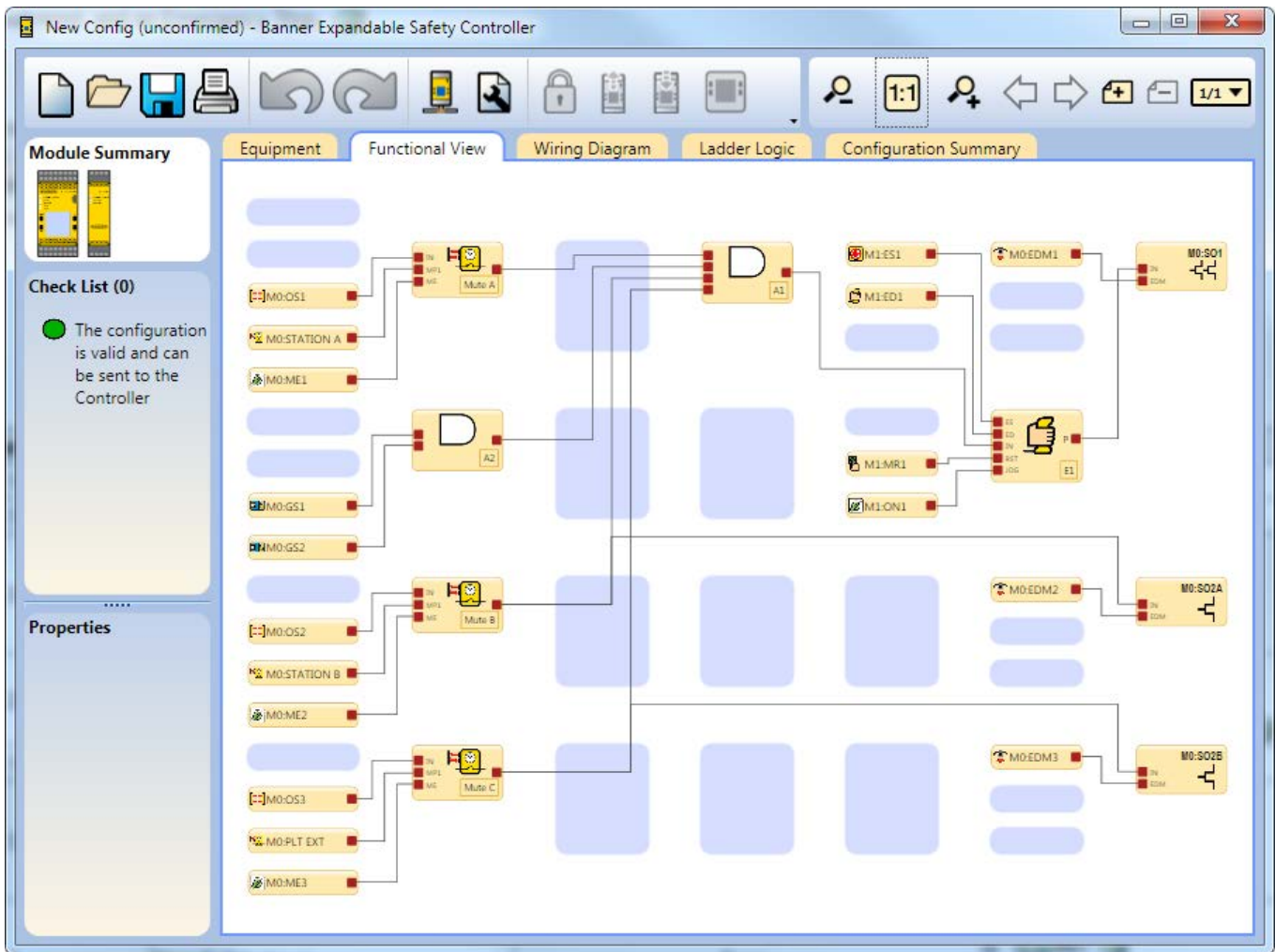
Figure 67. Sample Configuration—Functional View

4.21 Reference Signals

👉 Important: The configuration software incorporates Reference Signals that represent the state of controller outputs, input devices and both Function and Logic Blocks. A Safety Output reference signal can be used to control another Safety Output. In this type of configuration, the physical On state of the controlling Safety Output is not known. If the Safety Output On state is critical for the application safety, an external feedback mechanism is required. Note that the safe state of this controller is when the outputs are turned Off. If it is critical that Safety Output 1 is On before Safety Output 2 turns On, then the device that is being controlled by the Safety Output 1 needs to be monitored to create an input signal that can be used to control Safety Output 2. The Safety Output 1 reference signal may not be adequate in this case.

Figure 68 on page 73 shows how one Safety Output can control another Safety Output. When Manual Reset M0:MR1 is pressed, it turns On Safety Output M0:SO2, which, in turn, turns On Safety Output M0:SO1.
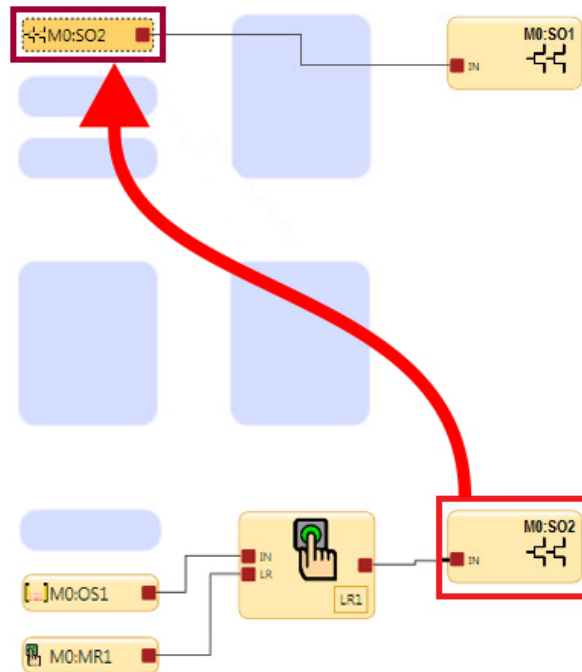
Figure 68. Safety Output controlled by another Safety Output

4.22 SC-XM2 Drive and SC-XMP2 Programming Tool

The SC-XM2 drive is used to store a **confirmed** configuration. The configuration can be written directly by the Safety Controller, when the drive is plugged in to the micro-USB port (see *Configuration Mode* on page 75), or via the SC-XMP2 Programming Tool using only the PC Interface without the need to plug in the controller.

👉 Important: Verify that the configuration that is being imported to the controller is the correct configuration (via the PC Interface or writing on the white label on the SC-XM2 drive).

Click 🖱 to access the programming tool options:
- Read—reads the current controller configuration from the SC-XM2 drive and loads it to the PC Interface
- Write—writes a confirmed configuration from the PC Interface to the SC-XM2 drive
- Lock—locks the SC-XM2 drive preventing any configurations from being written to it (empty drive cannot be locked)

✏ Note: You will not be able to unlock the SC-XM2 drive after it has been locked.

5 Onboard Interface

The Safety Controller's Onboard Interface is used to access the following:
- System Status—displays the current status of Safety Outputs, and, when selected, inputs connected to that output
- Fault **Diagnostics**—displays the current faults, fault log, and an option to clear the fault log (see *Finding and Fixing Faults* on page 118)
- **Configuration** Mode—enters the Configuration Mode (password required) and provides access to copy or write the configuration from and to the SC-XM2 drive (see *Configuration Mode* on page 75)
- **Configuration** Summary—provides the access to terminal assignments, network settings, and configuration CRC
- Model #—displays the current model number and software version
- Set Display Contrast—provides the controls to adjust display brightness
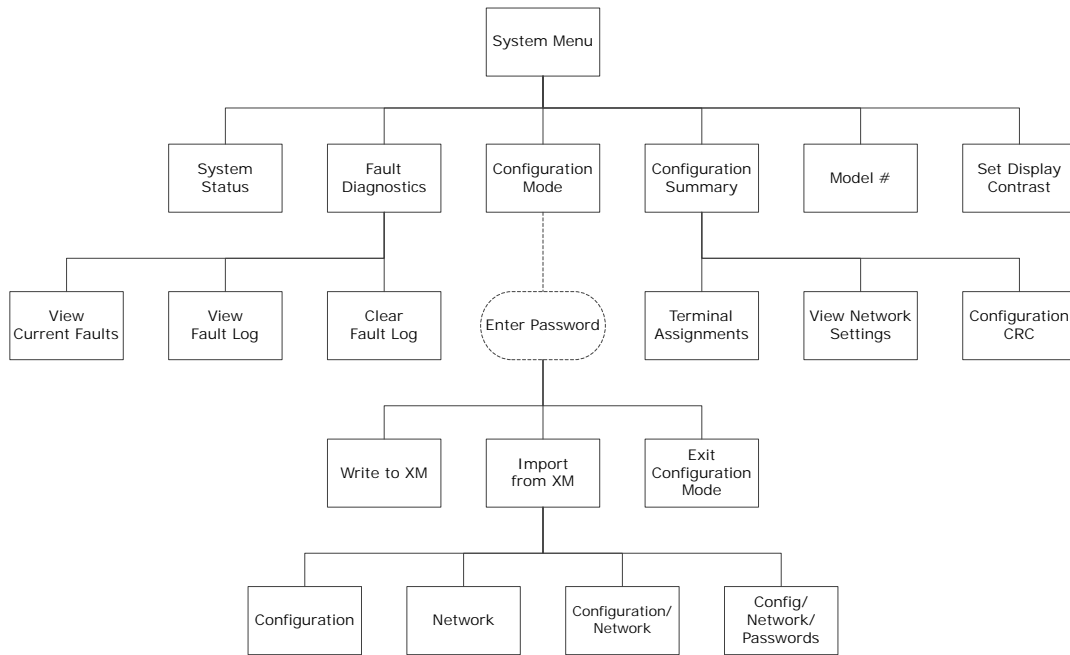
Figure 69. Onboard Interface Map

5.1 **Configuration** Mode

Configuration Mode provides options to send the current configuration to an SC-XM2 drive and to receive a configuration from the SC-XM2 drive.

Note: A password is required to access the **Configuration** Mode menu.

Important: Entering the **Configuration** Mode turns Off Safety Outputs.

To write data to an SC-XM2 drive:

1. Insert the SC-XM2 drive into the Safety Controller.
2. From the System Menu, select **Configuration** Mode.
3. Enter the password.
4. Hold OK until the **Configuration** Mode menu appears.
5. Select Write to XM.

Note: Writing to XM process copies all data (Configuration, Network Settings, and passwords to the SC-XM drive.

6. Wait for the write process to complete.
7. Reset the System.

To import data from an SC-XM2 drive:

1. Insert the SC-XM2 drive into the Safety Controller.
2. From the System Menu, select **Configuration** Mode.
3. Enter the password.
4. Hold OK until **Configuration** Mode menu appears.
5. Select Import from XM:
   - For configuration only, select **Configuration**
   - For network settings only, select Network **Settings**
   - For configuration and network settings, select **Configuration/Network**
   - For all data, which includes configuration, network settings, and user passwords, select **Config/Network/Passwords**
6. Wait for the import process to complete.
7. Reset the System.

6 System **Installation**

6.1 Appropriate **Application**

The correct application of the Safety Controller depends on the type of machine and the safeguards that are to be interfaced with the Controller. If there is any concern about whether or not your machinery is **compatible** with this Controller, contact Banner Engineering.

⚠️ WARNING: Not a Stand-Alone Safeguarding Device

This Banner device is considered complementary equipment that is used to augment safeguarding that limits or eliminates an individual's exposure to a hazard without action by the individual or others. Failure to properly safeguard hazards according to a risk assessment, local **regulations,** and relevant standards may lead to serious injury or death.

⚠️ WARNING: User Is Responsible for Safe **Application** of this device

The application examples described in this document depict generalized guarding situations. Every guarding application has a unique set of requirements.

Make sure that all safety requirements are met and that all installation instructions are followed. Direct any questions regarding safeguarding to a Banner applications engineer at the number or addresses listed this document.

⚠️ WARNING: Read this **Section** Carefully Before Installing the System

The Banner Safety Controller is a control device that is intended to be used in conjunction with a machine safeguarding device. Its ability to perform this function depends upon the appropriateness of the application and upon the Safety Controller's proper mechanical and electrical installation and interfacing to the machine to be guarded.

If all mounting, installation, interfacing, and checkout procedures are not followed properly, the Banner Safety Controller cannot provide the protection for which it was designed. The user is responsible for satisfying all local, state, and national laws, rules, codes, or regulations relating to the installation and use of this control system in any particular application. Make sure that all safety requirements have been met and that all technical installation and maintenance instructions contained in this document are followed.

6.2 Installing the Safety Controller

Do not exceed the operating specifications for reliable operation. The enclosure must provide adequate heat dissipation so that the air closely surrounding the Controller does not exceed its maximum operating temperature (see *Specifications* on page 12).

☞ Important: Mount the Safety Controller in a location that is free from large shocks and high-amplitude vibration.

⚠️ CAUTION: Electrostatic Discharge (ESD) can cause damage to electronic equipment. To prevent this, follow the proper ESD handling practices such as wearing an approved wrist strap or other grounding products, or touching a grounded object before handling the modules. See ANSI/ESD S20.20 for further information about managing ESD.

6.2.1 **Mounting Instructions**

The Safety Controller mounts to a standard 35 mm DIN-rail track. It must be installed inside an enclosure rated NEMA 3 (IEC IP54) or better. It should be mounted to a vertical surface with the vent openings at the bottom and the top to allow for natural convection cooling.

Follow the mounting instructions to avoid damage to the controller.

To mount the SC26-2 Programmable Safety Controller, XS26-2 Programmable Safety Controller, XS2so and XS4so Solid-State Safety Output Modules, XS8si and XS16si Safety Input Modules, XS1ro and XS2ro Safety Relay Modules:

1. Tilt the top of the module slightly backward and place it on the DIN rail.
2. Straighten the module against the rail.
3. Lower the module onto the rail.

To remove the SC26-2 Programmable Safety Controller, XS26-2 Programmable Safety Controller, XS2so and XS4so Solid-State Safety Output Modules, XS8si and XS16si Safety Input Modules, XS1ro and XS2ro Safety Relay Modules:

1. Push up on the bottom of the module.
2. Tilt the top of the module slightly forward.
3. Lower the module after the top rigid clip is clear of the DIN rail.

> Note: To remove an expansion module, pull apart other modules on each side of the desired module to free bus connectors.

6.3 Safety Input Devices

The Safety Controller monitors the state of the safety input devices that are connected to it. In general, when all of the input devices that have been configured to control a particular Safety Output are in the Run sate, the Safety Output turns or remains On. When one or more of the safety input devices change from Run state to Stop state, the Safety Output turns Off. A few special safety input device functions can, under predefined circumstances, temporarily suspend the safety input stop signal to keep the Safety Output On, for example, muting or bypassing.

The Safety Controller can detect input faults with certain input circuits that would otherwise result in a loss of the control of the safety function. When such faults are detected, the Safety Controller turns the associated outputs Off until the faults are cleared. The function blocks used in the configuration impact the safety outputs. It is necessary to carefully review the configuration if the input device faults occur.

Methods to eliminate or minimize the possibility of these faults include, but are not limited to:
- Physically separating the interconnecting control wires from each other and from secondary sources of power
- Routing interconnecting control wires in separate conduit, runs, or channels
- Locating all control elements (Safety Controller, interface modules, FSDs, and MPCEs) within one control panel, adjacent to each other, and directly connected with short wires
- Properly installing multi-conductor cabling and multiple wires through strain-relief fittings. Over-tightening of a strain-relief can cause short circuits at that point
- Using positive-opening or direct-opening components, as described by IEC 60947-5-1, that are installed and mounted in a positive mode
- Periodically checking the functional integrity/safety function
- Training the operators, maintenance personnel, and others involved with operating the machine and the safeguarding to recognize and immediately correct all failures

> Note: Follow the device manufacturer's installation, operation, and maintenance instructions and all relevant regulations. If there are any questions about the device(s) that are connected to the Safety Controller, contact Banner Engineering for assistance.
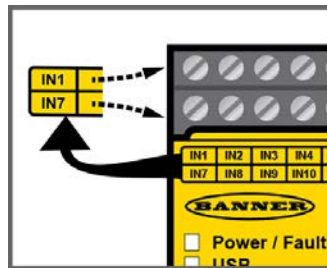
Figure 70. Input and output terminal locations

⚠️ WARNING: Input Device and Safety Integrity

The Safety Controller can monitor many different safety input devices. The user must conduct a Risk Assessment of the guarding application to determine what Safety Integrity Level needs to be reached in order to know how to properly connect the input devices to the controller. The user must also take steps to eliminate or minimize possible input signal faults/failures that may result in the loss of the safety functions.

6.3.1 Safety Circuit Integrity and ISO 13849-1 Safety Circuit Principles

Safety circuits involve the safety-related functions of a machine that minimize the level of risk of harm. These safety-related functions can prevent initiation, or they can stop or remove a hazard. The failure of a safety-related function or its associated safety circuit usually results in an increased risk of harm.

The integrity of a safety circuit depends on several factors, including fault tolerance, risk reduction, reliable and well-tried components, well-tried safety principles, and other design considerations.

Depending on the level of risk associated with the machine or its operation, an appropriate level of safety circuit integrity (performance) must be incorporated into its design. Standards that detail safety performance levels include ANSI B11.19 Performance Criteria for Safeguarding and ISO 13849-1 Safety-Related Parts of a Control System.

Safety Circuit Integrity Levels

Safety circuits in International and European standards have been segmented into Categories and Performance Levels, depending on their ability to maintain their integrity in the event of a failure and the statistical likelihood of that failure. ISO 13849-1 details safety circuit integrity by describing circuit architecture/structure (Categories) and the required performance level (PL) of safety functions under foreseeable conditions.

In the United States, the typical level of safety circuit integrity has been called "Control Reliability". Control Reliability typically incorporates redundant control and self-checking circuitry and has been loosely equated to ISO 13849-1 Category 3 or 4 and/or Performance Level "d" or "e" (see ANSI B11.19).

Perform a risk assessment to ensure appropriate application, interfacing/hookup, and risk reduction (see ANSI B11.0 or ISO 12100). The risk assessment must be performed to determine the appropriate safety circuit integrity in order to ensure that the expected risk reduction is achieved. This risk assessment must take into account all local regulations and relevant standards, such as U.S. Control Reliability or European "C" level standards.

The safety controller inputs support up to Category 4 PL e (ISO 13849-1) and Safety Integrity Level 3 (IEC 61508 and IEC 62061) interfacing/hookup. The actual safety circuit integrity level is dependent on the configuration, proper installation of external circuitry, and the type and installation of the safety input devices. The user is responsible for the determination of the overall safety rating(s) and full compliance with all applicable regulations and standards.

The following sections deal only with Category 2, Category 3, and Category 4 applications, as described in ISO 13849-1. The input device circuits shown in the table below are commonly used in safeguarding applications, though other solutions are possible depending on fault exclusion and the risk assessment. The table below shows the input device circuits and the safety category level that is possible if all of the fault detection and fault exclusion requirements are met.

⚠️ **WARNING: Risk Assessment**

The level of safety circuit integrity can be greatly affected by the design and installation of the safety devices and the means of interfacing of those devices. A risk assessment must be performed to determine the appropriate level of safety circuit integrity to ensure the expected risk **reduction** is achieved and all relevant **regulations** and standards are complied with.

⚠️ **WARNING: Input Devices with dual contact inputs using 2 or 3 terminals**

Detection of a short between two input channels (contact inputs, but not complementary contacts) is not possible, if the two contacts are closed. A short can be detected when the input is in the Stop state for at least 2 seconds (see the INx & IOx input terminals Tip in *Safety Input Device Function* on page 80).

⚠️ **WARNING: Category 2 or 3 Input Shorts**

Detection of a short between two input channels (contact inputs, but not complementary contacts), if they are supplied through the same source (for example, the same terminal from the Controller in a dual-channel, 3-terminal hookup, or from an external 24 V supply) is not possible, if the two contacts are closed.

Such a short can be detected only when both of the contacts are open and the short is present for at least 2 seconds.

Fault Exclusion

An important concept within the requirements of ISO 13849-1 is the probability of the occurrence of a failure, which can be reduced using a technique termed "fault exclusion." The rationale assumes that the possibility of certain well-defined failure(s) can be reduced via design, installation, or technical improbability to a point where the resulting fault(s) can be, for the most part, disregarded—that is, "excluded" in the evaluation.

Fault exclusion is a tool a designer can use during the development of the safety-related part of the control system and the risk assessment process. Fault exclusion allows the designer to design out the possibility of various failures and justify it through the risk assessment process to meet the requirements of ISO 13849-1/-2.

Requirements vary widely for the level of safety circuit integrity in safety applications (that is, Control Reliability or Category/ Performance Level) per ISO 13849-1. Although Banner Engineering always recommends the highest level of safety in any application, it is the responsibility of the user to safely install, operate, and maintain each safety system and comply with all relevant laws and regulations.

⚠️ **WARNING: Risk Assessment**

The level of safety circuit integrity can be greatly affected by the design and installation of the safety devices and the means of interfacing of those devices. A risk assessment must be performed to determine the appropriate level of safety circuit integrity to ensure the expected risk **reduction** is achieved and all relevant **regulations** and standards are complied with.

6.3.2 Safety Input Device **Properties**

The Safety Controller is configured via the PC Interface to accommodate many types of safety input devices. See *Adding Inputs and Status Outputs* on page 22 for more information on input device configuration.

Reset Logic: Manual or **Automatic** Reset

A manual reset may be required for safety input devices by using a Latch Reset Block or configuring a safety output for a latch reset before the safety output(s) they control are permitted to turn back On. This is sometimes referred to as "latch" mode because the safety output "latches" to the Off state until a reset is performed. If a safety input device is configured for automatic reset or "trip"
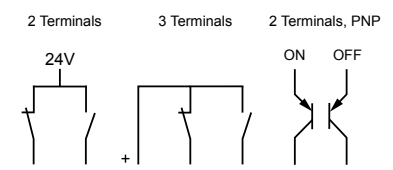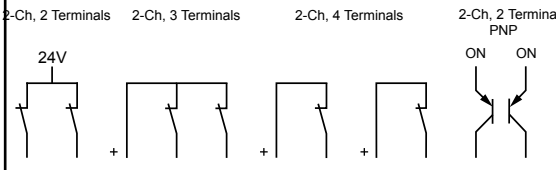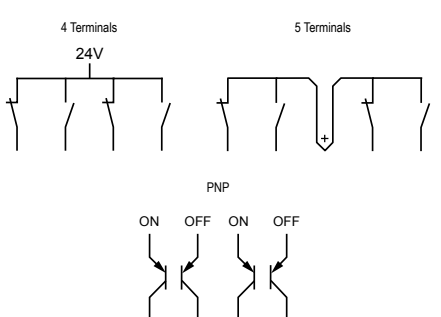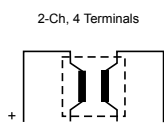
mode, the safety output(s) it controls will turn back On when the input device changes to the Run state (provided that all other controlling inputs are also in the Run state).

Connecting the Input Devices

The Safety Controller needs to know what device signal lines are connected to which wiring terminals so that it can apply the proper signal monitoring methods, Run and Stop conventions, and timing and fault rules. The terminals are assigned automatically during the configuration process and can be changed manually using the PC Interface.

Signal Change-of-State Types

Two change-of-state (COS) types can be used when monitoring dual-channel safety input device signals: Simultaneous or Concurrent.

Input Circuit	Input Signal COS Timing Rules	
	Stop State—SO turns **Off** when[4]:	Run State—SO turns On when[5]:
Dual-Channel A and B Complementary **Dual-Channel A and B**	At least 1 channel (A or B) input is in the Stop state.	Simultaneous: A and B are both in the Stop state and then both in the Run state within 3 seconds before outputs turn On. Concurrent: A and B are concurrently in the Stop state, then both in the Run state with no simultaneity to turn outputs On.
2X Complementary A and B	At least 1 channel (A or B) within a pair of contacts is in the Stop state.	Simultaneous: A and B are concurrently in the Stop state, then contacts within a channel in the Run state within 400 ms (150 ms for two-hand control), both channels are in the Run state within 3 seconds (0.5 seconds for two-hand control). Concurrent: A and B are concurrently in the Stop state, then contacts within a channel in the Run state within 3 seconds. Both channels are in the Run state with no simultaneity.
4-Wire Safety Mat	One of the following conditions is met: • Input channels are shorted together (normal operation) • At least 1 of the wires is disconnected • One of the normally low channels is detected high • One of the normally high channels is detected low	Each channel detects its own pulses.

Signal Debounce Times

Closed-to-Open Debounce Time (from 6 ms to 1000 ms in 1 ms intervals, except 6 ms to 1500 ms for mute sensors). The closed-to-open debounce time is the time limit required for the input signal to transition from the high (24 V dc) state to the steady low (0 V dc) state. This time limit may need to be increased in cases where high-magnitude device vibration, impact shock, or switch noise

---

[4] Safety Outputs turn Off when one of the controlling inputs is in the Stop state.
[5] Safety Outputs turn On only when all of the controlling inputs are in the Run state and after a manual reset is performed (if any safety inputs are configured for Manual reset and were in their Stop state).

conditions result in a need for longer signal transition times. If the debounce time is set too short under these harsh conditions, the system may detect a signal disparity fault and lock out. The default setting is 6 ms.

⚠️ CAUTION: Debounce and Response

Any changes in the debounce **times** may **affect** the Safety Output response (turn **Off) time.** This value is computed and displayed for each Safety Output when a configuration is created.

Open-to-Closed Debounce Time (from 10 ms to 1000 ms in 1 ms intervals, except 10 ms to 1500 ms for mute sensors). The open-to-closed debounce time is the time limit required for the input signal to transition from the low (0 V dc) state to the steady high (24 V dc) state. This time limit may need to be increased in cases where high magnitude device vibration, impact shock, or switch noise conditions result in a need for longer signal transition times. If the debounce time is set too short under these harsh conditions, the system may detect a signal disparity fault and lock out. The default setting is 50 ms.

6.4 Safety Input Device **Function**

General Circuit Symbols		Circuits shown in Run State						Circuits shown in Stop State	
		ES	GS	OS	RP	PS	SM	THC	ED
1 & 2 Terminal Single Channel (see note 1)		Cat 2	Cat 2	Cat 2	Cat 2	Cat 2			
2 & 3 Terminal Dual Channel (See note 2)		Cat 3	Cat 3	Cat 3	Cat 3	Cat 3		Type IIIa Cat 1 Type IIIb Cat 3	Cat 3
2 Terminal Dual Channel PNP w/ integral monitoring (see note 3)		Cat 4	Cat 4	Cat 4	Cat 4	Cat 4		Type IIIa Cat 1	Cat 4
3 & 4 Terminal Dual Channel (see notes 2 & 4)		Cat 4	Cat 4	Cat 4	Cat 4	Cat 4		Type IIIa Cat 1 Type IIIb Cat 3	Cat 4
2 & 3 Terminal Dual Channel Complimentary			Cat 4	Cat 4	Cat 4	Cat 4			Cat 4
2 Terminal Dual Channel Complimentary PNP			Cat 4	Cat 4	Cat 4	Cat 4			Cat 4
4 & 5 Terminal Dual Channel Complimentary			Cat 4					Type IIIc Cat 4	Cat 4
4 Terminal Dual Channel Complimentary PNP			Cat 4					Type IIIc Cat 4	Cat 4
4 Terminal Safety Mat							Cat 3		

Figure 71. Input Device Circuit—Safety Category Guide

⚠️ WARNING: Incomplete **Information**—many installation considerations that are necessary to properly apply input devices are not covered in this document. Refer to the appropriate device **installation instructions** to ensure the safe **application** of the device.

⚠️ WARNING: This table lists the highest safety categories possible for common safety rated input device circuits. If the additional requirements stated in the notes below are not possible due to safety device or installation limitations, or if, for example, the controller's IOx input terminals are all in use, then the highest safety category may not be possible.

💡 Tip: INx & IOx input terminals, these circuits can be manually configured to meet Category 4 circuit requirements by changing the first (left most) standard input terminal (INx) to any available convertible terminal (IOx) as shown below. These circuits will detect shorts to other power sources and between channels when the input has been in the Stop state for at least 2 seconds.
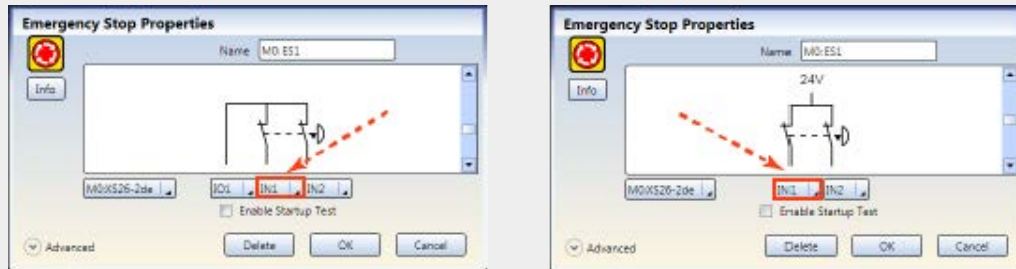
Notes:

1. Circuit typically meets up to ISO 13849-1 Category 2 if input devices are safety rated and fault exclusion wiring practices prevent a) shorts across the contacts or solid state devices and b) shorts to other power sources.
2. Circuit typically meets up to ISO 13849-1 Category 3 if input devices are safety rated (see Tip: INx & IOx input terminals above).
   The 2 Terminal circuit detects a single channel short to other power sources when the contacts open and close again (concurrency fault).
   The 3 Terminal circuit detects a short to other power sources whether the contacts are open or closed.
3. Circuit meets up to ISO 13849-1 Category 4 if input devices are safety rated and provide internal monitor of the PNP outputs to detect a) shorts across channels and b) shorts to other power sources.
4. Circuit meets up to ISO 13849-1 Category 4 if input devices are safety rated (see Tip: INx & IOx input terminals above). These circuits can detect both shorts to other power sources and shorts between channels.

6.4.1 Safety Circuit Integrity Levels

The application requirements for safeguarding devices vary for the level of control reliability or safety category per ISO 13849-1 (EN954-1). While Banner Engineering always recommends the highest level of safety in any application, the user is responsible to safely install, operate, and maintain each safety system and comply with all relevant laws and regulations.

The safety performance (integrity) must reduce the risk from identified hazards as determined by the machine's risk assessment. See *Safety Circuit Integrity and ISO 13849-1 Safety Circuit Principles* on page 77 for guidance if the requirements as described by ISO 13849-1 need to be implemented.

6.4.2 Emergency Stop Push **Buttons**

🔴 The Safety Controller safety inputs may be used to monitor emergency stop push buttons.

⚠️ WARNING: Emergency Stop **Functions**

Do not mute or bypass any Emergency Stop device. ANSI NFPA79 and IEC/EN 60204-1 require that the Emergency Stop function remain active at all times. **Muting** or bypassing the safety outputs will render the emergency stop **function ineffective.**

The Safety Controller Emergency Stop **configuration** prevents **muting** or bypassing of the E-Stop input(s). However, the user **still** must ensure that the E-Stop device remains **active** at all **times.**

⚠️ WARNING: Reset **Routine** Required

U.S. and international standards require that a reset routine be performed after clearing the cause of a stop condition (for example, arming an E-stop button, closing an interlocked guard, etc.). Allowing the machine to restart without **actuating** the normal start command/device can create an unsafe **condition** which may result in serious injury or death.

In addition to the requirements stated in this section, the design and installation of the Emergency Stop device must comply with ANSI NFPA 79 or ISO 13850. The stop function must be either a functional stop Category 0 or a Category 1 (see ANSI NFPA79).

Emergency Stop Push **Button** Requirements

E-stop switch must provide one or two contacts for safety which are closed when the switch is armed. When activated, the E-stop switch must open all its safety-rated contacts, and must require a deliberate action (such as twisting, pulling, or unlocking) to return to the closed-contact, armed position. The switch must be a positive-opening (or direct-opening) type, as described by IEC 60947-5-1. A mechanical force applied to such a button (or switch) is transmitted directly to the contacts, forcing them to open. This ensures that the switch contacts open whenever the switch is activated.

Standards ANSI NFPA 79, ANSI B11.19, IEC/EN 60204-1, and ISO 13850 specify additional Emergency Stop switch device requirements, including the following:

- Emergency stop push buttons must be located at each operator control station and at other operating stations where emergency shutdown is required
- Stop and Emergency stop push buttons must be continuously operable and readily accessible from all control and operating stations where located. Do not mute or bypass any E-stop **button**
- Actuators of emergency stop devices must be colored red. The background immediately around the device actuator must be colored yellow. The actuator of a push-button-operated device must be of the palm or mushroom-head type
- The Emergency stop actuator must be a self-latching type

> Note: Some applications may have additional requirements; the user is responsible to comply with all relevant regulations.

6.4.3 Rope (Cable) Pull

Rope (cable) pull emergency stop switches use steel wire rope; they provide emergency stop actuation continuously over a distance, such as along a conveyor.

Rope pull emergency stop switches have many of the same requirements as emergency stop push buttons, such as positive (direct) opening operation, as described by IEC 60947-5-1. See *Emergency Stop Push Buttons* on page 81 for additional information.

In emergency stop applications, the rope pull switches must have the capability not only to react to a pull in any direction, but also to a slack or a break of the rope. Emergency stop rope pull switches also need to provide a latching function that requires a manual reset after actuation.

Rope (Cable) Pull **Installation** Guidelines

ANSI NFPA 79, ANSI B11.19, IEC/EN 60204-1, and ISO 13850 specify emergency stop requirements for rope (cable) pull installations, including the following:

- Rope (cable) pulls must be located where emergency shutdown is required
- Rope (cable) pulls must be continuously operable, easily visible, and readily accessible. Do not mute or bypass
- Rope (cable) pulls must provide constant tension of the rope or cable pull
- The rope or cable pull, as well as any flags or markers, must be colored Red
- The rope or cable pull must have the capability to react to a force in any direction
- The switch must:
  - Have a self-latching function that requires a manual reset after actuation
  - Have a direct opening operation
  - Detect a slack condition or a break of the rope or cable

Additional installation guidelines:

- The wire rope should be easily accessible, red in color for E-Stop functions, and visible along its entire length. Markers or flags may be fixed on the rope to increase its visibility
- Mounting points, including support points, must be rigid and allow sufficient space around the rope to allow easy access
- The rope should be free of friction at all supports. Pulleys are recommended. Lubrication may be necessary. Contamination of the system, such as dirt, metal chips or swarf, etc, must be prevented from adversely affecting operation
- Use only pulleys (not eye bolts) when routing the rope around a corner or whenever direction changes, even slightly
- Never run rope through conduit or other tubing
- Never attach weights to the rope
- A tensioning spring is recommended to ensure compliance with direction-independent actuation of the wire rope and must be installed on the load bearing structure (machine frame, wall, etc.)
- Temperature affects rope tension. The wire rope expands (lengthens) when temperature increases, and contracts (shrinks) when temperature decreases. Significant temperature variations require frequent checks of the tension adjustment

> WARNING: Failure to follow the installation guidelines and procedures may result in the ineffectiveness or non-operation of the Rope Pull system and create an unsafe condition resulting in a serious injury or death.

6.4.4 Enabling Device

An enabling device is a manually operated control which, when continuously actuated, allows a machine cycle to be initiated in conjunction with a start control. Standards that cover the design and application of enabling devices include: ISO 12100-1/-2, IEC 60204-1, ANSI/NFPA 79, ANSI/RIA R15.06, and ANSI B11.19.

The enabling device **actively** controls the suspension of a Stop signal during a **portion** of a machine **operation** where a hazard may occur. The enabling device permits a hazardous **portion** of the machine to run, but must not start it. An enabling device can control one or more safety outputs. When the enable signal switches from the Stop state to the Run state, the Controller enters the Enable mode. A separate machine command signal from another device is needed to start the hazardous **motion**. This enabling device must have **ultimate** hazard turn **Off** or Stop authority.

6.4.5 **Protective** (Safety) Stop

A **Protective** (Safety) Stop is designed for the **connection** of miscellaneous devices that could include safeguarding (**protective**) devices and complementary equipment. This stop **function** is a type of **interruption** of **operation** that allows an orderly **cessation** of motion for safeguarding purposes. The **function** can be reset or **activated** either **automatically** or manually.

Protective (Safety) Stop Requirements

The required safety circuit integrity level is determined by a risk assessment and indicates the level of control performance that is acceptable, for example, category 4, Control Reliability (see *Safety Circuit Integrity and ISO 13849-1 Safety Circuit Principles* on page 77). The **protective** stop circuit must control the safeguarded hazard by causing a stop of the hazardous **situation(s)**, and removing power from the machine actuators. This **functional** stop typically meets category 0 or 1 as described by ANSI NFPA 79 and IEC60204-1.

6.4.6 Interlocked Guard or Gate

The Safety Controller safety inputs may be used to monitor electrically interlocked guards or gates.

Safety Interlock Switch Requirements

The following general requirements and **considerations** apply to the **installation** of interlocked guards and gates for the purpose of safeguarding. In **addition,** the user must refer to the relevant **regulations** to ensure compliance with all necessary requirements.

Hazards guarded by the interlocked guard must be prevented from **operating until** the guard is closed; a stop command must be issued to the guarded machine if the guard opens while the hazard is present. Closing the guard must not, by itself, **initiate** hazardous **motion**; a separate procedure must be required to **initiate** the **motion**. The safety interlock switches must not be used as a mechanical or end-of-travel stop.

The guard must be located an adequate distance from the danger zone (so that the hazard has **time** to stop before the guard is opened **sufficiently** to provide access to the hazard), and it must open either laterally or away from the hazard, not into the safeguarded area. The guard also should not be able to close by itself and **activate** the interlocking circuitry. In **addition,** the **installation** must prevent personnel from reaching over, under, around, or through the guard to the hazard. Any openings in the guard must not allow access to the hazard (see OSHA 29CFR1910.217 Table O-10, ANSI B11.19, ISO 13857, ISO14120/EN953 or the appropriate standard). The guard must be strong enough to contain hazards within the guarded area, which may be ejected, dropped, or **emitted** by the machine.

The safety interlock switches, actuators, sensors, and magnets must be designed and installed so that they cannot be easily defeated. They must be mounted securely so that their physical **position** cannot **shift,** using reliable fasteners that require a tool to remove them. **Mounting** slots in the housings are for **initial** adjustment only; **final mounting** holes must be used for permanent **location**.

> ⚠️ WARNING: Perimeter Guarding **Applications**
>
> If the **application** may result in a pass-through hazard (for example, perimeter guarding), either the safeguarding device or the guarded machine's MSCs/MPCEs must cause a Latched response following a Stop command (for example, **interruption** of the sensing **field** of a light curtain, or opening of an interlocked gate/guard). The reset of this Latched **condition** may only be achieved by **actuating** a reset switch that is separate from the normal means of machine cycle **initiation**. The switch must be **positioned** as described in this document.
>
> Lockout/Tagout procedures per ANSI Z244.1 may be required, or **additional** safeguarding, as described by ANSI B11 safety requirements or other appropriate standards, must be used if a passthrough hazard cannot be eliminated or reduced to an acceptable level of risk. Failure to observe this warning may result in serious bodily injury or death.

6.4.7 **Optical** Sensor

The Safety Controller safety inputs may be used to monitor **optical-based** devices that use light as a means of **detection**.

Optical Sensor Requirements

When used as safeguarding, **optical** sensors are described by IEC61496-1/-2/-3 as **Active** Opto-electronic **Protective** Devices (AOPD) and **Active** Opto-electronic **Protective** Devices responsive to **Diffuse Reflection** (AOPDDR).

AOPDs include safety light screens (curtains) and safety grids and points (**multiple-/single-beam** devices). These devices generally meet Type 2 or Type 4 design requirements; a Type 2 device is allowed to be used in a Category 2 **application,** per ISO 13849-1, and a Type 4 device can be used in a Category 4 **application.**

AOPDDRs include area or laser scanners. The primary **designation** for these devices is a Type 3, for use in up to Category 3 **applications.**

Optical safety devices must be placed at an appropriate safety distance (minimum distance), according to the application standards. Refer to the applicable standards and to manufacturer documentation specific to your device for the appropriate calculations. The response time of the Safety Controller outputs to each safety input is provided on the **Configuration** Summary view in the PC Interface.

If the application includes a pass-through hazard (a person could pass through the optical device beams and stand undetected on the hazard side), other safeguarding may be required, and manual reset should be selected (see *Manual Reset Input* on page 34).

6.4.8 Two-Hand Control

The Safety Controller may be used as an initiation device for most powered machinery when machine cycling is controlled by a machine operator.

The Two-Hand Control (THC) actuators must be positioned so that hazardous motion is completed or stopped before the operator can release one or both of the buttons and reach the hazard (see *Two-Hand Control Safety Distance (Minimum Distance)* on page 84).

The Safety Controller safety inputs used to monitor the actuation of the hand controls for two-hand control comply with the functionality of Type III requirements of IEC 60204-1 and ISO 13851 (EN 574) and the requirements of ANSI NFPA79 and ANSI B11.19 for two-hand control, which include:
- Simultaneous actuation by both hands within a 500 ms time frame
- When this time limit is exceeded, both hand controls must be released before operation is initiated
- Continuous actuation during a hazardous condition
- Cessation of the hazardous condition if either hand control is released
- Release and re-actuation of both hand controls to re-initiate the hazardous motion or condition (anti-tie down)
- The appropriate performance level of the safety-related function (Control Reliability, Category/Performance level, or appropriate regulation and standard, or Safety Integration Level) as determined by a risk assessment

> WARNING: **Point-of-Operation** Guarding
>
> When properly installed, a two-hand control device provides protection only for the hands of the machine operator. It may be necessary to install **additional** safeguarding, such as safety light screens, **additional** two-hand controls, and/or hard guards, to protect all individuals from hazardous machinery.
>
> Failure to properly guard hazardous machinery can result in a dangerous **condition** which could lead to serious injury or death.

> CAUTION: Hand Controls
>
> The environment in which hand controls are installed must not adversely **affect** the means of **actuation.** Severe contamination or other environmental influences may cause slow response or false On conditions of mechanical or ergonomic buttons. This may result in exposure to a hazard.

The level of safety achieved (for example, ISO 13849-1 Category) depends in part on the circuit type selected.

Consider the following when installing hand controls:
- Failure modes, such as a short circuit, a broken spring, or a mechanical seizure, that may result in not detecting the release of a hand control
- Severe contamination or other environmental influences that may cause a slow response when released or false ON condition of the hand control(s), for example, sticking of a mechanical linkage
- Protection from accidental or unintended operation, for example, mounting position, rings, guards, or shields
- Minimizing the possibility of defeat, for example, hand controls must be far enough apart so that they cannot be operated by the use of one arm—typically, not less than 550 mm (21.7 in) in a straight line, per ISO 13851
- The functional reliability and installation of external logic devices
- Proper electrical installation per NEC and NFPA79 or IEC 60204

> CAUTION: Install Hand Controls to Prevent Accidental **Actuation**
>
> Total protection for the two-hand control system from defeat is not possible. However, the user is required by U.S. and **International** standards to arrange and protect hand controls to minimize the possibility of defeat or accidental **actuation.**

> CAUTION: Machine Control Must Provide **Anti-Repeat** Control
>
> Appropriate anti-repeat control must be provided by the machine control and is required by U.S. and International standards for single-stroke or single-cycle machines.
>
> This Banner device can be used to assist in accomplishing anti-repeat control, but a risk assessment must be accomplished to determine the suitability of such use.

Two-Hand Control Safety Distance (Minimum Distance)

The hand controls operator must not be able to reach the hazardous area with a hand or any other body part before the machine motion ceases. Use the formula below to calculate the safety distance (minimum distance).

⚠️ **WARNING: Location of Touch Button Controls**

Hand controls must be mounted a safe distance from moving machine parts, as determined by the appropriate standard. It must not be possible for the operator or other non-qualified persons to relocate them. Failure to establish and maintain the required safety distance may result in serious injury or death.

U.S. Applications

The Safety Distance formula, as provided in ANSI B11.19:

Part-Revolution Clutch Machinery (the machine and its controls allow the machine to stop motion during the hazardous portion of the machine cycle)

$$D_S = K \times (T_S + T_r + T_h)$$

For *Full-Revolution* Clutch Machinery (the machine and its controls are designed to complete a full machine cycle)

$$D_S = K \times (T_m + T_r + T_h)$$

D_S

the Safety Distance (in inches)

K

the OSHA/ANSI recommended hand-speed constant (in inches per second), in most cases is calculated at 63 in/sec, but may vary between 63 in/sec to 100 in/sec based on the application circumstances;

not a conclusive determination; consider all factors, including the physical ability of the operator, when determining the value of K to be used

T_h

the response time of the slowest hand control from the time when a hand disengages that control until the switch opens;

T_h is usually insignificant for purely mechanical switches. However, T_h should be considered for safety distance calculation when using electronic or electromechanical (powered) hand controls. For Banner Self-checking Touch Buttons (STBs) the response time is 0.02 seconds

T_m

the maximum time (in seconds) the machine takes to cease all motion after it has been tripped. For full revolution clutch presses with only one engaging point, T_m is equal to the time necessary for one and one-half revolutions of the crankshaft. For full revolution clutch presses with more than one engaging point, T_m is be calculated as follows:

$$T_m = (1/2 + 1/N) \times T_{cy}$$

N = number of clutch engaging points per revolution

T_{cy} = time (in seconds) necessary to complete one revolution of the crankshaft

T_r

the response time of the Safety Controller as measured from the time a stop signal from either hand control. The Safety Controller response time is obtained from the Configuration Summary in the PC Interface.

T_S

the overall stop time of the machine (in seconds) from the initial stop signal to the final ceasing of all motion, including stop times of all relevant control elements and measured at maximum machine velocity

T_S is usually measured by a stop-time measuring device. If the specified machine stop time is used, add at least 20% as a safety factor to account for brake system deterioration. If the stop-time of the two redundant machine control elements is unequal, the slower of the two times must be used for calculating the separation distance

European Applications

The Minimum Distance Formula, as provided in ISO 13855:

$$S = (K \times T) + C$$

S

the Minimum Distance (in millimeters)

K

the ISO 13855 recommended hand-speed constant (in millimeters per second), in most cases is calculated at 1600 mm/sec, but may vary between 1600 to 2500 mm/sec based on the application circumstances;

· not a conclusive determination; consider all factors, including the physical ability of the operator, when determining the value of K to be used.

European **Applications**

T

the overall machine stopping response time (in seconds), from the physical initiation of the safety device to the final ceasing of all motion

C

the added distance due to the depth penetration factor equals 250 mm, per ISO 13855. The ISO 13855 C factor may be reduced to 0 if the risk of encroachment is eliminated, but the safety distance must always be 100 mm or greater

6.4.9 Safety Mat

The Safety Controller may be used to monitor pressure-sensitive safety mats and safety edges.

The purpose of the Safety Mat input of the Safety Controller is to verify the proper operation of 4-wire presence-sensing safety mats. Multiple mats may be connected in series to one Controller, 150 ohms maximum per input (see *Safety Mat Hookup Options* on page 88).

> Important: The Controller is not designed to monitor 2-wire mats, bumpers, or edges (with or without sensing resistors).

The controller monitors the contacts (contact plates) and the wiring of one or more safety mat(s) for failures and prevents the machine from restarting if a failure is detected. A reset routine after the operator steps off the safety mat may be provided by the Safety Controller, or, if the Controller is used in auto-reset mode, the reset function must be provided by the machine control system. This prevents the controlled machinery from restarting automatically after the mat is cleared.

> WARNING: **Application** of Safety Mats
>
> Safety Mat application requirements vary for the level of control reliability or category and performance level as described by ISO 13849-1 and ISO 13856. While Banner Engineering always recommends the highest level of safety in any application, the user is responsible to safely install, operate, and maintain each safety system per the manufacturer's **recommendations** and comply with all relevant laws and **regulations.**
>
> Do not use safety mats as a tripping device to **initiate** machine **motion** (such as in a presence-sensing device initiation application), due to the possibility of unexpected start or re-start of the machine cycle resulting from failure(s) within the mat and the interconnect cabling.
>
> Do not use a safety mat to enable or provide the means to allow the machine control to start hazardous **motion** by simply standing on the safety mat (for example, at a control station). This type of application uses reverse/ negative logic and certain failures (for example, loss of power to the Module) can result in a false enable signal.

Safety Mat Requirements

The following are minimum requirements for the design, construction, and installation of four-wire safety mat sensor(s) to be interfaced with the Safety Controller. These requirements are a summary of standards ISO 13856-1, ANSI/RIA R15.06 and ANSI B11.19. The user must review and comply with all applicable regulations and standards.

Safety Mat System Design and **Construction**

The safety mat system sensor, Safety Controller, and any additional devices must have a response time that is fast enough to reduce the possibility of an individual stepping lightly and quickly over the mat's sensing surface (less than 100 to 200 ms, depending on the relevant standard).

For a safety mat system, the minimum object sensitivity of the sensor must detect, at a minimum, a 30 kg (66 lb) weight on an 80 mm (3.15 in) diameter circular disk test piece anywhere on the mat's sensing surface, including joints and junctions. The effective sensing surface or area must be identifiable and can comprise one or more sensors. The safety mat supplier should state this minimum weight and diameter as the minimum object sensitivity of the sensor.

User adjustments to actuating force and response time are not allowed (ISO 13856-1). The sensor should be manufactured to prevent any reasonably foreseeable failures, such as oxidation of the contact elements which could cause a loss in sensitivity.

The environmental rating of the sensor must meet a minimum of IP54. When the sensor is specified for immersion in water, the sensor's minimum enclosure level must be IP67. The interconnect cabling may require special attention. A wicking action may result in the ingress of liquid into the mat, possibly causing a loss of sensor sensitivity. The termination of the interconnect cabling may need to be located in an enclosure that has an appropriate environmental rating.

The sensor must not be adversely affected by the environmental conditions for which the system is intended. The effects of liquids and other substances on the sensor must be taken into account. For example, long-term exposure to some liquids can cause degradation or swelling of the sensor's housing material, resulting in an unsafe condition.

The sensor's top surface should be a lifetime non-slip design, or otherwise minimize the possibility of slipping under the expected operating conditions.

The four-wire connection between the interconnect cables and the sensor must withstand dragging or carrying the sensor by its cable without failing in an unsafe manner, such as broken connections due to sharp or steady pulls, or continuous flexing. If such connection is not available, an alternative method must be employed to avoid such failure, for example, a cable which disconnects without damage and results in a safe situation.

Safety Mat Installation

The mounting surface quality and preparation for the safety mat must meet the requirements stated by the sensor's manufacturer. Irregularities in the mounting surfaces may impair the function of the sensor and should be reduced to an acceptable minimum. The mounting surface should be level and clean. Avoid the collection of fluids under or around the sensor. Prevent the risk of failure due to a build-up of dirt, turning chips, or other material under the sensor(s) or the associated hardware. Special consideration should be given to joints between the sensors to ensure that foreign material does not migrate under or into the sensor.

Any damage (cuts, tears, wear, or punctures) to the outer insulating jacket of the interconnect cable or to any part of the exterior of the safety mat must be immediately repaired or replaced. Ingress of material (including dirt particles, insects, fluid, moisture, or turning-chips), which may be present near the mat, may cause the sensor to corrode or to lose its sensitivity.

Routinely inspect and test each safety mat according to the manufacturer's recommendations. Do not exceed operational specifications, such as the maximum number of switching operations.

Securely mount each safety mat to prevent inadvertent movement (creeping) or unauthorized removal. Methods include, but are not limited to, secured edging or trim, tamper-resistant or one-way fasteners, and recessed flooring or mounting surface, in addition to the size and weight of large mats.

Each safety mat must be installed to minimize tripping hazards, particularly towards the machine hazard. A tripping hazard may exist when the difference in height of an adjacent horizontal surface is 4 mm (1/8 in) or more. Minimize tripping hazards at joints, junctions, and edges, and when additional coverings are used. Methods include a ground-flush installation of the mat, or a ramp that does not exceed 20° from horizontal. Use contrasting colors or markings to identify ramps and edges.

Position and size the safety mat system so that persons cannot enter the hazardous area without being detected, and cannot reach the hazard before the hazardous conditions have ceased. Additional guards or safeguarding devices may be required to ensure that exposure to the hazard(s) is not possible by reaching over, under, or around the device's sensing surface.

A safety mat installation must take into account the possibility of easily stepping over the sensing surface and not being detected. ANSI and international standards require a minimum depth of field of the sensor surface (the smallest distance between the edge of the mat and hazard) to be from 750 to 1200 mm (30 to 48 in), depending on the application and the relevant standard. The possibility of stepping on machine supports or other physical objects to bypass or climb over the sensor also must be prevented.

Safety Mat Safety Distance (Minimum Distance)

As a stand-alone safeguard, the safety mat must be installed at a safety distance (minimum distance) so that the exterior edge of the sensing surface is at or beyond that distance, unless it is solely used to prevent start/restart, or solely used for clearance safeguarding (see ANSI B11.19, ANSI/RIA R15.06, and ISO 13855).

The safety distance (minimum distance) required for an application depends on several factors, including the speed of the hand (or individual), the total system stopping time (which includes several response time components), and the depth penetration factor. Refer to the relevant standard to determine the appropriate distance or means to ensure that individuals cannot be exposed to the hazard(s).
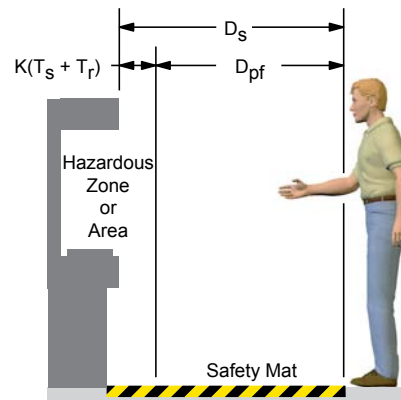
Figure 72. Determining safety distance for the safety mat

U.S. Applications

The Safety Distance formula, as provided in ANSI B11.19:

$$D_S = K \times (T_S + T_r) + D_{pf}$$

D_S

    the Safety Distance (in inches)

T_r

    the response time of the Safety Controller as measured from the time a stop signal from either hand control. The Safety Controller response time is obtained from the Configuration Summary in the PC Interface.

K

the OSHA/ANSI recommended hand-speed constant (in inches per second), in most cases is calculated at 63 in/sec, but may vary between 63 in/sec to 100 in/sec based on the application circumstances;

not a conclusive determination; consider all factors, including the physical ability of the operator, when determining the value of K to be used

T_S

the overall stop time of the machine (in seconds) from the initial stop signal to the final ceasing of all motion, including stop times of all relevant control elements and measured at maximum machine velocity

T_S is usually measured by a stop-time measuring device. If the specified machine stop time is used, add at least 20% as a safety factor to account for brake system deterioration. If the stop-time of the two redundant machine control elements is unequal, the slower of the two times must be used for calculating the separation distance

D_{pf}

the added distance due to the penetration depth factor

equals 48 in, per ANSI B11.19

European **Applications**

The Minimum Distance Formula, as provided in ISO 13855:

```
S = (K x T) + C
```

S

the Minimum Distance (in millimeters)

K

the ISO 13855 recommended hand-speed constant (in millimeters per second), in most cases is calculated at 1600 mm/sec, but may vary between 1600 to 2500 mm/sec based on the application circumstances;

· not a conclusive determination; consider all factors, including the physical ability of the operator, when determining the value of K to be used.

T

the overall machine stopping response time (in seconds), from the physical initiation of the safety device to the final ceasing of all motion

C

the added distance due to the depth penetration factor equals 1200 mm, per ISO 13855

Safety Mat Hookup **Options**

Pressure-sensitive mats and pressure-sensitive floors must meet the requirements of the category for which they are specified and marked. These categories are defined in ISO 13849-1.

The safety mat, its Safety Controller, and any output signal switching devices must meet, at a minimum, the Category 1 safety requirements. See ISO 13856-1 (EN 1760-1) and ISO 13849-1 for relevant requirement details.

The Safety Controller is designed to monitor 4-wire safety mats and is not **compatible** with two-wire devices (mats, sensing edges, or any other devices with two wires and a sensing resistor).

4-Wire
This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements depending on the safety rating and installation of the mat(s). The Safety Controller enters a Lockout mode when an open wire, a short to 0 V, or a short to another source of power is detected.
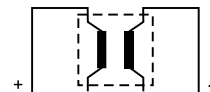
6.4.10 **Muting** Sensor

 Safety device muting is an automatically controlled suspension of one or more safety input stop signals during a portion of a machine operation when no immediate hazard is present or when access to the hazard is safeguarded. Muting sensors can be mapped to one or more of the following safety input devices:

- Safety gate (interlocking) switches
- Optical sensors
- Two-hand controls
- Safety mats

- Protective stops

US and International standards require the user to arrange, install, and operate the safety system so that personnel are protected and the possibility of defeating the safeguard is minimized.

Examples of **Muting** Sensors and Switches

⚠️ WARNING: Avoid Hazardous **Installations**

Two or four independent **position** switches must be properly adjusted or **positioned** so that they close only **after** the hazard no longer exists, and open again when the cycle is complete or the hazard is again present. If the switches are improperly adjusted or **positioned,** injury or death may result.

The user is responsible to satisfy all local, state, and national laws, rules, codes, and regulations relating to the use of safety equipment in any particular application. Make sure that all appropriate agency requirements have been met and that all installation and maintenance instructions contained in the appropriate manuals are followed.

Photoelectric Sensors (Opposed Mode)

Opposed-mode sensors should be configured for dark operate (DO) and have open (non-conducting) output contacts in a power Off condition. Both the emitter and receiver from each pair should be powered from the same source to reduce the possibility of common mode failures.

Photoelectric Sensors (Polarized **Retroreflective** Mode)

The user must ensure that false proxying (activation due to shiny or reflective surfaces) is not possible. Banner low profile sensors with linear polarization can greatly reduce or eliminate this effect.

Use a sensor configured for light operate (LO or N.O.) if initiating a mute when the retroreflective target or tape is detected (home position). Use a sensor configured for dark operate (DO or N.C.) when a blocked beam path initiates the muted condition (entry/exit). Both situations must have open (non-conducting) output contacts in a power Off condition.

Positive-Opening Safety Switches

Two (or four) independent switches, each with a minimum of one closed safety contact to initiate the mute cycle, are typically used. An application using a single switch with a single actuator and two closed contacts may result in an unsafe situation.

Inductive Proximity Sensors

Typically, inductive proximity sensors are used to initiate a muted cycle when a metal surface is detected. Do not use two-wire sensors due to excessive leakage current causing false On conditions. Use only three- or four-wire sensors that have discrete PNP or hard-contact outputs that are separate from the input power.

Mute Device Requirements

The muting devices must, at a minimum, comply with the following requirements:

1. There must be a minimum of two independent hard-wired muting devices.
2. The muting devices must have one of the following: normally open contacts, PNP outputs (both of which must fulfill the input requirements listed in the *Specifications* on page 12), or a complementary switching action. At least one of these contacts must close when the switch is actuated, and must open (or not conduct) when the switch is not actuated or is in a power-off state.
3. The activation of the inputs to the muting function must come from separate sources. These sources must be mounted separately to prevent an unsafe muting condition resulting from misadjustment, misalignment, or a single common mode failure, such as physical damage to the mounting surface. Only one of these sources may pass through, or be affected by, a PLC or a similar device.
4. The muting devices must be installed so that they cannot be easily defeated or bypassed.
5. The muting devices must be mounted so that their physical position and alignment cannot be easily changed.
6. It must not be possible for environmental conditions, such as extreme airborne contamination, to initiate a mute condition.
7. The muting devices must not be set to use any delay or other timing functions unless such functions are accomplished so that no single component failure prevents the removal of the hazard, subsequent machine cycles are prevented until the failure is corrected, and no hazard is created by extending the muted period.

6.4.11 Bypass Switch

🔑 The safety device bypass is a manually activated and temporary suspension of one or more safety input stop signals, under supervisory control, when no immediate hazard is present. It is typically accomplished by selecting a bypass mode of operation using a key switch to facilitate machine setup, web alignment/adjustments, robot teach, and process troubleshooting.

Bypass switches can be mapped to one or more of the following safety input devices:
- Safety gate (interlocking) switches
- Optical sensors
- Two-Hand Controls
- Safety mats

- Protective stop

Requirements of Bypassing Safeguards

Requirements to bypass a safeguarding device include[6]:
- The bypass function must be temporary
- The means of selecting or enabling the bypass must be capable of being supervised
- Automatic machine operation must be prevented by limiting range of motion, speed, or power (used inch, jog, or slow-speed modes). Bypass mode must not be used for production
- Supplemental safeguarding must be provided. Personnel must not be exposed to hazards
- The means of bypassing must be within full view of the safeguard to be bypassed
- Initiation of motion should only be through a hold-to-run type of control
- All emergency stops must remain active
- The means of bypassing must be employed at the same level of reliability as the safeguard
- Visual indication that the safeguarding device has been bypassed must be provided and be readily observable from the location of the safeguard
- Personnel must be trained in the use of the safeguard and in the use of the bypass
- Risk assessment and risk reduction (per the relevant standard) must be accomplished
- The reset, actuation, clearing, or enabling of the safeguarding device must not initiate hazardous motion or create a hazardous situation

Bypassing a safeguarding device should not be confused with *muting*, which is a temporary, automatic suspension of the safeguarding function of a safeguarding device during a non-hazardous portion of the machine cycle. Muting allows for material to be manually or automatically fed into a machine or process without issuing a stop command. Another term commonly confused with bypassing is *blanking*, which desensitizes a portion of the sensing field of an optical safeguarding device, such as disabling one or more beams of a safety light curtain so that a specific beam break is ignored.

6.4.12 Adjustable Valve Monitoring (AVM) **Function**

The Adjustable Valve (Device) Monitoring (AVM) function is similar in function to One-Channel External Device Monitoring (1-channel EDM, see *External Device Monitoring (EDM)* on page 101). The AVM function monitors the state of the device(s) that are controlled by the safety output to which the function is mapped. When the safety output turns Off, the AVM input must be high/On (+24 V dc applied) before the AVM timer expires or a lockout will occur. The AVM input must also be high/On when the safety output attempts to turn On or a lockout will occur.

---

[6] This summary was compiled from sources including ANSI NFPA79, ANSI/RIA R15.06, ISO 13849-1 (EN954-1), IEC60204-1, and ANSI B11.19.

Adjustable Valve
Monitoring

SO1

AVM
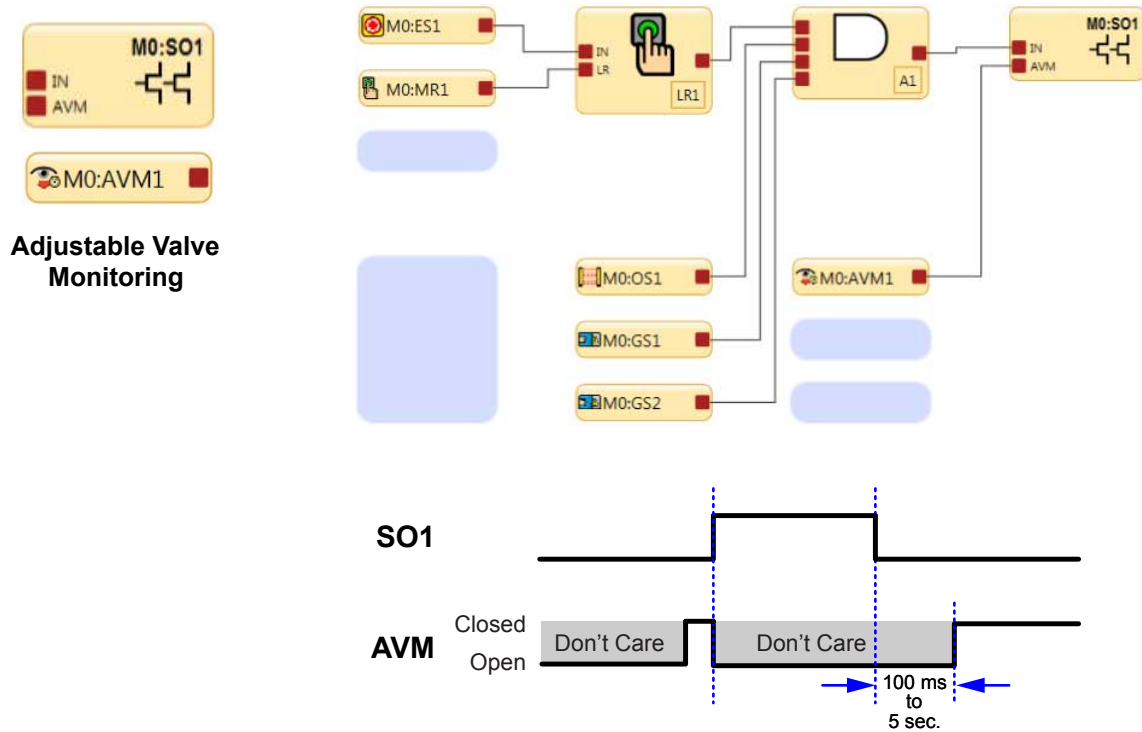
Adjustable Valve Monitoring AVM is a way to check the operation of dual channel valves. The force guided N.C. monitoring contacts of the valves are used as an input to detect a "stuck on" fault condition and will prevent the safety controller outputs from turning On.

> Note: 100 ms to 5 s time period is adjustable in 50 ms intervals (default is 100 ms).

Figure 73. Timing logic—AVM Function

The Adjustable Valve (Device) Monitoring function is useful for dynamically monitoring devices under the control of the safety output that may become slow, stick, or fail in an energized state or position, and whose operation needs to be verified after a Stop signal occurs. Example applications include single- or dual-solenoid valves controlling clutch/brake mechanisms, and position sensors that monitor the home position of a linear actuator.

Synchronization or checking a maximum differential timing between two or more devices, such as dual valves, may be achieved by mapping multiple AVM functions to one safety output and configuring the AVM timer to the same values. Any number of AVM inputs can be mapped to one safety output. An input signal can be generated by a hard/relay contact or a solid-state PNP output.

> ⚠ CAUTION: Adjustable Valve Monitoring (AVM) **Operation**
>
> When an input is configured with automatic reset logic and is quickly cycled (from Run to Stop to Run), the Safety Output(s) will not turn ON until the AVM input is satisfied. This could result in an On-Delay up to the **configured** AVM monitoring **time.**
>
> The user is responsible to make sure that the AVM monitoring **time** is properly **configured** for the **application** and to instruct all individuals associated with the machine about the possibility of the On-Delay **effect,** which may not be readily apparent to the machine operator or other personnel.

6.5 Non-Safety Input Devices

The non-safety input devices include manual reset devices, On/Off switches, mute enable devices, and cancel delay inputs.

Manual Reset Devices are used to create a reset signal for an output or function block configured for a manual reset, requiring an operator action for the output of that block to turn on. Resets can also be created using virtual reset input; see *Virtual Non-Safety Input Devices (FID 2 Only)* on page 93.

> ⚠ **WARNING: Non-Monitored Resets**
>
> If a non-monitored reset (either latch or system reset) is **configured** and if all other conditions for a reset are in place, a short from the Reset terminal to +24 V will turn On the safety output(s) immediately.

ON/Off Switch: provides an On or Off command to the machine. When all of the controlling safety inputs are in the Run state, this function permits the safety output to turn On and Off. This is a single-channel signal; the Run state is 24 V dc and the Stop state is 0 V dc. An On/Off input can be added without mapping to a safety output, which allows this input to control only a status output. An On/Off switch can also be created using a virtual input; see *Virtual Non-Safety Input Devices (FID 2 Only)* on page 93.

Mute Enable Switch: signals the Controller when the mute sensors are permitted to perform a mute function. When the mute enable function is configured, the mute sensors are not enabled to perform a mute function until the mute enable signal is in the Run state. This is a single-channel signal; the enable (Run) state is 24 V dc and the disable (Stop) state is 0 V dc. A mute enable switch can also be created using a virtual input; see *Virtual Non-Safety Input Devices (FID 2 Only)* on page 93.

Cancel **Off-Delay** Devices: provide the option to cancel a configured Off-delay time of a safety output or a delay block output. It functions in one of the following ways:
- Keeps the safety output or delay block output On
- Turns the safety output or delay block output Off immediately after the Controller receives a Cancel Off-Delay signal
- When Cancel Type is set to "Control Input", the safety output or delay block output stays on if the input turns On again before the end of the delay

A status output function (Output Delay in Progress) indicates when a Cancel Delay Input can be activated in order to keep the Off-delayed safety output On. A cancel off-delay device can also be created using a virtual input; see *Virtual Non-Safety Input Devices (FID 2 Only)* on page 93.

Cancel **Off-Delay** Timing
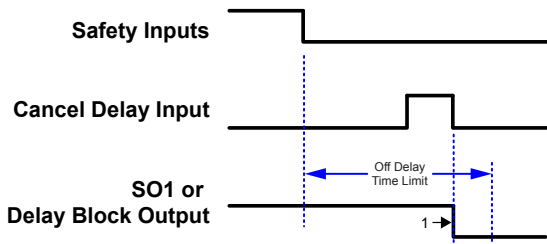
Note 1 - If "turn output off" function is selected

Figure 74. Safety Input remains in Stop mode
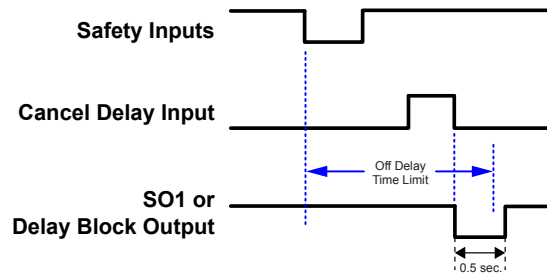
Figure 75. Turn Output Off function
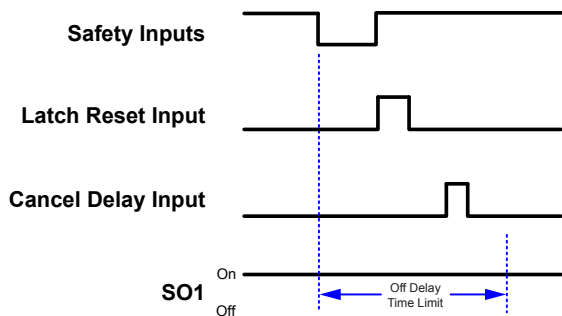
Figure 76. Keep Output On function for Safety Inputs with the Latch Reset
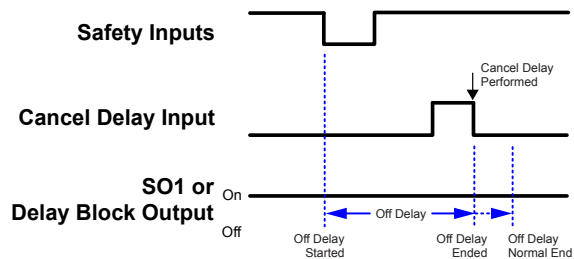
Figure 77. Keep Output On function for Safety Inputs without the Latch Reset

6.6 Virtual Non-Safety Input Devices (FID 2 Only)

All virtual inputs require FID 2. The virtual non-safety input devices include manual reset, On/Off, mute enable, and cancel off delay.

⚠️ WARNING: Virtual Non-Safety Inputs must never be used to control any safety-critical applications. If a Virtual Non-Safety Input is used to control a safety-critical application, a failure to danger is possible and may lead to serious injury or death.

☞ Important: Resetting a safeguard must not initiate hazardous motion. Safe work procedures require a start-up procedure to be followed and the individual performing the reset to verify that the entire hazardous area is clear of all personnel before each reset of the safeguard is performed. If any area cannot be observed from the reset switch location, additional supplemental safeguarding must be used: at a minimum, visual and audible warnings of the machine start-up.

6.6.1 Virtual Manual Reset and Cancel Delay (RCD) Sequence

According to section 5.2.2 of EN ISO 13849-1:2015, a "deliberate action" by the operator is required to reset a safety function. Traditionally, this requirement is met by using a mechanical switch and associated wires connected to specified terminals on the safety controller. For a monitored reset, the contacts must be open initially, then closed, and then open again within the proper timing. If the timing is not too short or too long, it is determined to be deliberate and the reset is performed.

Banner has created a virtual reset solution that requires deliberate action. For example, in place of the mechanical switch, an HMI may be used. In place of the wires, a unique Actuation Code is used for each safety controller on a network. Also, each virtual reset within a controller is associated with a specific bit in a register. This bit, along with the Actuation Code, must be written and cleared in a coordinated way. If the steps are completed with the proper sequence and timing, it is determined to be deliberate and the reset is performed.

While the standards do not require a "deliberate action" to perform a virtual cancel delay, to avoid additional complexity, Banner has implemented this function in the same way as the virtual manual reset.

The user must set matching Actuation Codes in both the safety controller and the controlling network device (PLC, HMI, etc.). The Actuation Code is part of the network settings and is not included in the configuration CRC. There is no default Actuation Code. The user must set one up. The Actuation Code can be active for up to 2 seconds for it to be effective. Different safety controllers on the same network should have different Actuation Codes.

The HMI/PLC programmer can choose from two different methods depending on their preferences; a feedback-based sequence or a timed sequence. These methods are described in the following figures. The actual register location depends upon which protocol is being used.

Virtual Reset or Cancel Delay (RCD) Sequence—Feedback Method

Figure 78. Virtual Reset or Cancel Delay (RCD) Sequence—Feedback Method

1. Write a logical 1 to the RCD Register Bit(s) corresponding to the desired Virtual Reset or Cancel Delay.
2. At the same time, or any time later, write the Actuation Code to the RCD Enable Register.
3. Monitor the RCD Enable Feedback Register for the Actuation Code to appear (125 ms typical). Then write a logical 0 to the RCD Register Bit.
4. At the same time, or any time later, clear the Actuation Code (write a logical 0 to the RCD Enable Register). This step must be completed within 2 seconds of when the code was first written (step 2).
5. If desired, monitor the RCD Feedback Register to know if the desired Reset or Cancel Delay was accepted (175 ms typical).

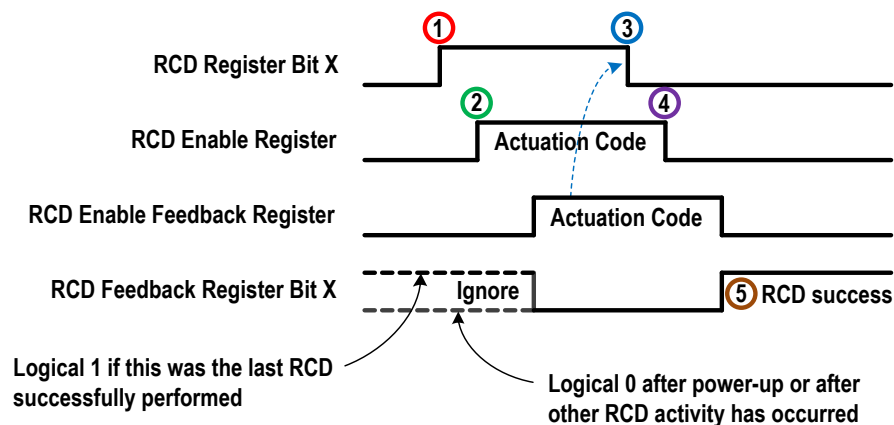Virtual Reset or Cancel Delay (RCD) Sequence—Timed Method
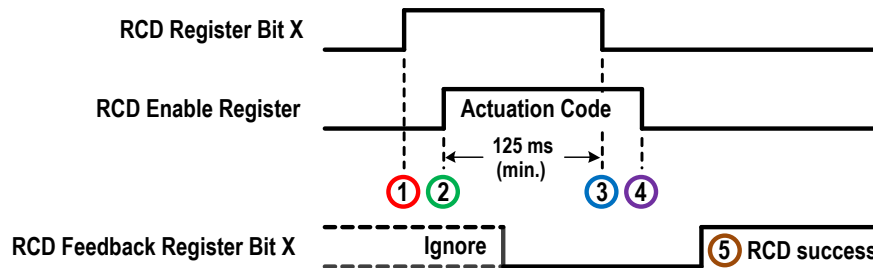
Figure 79. Virtual Reset or Cancel Delay (RCD) Sequence—Timed Method

1. Write a logical 1 to the RCD Register Bit(s) corresponding to the desired Virtual Reset or Cancel Delay.
2. At the same time, or any time later, write the Actuation Code to the RCD Enable Register.
3. At least 125 ms after step 2, write a logical 0 to the RCD Register Bit.
4. At the same time, or any time later, clear the Actuation Code (write a logical 0 to the RCD Enable Register). This step must be completed within 2 seconds from when the code was first written (step 2).
5. If desired, monitor the RCD Feedback Register to know if the desired Reset or Cancel Delay was accepted (175 ms typical).

Virtual Manual Reset Devices are used to create a reset signal for an output or function block configured for a manual reset, requiring an operator action for the output of that block to turn on. Resets can also be created using physical reset input; see *Non-Safety Input Devices* on page 91.

⚠ WARNING: Virtual Manual Reset

Any Virtual Manual Reset configured to perform a Manual Power Up function in conjunction with equipment in several locations on the same network should be avoided unless all hazardous areas can be verified safe.

Virtual Cancel **Off-Delay** Devices: provide the option to cancel a configured Off-delay time. It functions in one of the following ways:
*   Keeps the safety output or delay block output On
*   Turns the safety output or delay block output Off immediately after the Controller receives a Cancel Off-Delay signal
*   When Cancel Type is set to "Control Input", the safety output or delay block output stays on if the input turns On again before the end of the delay

A status output function (Output Delay in Progress) indicates when a Cancel Delay Input can be activated in order to keep the Off-delayed safety output On. A cancel off-delay device can also be created using a physical input; see *Non-Safety Input Devices* on page 91.

Virtual Cancel **Off-Delay** Timing
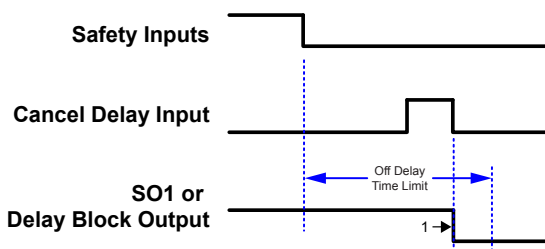
Note 1 - If "turn output off" function is selected

Figure 80. Safety Input remains in Stop mode
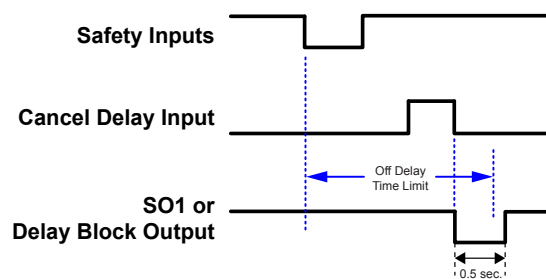
Figure 81. Turn Output Off function
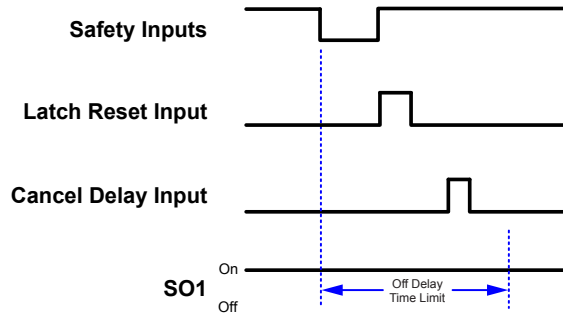
Figure 82. Keep Output On function for Safety Inputs with the Latch Reset

Figure 83. Keep Output On function for Safety Inputs without the Latch Reset

6.6.2 Virtual ON/OFF and Mute Enable

Virtual **ON/Off:** provides an On or Off command to the machine. When all of the controlling safety inputs are in the Run state, this function permits the safety output to turn On and Off. The Run state is a logical 1 and the Stop state is a logical 0. A virtual On/Off input can be added without mapping to a safety output, allowing it to control a non-safety status output. An On/Off switch can also be created using a physical input; see *Non-Safety Input Devices* on page 91.

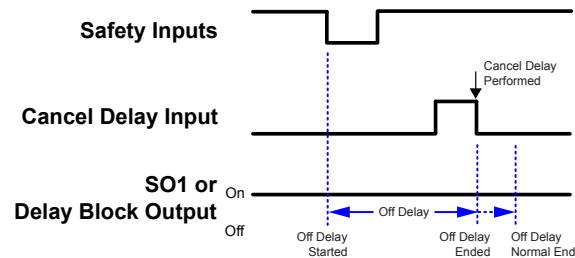Virtual Mute Enable: signals the Controller when the mute sensors are permitted to perform a mute function. When the mute enable function is configured, the mute sensors are not enabled to perform a mute function until the mute enable signal is in the Run state. The enable (Run) state is a logical 1 and the disable (Stop) state is a logical 0. A mute enable switch can also be created using a physical input; see *Non-Safety Input Devices* on page 91.

6.7 Safety Outputs

The Base Controller has two pairs of Solid-State Safety Outputs (terminals SO1a and b, and SO2a and b). These outputs provide up to 500 mA each at 24 V dc. Each redundant Solid-State Safety Output can be configured to function individually or in pairs, for example, split SO1a independent of SO1b, or SO1 as a dual-channel output.

Additional Safety Outputs can be added to expandable models of the Base Controller by incorporating I/O modules. These additional safety outputs can be isolated relay outputs that can be used to control/switch a wide range of power characteristics (see *Specifications* on page 12).

⚠️ WARNING: Safety Outputs must be connected to the machine control so that the machine's safety-related control system interrupts the circuit to the machine primary control element(s), resulting in a non-hazardous condition.

Do not wire an intermediate device(s), such as a PLC, PES, or PC, that can fail in such a manner that there is the loss of the safety stop command, or that the safety function can be suspended, overridden, or defeated, unless accomplished with the same or greater degree of safety.

The following list describes additional nodes and attributes that can be configured from the Safety Output function block **Properties** window (see *Adding Inputs and Status Outputs* on page 22):

EDM (External Device Monitoring)

Enables the safety controller to monitor devices under control (FSDs and MPCEs) for proper response to the stopping command of the safety outputs. It is strongly recommended to incorporate EDM (or AVM) in the machine design and the safety controller configuration to ensure the proper level of safety circuit integrity (see *EDM and FSD Hookup* on page 101).

AVM (Adjustable Valve Monitoring)

Enables the safety controller to monitor valves or other devices that may become slow, "sticky", or fail in an energized state or position and whose operation needs to be verified after a Stop signal occurs. Up to three AVM inputs can be selected if EDM is not used. It is strongly recommended to incorporate AVM (or EDM) in the machine design and the safety controller configuration to ensure the proper level of safety circuit integrity (see *Adjustable Valve Monitoring (AVM) Function* on page 90).

LR (Latch Reset)

Keeps the SO or RO output Off until the input changes to the Run state and a manual reset operation is performed See *Manual Reset Input* on page 34 for more information.

RE (Reset Enable)

This option appears only if LR (Latch Reset) is enabled. The Latch Reset can be controlled by selecting Reset Enable to restrict when the Safety Output can be reset to a Run condition.

FR (Fault Reset)

Provides a manual reset function when input faults occur. The FR node needs to be connected to a Manual Reset button or signal. This function is used to keep the SO or RO output Off until the Input device fault is cleared, the faulted device is in the Run state , and a manual reset operation is performed. This replaces power down/up cycle reset operation. See *Manual Reset Input* on page 34 for more information.

Power up mode

The Safety Output can be configured for three power-up scenarios (operational characteristics when power is applied):
- Normal Power-Up Mode (default)
- Manual Power-up Mode
- Automatic Power-Up Mode

See *Manual Reset Input* on page 34 for more information.

Split (Safety Outputs)

This option is only available for Solid-State Safety Outputs. Each redundant Solid-State Safety Output can be configured to function individually or in pairs (default). Splitting a solid-state safety output creates two independent single channel outputs (control of SO1a is independent of SO1b). To combine a split safety output, open the Mx:SOxA **Propeties** window and click Join.

On-Delays and **Off-Delays**

Each safety output can be configured to function with either an On-Delay or an Off-Delay (see *Figure 84* on page 97), where the output turns On or Off only after the time limit has elapsed. An output cannot have both On- and Off-Delays. The On- and Off-Delay time limit options range from 100 milliseconds to 5 minutes, in 1 millisecond increments.
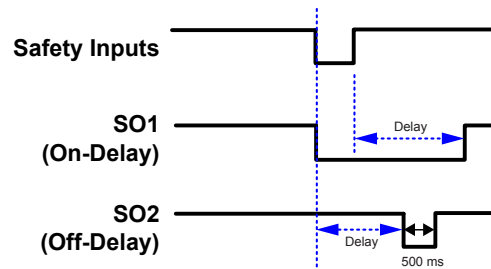
Figure 84. Timing Diagram—General Safety Output On-Delay and Off-Delay

⚠️ WARNING: **Off-Delays**

A safety output Off-Delay time will be honored even if the safety input that caused the Off-Delay timer to start changes back to the Run state before the delay time expires. However, in cases of a power **interruption** or a power loss, an **Off-Delay time** can end immediately. If such an immediate machine stop **condition** could cause a **potential** danger, **additional** safeguarding measures must be taken to prevent injuries.

Two Safety Outputs can be linked together when one of the Safety Outputs is configured for an Off-Delay, and the other does not have a delay. After it is linked, the non-delayed output does not immediately turn back on if the controlling input turns on during the Off Delay as shown in *Figure 85* on page 97. To link two Safety Outputs:
1. Open the **Properties** window of the Safety Output that needs to have an Off-Delay.
2. Select "Off-Delay" from the *Safety Output Delay* drop-down list.
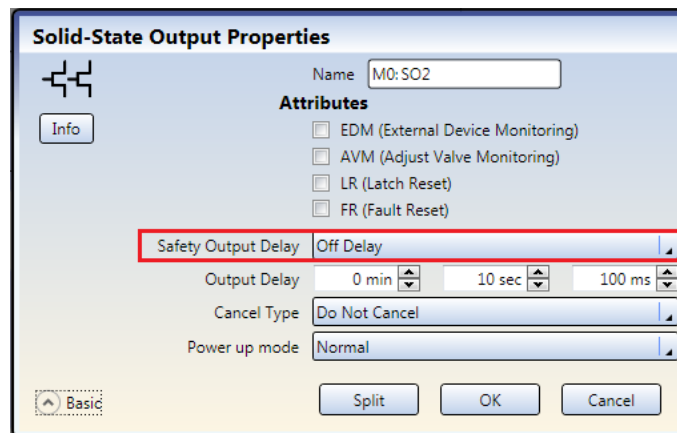
3. Set the desired Output Delay time.
4. Click OK.
5. Open the **Properties** window of the Safety Output that will link to the Safety Output with an Off-Delay.
6. From *Link to Safety Output* drop-down list, select the Safety Output with an Off-Delay to which you wish to link this Safety Output.

Note: The same input(s) need to be connected to both Safety Outputs in order for outputs to show up as available for linking.
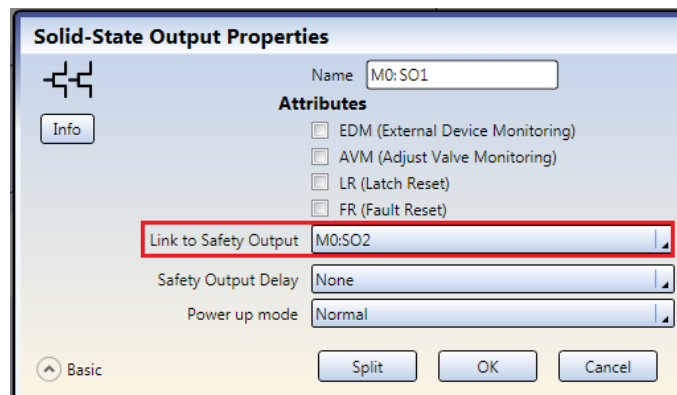
6.7.1 Solid-State Safety Outputs

The solid-state Safety Outputs, for example, SO1a and b, and SO2a and b, are actively monitored to detect short circuits to the supply voltage, to each other, and to other voltage sources and are designed for Category 4 safety applications. If a failure is detected on one channel of a safety output pair, both outputs attempt to turn Off and will enter a lockout state. The output without the fault is able to turn off the hazardous motion.

Similarly, a Safety Output that is used individually (split), is also actively monitored to detect short circuits to other power sources, but is unable to perform any actions. Take extreme care in the wiring of the terminals and in the routing of the wires to avoid the possibility of shorts to other voltage sources, including other Safety Outputs. Each split Safety Output is sufficient for Category 3 applications due to an internal series connection of two switching devices, but an external short must be prevented.

☞ Important: When Solid-State Safety Output modules (XS2so or XS4so) are used, the power to those modules must be applied either prior to or within 5 seconds after applying the power to the Base Controller, if using separate power supplies.

⚠ WARNING: Single Channel (Split) Outputs use in Safety **Critical Applications**

If a single channel output is used in a safety critical application then fault exclusion principles must be incorporated to ensure Category 3 safety operation. Routing and managing single channel output wires so shorts to other outputs or other voltage sources are not possible is an example of a proper fault exclusion method. Failure to incorporate proper fault exclusion methods when using single channel outputs in safety critical applications may cause a loss of safety control and result in a serious injury or death.

Whenever possible, incorporating External Device Monitoring (EDM) and/or Adjustable Valve Monitoring (AVM) is highly recommended to monitor devices under control (FSDs and MPCEs) for unsafe failures. See *External Device Monitoring (EDM)* on page 101 for more information.

Output **Connections**

The Safety Outputs must be connected to the machine control such that the machine's safety related control system interrupts the circuit or power to the machine primary control element(s) (MPCE), resulting in a non-hazardous condition.

When used, Final Switching Devices (FSDs) typically accomplish this when the safety outputs go to the Off state. Refer to the *Specifications* on page 12 before making connections and interfacing the Controller to the machine.

The level of the safety circuit integrity must be determined by risk assessment; this level is dependent on the configuration, proper installation of external circuitry, and the type and installation of the devices under control (FSDs and MPCEs). The solid-state safety outputs are suitable for Category 4 PL e / SIL 3 applications when controlled in pairs (not split) and for applications up to Category 3 PL d / SIL 2 when acting independently (split) when appropriate fault exclusion has been employed. See *Figure 86* on page 99 for hookup examples.

⚠ WARNING: Safety Output Lead Resistance

To ensure proper **operation,** the resistance in the safety output wires should not exceed 10 ohms. A resistance higher than 10 ohms may mask a short between the dual-channel safety outputs and create an unsafe condition that may lead to serious bodily injury or death.

Common Wire **Installation**

Consider the wire resistance of the 0 V common wire and the currents flowing in that wire to avoid nuisance lockouts. Notice the location of the resistance symbol in the diagram below representing 0 V common wire resistance (RL).

Methods to prevent this situation include:
- Using larger gauge or shorter wires to reduce the resistance (R_L) of the 0 V common wire
- Separate the 0 V common wire from the loads connected to the safety controller and the 0 V common wire from other equipment powered by the common 24 V supply
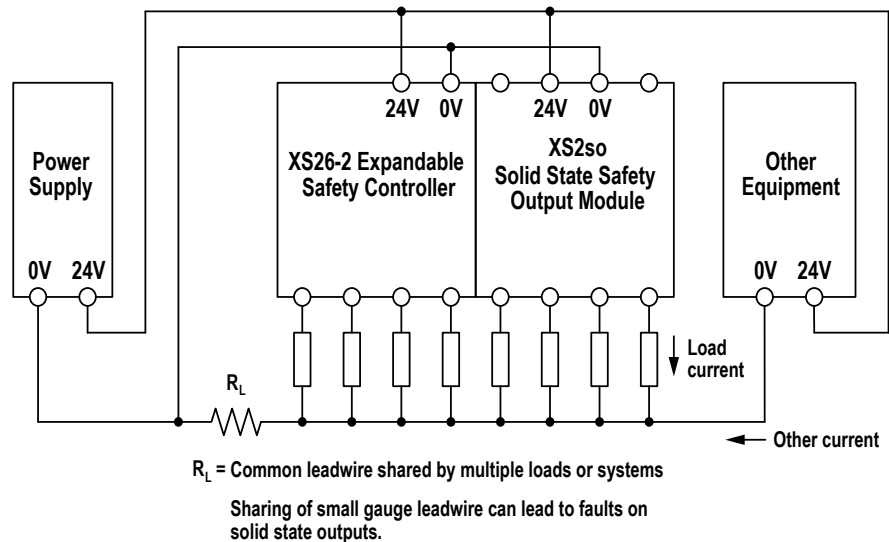
Figure 86. Common Wire Installation

Note: When the Safety Output turns Off, the voltage at that output terminal must drop below 1.7 V with respect to the 0V terminal on that module. If the voltage is higher than 1.7 V, the Controller will decide that the output is still on resulting in a lockout. Consider using larger gauge wires, shorter wires, or using a single point grounding scheme similar to what is shown in the following diagrams.

Preferred 0V routing plan when a single power supply is used
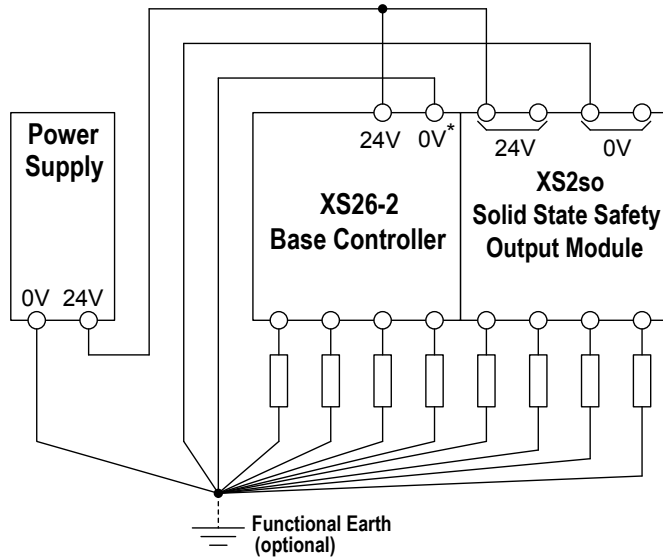
* **The voltage for all safety input devices (including all Input Expansion Modules) should be measured in reference to the 0V terminal of the Base Controller**

Preferred 0V routing plan when separate power supplies are used
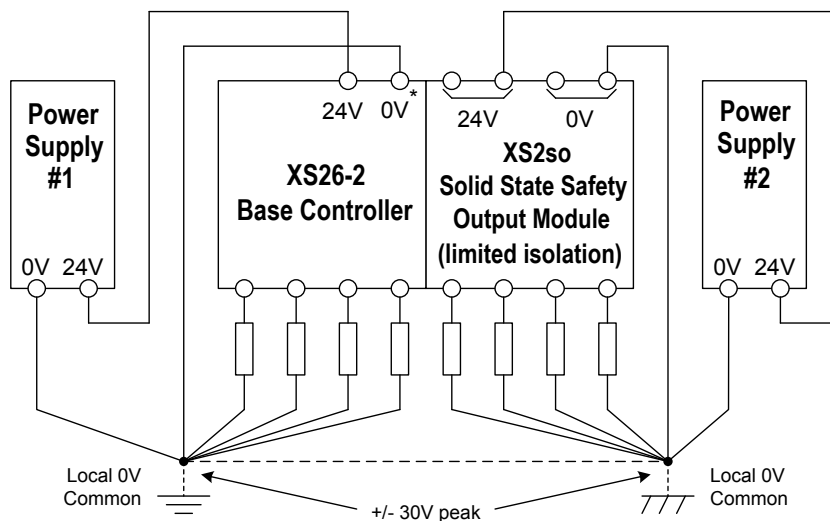
Figure 87. Wiring Diagram—Recommended Grounding

6.7.2 Safety Relay Outputs

Expansion Safety Relay modules have isolated redundant relay outputs that can be used to control/switch a wide range of power characteristics (see *Specifications* on page 12). Unlike a solid-state Safety Output, within an output module an individual safety relay output (Mx:ROx) functions as a group and cannot be split.

The Safety Relay Outputs are controlled and monitored by the Base Controller without requiring additional wiring.

For circuits requiring the highest levels of safety and reliability, when used in pairs (two N.O. or N.O. and a N.C.), either Safety Output must be capable of stopping the motion of the guarded machine controlled by a safety output in an emergency. When used individually (a single N.O. output), fault exclusion must ensure that failures cannot occur that would result in the loss of the safety function, for example, a short-circuit to another safety output or a secondary source of energy or voltage. For more information, see *Single-channel Control* in *Safety (Protective) Stop Circuits* on page 103 and *Fault Exclusion* on page 78.

Whenever possible, incorporating External Device Monitoring (EDM) and/or Adjustable Valve Monitoring (AVM) is highly recommended to monitor devices under control (FSDs and MPCEs) for unsafe failures. See *External Device Monitoring (EDM)* on page 101 for more information.

XS/SC26-2 Safety Controller

Output **Connections**—when used, Final Switching Devices (FSDs) typically accomplish this when the safety outputs go to the **Off** state. The Safety Relay Outputs must be connected to the machine control such that the machine's safety related control system interrupts the circuit or power to the machine primary control element(s) (MPCE), resulting in a non-hazardous condition.

The Safety Relay Outputs can be used as the Final Switching Device (FSD) and can be interfaced in either a Dual-Channel or Single-Channel safety (protective) stop circuit (see *FSD Interfacing Connections* on page 103). Refer to *Specifications* on page 12 before making connections and interfacing the Safety Controller to the machine.

The level of the safety circuit integrity must be determined by risk assessment; this level is dependent on the configuration, proper installation of external circuitry, and the type and installation of the devices under control (FSDs and MPCEs). The safety relay outputs are suitable for Category 4 PL e / SIL 3. See *Figure 86* on page 99 for hookup examples.

👉   Important: The user is responsible for supplying overcurrent protection for all relay outputs.

6.7.3 EDM and FSD Hookup

External Device Monitoring (EDM)

The Controller's safety outputs can control external relays, contactors, or other devices that have a set of normally closed (N.C.), force-guided (mechanically linked) contacts that can be used for monitoring the state of the machine power contacts. The monitoring contacts are normally closed (N.C.) when the device is turned Off. This capability allows the Controller to detect if the devices under load are responding to the safety output, or if the N.O. contacts are possibly welded closed or stuck On.

The EDM function provides a method to monitor these types of faults and to ensure the functional integrity of a dual-channel system, including the MPCEs and the FSDs.

A single EDM input can be mapped to one or multiple Safety Outputs. This is accomplished by opening the Safety Output **Properties** window and checking EDM, then adding External Device Monitoring from the Safety Input tab in the Add Equipment window (accessed from the Equipment view or **Functional** View), and connecting the External Device Monitoring input to the EDM node of the Safety Output.

The EDM inputs can be configured as one-channel or two-channel monitoring. One-channel EDM inputs are used when the OSSD outputs directly control the de-energizing of the MPCEs or external devices.
- One-Channel Monitoring—a series connection of closed monitor contacts that are forced-guided (mechanically linked) from each device controlled by the Controller. The monitor contacts must be closed before the Controller outputs can be reset (either manual or automatic). After a reset is executed and the safety outputs turn On, the status of the monitor contacts are no longer monitored and may change state. However, the monitor contacts must be closed within 250 milliseconds of the safety outputs changing from On to Off.
- Two-Channel Monitoring—an independent connection of closed monitor contacts that are forced-guided (mechanically linked) from each device controlled by the Controller. Both EDM inputs must be closed before the Controller can be reset and the OSSDs can turn On. While the OSSDs are On, the inputs may change state (either both open, or both closed). A lockout occurs if the inputs remain in opposite states for more than 250 milliseconds.
- No Monitoring (default)—If no monitoring is desired, do not enable the Safety Output EDM node. If the Controller does not use the EDM function in Category 3 or Category 4 applications, the user must make sure that any single failure or accumulation of failures of the external devices does not result in a hazardous condition and that a successive machine cycle is prevented.

⚠   CAUTION: EDM **Configuration**

If the application does not require the EDM function, it is the user's responsibility to ensure that this does not create a hazardous situation.

⚠   CAUTION: External Device Monitoring Hookup

It is strongly recommended that at least one normally closed, forced-guided monitoring contact of each MPCE or external device is wired to monitor the state of the MPCEs (as shown in the hookup figures). If this is done, proper operation of the MPCEs will be verified. MPCE monitoring contacts must be used to maintain control reliability.

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Single-channel EDM used to monitor both MPCE feedback signals. If one or both channels do not close, the system enters a lockout mode.
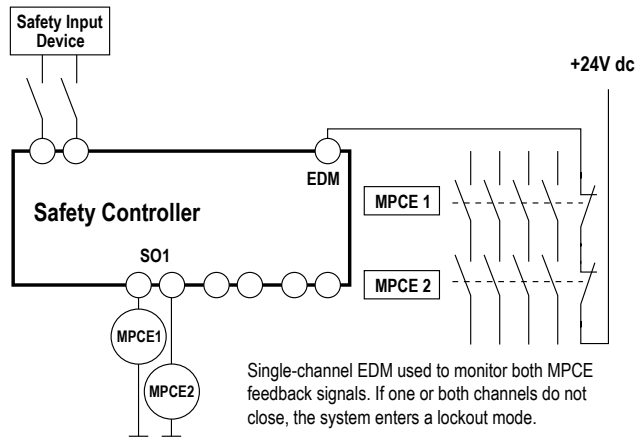
Figure 88. One-channel EDM hookup

Dual-channel EDM used to monitor both MPCE feedback signals. If the channels are not in the same state, the system enters a Lockout mode.
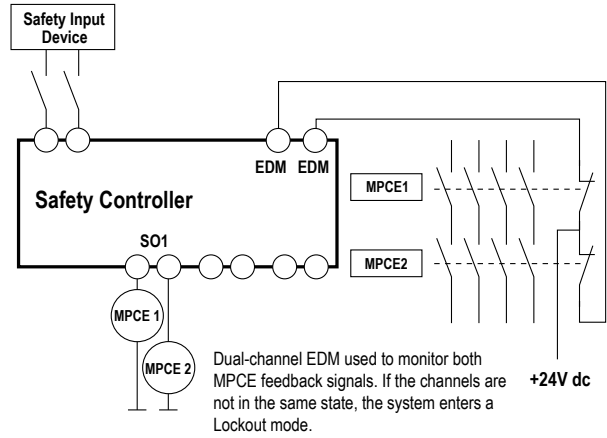
Figure 89. Two-channel EDM hookup

External Device Monitoring
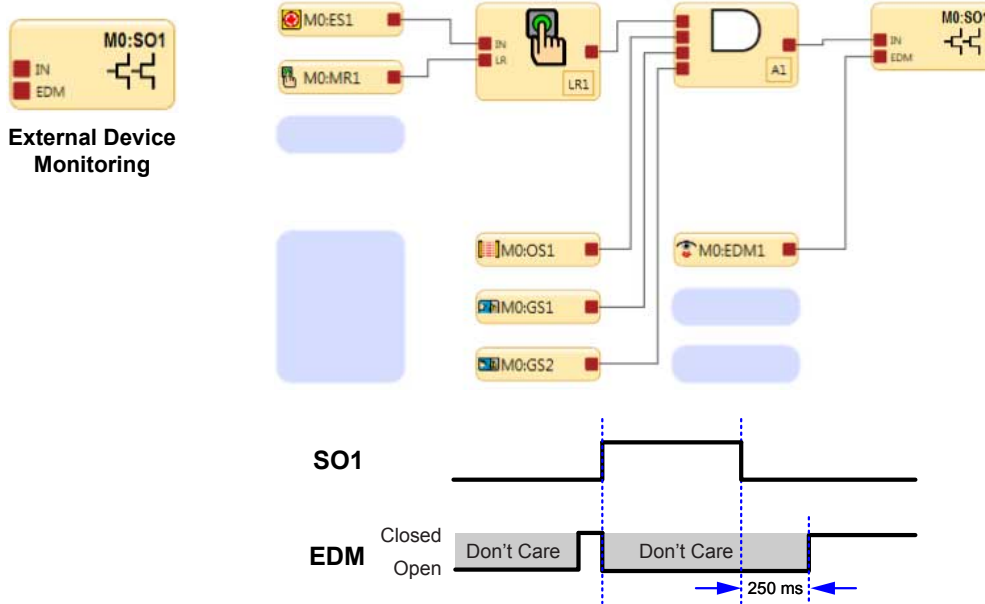
External Device Monitoring EDM is a way to check the operation of dual channel final switching devices or machine primary control elements. The force guided N.C. monitoring contacts of the FSD or MPCE are used as an input to detect a "stuck on" fault condition and will prevent the safety controller outputs from turning On.

Figure 90. Timing logic: One-channel EDM status, with respect to Safety Output

For two-channel EDM, as shown below, both channels must be closed before the Safety Output(s) turn On.
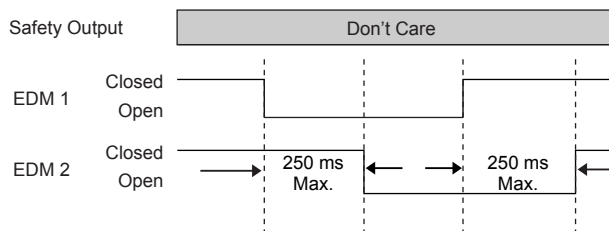
Figure 91. Timing logic: Two-channel EDM, timing between channels
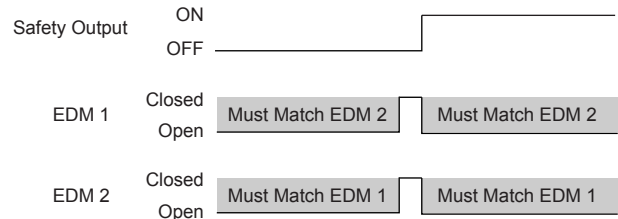
Figure 92. Timing logic: Two-channel EDM status, with respect to Safety Output

FSD Interfacing **Connections**

Final switching devices (FSDs) interrupt the power in the circuit to the Machine Primary Control Element (MPCE) when the Safety Outputs go to the Off-state. FSDs may play different roles, though the most common are forced-guided (mechanically linked) relays or Interfacing Modules. The mechanical linkage between the contacts allows the device to be monitored by the external device monitoring circuit for certain failures.

Depending on the application, the use of FSDs can facilitate controlling voltage and current that differs from the Safety Outputs of the Controller. FSDs may also be used to control an additional number of hazards by creating multiple safety stop circuits.

Safety **(Protective)** Stop Circuits

A safety stop allows for an orderly cessation of motion or hazardous situation for safeguarding purposes, which results in a stop of motion and removal of power from the MPCEs (assuming this does not create additional hazards). A safety stop circuit typically comprises a minimum of two normally open contacts from forced-guided (mechanically linked) relays (external device monitoring), which are monitored to detect certain failures so that the loss of the safety function does not occur. Such a circuit can be described as a "safe switching point."

Typically, safety stop circuits are a series connection of at least two N.O. contacts coming from two separate, positive-guided relays, each controlled by one separate safety output of the Controller. The safety function relies on the use of redundant contacts to control a single hazard, so that if one contact fails On, the second contact stops the hazard and prevents the next cycle from occurring.

Interfacing safety stop circuits must be wired so that the safety function cannot be suspended, overridden, or defeated, unless accomplished in a manner at the same or greater degree of safety as the machine's safety-related control system that includes the Controller.

The normally open outputs from an interfacing module are a series connection of redundant contacts that form safety stop circuits and can be used in either single-channel or dual-channel control methods.

Dual-Channel Control. Dual-channel (or two-channel) control has the ability to electrically extend the safe switching point beyond the FSD contacts. With proper monitoring, such as EDM, this method of interfacing is capable of detecting certain failures in the control wiring between the safety stop circuit and the MPCEs. These failures include a short-circuit of one channel to a secondary source of energy or voltage, or the loss of the switching action of one of the FSD outputs, which may lead to the loss of redundancy or a complete loss of safety if not detected and corrected.

The possibility of a wiring failure increases as the physical distance between the FSD safety stop circuits and the MPCEs increase, as the length or the routing of the interconnecting wires increases, or if the FSD safety stop circuits and the MPCEs are located in different enclosures. Thus, dual-channel control with EDM monitoring should be used in any installation where the FSDs are located remotely from the MPCEs.

Single-Channel Control. Single-channel (or one-channel) control uses a series connection of FSD contacts to form a safe switching point. After this point in the machine's safety-related control system, failures that would result in the loss of the safety function can occur, for example, a short-circuit to a secondary source of energy or voltage.

Thus, this method of interfacing should be used only in installations where FSD safety stop circuits and the MPCEs are physically located within the same control panel, adjacent to each other, and are directly connected to each other; or where the possibility of such a failure can be excluded. If this cannot be achieved, then two-channel control should be used.

Methods to exclude the possibility of these failures include, but are not limited to:
- Physically separating interconnecting control wires from each other and from secondary sources of power
- Routing interconnecting control wires in separate conduit, runs, or channels
- Routing interconnecting control wires with low voltage or neutral that cannot result in energizing the hazard
- Locating all elements (modules, switches, devices under control, etc.) within the same control panel, adjacent to each other, and directly connected with short wires
- Properly installing multi-conductor cabling and multiple wires that pass through strain-relief fittings. Over-tightening of a strain-relief can cause short circuits at that point
- Using positive-opening or direct-drive components installed and mounted in a positive mode

⚠️ WARNING: Use of Transient Suppressors

Transient suppressors are recommended. They MUST be installed across the coils of the FSDs. NEVER install suppressors directly across the contacts of the FSDs. It is possible for suppressors to fail as a short circuit. If installed directly across the contacts of the FSDs, a short-circuited suppressor creates an unsafe condition.

⚠️ WARNING: Safety Output Interfacing

To ensure proper operation, the Banner product output parameters and machine input parameters must be considered when interfacing the solid state safety outputs to the machine inputs. Machine control circuitry must be designed so that:

- The maximum cable resistance value between the Safety Controller solid-state safety outputs and the machine inputs is not exceeded
- The Safety Controller's solid-state safety output maximum Off state voltage does not result in an On condition
- The Safety Controller's solid-state safety output maximum leakage current, due to the loss of 0 V, does not result in an On condition

Failure to properly interface the safety outputs to the guarded machine may result in serious bodily injury or death.

⚠️ WARNING: Shock Hazard and Hazardous Energy

Always disconnect power from the safety system (for example, device, module, interfacing, etc.) and the machine being controlled before making any connections or replacing any component.

Electrical installation and wiring must be made by Qualified Personnel[7] and must comply with the relevant electrical standards and wiring codes, such as the NEC (National Electrical Code), ANSI NFPA79, or IEC 60204-1, and all applicable local standards and codes.

Lockout/tagout procedures may be required. Refer to OSHA 29CFR1910.147, ANSI Z244-1, ISO 14118, or the appropriate standard for controlling hazardous energy.

⚠️ WARNING: Proper Wiring

The generalized wiring configurations shown are provided only to illustrate the importance of proper installation. The proper wiring of the Safety Controller to any particular machine is solely the responsibility of the installer and end user.

Generic Hookup: Safety Output with EDM

Figure 93. Generic Hookup: Solid-State Safety Output with EDM

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[7] A person who, by possession of a recognized degree or certificate of professional training, or who, by extensive knowledge, training and experience, has successfully demonstrated the ability to solve problems relating to the subject matter and work.

Safety Relay Outputs 43/44, 53/54 and 61/62 can be wired similarly, but require a separate EDM or AVM input for monitoring.

XS26-2xx

+24Vdc

0Vdc

EDM

XS1ro or XS2ro

13   14

23   24

31   32

Machine Control Circuit

L1/+V

+24Vdc   0Vdc

L2/-V

MPCE1

MPCE2

*

*

* **Arc Suppressors**

Feedback Loop (optional)
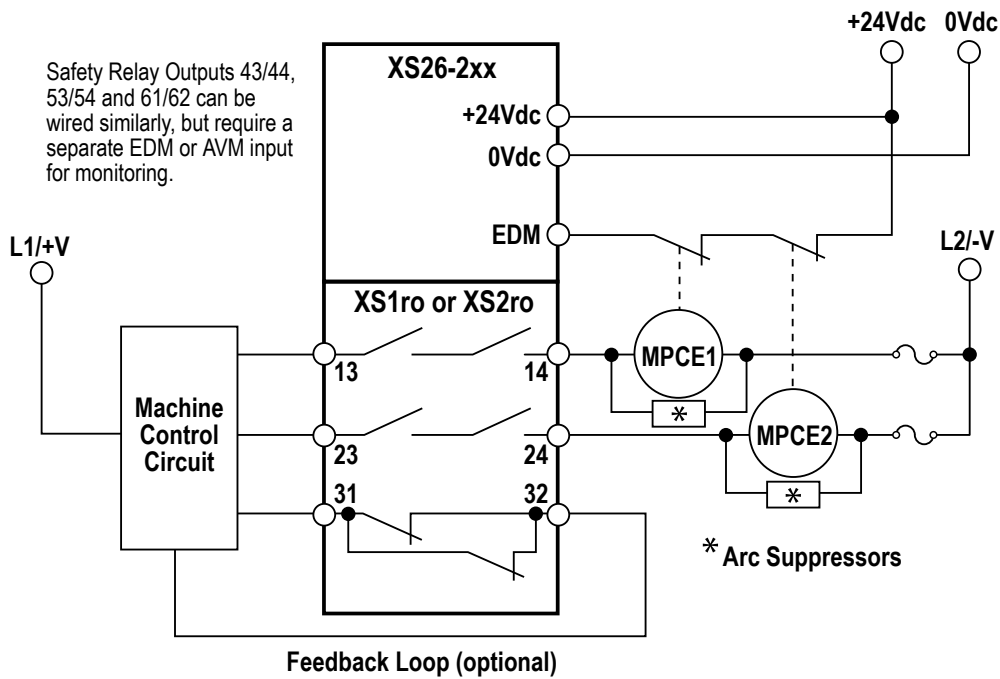
Figure 94. Generic Hookup: Safety Relay Output (Dual-Channel) with EDM

XS/SC26-2xx

0V dc

+24Vdc

0Vdc

SO1b

(SO1 not split)

SO1a

EDM

+24V dc

IM-T-9A

S3   K2   K1   S1

S4   S2

Y3   Y4

Y1   Y2

13   14

23   24

33   34

Machine Control

MPCE 1

MPCE 2

*

*

Feedback (optional)
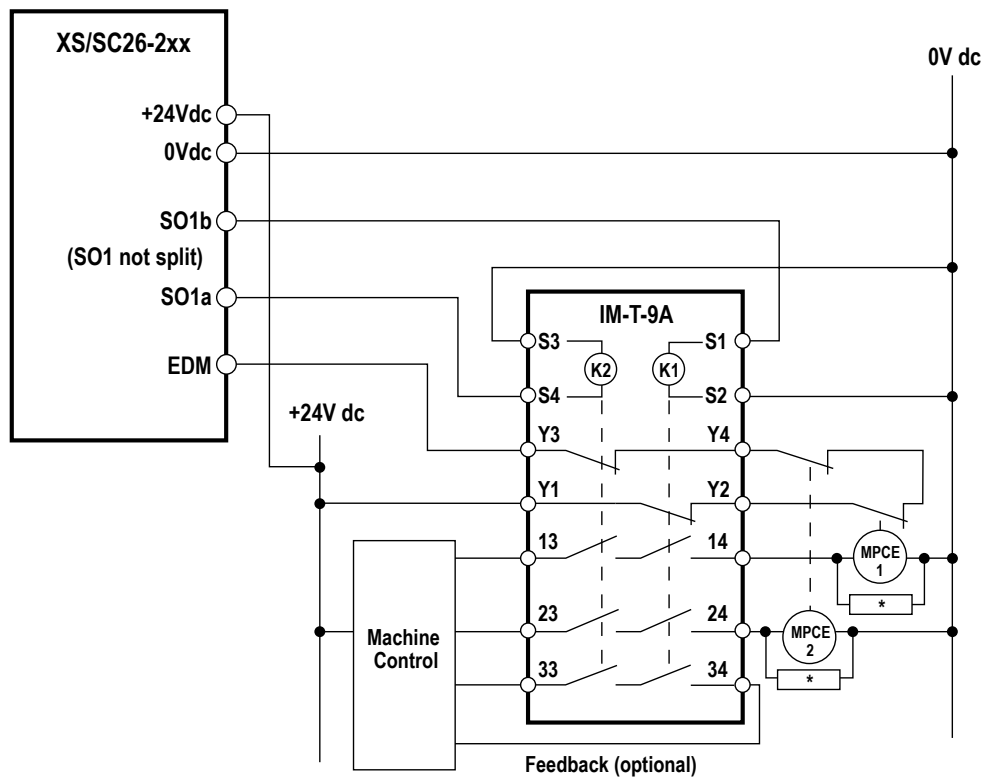
* Installation of transient (arc) suppressors across the coils of MPCE1 and MPCE2 is recommended (see Warning)

Figure 95. Generic Hookup: Solid-State Safety Output to IM-T-9A

6.8 Status Outputs

6.8.1 Status Output Signal **Conventions**

There are two signal conventions selectable for each status output: "PNP On" (sourcing 24 V dc), or "PNP Off" (non-conducting). The default convention is Active = PNP On.

Table 3: Status Output Signal Conventions

Function	Signal **Conventions**			
	Active = PNP On		**Active** = PNP **Off**	
	Status Output State		Status Output State	
	+24 V dc	**Off**	**Off**	24 V dc
Bypass	Bypassed	Not Bypassed	Bypassed	Not Bypassed
Mute	Muted	Not Muted	Muted	Not Muted
Output Delay In Progress	Delay	No Delay	Delay	No Delay
Track Input	Run	Stop	Run	Stop
Track Input Fault	Fault	Ok	Fault	Ok
Track Any Input Fault	Fault	Ok	Fault	Ok
Track Input Group	Initiated Stop	Other Input Caused Stop	Initiated Stop	Other Input Caused Stop
Track Output	SO On	SO Off	SO On	SO Off
Track Output Fault	Fault	Ok	Fault	Ok
Track Output Fault All	Fault	Ok	Fault	Ok
Track Output Logical State	Logically On	Logically Off	Logically On	Logically Off
Track **Function** Block State (FID 2 Only)	Run	Stop	Run	Stop
Waiting for Manual Reset	Reset Needed	Not Satisfied	Reset Needed	Not Satisfied
System Lockout	Lockout	Run Mode	Lockout	Run Mode

6.8.2 Status Output **Functionality**

Up to 32 convertible inputs or Safety Outputs may be used as a Status Output. Solid-State Safety Outputs may be split and used as Status Outputs. Relay Safety Outputs cannot be used as Status Outputs and cannot be split.

Status Outputs can be configured to perform the following functions:

Bypass

Indicates when a particular Safety Input is bypassed.

Mute

Indicates a muting active status for a particular mutable Safety Input:
- On when a mutable input is muted
- Off when a mutable input is not muted
- Flashing when the conditions to start a mute-dependent override exist (an inactive muting cycle, the mutable Safety Input is in the stop state, and at least one muting sensor is in the stop (blocked) state); not available for Virtual Status Output
- On during an active mute-dependent override function (not a bypass function) of a mutable Safety Input

Output Delay In Progress

Indicates if either On- or Off-Delay is active.

Track Input

Indicates the state of a particular Safety Input.

Track Input Fault

Indicates when a particular Safety Input has a fault.

Track Any Input Fault

Indicates when any Safety Input has a fault.

Track Input Group

Indicates the state of a group of Safety Inputs, for example, which Safety Input turned off first. Once this function has been indicated, the function may be re-enabled by a configured Reset Input. Up to three Input Groups can be tracked.

Track Output

Indicates the physical state of a particular Safety Output (On or Off).

Track Output Fault

Indicates when a particular Safety Output has a fault.

Track Output Fault All

Indicates a fault from any Safety Output.

Track Output Logical State

Indicates the logical state of a particular Safety Output. For example, the logical state is Off but the Safety Output is in an Off-Delay and not physically off yet.

Track **Function** Block State (FID 2 Only)

Indicates the state of a particular Function Block.

Waiting for Manual Reset

Indicates a particular configured reset is needed.

System Lockout

Indicates a Non-Operating Lockout Condition, for example unmapped input connected to 24 V.

6.9 Virtual Status Outputs

Up to 64 Virtual Status Outputs can be added for any configuration using Modbus/TCP, EtherNet/IP Input Assemblies, EtherNet/IP Explicit Messages, and PCCC protocols on FID 1 Base Controllers and up to 256 virtual Status Outputs can be added on FID 2 Base Controllers. FID 2 Base Controllers can also use PROFINET. These outputs can communicate the same information as the Status Outputs over the network. See *Status Output Functionality* on page 106 for more information. The Auto **Configure** function, located on the Industrial Ethernet tab of the PC Interface, automatically configures the Virtual Status Outputs to a set of commonly used functions, based on the current configuration. This function is best used after the configuration has been determined. Virtual Status Output configuration can be manually revised after the Auto **Configure** function has been used. The information available over the network is consistent with the logical state of the inputs and outputs within 100 ms for the Virtual Status Output tables (viewable via the PC Interface) and within 1 second for the other tables. The logical state of inputs and outputs is determined after all internal debounce and testing is complete. See *Industrial Ethernet* on page 49 for details on configuring Virtual Status Outputs.

7 System Checkout

7.1 Schedule of Required Checkouts

Verifying the configuration and proper functioning of the Safety Controller includes checking each safety and non-safety input device, along with each output device. As the inputs are individually switched from the Run state to the Stop state, the safety outputs must be validated that they turn On and Off as expected.

> ⚠️ WARNING: Do Not Use Machine **Until** System Is Working Properly
>
> If all of these checks cannot be **verified,** do not **attempt** to use the safety system that includes the Banner device and the guarded machine until the defect or problem has been corrected. **Attempts** to use the guarded machine under such **conditions** may result in serious bodily injury or death.

A comprehensive test must be used to verify the operation of the Safety Controller and the functionality of the intended configuration. *Initial Setup, Commissioning and Periodic Checkout Procedures* on page 109 is intended to assist in developing a customized (configuration-specific) checklist for each application. This customized checklist must be made available to maintenance personnel for commissioning and periodic checkouts. A similar, simplified daily checkout checklist should be made for the operator (or Designated Person[8]). It is highly recommended to have copies of the wiring and logic diagrams and the configuration summary available to assist in the checkout procedures.

> ⚠️ WARNING: Periodic Checkouts
>
> The commissioning, periodic and daily safety system checks must be performed by appropriate personnel at the appropriate times (as described in this manual) in order to ensure that the safety system is operating as intended. Failure to perform these checks may create a **potentially** dangerous **situation** which could lead to serious injury or death.

Commissioning Checkout: A Qualified Person[8] must perform a safety system commissioning procedure before the safeguarded machine application is placed into service and after each Safety Controller configuration is created or modified.

Periodic (Semi-Annual) Checkout: A Qualified Person[8] must also perform a safety system re-commissioning semi-annually (every 6 months) or at periodic intervals based on the appropriate local or national regulations.

Daily **Operational** Checks: A Designated Person[8] must also check the effectiveness of the protective devices per the device manufacturers' recommendation each day that the safeguarded machine is in service.

> ⚠️ WARNING: Before Applying Power to the Machine
>
> Verify that the guarded area is clear of personnel and unwanted materials (such as tools) before applying power to the guarded machine. Failure to do so may result in serious bodily injury or death.

7.2 Commissioning Checkout Procedure

Before proceeding, verify that:

- All solid state and relay output terminals of the complete Safety Controller system are not connected to the machine. Disconnecting all of the Safety Controller's safety output plug-on terminals is recommended.
- Power has been removed from the machine, and no power is available to the machine controls or actuators

Permanent connections are made at a later point.

7.2.1 Verifying System **Operation**

The commissioning checkout procedure must be performed by a **Qualified** Person[9]. It must be performed only **after configuring** the Controller and **after** properly installing and **configuring** the safety systems and safeguarding devices connected to its inputs (see *Safety Input Device Function* on page 80 and the appropriate standards).

The commissioning checkout procedure is performed on two occasions:

1. When the Controller is first installed, to ensure proper installation
2. Whenever any maintenance or modification is performed on the System or on the machine being guarded by the System, to ensure continued proper Controller function (see *Schedule of Required Checkouts* on page 108)

For the **initial** part of the commissioning checkout, the Controller and associated safety systems must be checked without power being available to the guarded machine. Final interface connections to the guarded machine cannot take place until these systems have been checked out.

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[8] See *Glossary* on page 125 for definitions.
[9] See *Glossary* on page 125 for definitions.

Verify that:
- The Safety Output leads are isolated—not shorted together, and not shorted to power or ground
- If used, the external device monitoring (EDM) connections have been connected to +24 V dc via the N.C. monitoring contacts of the device(s) connected to the safety outputs, as described in *External Device Monitoring (EDM)* on page 101 and the wiring diagrams
- The proper Controller configuration file for your application has been installed into the Safety Controller
- All connections have been made according to the appropriate sections and comply with NEC and local wiring codes

This procedure allows the Controller and the associated safety systems to be checked out, by themselves, before permanent connections are made to the guarded machine.

7.2.2 **Initial** Setup, Commissioning and Periodic Checkout Procedures

There are 2 ways to verify that the Safety Outputs are changing state at the appropriate times in the initial configuration check out phase (open **Configuration** Summary in the PC Interface to view the Start-up test and Power-up configuration settings):
- Start the Live Mode in the PC Interface (the Controller must be powered up and plugged in to the PC via the SC-USB2 cable).
- Use a voltmeter or a 24 V dc light to verify the presence (or the absence) of the 24 V dc signal on the output terminals.

Start-Up **Configuration**
Outputs associated with Two-Hand Control, Bypass or Enabling Device functions do not turn on at power-up. After power-up, switch these devices to the Stop state and back to the Run state for their associated outputs turn On.

If **configured** for Normal Power-Up

If latch function is not used: verify that Safety Outputs turn on after power-up.

If either input devices or outputs use the latch function: verify that Safety Outputs do not turn on after the power-up until the specific manual latch reset operations are performed.

If **configured** for **Automatic** Power-Up

Verify that all Safety Outputs turn On within approximately 5 seconds (outputs with On-Delay enabled may take longer to turn On).

If **configured** for Manual Power-Up

Verify that all Safety Outputs remain Off after power up.

Wait at least 10 seconds after power-up and perform the Manual Power-Up reset.

Verify that the Safety Outputs turn On (outputs with On-Delay enabled may take longer to turn On).

> ⚠️ CAUTION: Verifying Input and Output **Function**
>
> The Qualified Person is responsible to cycle the input devices (Run state and Stop state) to verify that the Safety Outputs turn On and Off to perform the intended safeguarding functions under normal operating conditions and foreseeable fault conditions. Carefully evaluate and test each Safety Controller configuration to make sure that the loss of power to any safeguarding input device, the Safety Controller, or the inverted input signal from a safeguarding input device, do not cause an unintended Safety Output On condition, mute condition, or bypass condition.

> ✏️ Note: If an Input or Output indicator is flashing Red, see *Troubleshooting* on page 115.

Safety Input Device **Operation** (E-Stop, Rope Pull, **Optical** Sensor, Safety Mat, **Protective** Stop)
1. While the associated Safety Outputs are On, actuate each safety input device, one at a time.
2. Verify that each associated Safety Output turns Off with the proper Off-Delay, where applicable.
3. With the safety device in the Run state:
   - If a safety input device is **configured** with a Latch Reset **function,**
     1. Verify that the Safety Output remains Off.
     2. Perform a latch reset to turn the outputs On.
     3. Verify that each associated Safety Output turns On.
   - If no Latch Reset **functions** are used, verify that the Safety Output turns On

> 👉 Important: Always test the safeguarding devices according to the recommendations of the device manufacture.

In the sequence of steps below, if a **particular function** or device is not part of the **application,** skip that step and proceed to the next check list item or to the **final** commissioning step.

Two-Hand Control **Function** without **Muting**
1. Make sure the Two-Hand Control actuators are in the Stop state.
2. Make sure that all other inputs associated with Two-Hand Control function are in the Run state and activate the Two-Hand Control actuators to turn the associated Safety Output On.
3. Verify that the associated Safety Output remains Off unless both actuators are activated within 0.5 seconds of each other.
4. Verify that Safety Output turns Off and remains Off when any single hand is removed and replaced (while maintaining the other actuator in the Run state).
5. Verify that switching a safety input (non Two-Hand Control actuator) to the Stop state causes the associated Safety Output to turn Off or stay Off.
6. If more than one set of Two-Hand Control actuators is used then the additional actuators need to be activated before the Safety Output turns On. Verify that the Safety Output turns Off and remains Off when any single hand is removed and replaced (while maintaining the other actuators in the Run state).

Two-Hand Control **Function** with **Muting**
1. Follow the verification steps in Two-Hand Control function above.
2. Activate the Two-Hand Control actuators then activate the MP1 sensors.
3. With the MSP1 sensors active, remove your hands from the Two-Hand Control and verify that the Safety Output stays On
4. Verify that the Safety Output turns Off when either:
    • MSP1 sensors are switched to the stop state
    • Mute time limit expires
5. For multiple Two-Hand Control actuators with at least one set of non-mutable actuators: verify that while in an active mute cycle, removing one or both hands from each non-muted actuators causes the Safety Outputs to turn Off.

Bidirectional (Two Way) **Muting Function** (Also valid for Zone Control Mute **Functions)**
1. With the muted safeguard in the Run state, activating the Mute Enable input (if used) and then activate each mute sensor, in sequential order, within 3 seconds.
2. Generate a stop command from the muted safeguarding device:
    a. Verify that the associated Safety Outputs remain On.
    b. If a mute time limit has been configured, verify that the associated Safety Outputs turn Off when the mute timer expires.
    c. Repeat above steps for each Muting Sensor Pair.
    d. Verify proper operation with each muted safeguarding device.
    e. Generate a stop command from any non-muted safeguarding devices one at a time while in the mute cycle and verify that the associated Safety Outputs turn Off.
    f. Verify the mute process in the opposite direction repeating the process above, activating the mute sensors in the reverse order

Unidirectional (One Way) **Muting Function**
1. With the mute sensors not activated, muted safeguarding devices in the Run state and Safety Outputs On:
    a. Activate Muting Sensor Pair 1.
    b. Change the muted safeguarding device to the Stop state.
    c. Activate Muting Sensor Pair 2.
    d. Deactivate Muting Sensor Pair 1.
2. Verify the associated Safety Output remains On throughout the process.
3. Repeat the test in the *wrong direction* (Muting Sensor Pair 2, then the safeguarding device, then Muting Sensor Pair 1).
4. Verify that when the safeguard changes to the Stop state the output turns Off.

If a mute **time** limit has been **configured:**
1. Verify that the associated Safety Outputs turn Off when the mute timer expires.

Mute **Function** with Power-Up **Operation** (not applicable for Two-Hand Control)
1. Turn the Safety Controller power Off.
2. Activate the Mute Enable input if used.
3. Activate an appropriate Muting Sensor Pair for starting a mute cycle.
4. Make sure that all mutable safeguarding devices are in the Run state.
5. Apply power to the Controller.
6. Verify that the Safety Output turns On and that a mute cycle begins.
7. Repeat this test with the mutable safeguard device in the Stop state.
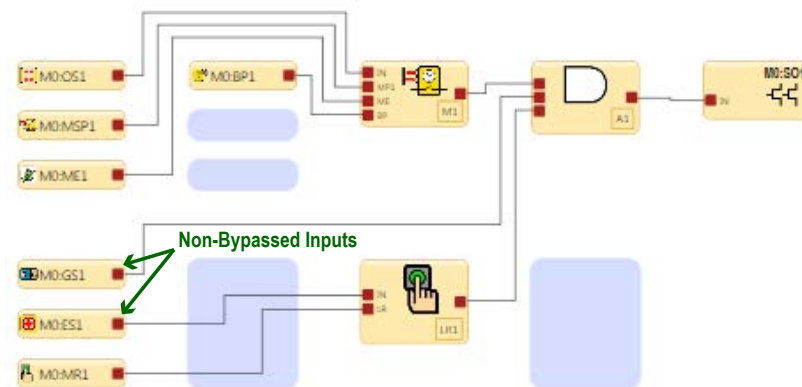8. Verify that the Safety Output stays Off.

Mute **Function** with Mute-Dependent Override
1. Make sure mute sensors are not activated and mute safeguarding devices are in the Run state.
2. Verify that the Safety Outputs are On.
3. Switch the safeguarding device to the Stop state.
4. Verify that the Safety Output turns Off.

5. Activate one of the mute sensors.
6. Verify the optional mute lamp is flashing
7. Start the mute dependent override by activating the Bypass Switch.
8. Verify that the Safety Output turns On.
9. Verify that the Safety Output turns Off under any of the following conditions:
   - Mute Time limit expires
   - Mute sensors are deactivated
   - The Bypass device is deactivated

Mute Function with Bypass

1. Verify that each safety input, that can be both muted and bypassed, is in the Stop state.
2. Verify that when the Bypass Switch is in the Run state:

   a. The associated Safety Outputs turn On.
   b. The associated Safety Outputs turn Off when the bypass timer expires.
3. Change the Bypass Switch to the Run state and verify that the associated Safety Outputs turn On.
4. Switch the associated non-bypassed input devices to their Stop state (one at a time) and verify that associated Safety Outputs turn Off while the Bypass Switch is in the Run state.

Bypass Function

1. Verify that the associated Safety Outputs are Off when the safety inputs to be bypassed are in the Stop state.
2. Verify that when the Bypass Switch is in the Run state:

   a. The associated Safety Outputs turn On
   b. The associated Safety Outputs turn Off when the bypass timer expires.
3. Change the Bypass Switch to the Run state and verify that the associated Safety Outputs turn On.
4. One at a time, switch the non-bypassed input devices to the Stop state and verify that the associated Safety Outputs turn Off while the Bypass Switch is in the Run state.

Safety Output Off-Delay Function

1. With any one of the controlling inputs in the Stop state and the delayed Safety Output in an Off delay state, verify that the Safety Output turns Off after the time delay is over.
2. With any one of the controlling inputs in the Stop state and the Off Delay timer is active, switch the input to the Run state and verify that the Safety Output is On and remains On.

Safety Output Off-Delay Function - Cancel Delay Input

1. With the associated inputs in the Stop state and the delayed Safety Output in an Off delay state, activate the Cancel Delay input and, verify that the Safety Output turns Off immediately.

Safety Output Off-Delay Function - Controlling Inputs

1. With any one of the controlling inputs in the Stop state and the delayed Safety Output is in an Off delay state, switch the input to the Run state and verify that the Safety Output is On and remains On.

Safety Output Off-Delay Function and Latch Reset

1. Make sure the associated input devices are in the Run state so that the delayed Safety Output is On.
2. Start the off delay time by switching an input device to the Stop state.
3. Switch the input device to the Run state again during the Off-Delay time and push the Reset button.
4. Verify that the delayed output turns Off at the end of the delay and remains Off (a latch reset signal during the delay time is ignored).

Enabling Device **Function** without Secondary Jog Output
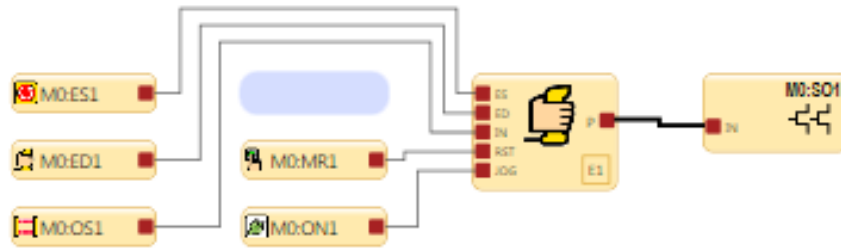
1. With the associated inputs in the Run state and the Enabling Device in the Stop state, verify that the Safety Output is On.
2. With the Enabling Device still in the Run state and the associated Safety Output On, verify that the Safety Output turns Off when the Enabling Device timer expires.
3. Return the Enabling Device to the Stop state and then back to the Run state, verify that the Safety Outputs turns On.
4. Switch the Enabling Device to the Stop state, verify that the associated Safety Outputs turn Off.
5. Switch each E-stop and Rope Pull device associated with the Enabling Device function to the Stop state, verify, one at a time, that the associated Safety Outputs are On and in the Enable mode.
6. With the Enabling Device in the Stop state, perform a system reset.
7. Verify that control authority is now based on associated input devices of the Enabling device function:

    a. If one or more input devices is in the Stop state, verify that the output is Off.
    b. If all of the input devices are in the Run state, verify that the output is On.

Enabling Device **Function—With** Jog feature on the Secondary Output
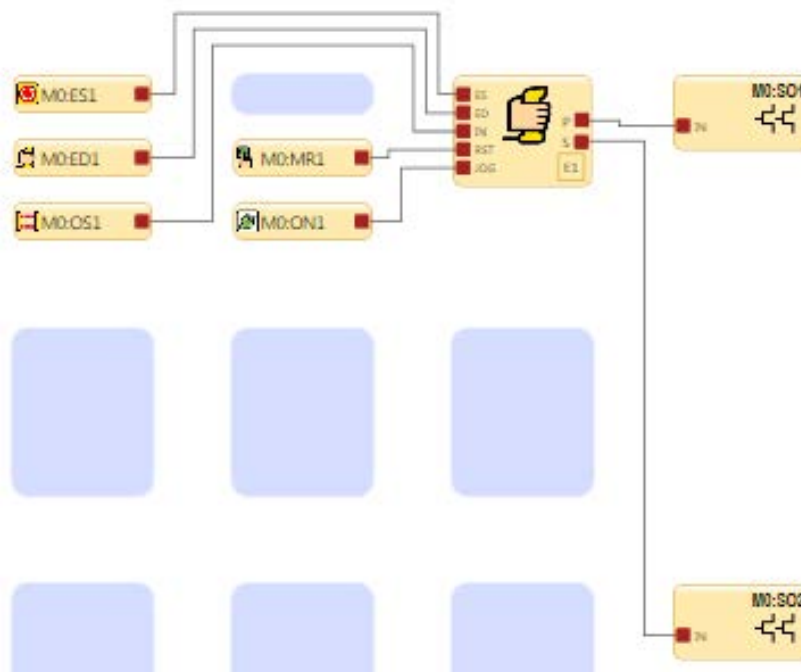
1. With Enabling Device and Jog button in Run state in control of the primary Safety Output, verify that the output turns Off when either the Enabling Device or the Jog button is switched to the Stop state.
2. With the Enabling Device in control of the primary Safety Output and the Jog button in control of the secondary output verify that the primary Output turns:

    a. On when the Enabling Device is in the Run state
    b. Off when the Enabling Device is in the Stop state and the Jog button is in the Run state
3. Verify that the output turns On only when the Enabling Device is in the Run state while the Jog button is in the Run state.
4. Verify that the secondary Output turns:

    a. On when the Enabling Device and the jog button are in the Run state.
    b. Off when the either the Enabling Device or the job button are in the Stop state.

8 **Operating Instructions**

The Safety Controller can be operated using either the Onboard or PC Interface to monitor ongoing status.

8.1 LED Status

LED	Status	Meaning
All	Off	Initialization Mode

	Sequence:
	    Green On for 0.5 s
	    Red On for 0.5 s
	    Off for 0.5 s min
		Power applied

Power/Fault	Off	Power Off
	Green: Solid	Run mode
	Green: Flashing	Configuration or Manual Power-Up mode
	Red: Flashing	Non-operating Lockout condition
	Red: Fast Flashing	Safety Bus Communication Issue
USB (Base Controller)	Off	No link to the PC established
	Green: Solid	Link to the PC established
	Green: Flashing for 5 s	XM configuration match
	Red: Flashing for 5 s	XM configuration mismatch
Inputs	Green: Solid	No input faults
	Red: Flashing	One or more inputs is in the Lockout condition
SO1, SO2	Off	Output not configured
	Green: Solid	Safety Output On
	Red: Solid	Safety Output Off
	Red: Flashing	Safety Output fault detected

LED Status for Split Outputs	Meaning
Green: Solid	Both outputs are On
Red: Solid	SO1 and/or SO2 Off
Red: Flashing	SO1 and/or SO2 fault detected

Ethernet Diagnostic LEDs		
Amber LED	Green LED	Description
On	Varies with traffic	Link established/normal operation
Off	Off	Hardware failure

Amber LED and Green LED Flash in Unison	Description
5 flashes followed by several rapid flashes	Normal power up
1 flash every 3 seconds	Contact Banner Engineering
2 flash repeating sequence	In the past 60 seconds, a cable was unplugged while active
3 flash repeating sequence	A cable is unplugged
4 flash repeating sequence	Network not enabled in the configuration
5+ flash repeating sequence	Contact Banner Engineering

PROFINET Flash Command	Meaning
The base module LEDs flash at a rate of twice per second for four seconds	The flashing LEDs indicate that the base module is connected. It is the result of the "Flash LED" command from the PROFINET network.

8.2 Live Mode **Information** - PC Interface

To display real-time Run mode information on a PC, the Controller must be connected to the computer via the SC-USB2 cable. Click Live Mode to access the Live Mode view. This feature continually updates and displays data, including Run, Stop, and Fault states of all inputs and outputs, as well as the Fault Codes table. The Equipment view and the **Functional** View also provide device-specific visual representation of the data. See *Live Mode* on page 67 for more information.

The Live Mode view provides the same information that can be viewed on the Controller LCD (models with display only).

8.3 Live Mode **Information** - Onboard Interface

To display real-time Run mode information on the Controller LCD (models with display only), select System Status[10] from the System Menu (see *Onboard Interface* on page 74 for navigation map). System Status shows input device and Safety Output states; Fault **Diagnostics** shows current Fault information (a brief description, remedy step(s), and the Fault Code) and provides access to the Fault Log.

The Controller display provides the same information that can be viewed via the Live Mode function in the PC Interface.

8.4 Lockout **Conditions**

Input lockout conditions are generally resolved by repairing the fault and cycling the input Off and then back On.

Output lockout conditions (including EDM and AVM faults) are resolved by repairing the fault and then cycling the Reset Input connected to the FR node on the Safety Output.

System faults, such as low supply voltage, overtemperature, or voltage detected on unassigned inputs, may be cleared by cycling the System Reset input (any Reset Input assigned to be the System Reset). Only one reset button, either physical or virtual, can be configured to perform this operation.

A system reset is used to clear lockout conditions not related to safety inputs or outputs. A lockout condition is a response where the Controller turns Off all affected Safety Outputs when a safety-critical fault is detected. Recovery from this condition requires all faults to be remedied and a system reset to be performed. A lockout will recur after a system reset unless the fault that caused the lockout has been corrected.

A system reset is necessary under the following conditions:
- Recovering from a system lockout condition
- Starting the Controller after a new configuration has been downloaded

For internal faults, the System Reset likely will not work. The power will have to be cycled in an attempt to run again.

⚠️ WARNING: Non-Monitored Resets

If a non-monitored reset (either latch or system reset) is **configured** and if all other conditions for a reset are in place, a short from the Reset terminal to +24 V will turn On the safety output(s) immediately.

⚠️ WARNING: Check Before Reset

When performing the system reset operation, it is the user's responsibility to make sure that all potential hazards are clear and free of people and unwanted materials (such as tools) that could be exposed to the hazard. Failure to do so may result in serious bodily injury or death.

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[10] System Status is the first screen that displays when the Controller turns On after a reset. Hit ESC to view the System Menu.

9 **Troubleshooting**

The Controller is designed and tested to be highly resistant to a wide variety of electrical noise sources that are found in industrial settings. However, intense electrical noise sources that produce EMI or RFI beyond these limits may cause a random trip or lockout condition. If random trips or lockouts occur, check that:
- The supply voltage is within 24 V dc ± 20%
- The Safety Controller's plug-on terminal blocks are fully inserted
- Wire connections to each individual terminal are secure
- No high-voltage or high-frequency noise sources or any high-voltage power lines are routed near the Controller or alongside wires that are connected to the Controller
- Proper transient suppression is applied across the output loads
- The temperature surrounding the controller is within the rated ambient temperature (see *Specifications* on page 12)

9.1 PC Interface - **Troubleshooting**

Live Mode **button** is unavailable (grayed out)

1. Make sure the SC-USB2 cable is plugged in both to the computer and the Controller.
2. Verify that the controller is installed properly—see *Verifying Driver Installation* on page 116.
3. Exit the software.
4. Unplug the controller and plug it back in.
5. Start the software.

Unable to read from the controller or send the **configuration** to the controller **(buttons** grayed out)

- Make sure Live Mode is disabled
- Make sure the SC-USB2 cable is plugged in both to the computer and the controller
- Verify that the controller is installed properly—see *Verifying Driver Installation* on page 116.
- Exit the software.
- Unplug the controller and plug it back in.
- Start the software.

Unable to move a block to a **different location**

Not all blocks can be moved. Some blocks can be moved only within certain areas.
- Safety Outputs are placed statically and cannot be moved. Referenced Safety Outputs can be moved anywhere within the left and middle areas.
- Safety and Non-Safety Inputs can be moved anywhere within the left and middle areas.
- **Function** and Logic blocks can be moved anywhere within the middle area.

SC-XM2 **button** is unavailable (grayed out)

1. Make sure all connections are secure—SC-USB2 to the SC-XMP2 Programming Tool, and SC-XMP2 the SC-XM2 drive.
2. Verify that the SC-XMP2 Programming Tool is installed properly—see *Verifying Driver Installation* on page 116.
3. Exit the software.
4. Disconnect and re-connect all connections— SC-USB2 to the SC-XMP2 Programming Tool, and SC-XMP2 the SC-XM2 drive.
5. Start the software.

Note: Contact a Banner Applications Engineer if you require further assistance.

9.1.1 Verifying Driver **Installation**

Windows 7 and 8

1. Click Start.
2. Type "Device Manager" in the *Search for programs and files* field at the bottom and click Device Manager when Windows locates it.
3. Expand the Ports (COM & LPT) dropdown menu.
4. Find XS26-2 Expandable Safety Controller followed by a COM port number (for example, COM3). It must not have an exclamation mark, a red ×, or a down arrow on the entry. If you do not have any of these indicators, your device is properly installed. If any of the indicators appear, follow the instructions after this table to resolve these issues.

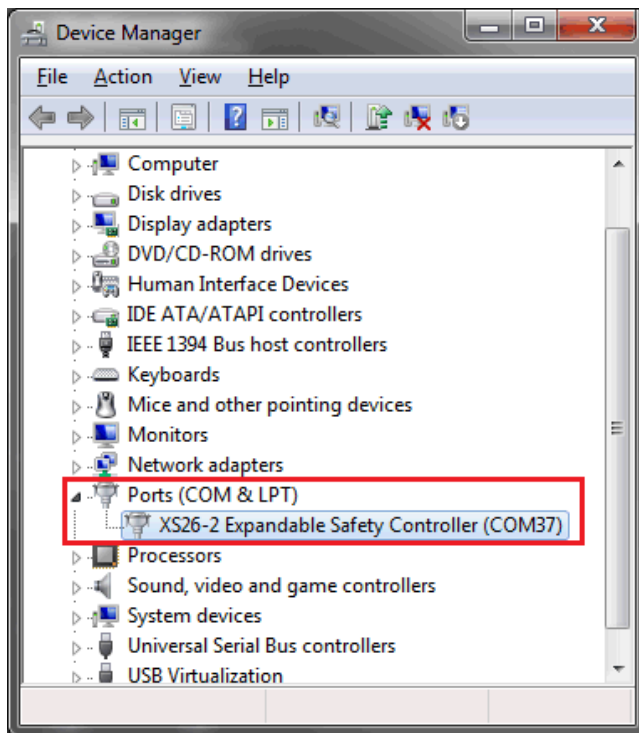| XS/SC26-2 Safety Controller Drivers	SC-XMP2 Drivers
1. Expand the Ports (COM & LPT) dropdown menu. 2. Find XS26-2 Expandable Safety Controller followed by a COM port number (for example, COM3). It must not have an exclamation mark, a red ×, or a down arrow on the entry. If you do not have any of these indicators, your device is properly installed. If any of the indicators appear, follow the instructions after this table to resolve these issues.	1. Expand the Universal Serial Bus controllers dropdown menu. 2. Find XMP2 Programmer A and XMP2 Programmer B. Either one of the entries must not have an exclamation mark, a red ×, or a down arrow on the entry. If you do not have any of these indicators, your device is properly installed. If any of the indicators appear, follow the instructions after this table to resolve these issues.

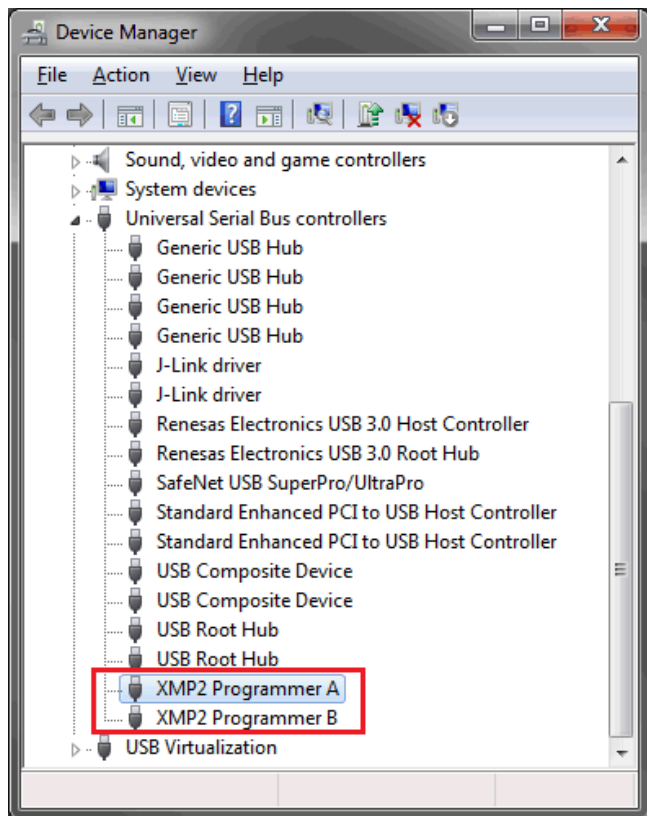Figure 96. XS/SC26-2 Safety Controller Drivers installed correctly

Figure 97. SC-XMP2 Drivers installed correctly

Windows XP and Vista

1. Click Start.
2. Right-click My Computer and click **Properties.**
3. Click Device Manager.

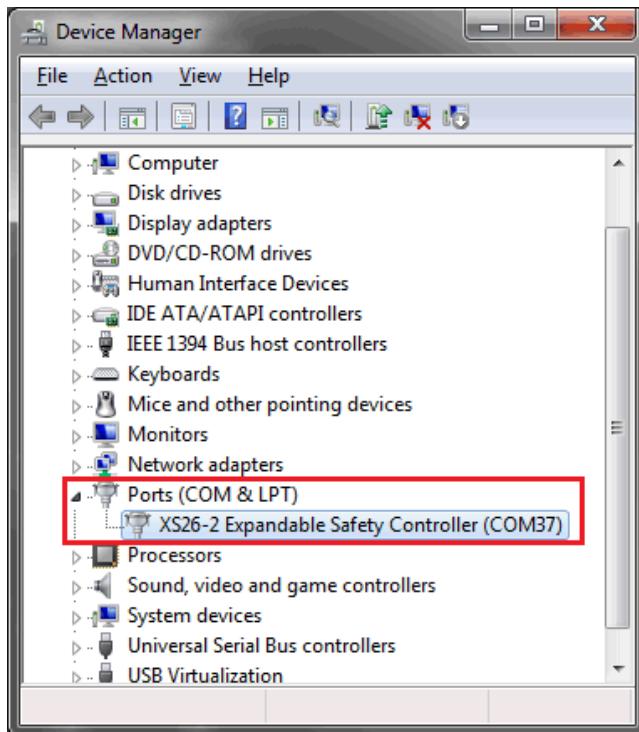| Windows XP and Vista	
XS/SC26-2 Safety Controller Drivers	**SC-XMP2 Drivers**
1. Expand the Ports (COM & LPT) dropdown menu. 2. Find XS26-2 Expandable Safety Controller followed by a COM port number (for example, COM3). It must not have an **exclamation** mark, a red ×, or a down arrow on the entry. If you do not have any of these indicators, your device is properly installed. If any of the indicators appear, follow the **instructions after** this table to resolve these issues.	1. Expand the Universal Serial Bus controllers dropdown menu. 2. Find XMP2 Programmer A <u>and</u> XMP2 Programmer B. Either one of the entries must not have an **exclamation** mark, a red ×, or a down arrow on the entry. If you do not have any of these indicators, your device is properly installed. If any of the indicators appear, follow the **instructions after** this table to resolve these issues.

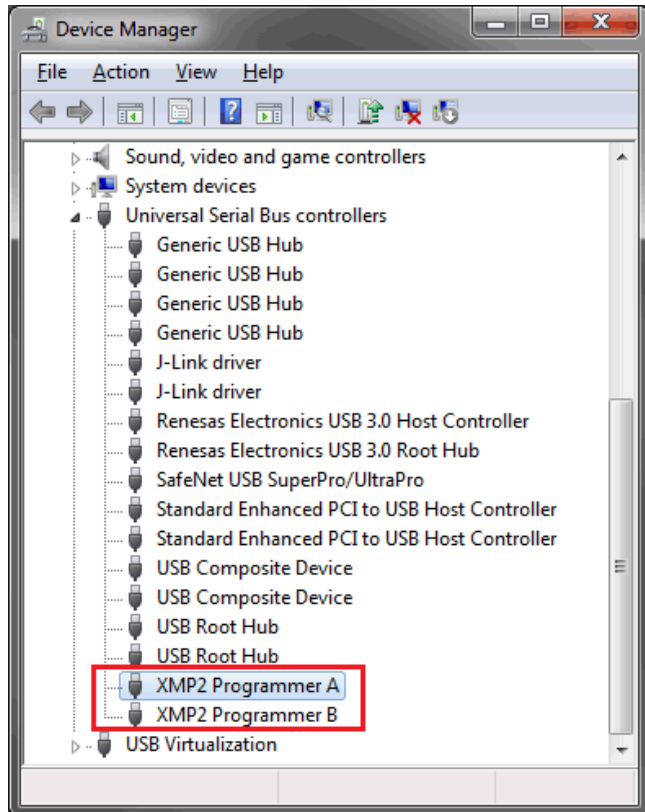*Figure 98. XS/SC26-2 Safety Controller Drivers installed correctly*

Figure 99. SC-XMP2 Drivers installed correctly

To resolve an **exclamation** mark, a red ×, or a down arrow indicator:

1. Make sure your device is enabled:
   a. Right-click on the entry that has the indicator.
   b. If you see Disable, the device is enabled; if you see Enable, the device is disabled.
      - If the device is enabled, **continue** with **troubleshooting** steps.
      - If the device is disabled, click Enable. If this does not remove the indicator, **continue** to the next step.
2. Unplug the USB cable either from the Safety Controller or from the computer, wait a few seconds and plug it back in. If this does not remove the indicator, **continue** to the next step.
3. Try plugging in the Safety Controller to a **different** USB port. If this does not remove the indicator, **continue** to the next step.
4. Reboot your computer. If this does not remove the indicator, **continue** to the next step.
5. Uninstall and re-install the **software** from Add/Remove Programs or Programs and Features located in the Control Panel. If this does not remove the indicator, **continue** to the next step.
6. Contact a Banner **Applications** Engineer.

9.2 Finding and Fixing Faults

Depending on the configuration, the Safety Controller is able to detect a number of input, output, and system faults, including:

- A stuck contact
- An open contact
- A short between channels
- A short to ground
- A short to a voltage source
- A short to another input
- A loose or open connection
- An exceeded operational time limit
- A power drop
- An overtemperature condition

When a fault is detected, a message describing the fault displays in the Fault **Diagnostics** menu (LCD models). For models not equipped with an LCD, use the Live Mode views in the PC Interface on a PC connected to Controller with the SC-USB2 cable. Fault diagnostics are also available over the network. An additional message may also be displayed to help remedy the fault.

9.2.1 Fault Code Table

Fault Code	Displayed Message	**Additional** Message	Steps to resolve
1.1	Output Fault	Base Module or Solid State Module Check for shorts Relay Module n/a	Base Module or Solid State Module A Safety Output appears On when it should be Off: • Check for a short to the external voltage source • Check the DC common wire size connected to the Safety Output loads. The wire must be a heavy-gauge wire or be as short as possible to minimize resistance and voltage drop. If necessary, use a separate DC common wire for each pair of outputs and/or avoid sharing this DC common return path with other devices (see *Common Wire Installation* on page 99) Relay Module • Replace Relay module
1.2	Output Fault	Base Module or Solid State Module Check for shorts Relay Module n/a	Base Module or Solid State Module A Safety Output is sensing a fault to another voltage source while the output is On: • Check for a short between Safety Outputs • Check for a short to the external voltage source • Check load device compatibility • Check the DC common wire size connected to the Safety Output loads. The wire must be a heavy-gauge wire or be as short as possible to minimize resistance and voltage drop. If necessary, use a separate DC common wire for each pair of outputs and/or avoid sharing this DC common return path with other devices (see *Common Wire Installation* on page 99) Relay Module • Replace Relay module
1.3 – 1.8	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121)
1.9	Output Fault	Internal Relay Failure	• Replace Relay module
1.10	Output Fault	Check Input Timing	Sequence timing error: • Perform a System Reset to clear the fault
2.1	Concurrency Fault	Cycle Input	On a dual-channel input with both inputs in the Run state, one input went to the Stop state then back to Run: • Check the wiring • Check the input signals • Consider adjusting the debounce times
2.2	Simultaneity Fault	Cycle Input	On a dual-channel input, one input went into the Run state but the other input did not follow within 3 seconds: • Check the wiring • Check the input signal timing

Fault Code	Displayed Message	**Additional** Message	Steps to resolve
2.3 or 2.5	Concurrency Fault	Cycle Input	On a complementary pair with both inputs in the Run state, one of the inputs changed to Stop then back to Run: • Check the wiring • Check the input signals • Check the power supply providing input signals • Consider adjusting the debounce times
2.4 or 2.6	Simultaneity Fault	Cycle Input	On a complementary pair, one input went into the Run state but the other input did not follow within the time limit: • Check the wiring • Check the input signal timing
2.7	Internal Fault		Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121)
2.8 – 2.9	Input Fault	Check Terminal xx	Input stuck high: • Check for shorts to other inputs or other voltage sources • Check the input device compatibility
2.10	Input Fault	Check Terminal xx	• Check for a short between inputs
2.11 - 2.12	Input Fault	Check Terminal xx	• Check for a short to ground
2.13	Input Fault	Check Terminal xx	Input stuck low • Check for a short to ground
2.14	Input Fault	Check Terminal xx	Missing test pulses: • Check for a short to other inputs or other voltage sources
2.15	Open Lead	Check Terminal xx	• Check for an open lead
2.16 – 2.18	Input Fault	Check Terminal xx	Missing test pulses: • Check for a short to other inputs or other voltage sources
2.19	Open Lead	Check Terminal xx	• Check for an open lead
2.20	Input Fault	Check Terminal xx	Missing test pulses: • Check for a short to ground
2.21	Open Lead	Check Terminal xx	• Check for an open lead
2.22 – 2.23	Input Fault	Check Terminal xx	• Check for an unstable signal on the input
2.24	Input Activated While Bypassed	Perform System Reset	A Two-Hand Control input was activated (turned On) while it was bypassed.
2.25	Input Fault	Monitoring Timer Expired Before AVM Closed	After the associated Safety Output turned Off, the AVM input did not close before its AVM monitoring time expired: • The AVM may be disconnected. Check the wiring to the AVM • Either the AVM is disconnected, or its response to the Safety Output turning Off is too slow • Check the wiring to the AVM • Check the timing setting; increase the setting if necessary • Contact Banner Engineering
2.26	Input Fault	AVM Not Closed When Output Turned On	The AVM input was open, but should have been closed, when the associated Safety Output was commanded On: • The AVM may be disconnected. Check the wiring to the AVM
3.1	EDMxx Fault	Check Terminal xx	EDM contact opened prior to turning On the Safety Outputs: • Check for a stuck On contactor or relay • Check for an open wire
3.2	EDMxx Fault	Check Terminal xx	EDM contact(s) failed to close within 250 ms after the Safety Outputs turned Off: • Check for a slow or stuck On contactor or relay • Check for an open wire
3.3	EDMxx Fault	Check Terminal xx	EDM contact(s) opened prior to turning On the Safety Outputs: • Check for a stuck On contactor or relay • Check for an open wire
3.4	EDMxx Fault	Check Terminal xx	EDM contact pair mismatched for longer than 250 ms: • Check for a slow or stuck On contactor or relay • Check for an open wire
3.5	EDMxx Fault	Check Terminal xx	• Check for an unstable signal on the input

Fault Code	Displayed Message	**Additional** Message	Steps to resolve
3.6	EDMxx Fault	Check Terminal xx	• Check for a short to ground
3.7	EDMxx Fault	Check Terminal xx	• Check for a short between inputs
3.8	AVMxx Fault	Perform System Reset	After this Safety Output turned Off, an AVM input associated with this output did not close before its AVM monitoring time expired: • The AVM may be disconnected or its response to the Safety Output turning Off may be too slow • Check the AVM input and then perform a System Reset to clear the fault
3.9	Input Fault	AVM Not Closed When Output Turned On	The AVM input was open, but should have been closed, when the associated Safety Output was commanded On: • The AVM may be disconnected. Check the wiring to the AVM
4.x	-	-	See the following table.
5.1 – 5.3	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121)
6.xx	Internal Fault	-	Invalid configuration data. Possible internal failure: • Try writing a new configuration to the Controller
10.xx	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121)

For fault codes 4.x, check the fault log for additional faults to determine the specific module in which the original fault occurred.

Fault Code	Displayed Message	**Additional** Message	Steps to resolve
4.1	Supply Voltage Low	Check the power supply	The supply voltage dropped below the rated voltage for longer than 6 ms: • Check the power supply voltage and current rating • Check for an overload on the outputs that might cause the power supply to limit the current
4.2	Internal Fault		A configuration parameter has become corrupt. To fix the configuration: • Replace the configuration by using a backup copy of the configuration • Recreate the configuration using the PC Interface and write it to the Controller
4.3 – 4.11	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121).
4.12	Configuration Timeout	Check Configuration	The Safety Controller was left in Configuration mode for more than one hour without pressing any keys.
4.13	Configuration Timeout	Check Configuration	The Safety Controller was left in Configuration mode for more than one hour without receiving any commands from the PC Interface.
4.14	Configuration Unconfirmed	Confirm Configuration	The Configuration was not confirmed after being edited: • Confirm configuration using the PC Interface
4.15 – 4.19	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121).
4.20	Unassigned Terminal in Use	Check Terminal xx	This terminal is not mapped to any device in the present configuration and should not be active: • Check the wiring
4.21 – 4.34	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121).
4.35	Overtemperature	-	An internal overtemperature condition has occurred. Verify that the ambient and output loading conditions meet the specifications of the controller.
4.36 – 4.39	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121).
4.40-4.41	Module Communication Failure	Check module power	An output expansion module lost contact with the Base Controller.
4.42	Module Mismatch	-	The module or modules detected do not match the Controller configuration.
4.43	Module Communication Failure	Check module power	An expansion module lost contact with the Base Controller.
4.44-4.45	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121).

Fault Code	Displayed Message	**Additional** Message	Steps to resolve
4.46-4.47	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121).
4.48	Unused output	Check output wiring	A voltage was detected on an unconfirmed terminal.
4.49 – 4.55	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121).
4.56	Display Comm Failure	-	Display Communication Failure: • Cycle power to the Controller. If fault code persists, contact Banner Engineering (see *Repairs and Warranty Service* on page 121
4.57 – 4.59	Internal Fault	-	Internal failure—Contact Banner Engineering (see *Repairs and Warranty Service* on page 121).
4.60	Output Fault	Check for shorts	An output terminal detected a short. Check output fault for details.

9.3 Recovering from a Lockout

To recover from a lockout condition:
- Follow the recommendation in the fault display (LCD models)
- Follow the recommended steps and checks listed in the *Fault Code Table* on page 118
- Perform a system reset
- Cycle the power and perform a system reset, if needed

If these steps do not remedy the lockout condition, contact Banner Engineering (see *Repairs and Warranty Service* on page 121).

9.4 Cleaning

Disconnect power to the Controller. Wipe down the polycarbonate enclosure and the display with a soft cloth that has been dampened with a mild detergent and warm water solution.

9.5 Repairs and Warranty Service

Contact Banner Engineering for troubleshooting of this device. Do not **attempt** any repairs to this Banner device; it contains no **field-replaceable** parts or components. If the device, device part, or device component is determined to be defective by a Banner Applications Engineer, they will advise you of Banner's RMA (Return Merchandise Authorization) procedure.

👉 Important: If instructed to return the device, pack it with care. Damage that occurs in return shipping is not covered by warranty.

To assist Banner Engineering with troubleshooting a problem, while the PC is connected to the Controller, go to Help in the software and click Support Information. Click Save Controller **Diagnostics** (located at Help > Support **Information**) to generate a file that contains status information. This information may be helpful to the support team at Banner. Send the file to Banner according to the instructions provided on screen.

10 Components, Models, and Accessories

10.1 Models

All Expandable and Non-Expandable Base modules have 18 Safety Inputs, 8 Convertible Safety I/Os, and 2 Solid-State Safety Output pairs. Up to eight expansion modules, in any combination of input and output modules, can be added to the expandable models of the Base Controller.

Table 4: Expandable Base Models

Model	Display	Network
XS26-2	No	No
XS26-2d	Yes	No
XS26-2e	No	Yes
XS26-2de	Yes	Yes

Table 5: Non-Expandable Base Models

Model	Display	Network
SC26-2	No	No
SC26-2d	Yes	No
SC26-2e	No	Yes
SC26-2de	Yes	Yes

Table 6: I/O Expansion Modules

Model	Description
XS16si	Safety Input Module - 16 inputs (4 convertible)
XS8si	Safety Input Module - 8 inputs (2 convertible)
XS2so	2 Dual Channel Solid-State Safety Output Module
XS4so	4 Dual Channel Solid-State Safety Output Module
XS1ro	1 Dual Channel Safety Relay Module
XS2ro	2 Dual Channel Safety Relay Module

10.2 Replacement Parts and Accessories

Model	Description
SC-TS2	Screw terminal blocks controller
SC-TS3	Screw terminal blocks expansion module
SC-TC2	Spring cage terminal blocks controller
SC-TC3	Spring cage terminal blocks expansion module
SC-USB2	USB cable
SC-XM2	External memory drive
SC-XMP2	Programming Tool for SC-XM2
DIN-SC	DIN End Clamp

10.3 Ethernet Cordsets

Cat5e Shielded Cordsets	Cat5e Crossover Shielded Cordsets	Length
STP07	STPX07	2.1 m (7 ft)
STP25	STPX25	7.62 m (25 ft)
STP50	STPX50	15.2 m (50 ft)
STP75	STPX75	22.9 m (75 ft)

10.4 Interface Modules

> Note: External device monitoring (EDM) is required to be wired separately to the N.C. contacts to comply with ISO 13849-1 categories and ANSI/OSHA control reliability; see *EDM and FSD Hookup* on page 101.

IM-T-9 series interface modules have 6A output, 22.5 mm DIN-mount housing, removable (plug-in) terminal blocks, low current rating of 1V ac/dc at 5 mA, high current rating of 250 V ac/dc at 6A. See datasheet p/n 62822 for more information.

Model	Supply Voltage	Inputs	Safety Outputs	Output Rating	EDM Contacts	Aux. Outputs
IM-T-9A	24V dc	2 (dual-channel hookup)	3 N.O.	6 amps	2 N.C.	—
IM-T-11A			2 N.O.			1 N.C.

10.4.1 Mechanically Linked Contactors

Mechanically Linked Contactors provide an additional 10 or 18 amp carrying capability to any safety system. If used, two contactors per Safety Output pair are required for Category 4. A single OSSD output with 2 contactors can achieve Category 3. The N.C. contacts are to be used in an external device monitoring (EDM) circuit.

> Note: EDM is required to be wired separately to the N.C. contacts to comply with ISO 13849-1 categories and ANSI/OSHA control reliability; see *EDM and FSD Hookup* on page 101 .

Model	Supply Voltage	Inputs	Outputs	Output Rating
11-BG00-31-D024	24 V dc	2 (dual-channel hookup)	3 N.O. and 1 N.C.	10 amps
BF1801L-024				18 amps

11 Standards and **Regulations**

The list of standards below is included as a convenience for users of this Banner device. Inclusion of the standards below does not imply that the device complies specifically with any standard, other than those specified in the Specifications section of this manual.

11.1 Applicable U.S. Standards

ANSI B11.0 Safety of Machinery, General Requirements, and Risk Assessment

ANSI B11.1 Mechanical Power Presses

ANSI B11.2 Hydraulic Power Presses

ANSI B11.3 Power Press Brakes

ANSI B11.4 Shears

ANSI B11.5 Iron Workers

ANSI B11.6 Lathes

ANSI B11.7 Cold Headers and Cold Formers

ANSI B11.8 Drilling, Milling, and Boring

ANSI B11.9 Grinding Machines

ANSI B11.10 Metal Sawing Machines

ANSI B11.11 Gear Cutting Machines

ANSI B11.12 Roll Forming and Roll Bending Machines

ANSI B11.13 Single- and Multiple-Spindle Automatic Bar and Chucking Machines

ANSI B11.14 Coil Slitting Machines

ANSI B11.15 Pipe, Tube, and Shape Bending Machines

ANSI B11.16 Metal Powder Compacting Presses

ANSI B11.17 Horizontal Extrusion Presses

ANSI B11.18 Machinery and Machine Systems for the Processing of Coiled Strip, Sheet, and Plate

ANSI B11.19 Performance Criteria for Safeguarding

ANSI B11.20 Manufacturing Systems

ANSI B11.21 Machine Tools Using Lasers

ANSI B11.22 Numerically Controlled Turning Machines

ANSI B11.23 Machining Centers

ANSI B11.24 Transfer Machines

ANSI/RIA R15.06 Safety Requirements for Industrial Robots and Robot Systems

ANSI NFPA 79 Electrical Standard for Industrial Machinery

ANSI/PMMI B155.1 Package Machinery and Packaging-Related Converting Machinery — Safety Requirements

11.2 Applicable OSHA **Regulations**

OSHA Documents listed are part of: Code of Federal Regulations Title 29, Parts 1900 to 1910

OSHA 29 CFR 1910.212 General Requirements for (Guarding of) All Machines

OSHA 29 CFR 1910.147 The Control of Hazardous Energy (lockout/tagout)

OSHA 29 CFR 1910.217 (Guarding of) Mechanical Power Presses

11.3 Applicable European and **International** Standards

ISO 12100 Safety of Machinery – General Principles for Design — Risk Assessment and Risk Reduction

ISO 13857 Safety Distances . . . Upper and Lower Limbs

ISO 13850 (EN 418) Emergency Stop Devices, Functional Aspects – Principles for Design

ISO 13851 (EN 574) Two-Hand Control Devices – Functional Aspects – Principles for Design

IEC 62061 Functional Safety of Safety-Related Electrical, Electronic and Programmable Control Systems

ISO 13849-1 Safety-Related Parts of Control Systems

ISO 13855 (EN 999) The Positioning of Protective Equipment in Respect to Approach Speeds of Parts of the Human Body

ISO 14119 (EN 1088) Interlocking Devices Associated with Guards – Principles for Design and Selection

IEC 60204-1 Electrical Equipment of Machines Part 1: General Requirements

IEC 61496 Electro-sensitive Protection Equipment

IEC 60529 Degrees of Protection Provided by Enclosures

IEC 60947-1 Low Voltage Switchgear – General Rules

IEC 60947-5-1 Low Voltage Switchgear – Electromechanical Control Circuit Devices

IEC 60947-5-5 Low Voltage Switchgear – Electrical Emergency Stop Device with Mechanical Latching Function

IEC 61508 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems

12 Glossary

A

Automatic Reset

The safety input device control operation setting where the assigned safety output will automatically turn on when all of its associated input devices are in the Run state.

C

Change of State (COS)

The change of an input signal when it switches from Run-to-Stop or Stop-to-Run state.

Closed-Open Debounce Time

Time to bridge a jittery input signal or bouncing of input contacts to prevent nuisance tripping of the Controller. Adjustable from 6 ms to 100 ms. The default value is 6 ms (50 ms for mute sensors).

Complementary Contacts

Two sets of contacts which are always in opposite states.

Concurrent (also Concurrency)

The setting in which both channels must be off at the same time before turning back on. If this is not satisfied, the input will be in a fault condition.

D

Designated Person

A person or persons identified and designated in writing, by the employer, as being appropriately trained and qualified to perform a specified checkout procedure.

Diverse-Redundancy

The practice of using components, circuitry or operation of different designs, architectures or functions to achieve redundancy and to reduce the possibility of common mode failures.

Dual-Channel

Having redundant signal lines for each safety input or safety output.

F

Fault

A state of a device characterized by the inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources. A fault is often the result of a failure of the device itself, but may exist without prior failure.

H

Hard (Fixed) Guard

Screens, bars, or other mechanical barriers affixed to the frame of the machine intended to prevent entry by personnel into the hazardous area(s) of a machine, while allowing the point of operation to be viewed. The maximum size of the openings is determined by the applicable standard, such as Table O-10 of OSHA 29CFR1910.217, also called a "fixed barrier guard."

M

Machine Response Time

The time between the activation of a machine stopping device and the instant when the dangerous parts of the machine reach a safe state by being brought to rest.

Manual reset

The safety input device control operation setting where the assigned safety output will turn On only after a manual reset is performed and if the other associated input devices are in their Run state.

O

Off Signal

The safety output signal that results when at least one of its associated input device signals changes to the Stop state. In this manual, the safety output is said to be Off or in the Off state when the signal is 0 V dc nominally.

On Signal

The safety output signal that results when all of its associated input device signals change to the Run state. In this manual, the safety output is said to be On or in the On state when the signal is 24 V dc nominally.

Open-Closed Debounce Time

Time to bridge a jittery input signal or bouncing of input contacts to prevent unwanted start of the machine. Adjustable from 10 ms to 500 ms. The default value is 50 ms.

P

Pass-Through Hazard

A pass-through hazard is associated with applications where personnel may pass through a safeguard (which issues a stop command to remove the hazard), and then continues into the guarded area, such as in perimeter guarding. Subsequently, their presence is no longer detected, and the related danger becomes the unexpected start or restart of the machine while personnel are within the guarded area.

PELV

Protected extra-low voltage power supply, for circuits with earth ground. Per IEC 61140: "A PELV system is an electrical system in which the voltage cannot exceed ELV (25 V ac rms or 60 V ripple free dc) under normal conditions, and under single-fault conditions, except earth faults in other circuits."

Q

Qualified Person

A person who, by possession of a recognized degree or certificate of professional training, or who, by extensive knowledge, training and experience, has successfully demonstrated the ability to solve problems relating to the subject matter and work.

R

Run Signal

The input signal monitored by the Controller that, when detected, causes one or more safety outputs to turn On, if their other associated input signals are also in the Run state.

S

SELV

Separated or safety extra-low voltage power supply, for circuits without earth ground. Per IEC 61140: "A SELV system is an electrical system in which the voltage cannot exceed ELV (25 V ac rms or 60 V ripple free dc) under normal conditions, and under single-fault conditions, including earth faults in other circuits."

Simultaneous (also Simultaneity)

The setting in which both channels must be off at the same time AND, when they turn back on, they must turn on within 3 seconds of each other. If both conditions are not satisfied, the input will be in a fault condition.

Single-Channel

Having only one signal line for a safety input or safety output.

Start Up Test

For certain safety devices, like safety light screens or safety gates, it can be an advantage to test the device on power up at least one time for proper function.

Stop Signal

The input signal monitored by the Controller that, when detected, causes one or more safety outputs to turn Off. In this manual, either the input device or device signal is said to be in the Stop state.

System Reset

A configurable reset of one or more safety outputs to turn On after Controller power-up, when set for manual power-up, or lockout (fault detection) situations.

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