SC22-3/-3E Safety Controller Instruction Manual

Instruction Manual

Original Instructions
133487 Rev. D
28 October 2015

133487

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 5.

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

This manual contains numerous WARNING and CAUTION statements:

- Warnings refer to potentially hazardous situations which, if not avoided, may lead to serious injury or death.
- Cautions refer to potentially hazardous situations which, if not avoided, which may lead to minor or moderate injury or potential damage to equipment. Cautions are also used to alert against unsafe practices.

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 SC22 Safety Controllers to meet the various safeguarding application requirements. These individuals are responsible to read and abide by these statements.

1.2 EC Declaration of Conformity (DoC)

Banner Engineering Corp. herewith declares that the SC22-3 Series Safety Controller is in conformity with the provisions of the Machinery Directive 98/37/EEC 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 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.

1.3.1 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

1.3.2 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

1.3.3 International/European 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

1.3.4 Sources of Standards and Regulations

OSHA Documents: *www.osha.gov* (Tel: 202-512-1800)

American National Standards Institute (ANSI): *www.ansi.org* (Tel: 212-642-4900)

Robotics Industries Association (RIA): *www.robotics.org* (Tel: 734-994-6088)

National Fire Protection Association (NFPA): *www.nfpa.org* (Tel: 800-344-3555)

NSSN National Resource for Global Standards : *www.nssn.org* (Tel: 212-642-4980)

IHS Standards Store: *www.global.ihs.com* (Tel: 303-397-7956, 800-854-7179)

Document Center: *www.document-center.com/home.cfm* (Tel: 650-591-7600)

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1.5 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.

THIS LIMITED WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES WHETHER EXPRESS OR IMPLIED (INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE), AND WHETHER ARISING UNDER COURSE OF PERFORMANCE, COURSE OF DEALING OR TRADE USAGE.

This Warranty is exclusive and limited to repair or, at the discretion of Banner Engineering Corp., replacement. IN NO EVENT SHALL BANNER ENGINEERING CORP. BE LIABLE TO BUYER OR ANY OTHER PERSON OR ENTITY FOR ANY EXTRA COSTS, EXPENSES, LOSSES, LOSS OF PROFITS, OR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES RESULTING FROM ANY PRODUCT DEFECT OR FROM THE USE OR INABILITY TO USE THE PRODUCT, WHETHER ARISING IN CONTRACT OR WARRANTY, STATUTE, TORT, STRICT LIABILITY, NEGLIGENCE, OR OTHERWISE.

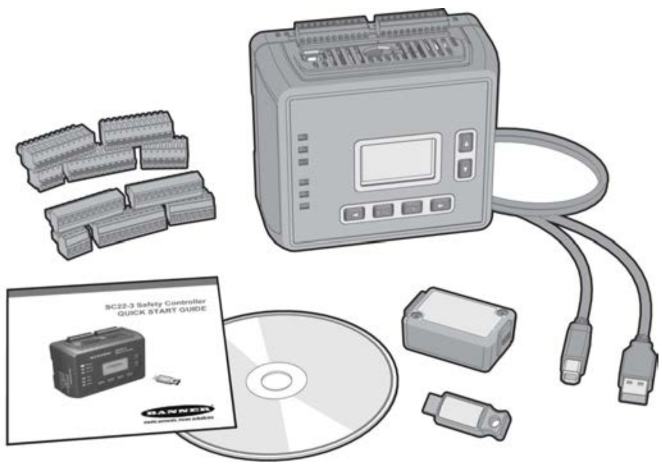
Banner Engineering Corp. reserves the right to change, modify or improve the design of the product without assuming any obligations or liabilities relating to any product previously manufactured by Banner Engineering Corp.

2 Overview

NOTE: This section of this document provides a high-level discussion of the Banner SC22 Safety Controllers to acquaint the user with the Controller's capabilities and features. For in-depth information about installation, wiring, and use of the product, refer to later sections.

The Banner SC22 Safety Controllers (the Safety Controller, or the Controller) are easy-to-use, configurable, 24V dc safety modules designed to monitor multiple safety and non-safety input devices and control up to three independent machine primary control elements (MPCEs). They provide safety 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, gate interlocking switches, safety light curtains, and other safeguarding devices. It also can be used in place of safety PLCs and other safety logic devices when they are excessive for the application.

Configurations are created using an Onboard LCD and push-button interface, or using a PC connected to the Safety Controller via a USB port.



2.1 Ethernet-Compatible Model

The model SC22-3E provides the same features of the SC22-3, and in addition provides the ability to interface to Ethernet (for example to a PLC or HMI human interface touch panel), using Modbus/TCP or EtherNet/IP™ protocols.

Modbus/TCP is an open standard protocol developed by the Modbus IDA. It is similar to Modbus RTU, except that it uses standard Internet communication protocols, just like Web communications or email. The master is referred to as the “client,” and the slave is the “server.” (The SC22-3E is a “server.”) Modbus/TCP follows the same structure as Modbus RTU: clients initiate all communication, servers can only respond.

EtherNet/IP (EtherNet Industrial Protocol) is an open standard protocol developed by Allen-Bradley, but managed by the ODVA. EtherNet/IP is an adaptation of the DeviceNet serial fieldbus protocol, using Internet communications protocols. EtherNet/IP is DeviceNet over Ethernet. Compatible devices supported are:

- EtherNet/IP connection (using the CIP protocol) to the Allen-Bradley ControlLogix family of PLCs. Both implicit and explicit messaging is supported
- EtherNet/IP connection (using the PCCC protocol) to the Allen-Bradley SLC and PLC5 families of PLCs
- Modbus/TCP connection to any compatible PLCs, HMIs, or devices

2.2 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

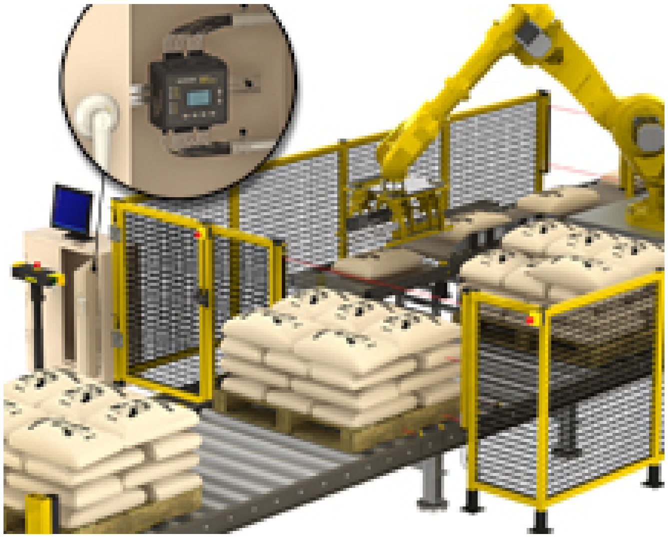


Figure 1. A palletizing application with multiple safeguarding controlled by the Safety Controller

2.3 Design and Testing

The Safety Controller is 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 the UL, IEC, and ISO 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.

See section *Input Device and Safety Category Reference* on page 86 for specific information about integrating devices with the controller.

2.4 Components

The Safety Controller Starter Kit includes:

- 1 Safety Controller (model SC22-3 or SC22-3E)
- 1 set of removable terminals (choose screw or clamp type)
- 1 SC-XM1 external memory (XM) card
- 1 USB A/B cable (Ethernet models)
- 1 SC-XMP XM card programming tool (some models)
- 1 CD containing PCI software, instruction manual, and configuration tutorials (p/n 134534)
- 1 Quick Start Guide

Ethernet connection cables (for model SC22-3E) are user-supplied.

2.4.1 PC Requirements

Operating system
Microsoft Windows® XP, Windows 2000, Vista®, Windows 7

Hard drive space
100 MB (plus up to 280 MB for Microsoft .NET 2.0, if not already installed)

Third-party software
Microsoft .NET 2.0, included and installed with PCI, if not already on computer Adobe® Reader® for Windows version 7.0 or newer

USB port
USB 1.1 or 2.0 type A port

2.4.2 USB Connections

The Safety Controller is connected to the PC via the USB A/B cable. The cable is also used to connect the PC to the SC-XMP programming tool in order to download a configuration to the XM card.

Figure 2. USB connections: PC to SC-XMP programming tool connection

Figure 3. USB connections: PC to Safety Controller USB port connection

2.4.3 Ethernet Connections

Ethernet connections are made using an ethernet cable connected from the SC22-3E Ethernet port to a network switch or the user’s control device. The SC22-3E supports either the standard or crossover-style cables. A shielded cable may be needed in high-noise environments.

1. USB Port
2. XM Card Port
3. Ethernet Port

Figure 4. Safety Controller Connections

2.4.4 SC-XMP Programming Tool

The programming tool is used to transfer a configuration from a PC (running the PCI software) to an XM card, or from an XM card to the PC, without requiring a Safety Controller. It connects to the PC via the USB A/B cable.

2.4.5 SC-XM1 External Memory (XM) Card

The model SC-XM1 external memory (XM) card is a removable memory module that can store or be used to transfer a single configuration. The XM card has a write-on label on its reverse side where a configuration name or a machine identification can be noted.

The XM card can be used to:
- Keep a backup copy of the Safety Controller's configuration (to minimize downtime in the case of a hardware failure that may require a Controller replacement)
- Transfer configurations from one Safety Controller to another Safety Controller
- Send (download) identical configurations into multiple Safety Controllers
- Transfer configurations between the Safety Controller and a personal computer

Store a configuration on the XM card in one of two ways:
- Send a copy to the XM card using the PC Interface (PCI) and the SC-XMP programming tool
- Send a copy from the Controller to the XM card, using the Onboard Interface (OBI)

NOTE:
1. A configuration can be stored permanently in an XM card, if the "lock" function is performed. However, once the card is locked, it cannot be unlocked (it becomes "read-only").
2. Configurations on an XM card do NOT contain any network settings. The PCI software must be used to change network settings.

2.5 Configuring the Safety Controller

The Safety Controller can be configured using either of the two interfaces: the push buttons and the LCD screen on the controller itself (the Onboard Interface, or OBI), or the PCI software included on the enclosed CD (p/n 134534). 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.
   - Select safety input device types and circuit connections
   - Map each input to one or more safety outputs, or to other input devices
   - Set optional safety output ON- or OFF-time delays
   - Select non-safety input device types and circuit connections, if needed
   - Assign status output signals, if needed
   - Create configuration name, file name, date, and author name
3. Confirm the configuration.
   - Controller verifies that the desired configuration is valid
   - User confirms that the configuration is as expected

2.5.1 Onboard Interface (OBI)

The Safety Controller can be configured using its built-in push buttons and LCD screen, the Onboard Interface (OBI). The LCD display provides I/O device and system status information for any event that causes one or more of the Safety Outputs to turn OFF. The display is used in conjunction with the six push buttons to:
- Create or modify password-protected configurations
- Retrieve fault log information
- Review device wiring detail and I/O logic relationships
- Display I/O device fault details and likely remedial steps
- Display configuration checksum

NOTE:
1. Onboard Interface functions are covered in more detail in Section 5 and the OBI tutorial, located separately on the disk.
2. The OBI cannot be used to change network settings; the PCI must be used for that function.

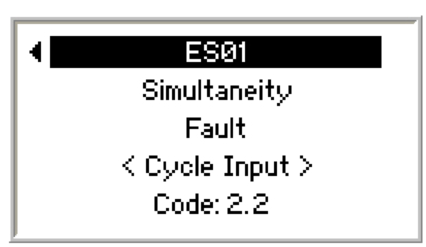
1. Moves cursor to the left or selects settings.
2. Moves cursor to the pre-established point in the program to re-establish a menu reference point.
3. Enters/stores the item highlighted in the display as the intended selection or toggles a setting.
4. Moves cursor to the right or selects settings.
5. Moves cursor down or moves through a list to display individual list items. Also used to select settings.
6. Moves cursor up or moves through a list to display individual list items. Also used to select settings.
7. Ethernet connector indicators (Yellow and Green; Ethernet models only)
8. Status indicators
9. LCD display

Figure 5. Onboard Interface, including push buttons, LCD display and status indicators (model SC22-3E shown)

Status Indicator	Condition	Indicates Controller Status
All Indicators OFF	—	Initiation Mode
Power	ON Green	Power ON
	OFF	Power OFF
Status (Controller Mode)	ON Red	Configuration mode
	Flashing Red	Lockout mode
	OFF	Run mode
USB or Tx/Rx (depending on model)	Flashing Green	Transmitting or receiving data (a link is established with the PC)
	OFF	Not transmitting or receiving data
Safety Output SO1, SO2, SO3	ON Green	Safety Output ON
	ON Red	Safety Output OFF
	Flashing Red	Safety Output fault detected
	Flashing Green	Safety Output waiting for reset
Ethernet Connector (model SC22-3E only)	Yellow OFF	No link
	Yellow ON	Link OK
	Green OFF	No activity
	Green ON or flashing	Activity detected

Accessing Fault Codes

Fault codes are displayed on the last line of the OBI fault diagnostics menu (see example on the right). Refer to *Fault Diagnostics—OBI* on page 84 for more information.



2.5.2 Personal Computer Interface (PCI)

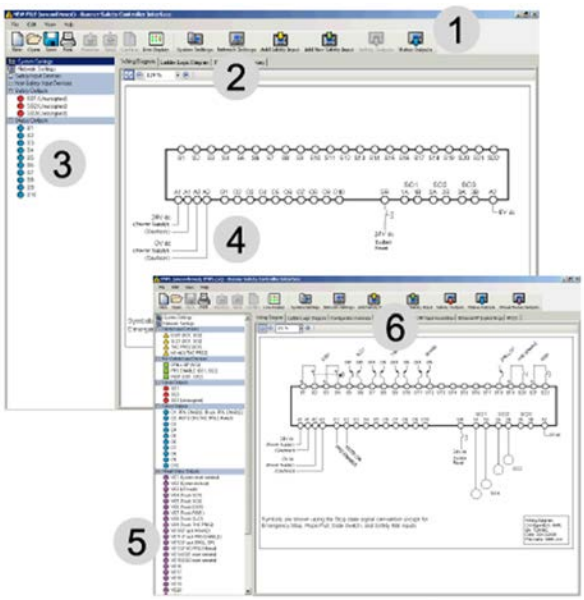
The Safety Controller can also be configured using a Windows®-based computer and the Safety Controller PC Interface (PCI) program. This user-friendly interface makes use of icons and circuit symbols to simplify the selection of device properties during configuration. The configuration wiring and ladder logic diagrams develop automatically as the configuration progresses.

Creating a configuration is simple. Once a configuration is created, it:

- Can be stored to a computer file for archiving and future use
- Can be emailed to a remote location as an attachment
- Can be sent directly to another Safety Controller or to the plug-in external memory card

The PCI can be used to create a configuration, save it and send it as described above, and also monitor the function of a Controller using the live display, as well as monitor the fault log for troubleshooting purposes.

To access the Ethernet functionality of the model SC22-3E, click on the Network Settings icon and check the Enable Network Interface box. The Virtual Status Outputs will appear on the I/O Properties menu, as will additional tabs above the document section of the screen, as shown in the following figure.



1. Toolbar
2. Network settings
3. I/O properties
4. Document (in this case, Wiring Diagram)
5. Virtual Status Outputs (These outputs become visible after the Enable Network Interface box is checked under the Network Settings tab.)
6. New tab selections also become visible.

Figure 6. PC User Interface (PCI) main screens

- PC Interface functions are covered in more detail in section *PC Interface (PCI) Overview* on page 50 and in the PCI tutorial
- PC Interface network functions are covered in more detail in sections *Virtual Status Outputs* on page 49 and *Ethernet Reference* on page 116

PCI Software Compatibility

To identify the version of your PCI software (PC Interface), click the Help tab located on the top tool bar and then click Compatibility Information. The information contained in the pop-up window identifies what PCI software version is running and lists when a feature was added or changed.

Newer PCI versions are backwards compatible with earlier SC22 firmware versions, although features must be supported by the SC22 firmware version or the feature will be unavailable. If an unsupported feature is attempted to be downloaded, an error message will be displayed. The SC22 firmware version can be identified via the Onboard Interface (OBI) "Model #" menu item; see section *Display Controller Information — Onboard Interface (OBI)* on page 68. This screen identifies the Safety Controller model, the firmware versions of microprocessors A and B, and the hardware version. Contact a Banner Applications Engineer with any questions.

2.6 Input and Output Connections

2.6.1 Safety and Non-Safety Input Devices

The Safety Controller has 22 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. Each of these 22 input terminals can either monitor an input signal or provide 24V dc. The function of each input circuit depends on the type of the device connected; this function is established during the controller configuration.

For general and specific information about input devices, their requirements, hookup options, appropriate warnings and cautions, additional installation information, and calculating Safety Distance (Minimum Distance), refer to the sections *System Installation* on page 25 and *Input Device and Safety Category Reference* on page 86, which contain hookup information and other useful information about integrating the following devices:

- Safety Circuit Integrity
- Protective (Safety) Stop
- Optical Sensors
- Safety Gate (Interlock Guard)
- Two-Hand Control
- Safety Mat (Edges)
- Emergency Stop Push Buttons
- Rope (Cable) Pull
- Enabling Devices (Pendants)
- Bypass
- Muting

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

Safety Device Hookup Considerations

The Safety Controller inputs can be configured to interface with many types of safety devices, including safeguarding devices, such as safety light curtains, complementary protective equipment, such as emergency stop push buttons, and other devices that impact the safe use of a machine, such as equipment protection.

The way these devices interconnect impacts their ability to exclude or detect faults that could result in the loss of the safety function. There are many standards, regulations and specifications that require certain capabilities of a safety circuit.

WARNING: User Responsibility

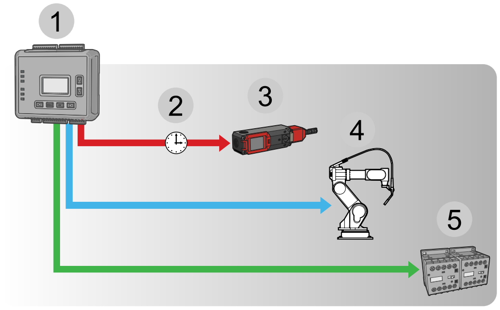
The user is responsible for ensuring that all local, state, and national laws, rules, codes, and regulations relating to the use of this device in any particular application are satisfied. Make sure that all legal requirements have been met and that all installation, operation, and maintenance instructions contained in the device documentation are followed.

2.6.2 Safety Outputs

The Safety Outputs are designed to control final switching devices (FSDs) and machine primary control elements (MPCEs) that are the last in the control chain to control the dangerous motion. These control elements include relays, contactors, solenoid valves, motor controls and other devices that incorporate force-guided (mechanically-linked) monitoring contacts, or control-reliable signals needed for external device monitoring.

The Safety Controller has three independently controlled and redundant solid-state Safety Outputs. 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 and the system's self-checking test signals.

The Safety Outputs, SO1, SO2 and SO3, can be controlled by input devices with both automatic and manual reset operation.



1. Safety Controller
2. OFF-Delay
3. Solenoid locking switch
4. Robot
5. Contactors

Figure 7. Safety Outputs

See section *Safety Outputs* on page 38 for more information about configuring Safety Outputs.

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.

ON-Delays and OFF-Delays

Each safety output can be configured to function with a time delay. There are two types of time delays: ON-delay and OFF-delay, where the outputs turn ON or OFF only after the time limit has elapsed. The ON and OFF time delay limit options are from 100 milliseconds to 5 minutes, in 100 millisecond increments.

Safety output ON-delays are sometimes used when a machine operation must be delayed before a safe machine startup is permitted. An example application would be a robot weld cell.

WARNING: Turning a Delayed Output On/Off

If an input that is mapped to both an immediate safety output and a delayed safety output opens and then closes before the delay time of the delayed output has expired, the immediate safety output will turn Off and remain Off while the delay time is running.

At the end of the delay time, the delayed output will also turn Off. Both outputs will then remain Off for about 500 ms, before they will turn back On. This will happen either automatically, if configured for auto reset, or after a valid manual reset signal, if configured for manual reset.

2.6.3 Status Outputs

The Safety Controller has ten configurable status outputs used to send non-safety status signals to programmable logic controllers (PLCs) or to human machine interfaces (HMIs), or they may be used to power indicator lights. These outputs can be configured to report on the status of input devices, safety outputs, or the controller itself. See section *Status Output Signal Conventions* on page 46 for more information.

Signal Convention

The status output signal convention can be configured to be 24V dc or 0V dc to indicate:

- When an input is in the Run state
- When a safety output is in the ON state (see Note 1 below)
- When a safety output is in a logical ON state (ON or in an ON-delay; see Note 1 below)
- When the system is in a Lockout condition
- When an I/O fault is present (see Note 2 below)
- When a system reset is needed
- When a safety output needs a reset (see Note 3 below)
- When a safety input is muted
- Which safety input, of a defined group of safety inputs, turned OFF first
- When a safety input is bypassed

- When a safety input has a Fault condition
- When a safety output's OFF-delay can be cancelled

NOTE:

1. Only safety outputs that have inputs mapped to them can be mapped to a status output.
2. An I/O fault is a failure of one or more safety inputs, safety outputs, or status outputs.
3. Only safety outputs mapped to inputs configured with manual reset logic can have a status output configured to indicate a reset is needed.

WARNING: Status Outputs

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

Monitored Mute Lamp Outputs

Status Outputs O9 and O10 can be configured to create a monitored mute lamp function for a mute operation. When the mute lamp is ON, the Controller monitors for a short circuit in the load. When the lamp is OFF, it monitors for an open circuit in the load. If an open circuit occurs before the start of a mute cycle, the next mute cycle will be prevented. If an open circuit occurs during a mute cycle, that mute cycle will finish, but the next mute cycle will be prevented. If a short occurs before or during a mute, that mute cycle will start and finish, but the next mute cycle will be prevented. If not used to monitor a mute lamp, these outputs may be used in the same ways as outputs O1–O8.

Important: Only terminals O9 and O10 have the extra monitoring circuitry needed for a monitored mute lamp. If monitoring of the mute lamp is not required (depending on applicable standards), any of the Status Outputs (O1–O10) may be used to indicate a mute condition. Because of this feature, these Status Outputs will always appear ON with no load (see *Specifications* on page 23).

2.6.4 Virtual Status Outputs

Using the PCI, the model SC22-3E (only) can configure up to 32 Virtual Status Outputs. These outputs can communicate the same information as the status outputs, but over the network.

WARNING: Virtual Status Outputs

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 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.

2.6.5 I/O Mapping: the I/O Control Relationship

The term "map" implies a control logic relationship between an input and an output, or between an input and another input, where the state of the first input determines the state of the output or of the second input.

Inputs Mapped to Outputs. The following devices can be mapped directly to the Safety Outputs:

- Emergency stop buttons
- Safety gate switches
- Optical sensors
- Two-hand control devices
- Safety mats
- Protective stop switches
- Rope pulls
- Enabling devices
- External device monitoring
- ON/OFF devices
- Manual reset devices
- Solenoid or press safety valves
- Cancel OFF-delay devices

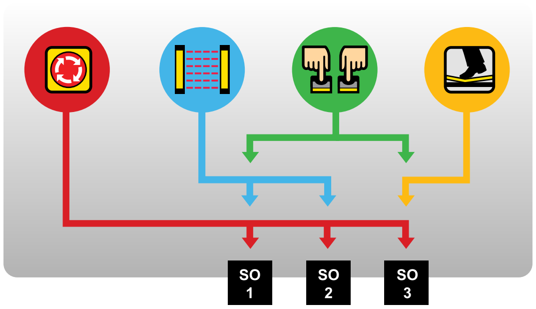


Figure 8. Input and Output mapping

Inputs Mapped to Inputs. Muting sensors and bypass switches work in conjunction with certain safety input devices to temporarily suspend the Stop signal of a safety input device. These sensors and switches are mapped directly to the safety inputs; they are then indirectly mapped to the safety output(s) controlled by the muted safety inputs (see section *Mute Function* on page 34).

2.7 System Settings

The controller's system settings define parameters for both the configuration file and the controller. These settings include:

- Configuration name
- Author's name
- Power-up mode
- Mute on power-up enable
- Monitored system reset

Configuration Name

The configuration name identifies the configuration that is used in a Safety Controller application. The configuration name is displayed on the controller and helps to ensure the correct controller configuration is used.

Author's Name

The author's name is helpful if questions about configuration settings arise.

Power-Up Mode (Operational Characteristics When Power Is Applied)

The controller provides three power-up modes to determine how the controller will behave after the power is supplied. These modes are: Normal, Automatic, and Manual.

- Normal Power-Up Mode (default). In a normal power-up mode, after power is applied:
    - Only those safety outputs that have automatic reset inputs will turn ON
    - Safety outputs that have one or more manual reset inputs will turn ON only after a manual (latch) reset operation is performed
    - *Exception:* Two-hand control inputs, bypass inputs, and enabling device inputs must be seen to be in the Stop state at power-up, regardless of the power-up mode selection. If these are seen to be in the Run state at power-up, the outputs will remain OFF.
- Automatic Power-Up Mode. In an automatic power-up mode, after power is applied:
    - All safety outputs will turn ON immediately if the inputs that are mapped to these outputs are all in the Run state.
    - *Exception:* Two-hand control inputs, bypass inputs, and enabling device inputs must be seen to be in the Stop state at power-up, regardless of the power-up mode selection. If these are seen to be in the Run state at power-up, the outputs will remain OFF.

WARNING: Automatic Power-Up

When the Controller is configured for automatic system reset power-up mode, the Controller acts as if all input devices are configured for auto (trip) reset. Each safety output will immediately turn on at power-up if the assigned input devices are all in the Run state, even if one or more of the input devices is configured for manual (latch) reset. If the application requires that a manual (latch) reset operation be performed before the Safety Output turns On, then either manual or normal power-up mode configuration must be used. Failure to do so could cause a machine to operate in an unexpected way at power-up or after temporary power interruptions.

- Manual Power-up Mode. In a Manual Power-up Mode, after power is applied:
    - Safety outputs will turn ON only after all inputs mapped to this output are in the Run state and a System Reset has been performed. (A manual latch reset is not required.)
    - *Exception:* Two-hand control inputs, bypass inputs, and enabling device inputs must be seen to be in the Stop state at power-up, regardless of the power-up mode selection. If these are seen to be in the Run state at power up, the outputs will remain OFF.

> **WARNING: Controller Operation on Power-Up**
>
> It is the responsibility of the user of the Controller to assess what safeguarding devices and methods are appropriate for any given machine or application. The Qualified Person[1] who configures, installs, and/or maintains it must be aware of the power-up behavior of the Controller and instruct the machine operator on the operation of the Controller and its associated devices.

Mute On Power-Up Enable

If configured, the Mute on Power-Up function will initiate a mute cycle after power is applied to the Safety Controller if the muted safety inputs are active (Run state or closed), and either M1-M2 or M3-M4 (but not all four) are signaling a muted condition (for example, active or closed).

- For more information on the Mute On Power-Up function, see section *Mute Function* on page 34.

Monitored System Reset

Monitored System Reset is enabled by default and requires an OFF-ON-OFF signal at the reset input, where the ON-duration must be between 0.3 and 2 seconds (trailing edge reset), in order to reset the system.

If unchecked (Monitored System Reset disabled), the reset input requires only a signal from OFF to ON (leading edge reset), in order to reset the system.

2.8 Internal Logic

The Controller's internal logic is designed so that a Safety Output can turn ON only if all the controlling input device signals are in the Run state and the Controller's self-check signals are in the No-Fault state.

Safety Input 1	Safety Input 2	Safety Controller	Safety Output 1
Stop	Stop	Run (No Fault)	OFF
Stop	Run	Run (No Fault)	OFF
Run	Stop	Run (No Fault)	OFF
Run	Run	Run (No Fault)	ON

The table above illustrates the logic for two safety input devices mapped to control Safety Output 1. If any of the safety input devices are in the Stop state, then Safety Output 1 is OFF. When both safety inputs are in the Run state, then Safety Output 1 will turn ON.

2.8.1 Additional Logic Functions

Other logic functions are slight variations of the general AND logic rule set.

- Two-Hand Control: The machine initiation signal incorporating a 0.5 second actuator simultaneity limit and anti-tie-down logic, designed to prevent single-actuator machine cycle operation
- Safety Device Muting: The automatic suspension of one or more safety input Stop signals during a portion of a machine operation when no hazard is present or when access to the hazard is otherwise safeguarded
- Safety Device Bypass: The manually activated, temporary suspension of one or more safety input Stop signals when the hazard is otherwise safeguarded
- Enabling Device Control: The actively controlled manual suspension of a Stop signal during a portion of a machine operation when a hazard could occur
- Cancel OFF-Delay: The option to cancel a configured OFF-delay time by either keeping the Safety Output ON, or turning it OFF immediately

The rules that apply to these special cases are explained in section *Input Device and Safety Category Reference* on page 86.

2.9 Password Overview

To provide security, in some cases, the Safety Controller requires the use of a password. For information about changing a controller's password, refer to *System Options* on page 63. If the password becomes lost, contact the Banner Engineering for assistance.

[1] 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.

Creating a Configuration

- Via computer using the Safety Controller PC Interface (PCI) program (no password needed)
- Via the Controller Onboard Interface (OBI) (password needed)

Confirming a Configuration

- Via the PCI, using the PC connected to a powered Controller (password needed)
- Via the OBI, on a powered Controller (password needed)

Sending a Confirmed Configuration to the Controller

- Via a direct connection between the PC and the Controller, using the SC-USB1 cable and the PC Interface program (password needed)
- Via the PC, the XM card programming tool, and the XM card (password needed)

2.10 Confirming a Configuration

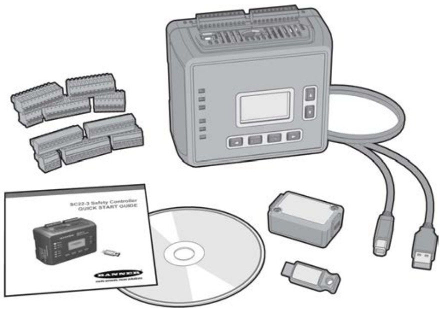
Although a controller will accept an unconfirmed configuration, it will only activate it (adopt the configuration and function according to its parameters) after the configuration is confirmed, using the OBI or PC Interface.

Important: If any modification is made to a confirmed configuration, or if a configuration is edited during the confirmation process, the PCI and the controller will recognize this modified configuration as being new and will require it to be confirmed before it can be activated and used.

Once confirmed, a configuration can be stored and reused without reconfirmation. The configuration code will be validated automatically each time it is downloaded to a controller and whenever the controller powers up. Configurations, confirmed or not, can be sent via email. Sending (downloading) a new confirmed configuration to a controller requires entry of the controller password.

3 Components and Specifications

The Safety Controller can be ordered alone, without terminals, as a replacement part. To order the Safety Controller ready for use, order it as part of a kit (see *SC22-3 Safety Controller Starter Kit Models* on page 21).



Kits include the Safety Controller, a set of plug-on terminal blocks (screw or cage-clamp type, depending on model), a USB A/B cable (for direct connection between a PC and the Safety Controller, included with some kits), external non-volatile memory card (XM card, with write-on label on reverse side), XM card programming tool (included with some models), a user CD (includes software interface, online manual, ethernet references and configuration tutorials), and quick start guide.

3.1 SC22-3 Safety Controller Starter Kit Models

Kit Model	Terminal Type	Safety Outputs	Status Outputs	Safety Output Rating	USB A/B Cable	XM Card	XM Card Programming Tool	Communication Protocol
SC22-3-S	Screw	6 PNP Terminals (3 pairs)	10 Status	0.75 amps each output	–	Yes	–	–
SC22-3-C	Clamp							
SC22-3-SU1	Screw				1.8 m		Yes	
SC22-3-CU1	Clamp							
SC22-3E-S	Screw		10 Status plus 32 Virtual Status	0.5 amps each output	–		–	EtherNet/IP & Modbus/TCP
SC22-3E-C	Clamp							
SC22-3E-SU1	Screw				1.8 m		Yes	
SC22-3E-CU1	Clamp							

3.2 Replacement Parts/Accessories

Model	Description
SC22-3	Replacement Controller (no terminals)
SC22-3E	Replacement Controller (no terminals), Ethernet compatible
SC-XM1	External memory card (XM card)
SC-XM1-5	Bulk pack of 5 XM cards
SC-XMP	USB programming tool for XM card
SC-TS1	Screw terminal replacement set
SC-TC1	Cage clamp terminal replacement set
SC-USB1	USB A/B cable, 1.8 m
134534	CD including PCI program and instruction manual

3.3 Ethernet Cordsets

Cat5e Shielded Cordsets	Cat5e Crossover Shielded Cordsets	Length
STP07	STPX07	2.1 m (7 ft)

Cat5e Shielded Cordsets	Cat5e Crossover Shielded Cordsets	Length
STP25	STPX25	7.62 m (25 ft)
STP50	STPX50	15.2 m (50 ft)
STP75	STPX75	22.9 m (75 ft)

3.4 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 *External Device Monitoring (EDM)* on page 37.

SC-IM9 series interface modules are used only with the Safety Controller; dry contacts are used with higher ac/dc voltage and current. The modules have 10A output, DIN-mount housing, removable (plug-in) terminal blocks for OSSD outputs (screw terminal block supplied). They measure 72 mm (2.8 in) high, 170 mm (6.7 in) deep, and 45 mm (1.8 in), 90 mm (3.5 in), or 140 mm (5.5 in) wide, depending on model. See datasheet p/n 131845 for more information.

Model	Description	Supply Voltage	Inputs (Safety Controller Outputs)	Safety Outputs	Output Rating	EDM Contacts
SC-IM9A	For use with 1 Safety Controller Safety Output	24V dc (Controller-supplied)	2 (SO1)	3 N.O.	10 amps	1 N.C. pair per output
SC-IM9B	For use with 2 Safety Controller Safety Outputs		4 (SO1 and SO2)	Total of 6 (3 N.O. per output)		
SC-IM9C	For use with 3 Safety Controller Safety Outputs		6 (SO1, SO2, and SO3)	Total of 9 (3 N.O. per output)		

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.

3.4.1 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. 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 *External Device Monitoring (EDM)* on page 37 .

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

3.5 Specifications

Power

24V dc, ± 20%

Model SC22-3: 0.4 A (Controller only), 5.9 A (all outputs ON at full rated load)

Model SC22-3E: 0.4 A (Controller only), 4.9 A (all outputs ON at full rated load)

The Controller 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.

Safety and Non-Safety Inputs (22 terminals)

Input ON threshold: > 15V dc (guaranteed on), 30V dc max.

Input OFF threshold: < 5V dc (guaranteed off with any 1 fault), –3V dc min.

Input ON current: 8 mA typical at 24Vdc, > 2 mA (guaranteed with 1 fault)

50 mA peak contact cleaning current at 24V dc

Sourcing current: 30 mA minimum continuous (3V dc max. drop)

Input lead resistance: 300 Ω max. (150 Ω per lead)

Input requirements for a 4-wire safety mat:

- Max. capacity between plates: 0.5 µF
- Max. capacity between bottom plate and ground: 0.5 µF
- Max. resistance between the 2 input terminals of one plate: 20 Ω

Safety Outputs (6 terminals, 3 redundant outputs)

Rated output current:

Model SC22-3: 0.75 A max. at 24V dc (1.0V dc max. drop)

Model SC22-3E: 0.5 A max. at 24V dc (1.0V dc max. drop)

Output OFF threshold: 0.6V dc typical (1.2V dc max. guaranteed with 1 fault)

Output leakage current: 50 µA max. with open 0V

Load: 0.1 µF max., 1 H max., 10 Ω max. per lead

Status Outputs (10 terminals)

Rated output current: 0.5A at 24V dc (individual), 1.0 A at 24V dc (total of all outputs)

O1 to O8 (General Purpose)—Output OFF voltage: < 0.5V dc (no load), 22 KΩ pull down to 0V

O9 and O10 (General Purpose or Monitored Mute Lamp)—

Output OFF voltage: Internal 94 KΩ pull up to 24V dc supply

Output ON/OFF threshold: 15V dc +/−4V dc at 24V dc supply

Response and Recovery Times

Response Time (ON to OFF): 10 ms max. (with standard 6 ms debounce; this can increase if debounce time increases. Refer to the configuration summary for actual response time.)

Recovery Time (OFF to ON): 400 ms max. (with manual reset option)

Recovery Time (OFF to ON): 400 ms max. plus input debounce time (auto reset)

Onboard LCD Information Display—Password Requirements

Password is not required:

Run mode (I/O status)

Fault (I/O fault detection and remedial steps)

Review configuration parameters (I/O properties and terminals)

Password is required:

Configuration mode (create/modify/confirm/download configurations)

Environmental Rating

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

Operating Conditions

Temperature range:0 °C to +55 °C (+32 °F to +131 °F)

Mechanical Stress

Shock: 15g for 11 milliseconds, half sine, 18 shocks total (per IEC 61131-2)

Bump: 10g for 16 milliseconds, 6000 cycles total (per IEC 61496-1)

Vibration: 3.5 mm occasional / 1.75 mm continuous at 5Hz to 9Hz, 1.0g occasional and 0.5g continuous at 9Hz to 150Hz: (per IEC 61131-2) and 0.35 mm single amplitude / 0.70 mm peak-to-peak at 10 to 55Hz (per IEC 61496-1), all at 10 sweep cycles per axis

EMC

Meets or exceeds all EMC requirements in IEC 61131-2, IEC 61496-1 (Type 4), and IEC 61326-3-1.

Removable Terminals

Screw terminals

Wire sizes: 16, 18, 20, 22 or 24 AWG (0.20 – 1.31 mm^2)

Wire strip length: 5.00 mm (0.197 in)

Tightening torque: 0.23 Nm (2 in. lbs.) nominal; 0.34 Nm (3.0 in. lbs.) maximum

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: 16, 18, 20, 22, or 24 AWG (0.20 – 1.31 mm^2)

Wire strip length: 9.00 mm (0.35 in)

Network Interface (Model SC22-3E 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

Data: 32 configurable virtual Status Outputs; fault diagnostic codes and messages; access to fault log

Product Performance Standards

IEC 62061 Safety of Machinery – Functional Safety of Safety-Related Electrical, Electronic and Programmable Electronic Control Systems: SIL CL 3

IEC 61508 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems: SIL 3

ISO 13849-1 (1999): Category 4

ISO 13849-1 (2006): Category 4 Performance Level (PL) e, complies with Machinery Directive 2006/42/EC

IEC 61131-2 Programmable Controllers, Part 2: Equipment Requirements and Tests

UL 508 Industrial Control Equipment

UL 1998 Software in Programmable Components

ANSI NFPA 79 Electrical Standards for Industrial Machinery

IEC 60204-1 Electrical Equipment of Machines: General Requirements

ISO 13851 (EN574) Safety of Machinery – Two-Hand Control Devices – Functional Aspects and Design Principles

ISO 13850 (EN418) Emergency Stop Devices

Also see front section of this manual for a list of other applicable U.S. and international standards.

Agency Approvals

CE, UL LISTED, c UL US LISTED

NOTE: For O9 and O10 (when configured as a monitored mute lamp output), if a short circuit or other fault condition causes the output to drop below this threshold while the output is ON, a lockout will occur. If an open circuit or other fault condition causes the output to rise above this threshold while the output is OFF, a lockout will occur.

3.5.1 Dimensions

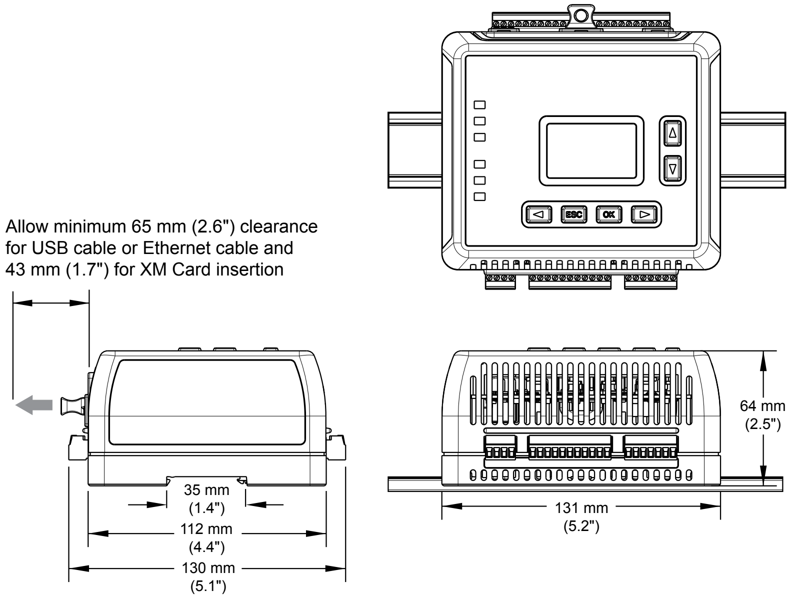


Figure 9. SC22-3 and SC22-3E dimensions

4 System Installation

4.1 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: 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[2] 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: 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.

4.2 Installing the Safety Controller

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 can be mounted in any orientation. The user must comply with all instructions contained within product manuals and relevant regulations.

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 *Operating Conditions* on page 23). Methods to reduce heat build-up include venting, forced air flow (for example, exhaust fans), adequate enclosure exterior surface area, and spacing between the Safety Controller and other sources of heat.

[2] 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.

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.

4.3 Safety Input Devices

Safety input devices allow for the cessation of motion, or an otherwise hazardous situation, by controlling the safety outputs of the Safety Controller. A Safety Output in the Off state results in a stop of motion and removal of power from the machine actuators (assuming this does not create additional hazards).

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. 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 and bypassing.

The Safety Controller input configurations, depending on the type, have means to detect failures and faults that would otherwise result in a loss of the control of the safety function. Once such a failure or fault is detected, the Safety Controller locks out until the problem it is fixed. Other input configurations do not have this detection capability. To eliminate or minimize the possibility of failures and faults that could result in a loss of the safety function(s), install the Safety Controller together with its associated safety and safeguarding devices.

Methods to eliminate or minimize the possibility of these failures 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 elements (modules, switches, and devices under control) 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 10. Input and output terminal locations

> WARNING: Sharing of Safety Inputs
>
> Multiple Safety Controllers must not share safety input devices; this includes solid-state outputs from light curtains, Safety Controllers, or other safety devices. A safety output from one Controller can be connected to a Safety Input of a second Controller. However, the second Controller should be the only device to which the output from the first Controller is connected.
>
> If a third device is also connected to the same safety output (now used as the safety input of the second Controller), during a power transition of the second Controller, the input may be a source of current, momentarily causing a false On (Run) signal at the input of the third device. Failure to connect multiple Controllers correctly could create an unsafe condition that may lead to serious bodily injury or death.

> WARNING: Failures and Faults
>
> The Safety Controller Safety control can be interfaced with input devices at differing levels of integrity. The user must conduct a Risk Assessment to determine the appropriate method of integration. The user must also eliminate or minimize the possibility of failures and faults that may result in the loss of the safety function(s).

4.3.1 Signals: Run and Stop States

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 adopts 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).

4.3.2 Safety Input Device Properties

The Controller can be configured to accommodate many types of safety input devices. However, the number of the device properties must be established (using either the OBI or PCI interface) so that the Controller can properly monitor their signals. The configurable properties include:

- Device name—generated automatically by the Controller and can be changed by the user
- Circuit type—the circuit and signal convention options that can be selected to define the input device
- Reset logic—Automatic (Trip mode) or Manual (Latch mode)
- Terminal number—the assignment of input terminals for a device
- I/O mapping—the logic control relationship between inputs and outputs or between inputs
- Signal change-of-state—Simultaneous or Concurrent type and signal convention (high or low)
- Signal debounce time—the signal state transition time
- Start-up test—an optional precautionary safety input device test required after each power-up
- Function time limit—the adjustable time limit within which a function is allowed to operate
- Mutable—determines whether or not the device can be muted
- Bypassable—determines whether or not the device can be bypassed

Circuit Types: Contact and Solid State Circuits

The table below depicts many of the input devices and circuit types the Controller can monitor. It highlights which of these properties can be configured, and for which devices. More description of some of these topics is included in the following paragraphs.

Not all circuit types meet the Category 4 classification per ISO 13849-1; refer to section *Safety Circuit Integrity and ISO 13849-1 Safety Circuit Principles* on page 86 for a discussion of safety circuit integrity levels.

	E-Stop	Safety Gate	Optical Sensor	Two-Hand Control	Rope Pull	Protect. Stop	Safety Mat	Enabling Device	Mute Sensors	Bypass Switch	EDM	AVM
Circuit Types	7	13	10	7	10	10	1	10	7	10	2	2
Reset Logic	Auto/ Manual	Auto/ Manual	Auto/ Manual	Auto	Auto/ Manual	Auto/ Manual	Auto/ Manual	Auto	Auto	Auto	—	—
I/O Mapping	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/I	I/I	I/O	I/O
Signal COS*	S/C	S/C	S/C	S	S/C	S/C	—	S/C	S	S/C	S	—
Debounce Times	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Start Up Test	—	Yes	Yes	—	—	—	—	—	—	—	—	—
Function Time Limit	—		—	—	—	—	—	Yes	Yes	Yes	—	Yes
Muteable	—	Yes	Yes	Yes	—	Yes	Yes	—	—	—	—	—
Bypassable	—	Yes	Yes	Yes	—	Yes	Yes	—	—	—	—	—

* Refer to change-of-state table.
S = Simultaneous
C = Concurrent

Figure 11. Device Monitoring

Reset Logic: Manual or Automatic Reset

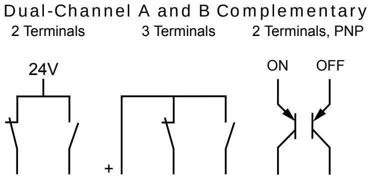
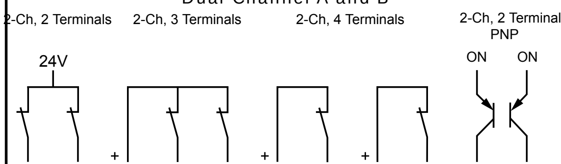
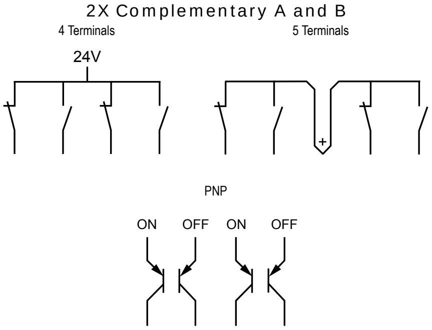
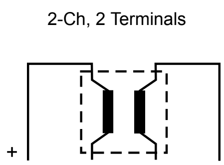
Safety input devices can be configured to require a manual reset before the safety output(s) they control are permitted to turn back On. This is sometimes referred to as "latch" mode because the safety output "latches" to the Off state until a reset is performed. If a safety input device is configured 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). Reset rules and types are discussed in the section *Input Device Resets* on page 31.

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 either the Onboard Interface or 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[3]:	Run State—SO turns On when[4]:
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 100 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 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 closed-to-open debounce time will affect the Safety Output response (turn Off) time. This value is computed and displayed for each Safety Output when a configuration is created. The values are also listed in the OBI and the PCI Configuration Summary documents. (Default setting is 6 ms.)

Open-to-Closed Debounce Time (from 10 ms to 500 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.

[3] Safety Outputs turn Off when one of the controlling inputs is in the Stop state.
[4] 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).

When a safety mat is used, the response time calculation for the safety mat depends on the Stop (6 to 100 ms) debounce time.

CAUTION: Response Times
- The response time for a complementary device is based on the closed contact(s) opening, not on the open contact(s) closing. Both will lead to a stop signal, but only one determines the response time.
- The configurable debounce of an On/Off input and an enabling device input are not part of the calculated and confirmed response times.
- Any changes in the open-to-closed debounce time will affect the Safety Output reaction (turn On) time

4.4 Non-Safety Input Devices

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

Configurable Properties	Manual Reset	ON/OFF	Mute Enable	Cancel Off-Delay
Circuit Types	3	3	3	3
Input and Output Mapping	I/O	I/O	I/I	I/O
Debounce Times	Fixed at 50 ms	Closed-to-open: 6 to 100 ms Open-to-closed: 10 to 500 ms	Fixed at 50 ms	Fixed at 50 ms
Monitored / Non-monitored	Yes	—	—	Yes

Manual Reset Devices: The manual reset is used to create a reset signal after a safety input device that has been configured to require a manual reset has been opened and closed. After the manual reset operation is performed, any of the Safety Outputs controlled by that safety input device can turn ON.

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.

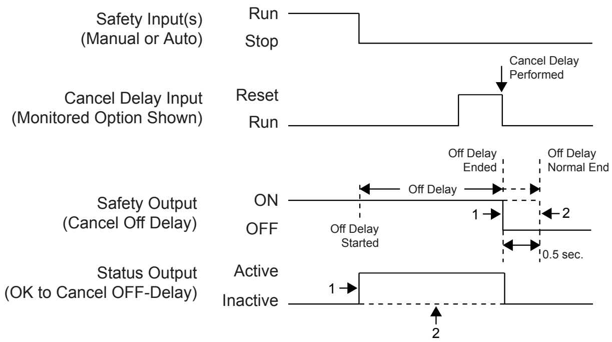
ON/Off Switch: provides an On or Off command to the machine. When all of the controlling safety inputs are in the Run state, this function permits the safety output to turn On and Off. This is a single-channel signal; the Run state is 24 V dc and the Stop state is 0 V dc. An On/Off input can be added without mapping to a safety output, which allows this input to control only a status output.

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.

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 On
- Turns the safety output Off immediately after the Controller receives a Cancel Off-Delay signal

A status output function (OK to Cancel Output's Off-Delay Status) indicates when a Cancel Delay Input can be activated in order to keep the Off-delayed safety output On.

Table 1: Cancel Off-Delay Timing



Note 1 - If "turn output off" function is selected

Note 2 - If "keep output on" function is selected

Figure 12. Safety Input remains in Stop mode

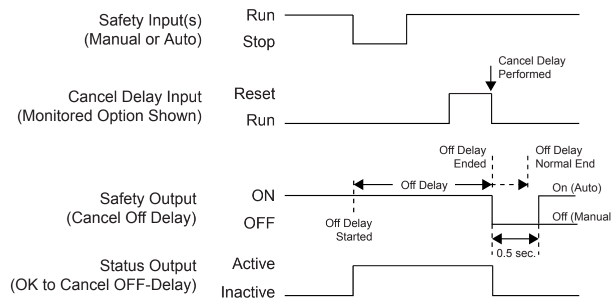


Figure 13. Turn Output Off function

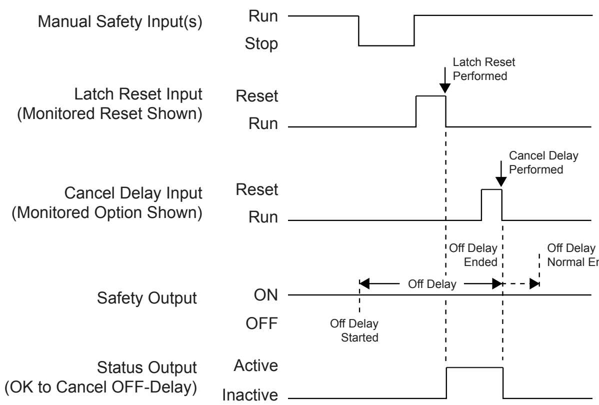


Figure 14. "Keep Output ON" function, manual (latch) Safety Input

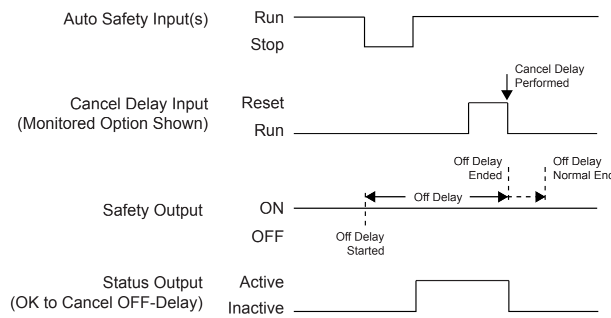


Figure 15. "Keep Output ON" function, auto (trip) Safety Input

4.5 Input Device Resets

There are three reset types available:

- Manual Reset: used to manually reset a safety output that turned OFF in response to a Stop signal from the safety input device configured for manual (latch mode) reset. The reset signal type can be configured to be either monitored (default setting) or non-monitored.
- System Reset: used to recover from a fault condition or to restart the Controller after the configuration has been altered. This reset device (a button or a switch) connects to a dedicated input terminal on the Safety Controller, labeled SR. The reset signal type can be configured to be either monitored (default setting) or non-monitored.
- Automatic Reset: used to allow a safety output to return to an ON state without action by an individual once the input device changes to the Run state (provided that all other controlling inputs are also in the Run state). Also known as trip mode, the automatic reset is typically used in applications in which the individual is continually being sensed by the safety input device.

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). See section *Perimeter Guarding and Pass-Through Hazards* on page 33 for more information.

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.

4.5.1 Reset Signal Requirements

Both manual (latch) reset and system reset signals 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 0.3 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 0.3 seconds. After the reset, the reset signal can be either high or low. This is called a leading-edge event.

4.5.2 Automatic and Manual Reset Inputs Mapped to the Same Safety Output

Safety input devices can be configured for either manual (latch mode) or automatic (trip mode) reset, and both types can be mapped to the same safety output. In order for a safety output to turn on, all associated safety input devices must be in their Run state. If one or more of these safety input devices is configured for manual reset and one or more of them change from the Stop state to the Run state, then the output needs a valid manual reset signal before it turns on.

If two safety inputs, each configured for manual reset, are mapped to the same safety output, then only one valid reset operation is required to reset the safety output. A manual reset operation is valid when all safety inputs mapped to the safety output are in the Run state and the manual reset is performed. If a manual reset is performed before a safety input is in the Run state, the manual reset signal is ignored, except in the case of a two-hand control and an ON/OFF input.

See sections *Manual Reset* on page 70 and *Automatic and Manual Reset Inputs Mapped to the Same Safety Output* on page 32 for more information about resets.

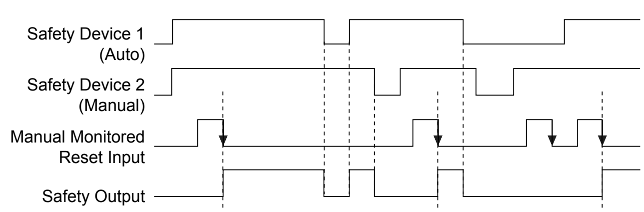


Figure 16. Timing logic: auto and manual monitored reset safety inputs mapped to the same Safety Output (no delay)

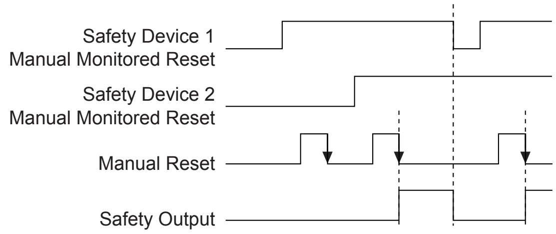


Figure 17. Timing logic: Safety Outputs with a common reset, mapped to the same Safety Output

4.5.3 Perimeter Guarding and Pass-Through Hazards

A pass-through hazard is associated with applications, such as perimeter guarding, where personnel may pass through a safeguard (which issues a stop command to remove the hazard), and then continue into the guarded area, where their presence is no longer detected. The related danger becomes the unexpected start or restart of the machine while personnel are within the guarded area.

Reducing or Eliminating Pass-Through Hazards

Eliminate or reduce pass-through hazards whenever possible. While it is recommended to eliminate the pass-through hazard altogether, this may not be possible due to machine layout, machine capabilities, or other application considerations.

- One solution is to ensure that personnel are continually sensed while within the hazardous area. This can be accomplished by using supplemental safeguarding, such as described by the ANSI B11 series of safety requirements or other appropriate standards.
- An alternate method is to ensure that when the safeguarding device is tripped, it will latch (manual reset), and will require a deliberate manual action to reset. This method of safeguarding relies upon the location of the reset switch as well as safe work practices and procedures to prevent an unexpected start or restart of the guarded machine.

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.

4.6 Safety Input Function

4.6.1 Internal Logic

The 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 table at right illustrates the logic for two safety input devices that are mapped to control Safety Output 1. If either safety input device is in the Stop state, the Safety Output will be OFF. When both safety inputs and the Controller are in the Run state, Safety Output 1 will be ON.

Safety Input 1	Safety Input 2	Safety Output 1
Stop	Stop	OFF
Stop	Run	OFF
Run	Stop	OFF
Run	Run	ON

4.6.2 Two-Hand Control (THC)

The two-hand control function requires that two hand actuators (for example, hand/palm buttons) each be activated within 0.5 seconds of each other in order to produce a Run signal to start a machine cycle. THC devices are always the last input (in time) to turn the safety output ON. If one or more of the other controlling input devices are configured for manual reset and are used to stop the machine, a manual reset must be performed before the THC device can cycle the machine again.

See section *Two-Hand Control* on page 96 for more information.

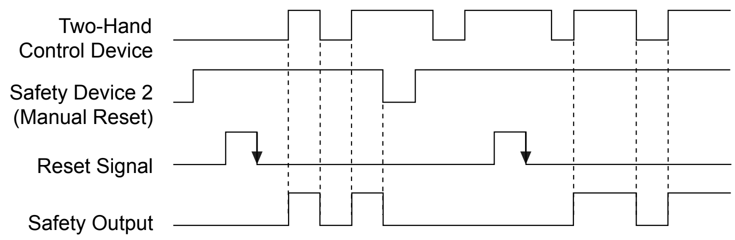


Figure 18. Timing logic: Two-Hand Control device and manual reset safety input device

Two-Hand Control Activation on Power-Up Protection. The Controller's two-hand control logic will 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 two-hand control device does not have a manual reset option.

4.6.3 Enabling Devices

The enabling device actively controls the suspension of a Stop signal during a portion of a machine operation where a hazard can occur. The enabling device permits a hazardous portion of the machine to run, but must not start it. 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 when being used.

An enabling device can be mapped to one or more safety outputs. When the enable signal goes from the Stop state to the Run state, the Controller will go into Enable mode. In this mode, the associated safety outputs will turn ON if any of the assigned EDM inputs are closed (these may open after the outputs turn ON) and all of the controlling E-stop or rope pull devices are in their Run state. With the exception of the E-stop and rope pull devices, all other safety input signals (Run or Stop) will be ignored while the Controller is in the Enable mode. Safety output enabling control resides in the enabling device function when in Enable mode. Repetitive enable cycles are allowed.

In order to exit Enable mode, the enabling device must be in the OFF state, and a system reset must be performed.

Enabling Device Time Limit. The enabling device time limit can be adjusted between 1 second and 30 minutes and cannot be disabled. When the time limit expires, the associated safety outputs will turn OFF. In order to start a new Enable mode cycle with the time limit reset set to its original time limit value, the enabling device must switch from ON to OFF, and the back to ON.

All ON- and OFF-delay time limits associated with the safety outputs that are controlled by the enabling device function will be followed during the Enable mode.

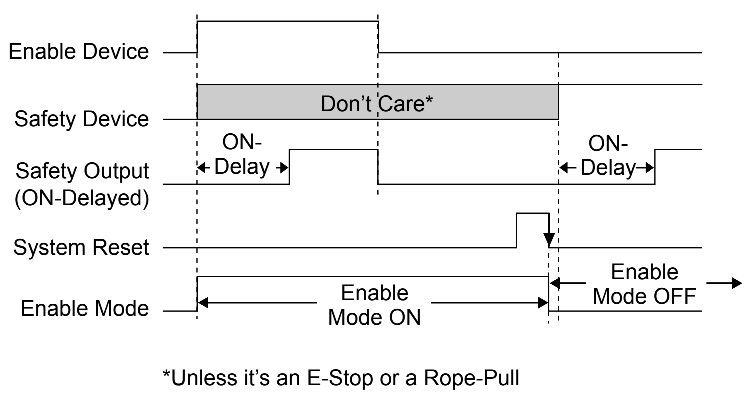


Figure 19. Timing logic: Enabling device and enable mode

See section *Enabling Device* on page 106 for more information.

4.6.4 Mute Function

Safety device muting is the 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 "mutable" safety input devices:

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

- Safety mats
- Protective stops

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

At least two mute sensors are required for each muting operation (the mute occurs typically 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; see section *Mute Sensor Pair* on page 110 for more information.

Mute Enable. The optional mute enable function can 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 mutable safety input device, this safety input device can be muted only if the mute enable switch is in the Enable (24V dc) state at the time the mute cycle is started. After the mute cycle starts, the mute enable input can be turned OFF. A mute enable input device can be mapped to one or more mutable safety inputs.

NOTE: Mute enable is not a safeguarding function, but rather a machine logic function.

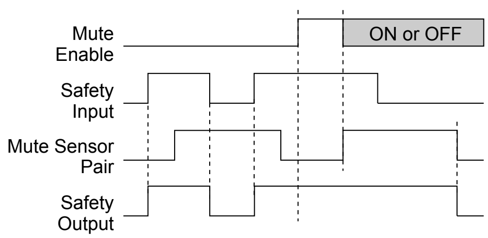


Figure 20. Timing logic: one mute sensor pair with mute enable

Mute Time Limit (Backdoor Timer). A time limit can be established to limit how long a mute cycle is permitted to be active. The time limit can be adjusted from 1 second to 30 minutes. A different time limit can be set for each mutable safety input device. Other input devices that are also muted are affected only by their own mute time limit setting. The mute time limit can be disabled. When disabled, the time limit for the mute function for that input device is infinite.

Directional Muting. As soon as two mute sensor pairs are configured and mapped to a mutable safety input, an advanced setting option appears in the PCI to provide the option of directional muting. Check the box "Enable Directional Muting," then select the muting sensor pair to be blocked first. The Controller requires sensor pair 1 to be blocked first, then the safeguard, then sensor pair 2 (all within the configured time limits) in order for the mute to take place.

Mute Sensor Debounce Time. The input debounce time, accessible under the "Advanced settings" in the Mute Sensor Pair properties window, can be used to extend a mute cycle after a mute sensor signal is removed. By configuring the "closed-to-open" debounce time, the mute cycle can 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-closed" debounce time.

Mute on Power-Up Function. If configured, the Mute on Power-Up function will initiate a mute cycle after power is applied to the Safety Controller if the muted safety inputs are active (Run state or closed), and either M1-M2 or M3-M4 (but not all four) are signaling a muted condition (active or closed).

WARNING: Mute on Power-Up

The Mute on Power-Up function should be used **only** in applications where:

- Muting the System (M1 and M2 closed) when power is applied is required, and
- Using it does not, in any situation, expose personnel to any hazard.

Mute on Power-Up Disabled. When the mute on power-up option is disabled, the Controller will not go into a mute cycle, even if the conditions for a valid mute cycle are fulfilled at power-up.

Mute on Power-Up Enabled. When the Mute on Power-Up option is enabled, the Controller will go into a mute cycle if the conditions for a valid mute cycle are fulfilled at power-up. Specific valid mute signal conditions must be present for a mute cycle to be initiated and maintained.

If Auto Power-Up is configured, the Controller allows approximately 2 seconds for the input devices to become active (closed) 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 system 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 only be used 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: 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.

See section *Mute Sensor Pair* on page 110 for more information.

4.6.5 Bypass Function

The safety device bypass is a manually activated and temporary suspension of one or more safety input stop signals when no immediate hazard is present. Bypass switches can be mapped to one or more of the following safety input devices:

- Safety gate (interlocking) switches
- Optical sensors
- Two-hand control devices
- Safety mats
- Protective stop

When the bypass switch signal changes to the Bypass (Run) state, it will turn On or keep On all of the safety outputs that are controlled by the bypassed safety input devices only if all other non-bypassed safety devices that are mapped to these Safety Outputs are in the Run state.

If an input that is configured for a manual reset is turned off during a bypass, a manual reset must occur before the end of the bypass or the Safety Outputs will turn off.

Bypass Time Limit. A bypass function time limit can 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 locks out and 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 mistake that the Two-Hand Control is functional and is aware that the bypassed Two-Hand Control is no longer providing the safeguarding function.

Mute-Dependent Override. When this option is enabled, and a mute sensor is mapped to the safety input device, and the safety input device is in the Stop state, at least one of the Mute sensors must be in the Mute (Run) state to start a new bypass cycle. If the conditions are right for the bypass, the mute status output indicator (if configured) starts flashing at 1 Hz. If this option is disabled, the safety input is not required to be in the Stop state and the mute sensors do not need to be blocked in order to start a new bypass cycle.

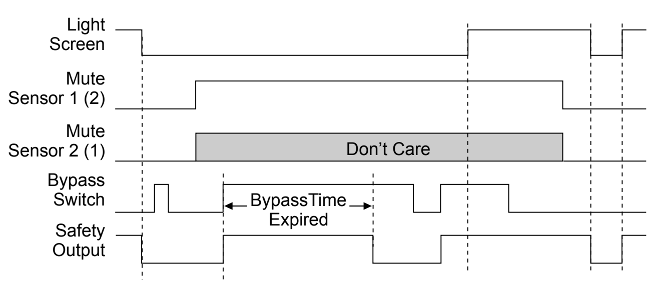
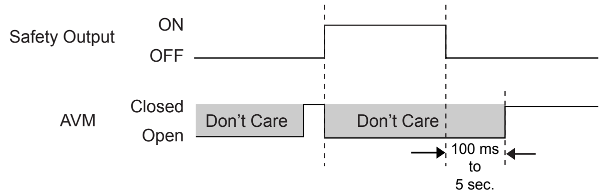


Figure 21. Timing logic: Light screen with mute sensors and bypass switch

4.6.6 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 37). 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.



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

Figure 22. 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.

4.7 EDM, OSSD (Safety Output), and FSD Hookup

4.7.1 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.

An EDM input can be mapped to only one safety output.

The EDM inputs can be configured as one-channel, two-channel, or no 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—If no monitoring is desired, do not select either the one-channel or two-channel monitoring option. 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.

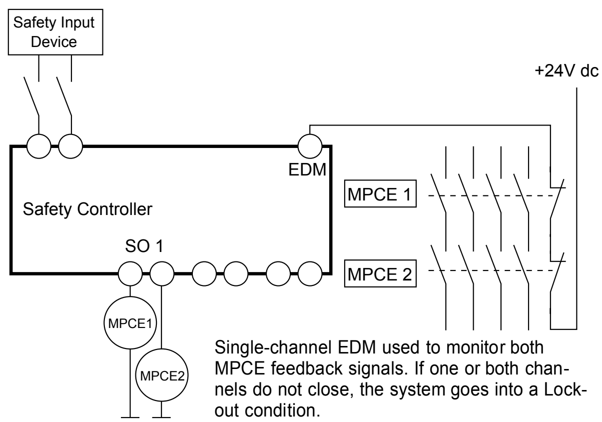


Figure 23. One-channel EDM hookup

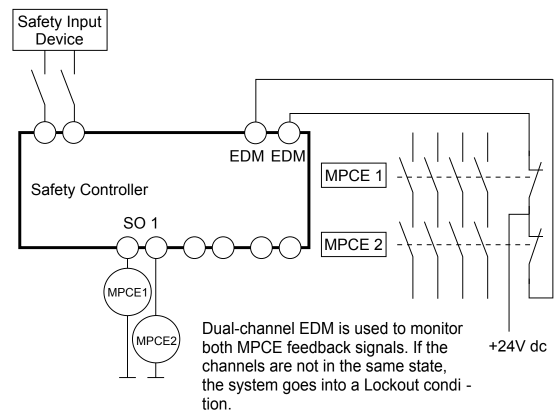


Figure 24. Two-channel EDM hookup

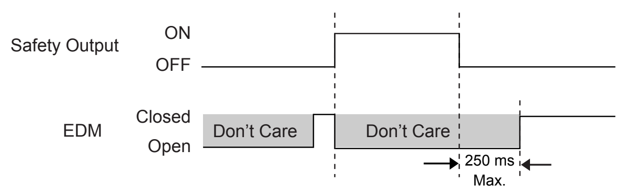


Figure 25. Timing logic: One-channel EDM status, with respect to Safety Output

For two-channel EDM, as shown below, both channels must be closed before the Safety Output(s) turn On.

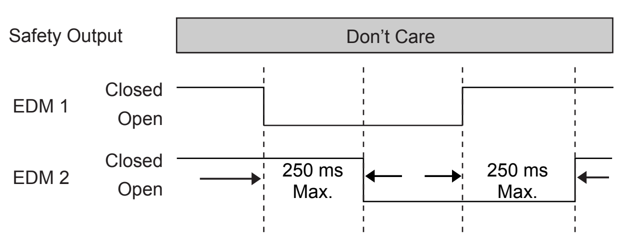


Figure 26. Timing logic: Two-channel EDM, timing between channels

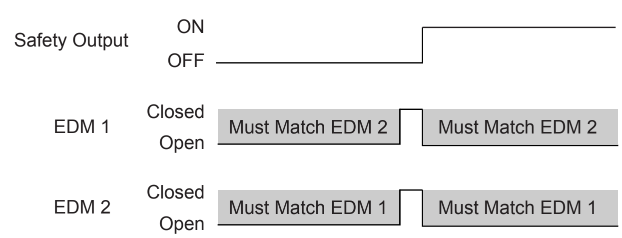


Figure 27. Timing logic: Two-channel EDM status, with respect to Safety Output

4.7.2 Safety Outputs

The Safety Controller has three pairs of solid-state Safety Outputs (SO1 a and b, SO2 a and b, and SO3 a and b). Each pair consists of two output signal switching devices (OSSDs). The solid-state Safety Outputs are actively monitored to detect short circuits to the supply voltage, to each other, and to other sources of electrical energy. If a failure is detected, the outputs will switch to an Off state. For circuits requiring the highest level of safety and reliability, either OSSD must be capable of stopping the motion of the guarded machine controlled by a safety output in an emergency.

OSSD Output Connections

The output signal switching device (OSSD) 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.

Final switching devices (FSDs) typically accomplish this when the safety outputs go to the Off state.

Refer to the *Safety Outputs (6 terminals, 3 redundant outputs)* on page 23 and the Warning below before making OSSD connections and interfacing the Controller to the machine.

ON-Delays and Off-Delays

Each safety output can be configured to function with either an On-delay or an Off-delay (see Figure below), 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 time delay limit options are from 100 milliseconds to 5 minutes, in 100 millisecond increments.

Current operation is to honor the Off-delay for internal and system faults, whenever possible.

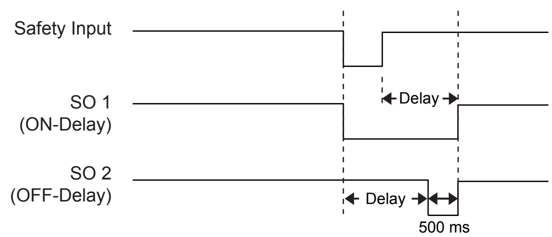


Figure 28. Timing logic: Safety Output with Off-delay

NOTE: Safety Outputs are Dual-Channel. An individual safety output is not, by itself, capable of meeting Category 4 applications (per ISO13849-1). When the risk assessment or relevant regulations require high levels of safety integrity (such as Category 4), both the output signal switching device (OSSD) outputs must be connected to the machine control so that the machine's safety related control system interrupts the circuit or power to the machine primary control element(s) (MPCEs), resulting in a non-hazardous condition. Final switching devices (FSDs) typically accomplish this when the OSSDs enter the Off state.

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.

WARNING: Interfacing of Both OSSDs

Both OSSD (Output Signal Switching Device) 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.

Never wire an intermediate device(s) (for example, PLC, PES, or PC) that can fail in such a manner that there is the loss of the safety stop command, OR in such a manner that the safety function can be suspended, overridden, or defeated, unless accomplished with the same or greater degree of safety.

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.

4.7.3 FSD Interfacing Connections

Final switching devices (FSDs) may take many forms, 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 OSSD 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 (see wiring diagrams).

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: OSSD Interfacing

To ensure proper operation, the Banner device 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 open ground leakage current must not result in an On condition
- 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[5] 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: 1-channel, 2-channel, and No EDM Options

The following figure is generic in nature and represents all three EDM options:

- Safety Output SO1 is shown with No EDM configured (typically used with self-monitored devices)
- Safety Output SO2 is shown with Two-Channel EDM configured
- Safety Output SO3 is shown with One-Channel EDM configured

Any particular Safety Controller configuration may use any combination of external device monitoring options, depending on the application.

[5] 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.

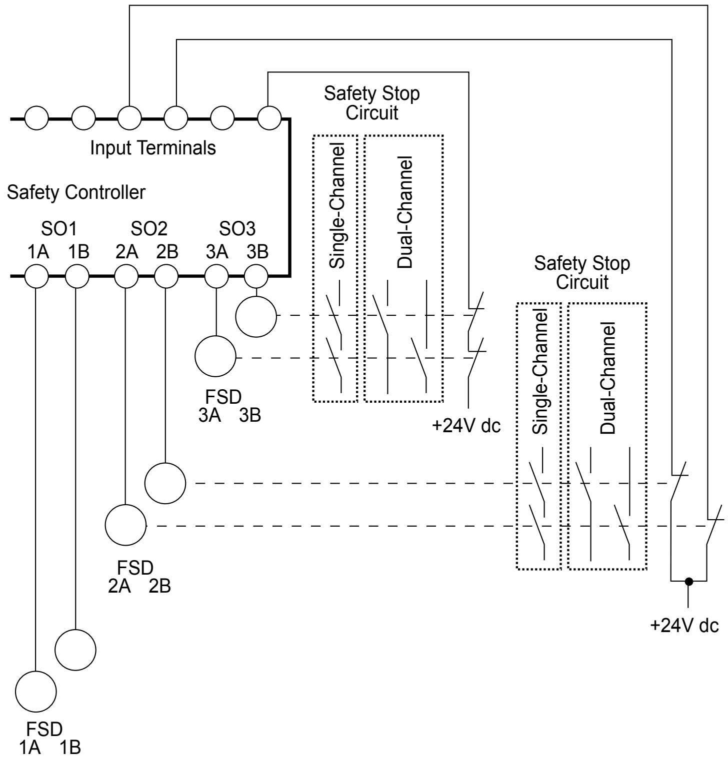
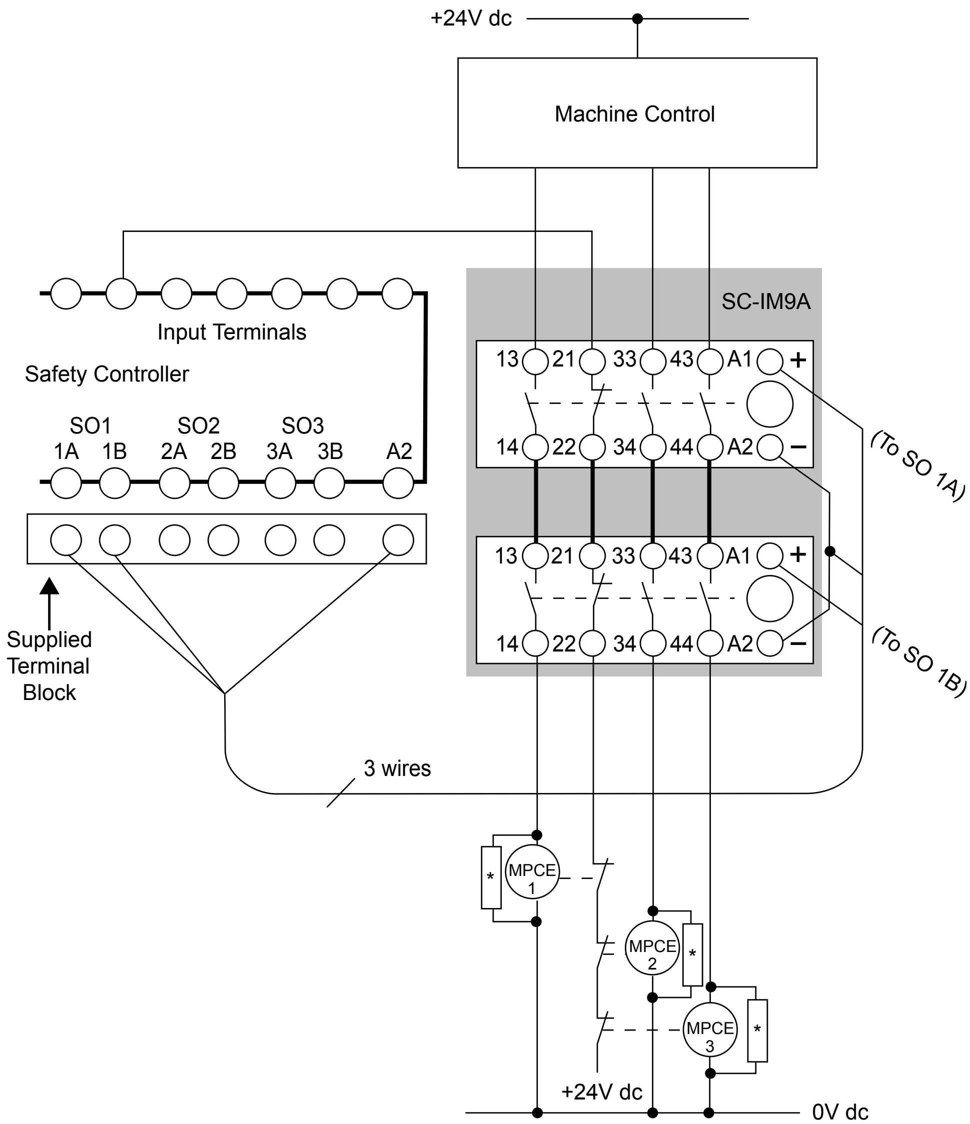


Figure 29. Generic Hookup: 1-channel, 2-channel, and no EDM

One-Channel EDM Hookup to SC-IM9A Interface Module

The SC-IM9A interface module depicted in the following figure is shown in one-channel EDM hookup. The SC-IM9B and SC-IM9C modules are connected in the same manner, using individual one-channel EDM circuits (terminals 21/22 on each pair of contactors).



* Installation of transient (arc) suppressors across the coils of MPCE1, MPCE2, and MPCE3 is recommended (see Warning)

Figure 30. One-channel EDM hookup to SC-IM9A interface module

Two-Channel EDM Hookup to IM-T-9A Interface Module

The IM-T-9A interface module depicted in the following figure is shown in two-channel EDM hookup. The IM-T-11A module is connected in a similar manner. Depending on the application, each Safety Output requires a separate and individually wired IM-T-..A module.

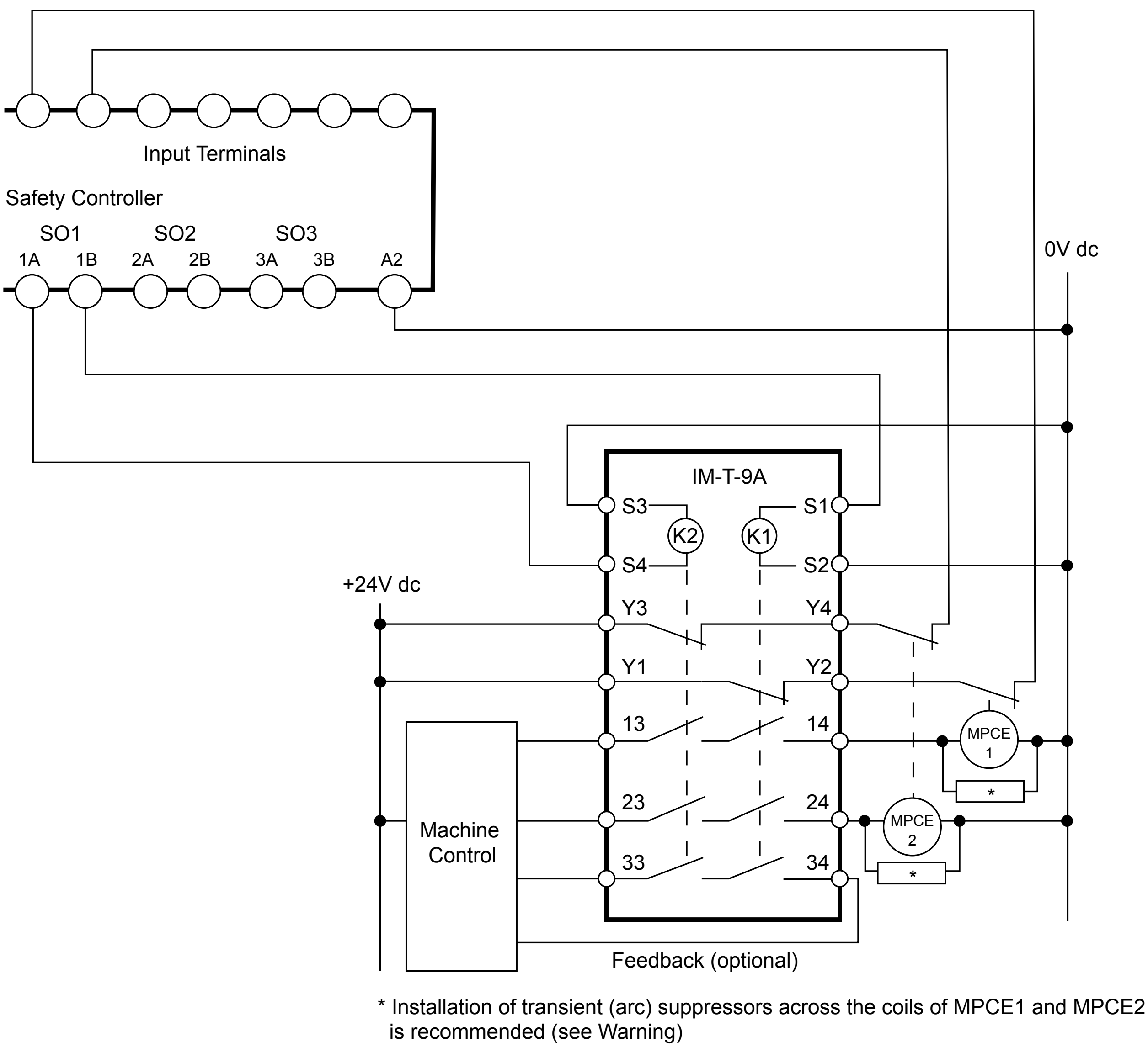


Figure 31. Hookup: Two-channel EDM hookup to IM-T-9A interface module

One-Channel EDM Hookup to IM-T-9A Interface Module

The IM-T-9A interface module depicted in the following figure is shown in one-channel EDM hookup. The IM-T-11A module is connected in a similar manner.

Depending on the application, each Safety Output requires a separate and individually wired IM-T-..A module.

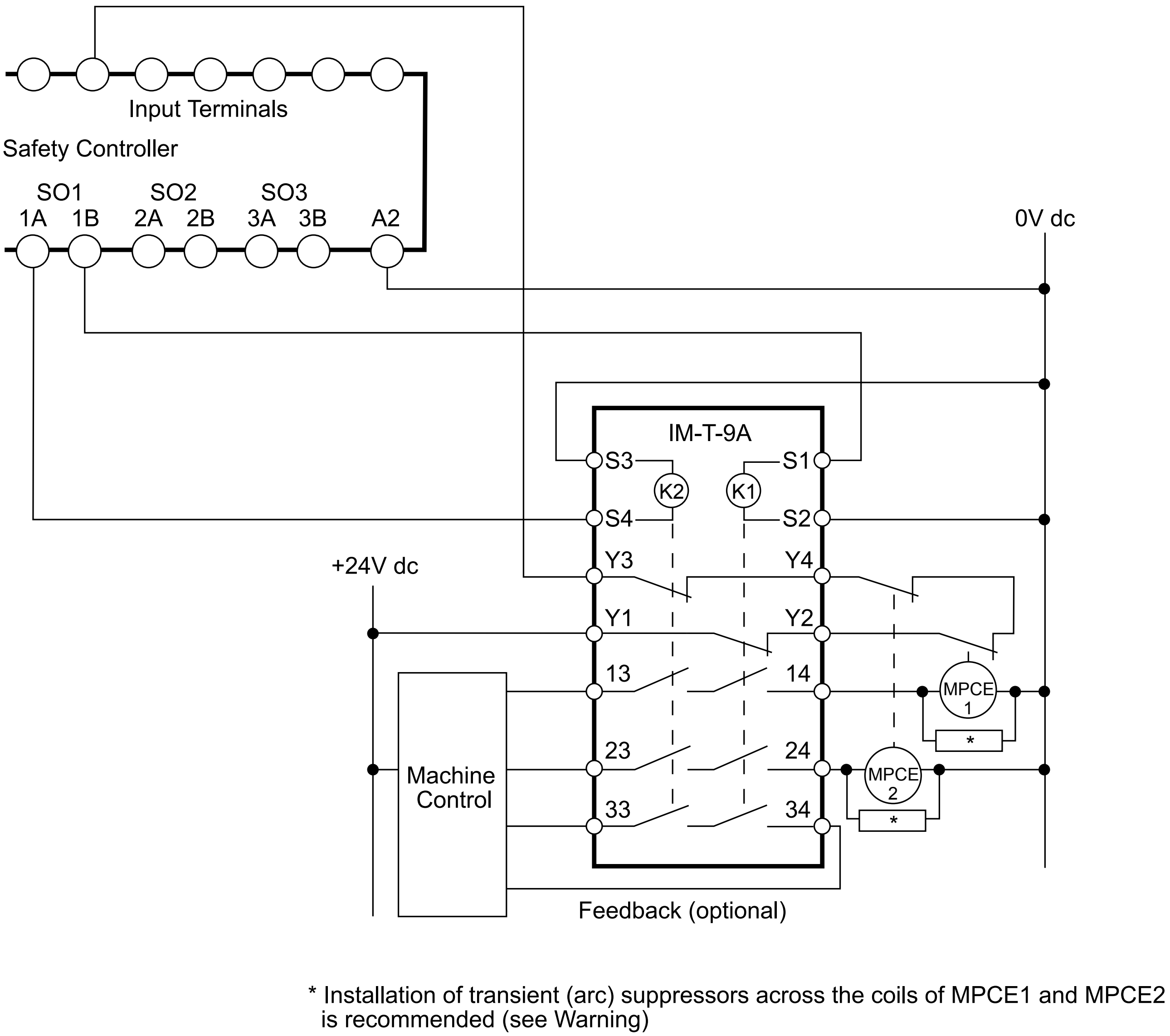


Figure 32. Hookup: One-channel EDM hookup to IM-T-9A interface module

4.7.4 Common Wire Installation

Keep in mind the lead wire resistance of the 0V common wire and the currents flowing in that wire to avoid nuisance lockout codes 1.1, 1.2, or 1.5. Note the location of the block in the diagram below representing lead wire resistance (RL).

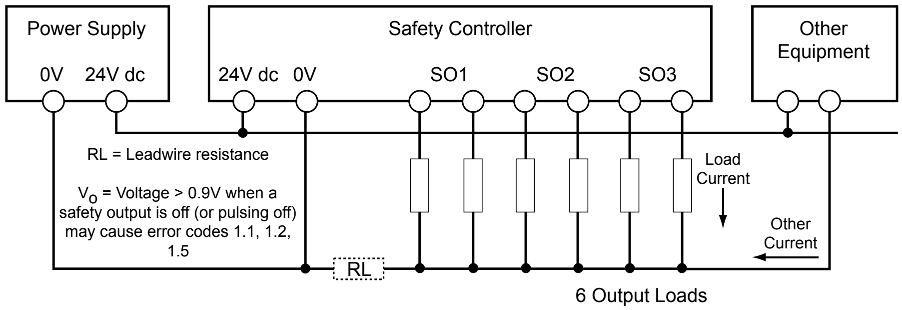


Figure 33. DC-common wire installation

When a safety output turns Off, the voltage at the output terminal (VO) must drop below 0.9V with respect to the 0V terminal of the Safety Controller. If the voltage is higher than 0.9V, the Controller may decide that the output is still on and lock out.

This residual voltage may occur in several ways:

- a large current flowing in a shared 0V conductor by other safety outputs that are still on
- a common mode current flowing from other equipment
- either of these, along with a 0V wire which is too small or too long

The solution is to increase the wire gauge of the 0V common wire and/or consider using the courtesy 0V terminals on the Safety Controller as shown in the following diagram. This eliminates the influence of common mode current from other equipment.

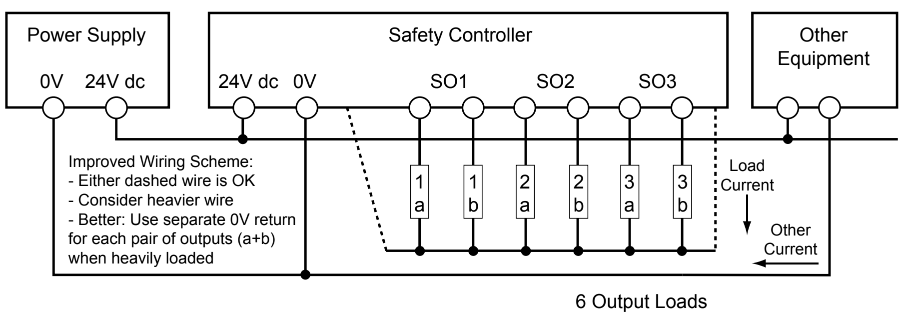


Figure 34. DC-common wire installation: eliminating the influence of common mode current from other equipment

4.8 Status Outputs

4.8.1 Status Output Signal Conventions

Two signal conventions are selectable for each status output. The default convention provides a 24V dc signal when the monitored input or output is active (closed, high or ON), when the system is in a Lockout, when there is an I/O-fault, when the system is waiting for a Reset, when the output is waiting for a reset, or during an active mute cycle. If the above conditions are not true, the signal output would show 0V. Signal convention 2 is the reverse of the convention 1, as shown in the following table.

Tracked Function	Mapped Status Output(s) State			
	Signal Convention 1 (default) 24V dc = Run		Signal Convention 2 0V dc = Run	
Track Input	Input Run	Input Stop	Input Run	Input Stop
	24V dc	0V dc	0V dc	24V dc

Tracked Function	Mapped Status Output(s) State			
	Signal Convention 1 (default) 24V dc = Run		Signal Convention 2 0V dc = Run	
Track Output	Output ON	Output OFF	Output ON	Output OFF
	24V dc	0V dc	0V dc	24V dc
System Lockout Status	Lockout	Run Mode	Lockout	Run Mode
	24V dc	0V dc	0V dc	24V dc
I/O Fault	Fault	No Fault	Fault	No Fault
	24V dc	0V dc	0V dc	24V dc
System Waiting for Reset	Reset Required	Reset Not Required	Reset Required	Reset Not Required
	24V dc	0V dc	0V dc	24V dc
Mute Status	Muted	No Mute	Muted	No Mute
	24V dc	0V dc	0V dc	24V dc
Track Input Group	Input That Turned OFF First	Other Linked Inputs	Input That Turned OFF First	Other Linked Inputs
	24V dc	0V dc	0V dc	24V dc
Bypass Status	Input Bypassed	Not Bypassed	Input Bypassed	Not Bypassed
	24V dc	0V dc	0V dc	24V dc
Track Input Fault	Fault	No Fault	Fault	No Fault
	24V dc	0V dc	0V dc	24V dc
OK to Cancel OFF-Delay	OK	Not OK	OK	Not OK
	24V dc	0V dc	0V dc	24V dc

4.8.2 Status Output Functionality

Track Input

A Status Output configured for this function will indicate the current state of an input.

Track Output

A Status Output configured for this function will indicate the current physical state of a Safety Output, either ON or OFF.

Track Output's Logical State

When selecting the Status Output function 'Track output,' an option to track the logical state, rather than the physical state, of a Safety Output is provided. This option may be used to indicate a Safety Output has been commanded OFF, but is not OFF yet, such as during an OFF-delay.

System Lockout Status

A Status Output configured for this function will be active when a lockout that affects the entire Safety Controller has been detected, such as an internal memory fault.

I/O Fault Status

A Status Output configured for this function will be active when a lockout affecting a particular input or output has been detected, such as a failed input or an EDM fault.

System Waiting for Reset

A Status Output configured for this function will be active under the following conditions:

- A system fault has occurred and all Safety Outputs are OFF.
- An EDM fault has occurred.
- An AVM fault has occurred.
- A fault on a Safety Output has occurred.
- A fault for monitoring a mute lamp has occurred.
- The Safety Controller is configured for manual reset on power-up.
- A fault on a THC input has occurred.

The following conditions involve the use of the system reset but no indication is provided by a Status Output:

- Exiting Configuration Mode
- Exiting Enable Mode
- Re-enabling a Track Input Group function of a Status Output

Output Waiting for Reset

A Status Output configured for this function will be active when a Safety Output is ready to be turned ON (a manual reset must be performed).

Mute Status

A Status Output configured for this function will be active for a particular mutable Safety Input under the following conditions:

- ON during an active muting cycle.
- OFF during an inactive muting cycle.
- Flashing when all conditions for bypassing a mutable Safety Input (override) are present.
- ON when bypassing a mutable Safety Input.

Track Input Group

Status Outputs configured for this function will indicate which Safety Input of a defined group of Safety Inputs turned OFF first. Use a system reset to re-enable the function after all Safety Inputs of the group are ON.

Bypass Status

Status Outputs configured for this function will indicate when an input is truly bypassed. A Safety Input is required to be determined inactive at least once before a bypass can take place. The Status Output is active when the input is bypassed. A bypass cannot take place (the input must be open) on power-up.

Track Input Fault

Status Outputs configured for this function will indicate any fault on an input.

OK to Cancel OFF-Delay

Status Outputs configured for this function will indicate when an OFF-delay can be cancelled — that is, when the cancel delay input can be activated in order to keep the OFF-delayed Safety Output ON, or to immediately turn the Safety Output OFF.

4.9 Virtual Status Outputs

Using the PCI, the Safety Controller (model SC22-3E only) can configure up to 32 virtual status outputs. These outputs can communicate the same information as the status outputs (see section *Status Output Signal Conventions* on page 46), but over a network. The virtual status outputs appear and can be configured after the Enable Network Interface box is checked on the Network Settings menu in section *Ethernet Reference* on page 116.

The Auto Configure function, located in the Properties window, 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 on the PCI) and within 1 second for the other tables (found on the included CD). The logical state of inputs and outputs is determined after all internal debounce and testing is complete. The PC Interface network functions are covered in more detail in the *Ethernet Reference* on page 116.

4.10 Commissioning Checkout

After power is connected to the Controller, the EDM has been properly configured, and the safety outputs have been connected to the machine to be guarded, the operation of the Controller with the guarded machine must be verified before the combined system may be put into service. To do this, a Qualified Person must perform the commissioning checkout procedure; see section *Commissioning Checkout Procedure* on page 72.

5 PC Interface Configuration (PCI)

5.1 PC Interface (PCI) Overview

The PC Interface (PCI) is a computer program with real-time display and diagnostic tools that can be used to:

- Create, confirm, edit, store, send, and receive a configuration
- Display real-time Run mode information
- Record and display fault log data
- Record specific, user-defined information onto a "Notes" page.

The PCI program uses Input Device icons and circuit symbols to aid making appropriate device property selections. As the various device properties and I/O control relationships are established, the program automatically builds the corresponding wiring and ladder logic diagrams. These diagrams provide I/O device wiring detail for the installer and a symbolic representation of the Controller's safeguarding logic for the use of the machine designer or controls engineer. See the Safety Controller PCI tutorial for further instruction.

5.1.1 Configuration Tools

The PC Interface screen has a tool bar above the work area for creating and managing configuration files. Use the Live Display button to display real time Run mode data from a working Controller over a USB connection. The screen below shows the status after the Enable Network Interface button has been checked, enabling the Virtual Status Outputs and additional tabs above the documents section.

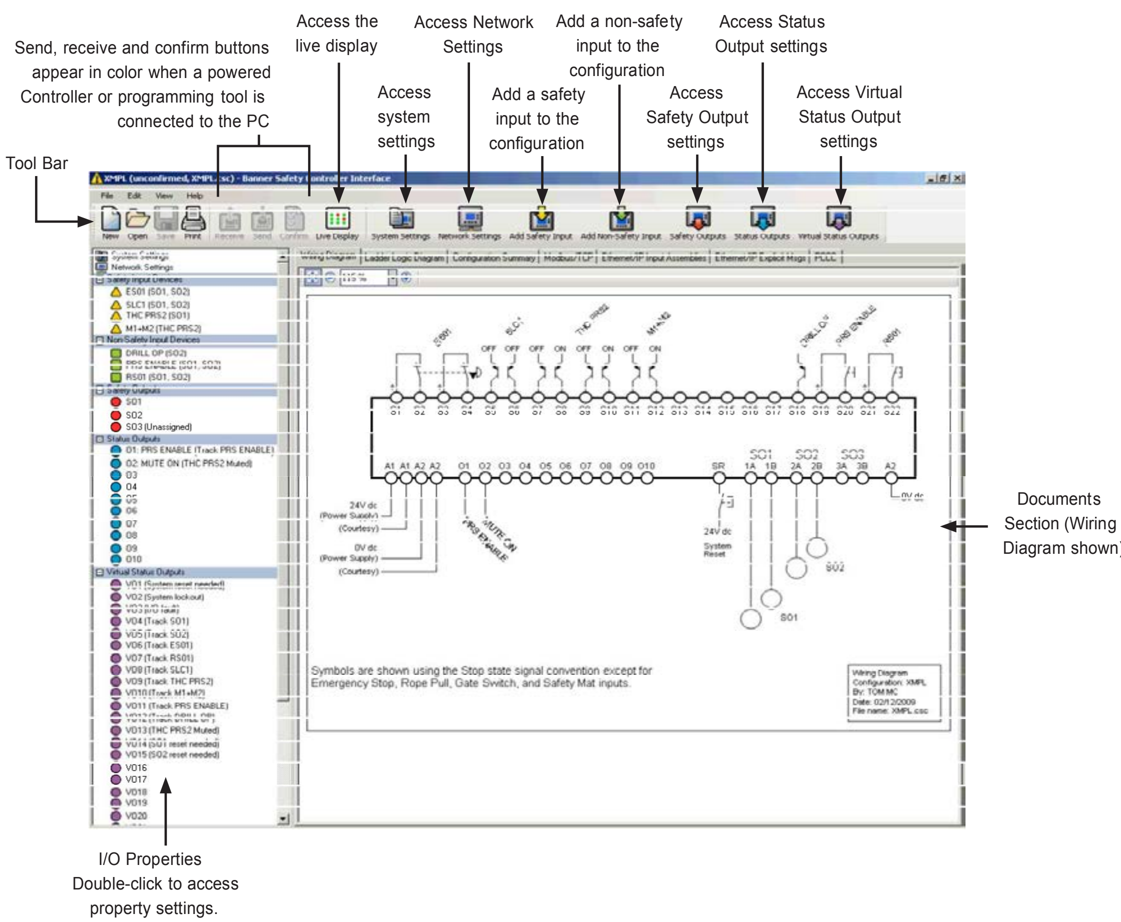


Figure 35. PCI Main screen components

5.1.2 Build a Configuration

To install the software on your computer, double-click on the Banner Safety Controller icon . Read and understand the warning on the Start-up page, and click OK. The main PCI screen should appear. The support documents, if opened at this point, show basic information, and auto-populate as the configuration develops; see following figure. Not shown is the Notes document, which remains blank until information is entered by the user, as desired.

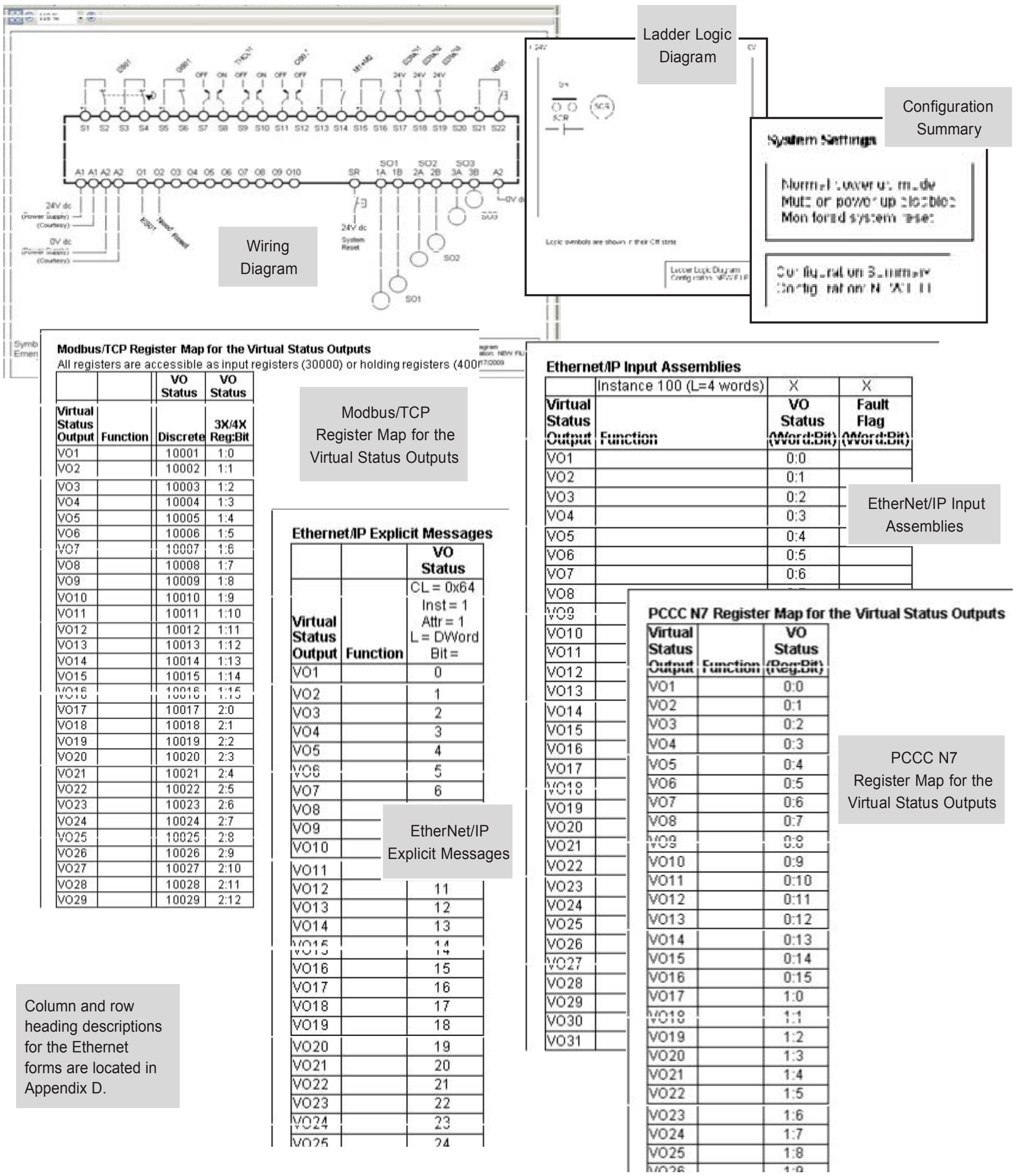


Figure 36. Configuration support documentation (notes not shown)

Create a New Configuration

Open the software program, and a new un-named file is created. You may name the Configuration and the Author, and establish the system settings at this time.

Double-click the System Settings icon, on the right-hand side of the Tool Bar.

When the pop-up menu appears, name the configuration file, using up to 16 alphanumeric characters.

Add your name in the Author's name box (up to 10 characters; abbreviate as needed).

Keep or change the default system settings:

- Power up mode: Auto, Manual, or Normal (default), see section *System Settings* on page 18
- Mute on power up: ON or OFF (default), see section *System Settings* on page 18
- Monitored system reset: OFF or ON (default), see section *Non-Safety Input Devices* on page 30

When complete, click OK.

Add an Input Device

Refer to section *Input Device and Safety Category Reference* on page 86 for more information about each of the input device types. Click the Add Safety Input icon and the Safety Input Device selection menu appears. It displays the device types the Controller can accommodate.

Safety Input Devices

- Emergency stop button
- Rope pull
- Gate (interlock) switch
- Optical sensor (single-/multiple-beam sensors, safety light curtain, area scanner, etc.)
- Two-hand control device
- Safety mat
- Protective stop (miscellaneous devices)
- Enabling device
- Muting sensors
- Bypass switches
- External device monitoring (EDM or AVM) contacts

Figure 37. Safety Input Device Selection menu

Click the Non-Safety Input icon and the Non-Safety Input Device selection menu appears.

Non-Safety Input Devices

- Manual reset switch
- ON/OFF switch
- Mute enable switch
- Cancel OFF-delay switch

While their functions differ, the procedure to add and configure the two types of devices is virtually identical. Click on the appropriate icon to select the desired device and click OK (or double-click on the icon).

Figure 38. Non-Safety Input Device Selection menu

Select the Input Device Properties

After an input device is selected, the Properties menu for that device pops up. This menu presents the properties that must be established for each type of input device. The user-defined properties include (depending on the device):

- Name—The name (or circuit designation) of each specific device (not device type)
- Circuit Type—A list of the types of contact or solid-state circuits that can be used for that device type
- Reset Logic—Automatic (Trip mode) and Manual (Latch mode) options for that device
- Input Terminal Assignment—These are assigned automatically but can be changed to any unused input terminal.
- I/O map—Establishes relationships between input devices and outputs

NOTE: Input device properties and functions are discussed in sections *Safety Input Device Properties* on page 27 and *Input Device and Safety Category Reference* on page 86.

Follow the configuration steps as they appear on the screen, as shown in the following figure.

Name: Change the name to something meaningful to you, such as: E-STOP1. Any input device can be renamed during the configuration process.

Circuit Type: Select the appropriate circuit type from the drop-down menu for your device. The selected circuit type will appear in the input terminals diagram, with automatically assigned terminal numbers; the terminal numbers can be reassigned using the drop-down menus. The plus signs at S13 and S15 designate that these terminals supply the +24V dc source for the device contacts.

NOTE: See section *Input Device and Safety Category Reference* on page 86 for more information about safety circuit integrity levels and the capabilities of each circuit type.

Reset Logic: Select between Manual or Automatic Reset from the drop-down menu.

Mapping: Map each safety input device to one or more Safety Outputs (at least one must be selected) by checking or un-checking the boxes. (Click on a box to select or deselect it.) If the safety input device is a muting sensor, a bypass switch, or a mute enable sensor, map those inputs to at least one of the other safety input devices.

When a safety input device with manual reset is added, a new window automatically appears to add a reset input device for that device. Any safety input device which keeps the default Manual reset logic setting requires a reset for any Safety Output mapped to that device. A separate reset may be assigned for each Safety Output.

The wiring diagram will begin to populate with your chosen device(s), as will the ladder logic diagram and configuration summary.

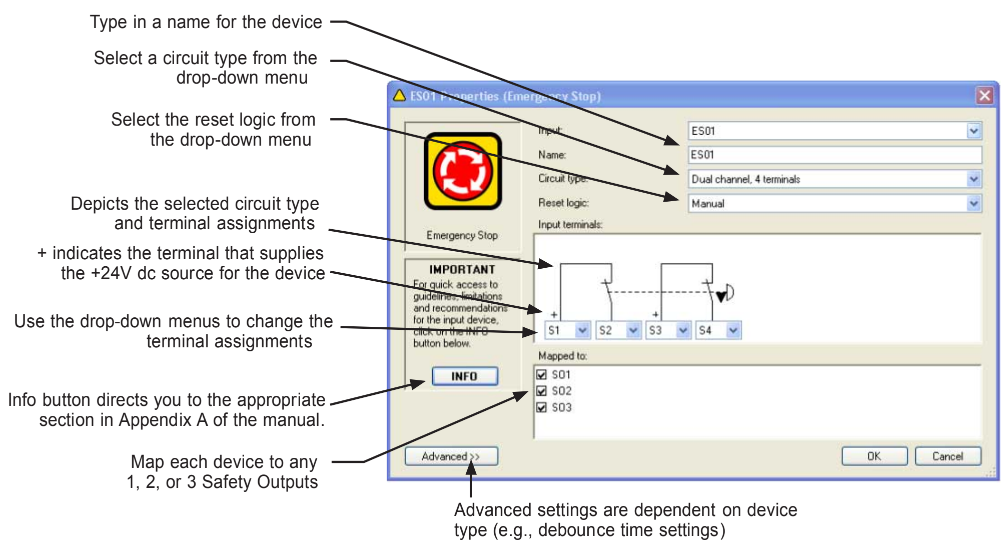


Figure 39. Safety Input Device Properties screen

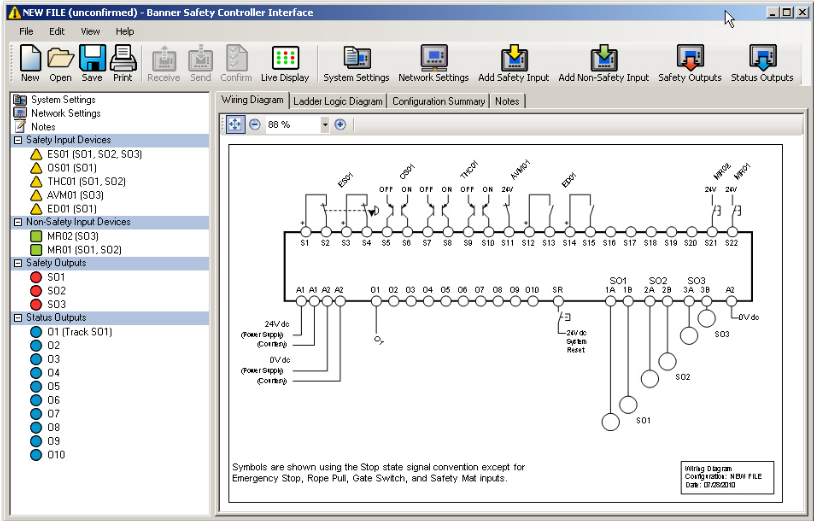


Figure 40. Wiring diagram populates with devices and output mapping

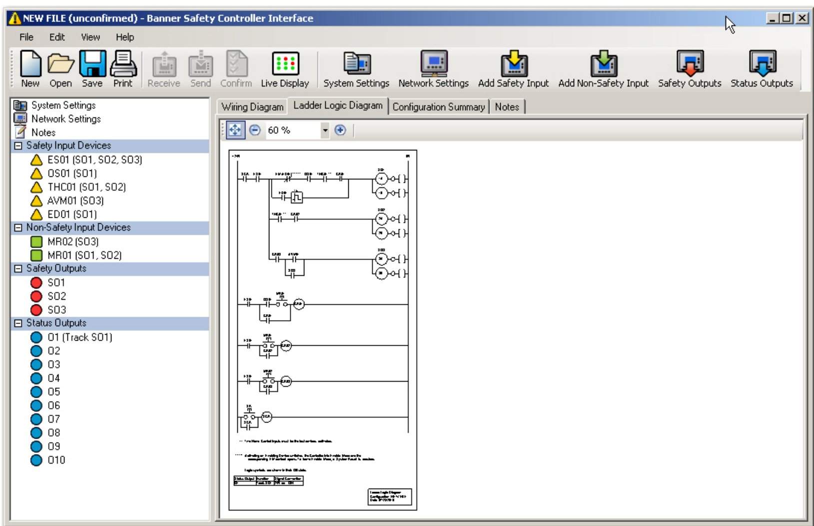


Figure 41. Ladder logic diagram develops along with wiring diagram

Finish the Configuration

Repeat the steps in the previous section to include additional safety or non-safety input devices.

Select Safety Outputs or Status Outputs from the tool bar to configure properties for these outputs, using the same menu-driven process as that for the inputs.

Safety Output Properties — assigned individually for each Safety Output. Select the output to be configured from the drop-down menu in the top field of the screen, and type in or select:

- Name
- Delay type and duration

Status Output Properties — assigned individually for each Status Output. Select the output to be configured from the drop-down menu in the top field of the screen, and type in or select:

- Name
- Function
- Source (depending on function selected)
- Signal convention (depending on function selected)

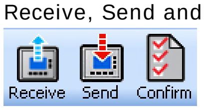
Save and Confirm the Configuration

You will need to confirm this new configuration before it can be used in a safeguarding application. A 4-digit Controller password is required to save and confirm a configuration and to enable it to run on a Safety Controller. The confirmation process has two parts:

1. Code validation: The microcontrollers in the Safety Controller receive and check a copy of the configuration to be sure that all safety-critical settings are appropriate (all device settings, control relationships, logic functions and other parameters are valid).
2. Configuration verification: When the validation step is complete, the Controller saves the configuration to the internal non-volatile memory, reads it back from memory, and sends a copy of the stored file back to the PCI for a manual content verification that the user performs.

To confirm a configuration:

1. Save the configuration file to the PC:
   a. Go to File > Save.
   b. Name the configuration file and select a file location on your computer.
   c. Click Save.
2. Connect the Safety Controller to the PC using the USB cable (see section *USB Connections* on page 11).
3. Apply 24V dc power to the Controller. When the powered Controller is properly connected with the computer, the Receive, Send and Confirm buttons in the screen's tool bar become active and convert from gray scale to color.



4. Click Confirm in the tool bar. A message asking if you want to save a copy of the Controller's existing configuration will appear. The Controller used for the confirmation process may already have a user-defined configuration. Any configuration already loaded in the Controller will be overwritten during the confirmation process. It is the user's responsibility to save the existing configuration, if needed.
   - Select Yes to save the configuration and to proceed to overwrite the Controller's existing configuration.
   - Configure EDM, if desired.
   - Enter the password (the factory default is 0000) on the Confirm Configuration pop-up menu.
   - Click OK.
   - A pop-up warning message will ask if you want to continue; select Yes.

   The configuration validation process takes a few seconds and when complete, the Verification screen appears.

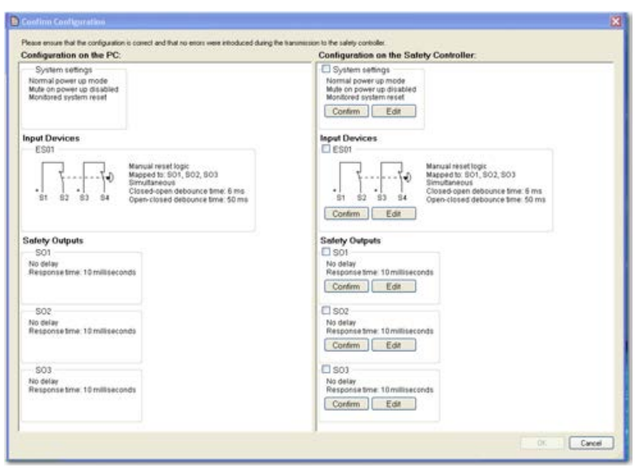


Figure 42. Verification screen, no devices yet confirmed by user

5. If the columns match, and no changes need to be made:
   - Verify that the properties in the right-hand column match those in the left-hand column. For each device, as you determine that its properties are correct, either click on Confirm or click in the corresponding checkbox. A check mark will appear in the box, and the section will compress to a list, as shown below.

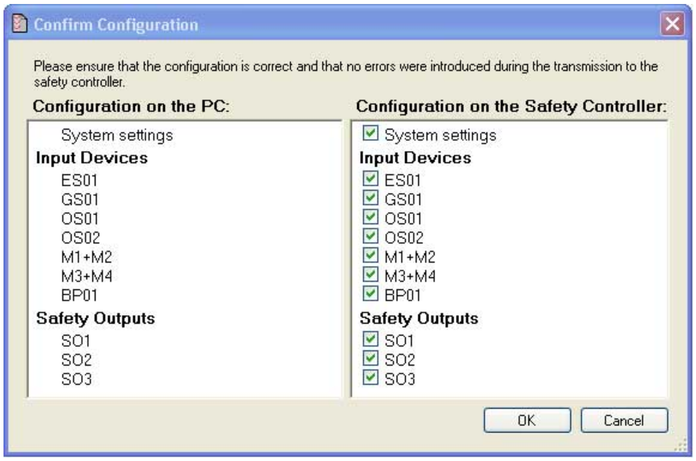


Figure 43. Confirm Configuration screen, all devices confirmed by user (checklist is compressed)

If the columns do not match, or if you wish to change any circuit:

- Select Edit for the device to be changed.
- The Properties menu for the device will open.
- Make the necessary change(s).
- Select OK.

A message will appear asking whether you want to edit any other devices or if you want to restart the confirmation process. If any device properties are changed while in the manual verification stage of the confirmation, the Controller will proceed to re-validate the code.

If the columns match, and no changes need to be made:

- Select Confirm for each device.
- The verification screen shows the summary that is created after each property has been verified.
- If you need to review a confirmed device property, un-check the checkbox and the Device Properties window will reappear. Edits may then be performed, as necessary.

6. When you are through with the manual verification, click OK.
7. When the verification process is complete, the Confirm Configuration summary screen is displayed. Select Close and perform a system reset; see section *System Reset* on page 56.
8. The Controller will activate the new configuration and will function according to the new parameters.

System Reset

The Controller requires a system reset under certain conditions:

- To place the Controller into Run mode after it has been configured.
- To recover from certain conditions (for example, lockouts).

To perform a system reset, either provide a 24V dc signal on the System Reset input (located next to the Status Output O10 terminal), or cycle power.

When the configuration is successfully confirmed, the Controller will switch to Run mode.

5.1.3 Revise an Existing Configuration

When the software program opens, go to File > Open or click the  icon to browse for the configuration to be changed. Make changes as described in section *Build a Configuration* on page 51.

5.1.4 Other Functions

Receive a Configuration from the Safety Controller

To receive a configuration from a Controller and display it in the PCI:

1. Connect the Safety Controller to the PC using the USB cable.
2. Apply 24V dc power to the Controller.

3. Click Receive  in the tool bar.
4. If the configuration is not already confirmed, you may choose to confirm it at this time.

Send a Configuration to the Safety Controller

To send a configuration from the PCI to a Controller:

1. Connect the Safety Controller to the PC, using the USB cable.
2. Apply 24V dc power to the Controller.
3. Click Send  in the tool bar.

Open a Configuration from the XM Card

Both confirmed and unconfirmed configurations can be sent to or received from the XM card. To open a copy of a configuration from the XM card and display it in the PCI:

1. Connect the SC-XMP programming tool to the PC using the USB cable.
2. Insert the XM card into the programming tool.
3. Go to File > Open From XM Card in the upper-left corner of the screen.

A message appears when the operation is complete.

Send a Configuration to the XM Card

Both confirmed and unconfirmed configurations can be sent to or received from the XM card. To send a copy of a configuration from the PCI to the XM card (via the programming tool):

1. Connect the SC-XMP programming tool to the PC using the USB cable.
2. Insert the XM card into the programming tool.
3. Select Open Folder  in the tool bar and open the intended configuration file.
4. Go to File > Send To XM Card in the upper-left corner of the screen.

A message appears when the operation is complete.

Lock the XM Card

It is important to note that this operation cannot be undone. Once the card is locked, another configuration can never be stored on it. This operation is useful when the XM card and its configuration will be transported to another Controller, or for storing and archiving a configuration. To lock the XM card so that the stored configuration cannot be changed:

1. Insert the XM card into the SC-XMP programming tool.
2. Verify that the correct file is stored on the XM card.
3. Go to File > Lock XM Card in the upper left of the tool bar.

A message appears when the operation is complete.

Changing the Password Using the Personal Computer Interface (PCI)

For this procedure, the PC must be connected to the Controller via USB cable, and the Controller must be ON.

1. Go to File > Change Safety Controller Password. The Change Password screen appears.
2. Fill in the boxes for Safety Controller password, new password, and new password again. Click OK.

   The Entering Configuration Mode screen appears with the message, “Are you sure you want to do this? All Safety Outputs will be turned off.” (If you click Yes, all Safety Outputs will turn OFF, along with the machine or system the Safety Controller is monitoring.)
3. Click Yes. The Change Password screen reappears.
4. Click Close. The password is changed. Record the password for safekeeping.

Figure 44. Change Password screen

NOTE: If the password becomes lost, contact Banner Engineering for assistance.

Export Documents

Configuration notes can be exported in different formats. To export a configuration document:

1. Open the configuration file that you want to save.
2. Go to File > Export in the upper left of the tool bar.
3. Select the configuration document you want to export.
4. Verify that the File name is correct and pick the Save as type file option you need.
5. Select Save.

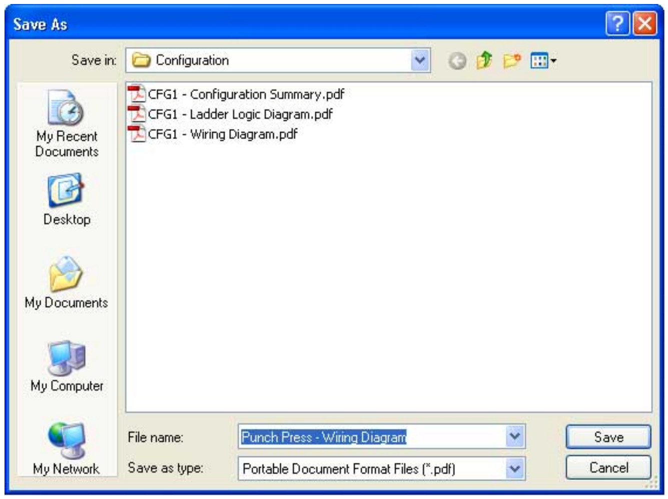


Figure 45. Save As screen

Print Options

To print a configuration file:

1. Open the configuration file that you want to print.
2. Go to File > Print in the upper left of the tool bar.
3. Select the configuration document you want to print.
4. A Page Setup menu will appear. Make the page and printer choices and click OK. (Hint: Wiring diagrams typically fit the page better when “landscape” is selected; the other documents fit better on “portrait.”)

6 Onboard Interface Configuration (OBI)

6.1 Onboard Interface (OBI) Overview

The Safety Controller's onboard interface (OBI) consists of a display and six push buttons that are used to:

- Select a language
- Create, confirm, edit, erase, send, and receive a configuration
- Display real-time Run mode information
- Display current fault data, fault log data, and to clear the fault log
- Display the model number of the Safety Controller
- Set a password

The configuration is used to define the input devices that will be connected to the Safety Controller and to establish relationships between input devices, and between the input devices and the outputs.

This section provides a "map" and description of Run mode and Configuration mode options, using the OBI. See the following figure for an overview of all the Run mode and Configuration mode options available. For an example of a beginning-to-end configuration process using the OBI, refer to the OBI tutorial in the SC22 Configuration Tutorial, found at *www.bannerengineering.com*.

Press the OK button to make a selection or move further into the menu tree; press the ESC button to move up a step. When a vertical list of options appears on the screen, use the Up/Down arrow buttons to highlight an option to select. Press OK to select the highlighted option. When a single option appears on the screen (for example, an input device) with an arrow running across the top of the screen, use the Left/Right arrow push buttons to step through the selections; press OK to select the option showing on the screen.

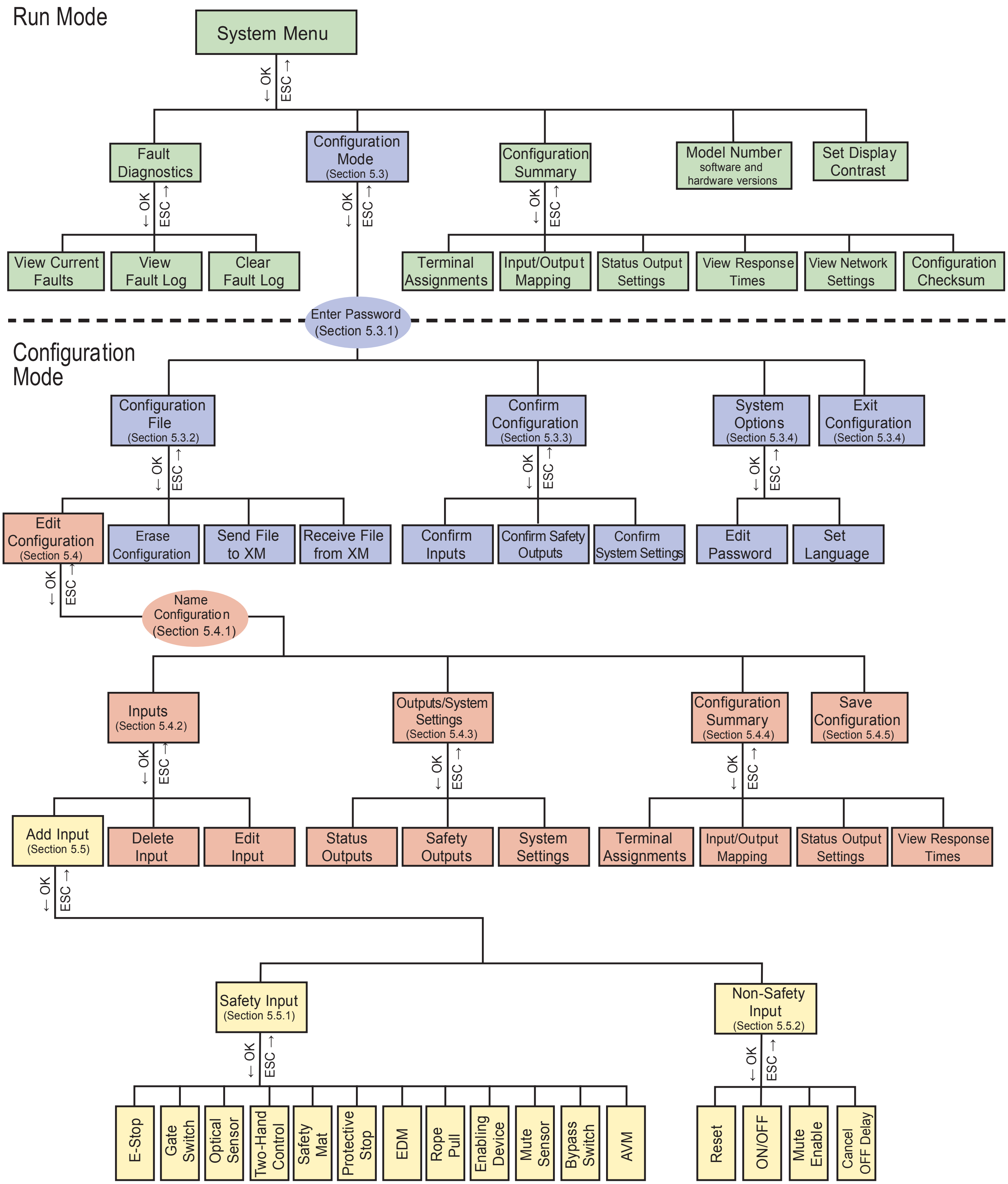


Figure 46. OBI Configuration Mode Map

6.2 Run Mode

From Run mode, press OK to view the System menu. This menu provides the ability to read fault diagnostic information, enter the Configuration mode to create or edit a configuration, read the configuration summary, view the Safety Controller's model number, and adjust the contrast of the display.

Use the Up/Down arrows to highlight your selection, then press OK to select.

Fault Diagnostics—Use this screen to view current faults and the fault log, or clear the fault log. Refer to section *Finding and Fixing Faults* on page 79 for more information.

Configuration Mode—Use this selection to enter the Configuration mode and to create or edit a configuration; refer to section *Configuration Mode* on page 61 for more information.

Configuration Summary—This selection provides read-only screens to review:

- Input device terminal assignments for each device in the current configuration
- The mapping relationships between input devices, and between input devices and safety outputs
- The current settings of the status outputs (to change the settings, see section *Configuration File* on page 61)
- Safety output response times (used to calculate safety distance) for each input mapped to the output
- The current network settings configured for network communication
- The configuration checksum: a unique identifier for any configuration that is programmed into a Safety Controller. It becomes available after a configuration is confirmed and is provided for the user to track configuration revisions

Use the Up/Down arrows to highlight your selection, then press OK to select it.

Model Number—Select this screen to see the Controllers' model number, and software and hardware versions. This can be useful when an applications help call is needed.

Set Display Contrast—Select this screen to adjust the brightness of the Controller display screen background and images for ambient conditions. Use the Left/Right arrows to adjust contrast level (left for lighter, right for more saturated); when contrast is correct, press OK.

6.3 Configuration Mode

The first step in creating a configuration using the OBI is entering the Configuration mode. To enter the Configuration mode from the main Run mode screen, press OK to display the System menu. At the System menu, press the Down arrow until Configuration Mode is highlighted and press OK.

6.3.1 Enter Controller Password

Before any configuration can take place, the password must be entered. The default password is 0000. For instructions on changing the password, refer to section *System Options* on page 63.

- Use the Left/Right arrows to select the password digit position.
- Use the Up/Down arrows to select the value for each position (choices 0-9).
- When the password is entered, press OK to enter the Configuration mode.
- Read the caution that the safety outputs will turn OFF when Configuration mode is entered and press OK.

6.3.2 Configuration File

Edit Configuration—To edit the configuration from the Configuration Mode menu, select Configuration File and press OK. See section *Name Configuration* on page 63 for more instructions. To begin editing the configuration, select Edit Configuration from the Configuration File menu and press OK.

Erase Configuration—This selection is used to remove the current configuration from the Controller, so a new configuration can be created (the Controller can hold only one configuration at a time). To keep the current file, send it to the XM card before erasing it from the Controller.

To perform an Erase, use the up/down arrows to select the option from the menu and press OK. When prompted whether you want to do this, highlight Yes and press OK.

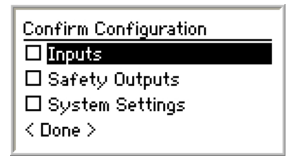
Send File to XM—This selection is used to send a configuration file to the XM card plugged into the Controller's XM port. The file can then be stored and/or transported to another Controller. Insert the XM card into the Controller's XM port, highlight the selection and press OK.

Receive File from XM—This selection is used to receive a configuration from the XM card. Highlight the selection and press OK. The Controller will ask if you want to overwrite the current configuration (if not, send the existing configuration to an empty XM card first). Answer Yes, then if one is not already in the port, insert an XM card and press OK. If the new configuration is unconfirmed, the Controller provides the option to confirm it at this time.

6.3.3 Confirm Configuration

Any changes are made to a configuration must be confirmed again before it can be used in a safeguarding application. Select Confirm Configuration and press OK.

The Confirm Configuration menu will appear. Safety-critical configurations for the inputs, safety outputs, and the system settings are available for the review. An unchecked box in the Confirm Configuration menu indicates the safety-critical settings have not yet been confirmed.



Confirm Configurations of Inputs—Select Confirm Inputs and press OK. The next menu lists all of the safety inputs in the configuration. Use the Up/Down arrows to select an input and press OK.

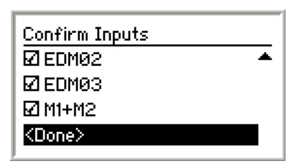
The next series of menus lists the safety-critical configurations for this input, including some or all of the following (depending on the device):

- Circuit type
- Safety Output mapping or input mapping
- Reset logic (manual or automatic)
- Simultaneity (simultaneous or concurrent)
- Startup test
- Mute time limit
- Enabling device time limit
- Bypass time limit
- Debounce times (if not equal to default)
- Directional muting (enabled or disabled)
- Mute-dependent override (enabled or disabled)
- AVM monitoring time limit

Press OK after reviewing each setting.

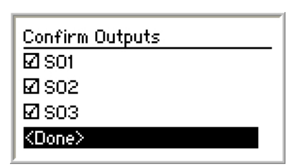
Repeat the confirmation process for each input. When all inputs have been confirmed, each input in the display will have a check mark.

To continue confirming the configuration, select <Done> and press OK.



Confirm Configuration of Safety Outputs—Select Safety Outputs and press OK. Use the Up/Down arrows to select a safety output and press OK. The next series of menus displays the safety-critical configurations for the selected safety output. Review each setting and press OK.

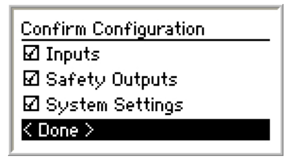
When a safety output has been confirmed, a checked box appears in front of it on the Confirm Outputs screen. Repeat the confirmation process for each safety output. When all safety outputs have been confirmed, each output in the display has a check mark.



After each output is confirmed, select <Done> and press OK.

The Confirm Configuration menu reappears, indicating whether the inputs and safety outputs are confirmed. If any boxes do not have a check mark, repeat the confirmation of those components.

Confirm System Settings—The last step is to confirm the system settings. Select System Settings and press OK. The next series of menus lists the safety-critical system settings. Review each setting and press OK to confirm.



Final Confirmation Step—After all of the safety-critical configuration settings are confirmed, the configuration can be used in a safeguarding application. If any changes are made to the configuration, the confirmation process must be repeated.

Select <Done> and press OK to exit the Confirm Configuration menu. Press ESC or go to Exit Configuration to return to Run mode.

6.3.4 System Options

Edit Password—Allows to change the password to something other than the default. The password may be unique to each Controller. The procedure is similar to that used to enter the default password initially:

1. Use the Left/Right arrows to select the password digit position.
2. Use the Up/Down arrows to select the value for each position (0-9).
3. When the password is entered, press OK.

Set Language—This screen is used to determine what language will appear on the display. The options are English, German, Spanish, French, Italian, Portuguese, and Japanese. Highlight the desired language then press OK.

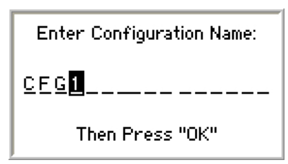
> NOTE: Language can also be changed immediately following power-up. The screen appears automatically, and the language selection can be changed at that time. If nothing is changed, the screen times out after 5 seconds and continues to Run mode in the language that was selected before the Controller was last powered down.

6.3.5 Exit Configuration

Use this screen to return to Run mode. Select Exit Configuration Mode and press OK to exit and return to the System Menu.

6.4 Edit Configuration

6.4.1 Name Configuration



Follow these steps to give the configuration a custom name:

1. Use the Left/Right arrows to select the character position. Up to 16 characters are possible.
2. Use the Up/Down arrows to select the character for each position (choices A-Z, 0-9, -, +, or space).
3. When the configuration name is entered, press OK.

6.4.2 Inputs

Add Input—Select this option to add either a safety or non-safety input device (see section *Add an Input* on page 65).

Delete Input—This option is used to remove a previously added input device from the configuration. A screen will appear with all of the previously configured inputs; use the Left/Right arrows to select a device and press OK. Select Yes to confirm the deletion and press OK. If No is selected, the screen will return to choose a different input to delete. To return to the Inputs menu, press ESC.

Edit Input—This option is used to edit a previously configured input device in the configuration. A screen will appear with all of the previously configured inputs; use the Left/Right arrows to select a device and press OK. A series of screens will appear, with the device's properties; select each property (in the same way used to define the input initially; see section *Add an Input* on page 65), and press OK.

The Inputs menu also displays when ESC is pressed after all of the required inputs have been added. Press ESC when the Inputs menu displays to return to the Edit Configuration menu.

6.4.3 Outputs/System Settings

Safety Outputs

This option is used to configure the safety outputs. Use the Up/Down arrows to select Safety Outputs and press OK. Select the output to configure and press OK. You will be given the opportunity to change the output's name, and give it an ON- or OFF-delay.

Status Outputs

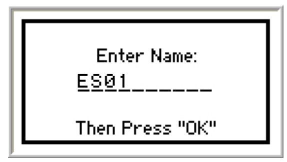
This option is used to configure the status outputs. Status outputs are configured individually. Use the Up/Down arrows to select Status Outputs and press OK.

Use the Left/Right arrows to select the status output to configure (O1 to O10), and press OK to view the Status Output Properties menu. The status outputs can be configured to indicate:

- The status of an input device
- The status of a safety output
- A system lockout
- An I/O fault
- The need to perform a system reset
- The need to perform a reset operation on a safety output
- When an input is being muted
- The logical status (ON or ON-delay) of a safety output

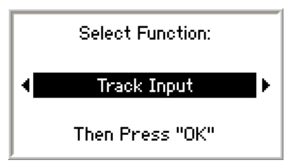
Name the Status Output—Use the Up/Down arrows to select Change Name and press OK.

1. Use the Left/Right arrows to select the character to be changed (up to 10 characters)
2. Use the Up/Down arrows to change the character (A-Z, 0-9, -, +, and space)
3. Press OK when done
4. When the display returns to the Status Output Properties menu, the top line of the display will reflect the new name



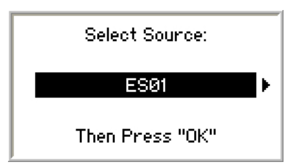
Select the function of the Status Output—Use the Up/Down arrows to select Select Function and press OK.

1. Use the Left/Right arrows to select a function, then press OK
2. The display returns to the Status Output Properties menu



Select the source for the Status Output function—Select Select Source and press OK.

1. Use the Left/Right arrows to select a device and press OK
2. The display returns to the Status Output Properties menu



Select the signal convention—The options are:

- 24V = Input Active and
- 24V = Input Inactive (for example, if tracking an input; see section *External Device Monitoring (EDM)* on page 37 for more information).

1. Use the Left/Right arrows to toggle between the selections and press OK.
2. To save the settings for this output, select <Done> and press OK. The display returns to the Outputs/System Settings menu. To configure additional status outputs, select Status Outputs, select another status output and repeat the steps above. When the last status output is configured, press ESC to return to the Edit Configuration menu.

System Settings

Select the output's reset mode, power up mode, and whether mute will be active on power-up.

System Reset—Use the Left/Right arrows to toggle between Monitored or Non-Monitored, and press OK.

Power Up Option—Use the Left/Right arrows to select among Normal, Auto, or Manual, and press OK.

Mute on Power-Up—Use the Left/Right arrows to toggle between Off or On, and press OK.

6.4.4 Configuration Summary

The Configuration Summary menu provides read-only screens to review:

- Input device Terminal Assignments for each device in the current configuration
- The mapping relationships between input devices, and between input devices and safety outputs
- The current settings of the status outputs (to change the settings, see section *Outputs/System Settings* on page 63)
- Safety output response times for each input mapped to the output. Response times can be used to calculate the minimum safety distance (separation distance)

Use the Up/Down arrows to navigate between options, then press OK to select.

6.5 Add an Input

Input devices are categorized as either safety inputs or non-safety inputs. While the devices differ, the process for adding either is virtually identical. Use the up/down arrow buttons to select Safety or Non-Safety and press OK.

6.5.1 Add a Safety Input

Safety input device options include:

- E-stop buttons
- Gate (interlock) switches
- Optical sensors (including safety light curtains, single-/multiple-beam sensors, and area scanners)
- Two-hand control devices
- Safety mats
- Protective stop devices
- External device monitoring (EDM and AVM) contacts
- Rope pulls
- Enabling devices
- Mute sensors
- Bypass switches

See section *Input Device and Safety Category Reference* on page 86 for more information about each of the input device types.

6.5.2 Add a Non-Safety Input

Non-safety input device options include:

- Manual reset switches
- ON/OFF switches
- Mute Enable switches
- Cancel OFF-delay switch

Select an Input Device (Either Safety or Non-Safety)—Use the left/right arrows to select the proper device, then press OK. The arrows at the top of the screen indicate whether more options are available to the left or to the right. After the device is selected, a new screen appears with the appropriate properties to select for that device.

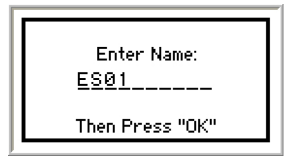
6.5.3 Configure Input Device Properties

For each input device, the following parameters must be configured:

- Name (or use the auto-generated default name)
- Circuit type
- Terminal assignments (or use the auto-generated terminal assignments)
- Reset logic (for some devices)
- Output mapping or input mapping (depending on device)

Enter Input Device Name—The Enter Name menu is displayed. A default name automatically appears, but the device may be renamed (up to 10 characters).

1. Use the left/right arrows to select the character position.
2. Use the up/down arrows to select the character for each position (choices A-Z, 0-9, -, +, or space).
3. When the screen (as shown below) shows the correct device name, press OK.



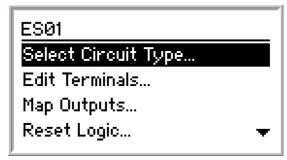
Input Properties Menu—The Input Properties menu is used to:

- Select the input device's circuit type
- Edit the terminal assignments, if needed
- Select the output(s) (or input), the input will control
- Select between automatic and manual reset logic (depending on device)

Select the Circuit Type of the Input—Use the up/down arrows to select Select Circuit Type, and press OK.

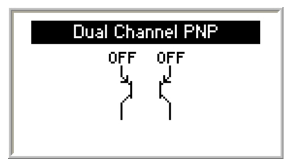
See section *Input Device and Safety Category Reference* on page 86 for more information about safety circuit integrity levels and the capabilities of each circuit type.

1. The Select Circuit Type menu appears.
2. Use the left/right arrows to select the desired circuit type (a dual-channel, 4-terminal circuit type is shown below) for the input device and press OK.
3. After the circuit type is selected, the display returns to the Input Properties menu.



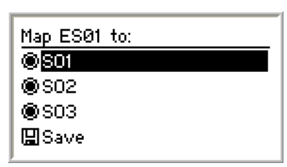
Edit the Terminal Assignments—When the input circuit type is selected, the Safety Controller automatically assigns the next available terminals for the input device. Only unassigned terminals can be assigned. (Exception: Terminals used for a specific input device can be assigned twice during the edit process, if the same terminals will be used, in a different order, for this specific device.) To view and change these terminal assignments, select Edit Terminals, and press OK.

1. Use the left/right arrow buttons to select the terminal assignment to be changed.
2. Use the up/down arrows to change the terminal assignment.
3. When the terminal assignments are as desired, press OK.
4. After the terminal assignments are approved, the display returns to the Input Properties menu.



Map Outputs—This option is used to select which of the Safety Output(s) the input controls. Any combination of 1, 2, or all 3 outputs may be selected, but *at least one must be selected.* All safety devices, plus reset and ON/OFF non-safety devices must be mapped to one or more Safety Outputs. Map mute enable devices, mute sensors, and bypass sensors to a safety input device.

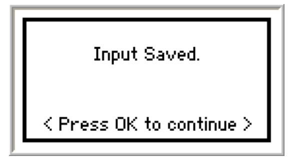
1. Select Map Outputs in the Input Properties menu, and press OK.
2. To map the input to an output, use the up/down arrows to select the output, then press OK.
3. A filled-in circle on the display indicates the input is mapped to the corresponding output; an empty circle indicates the input is not mapped to that output.
4. To add or remove the input mapping, select the output and press OK. When the input is mapped to the Safety Outputs as desired, select Save and press OK.
5. After the input is mapped to the Safety Outputs, the display returns to the Input Properties menu.



The screen shows device ES01 mapped to all three Safety Outputs.

Select Reset Logic—To select automatic or manual reset logic, select Reset Logic and press OK.

1. Use the left/right arrows to select the desired reset logic parameter and press OK.
2. The display returns to the Input Properties menu.



Save the Input Device Parameters—When all of the device's parameters have been set as desired, select < Done > and press OK to save the parameters.

1. The display indicates the input parameters were saved. Press OK to continue.
2. The display returns to the Edit Inputs menu.

7 Operating Instructions

7.1 Monitoring Controller Operation

The Safety Controller can be operated using either the OBI or the PCI interfaces to monitor ongoing status.

7.2 Display Controller Information — PC Interface (PCI)

To display real-time Run mode information on a PC, the computer must be connected to the Controller, via a USB cable (see Section 1.3 for connection instructions). Open the Banner Safety Controller program and click on the Live Display button in the PCI screen to launch the Live Display screen. This feature continually updates Run mode data and displays it in a pop-up screen.

The Live Display screen provides the same information that can be viewed on the Controller's LCD. It shows the status of each Safety Output and reports on any input device or system event that can cause a Safety Output to turn OFF.

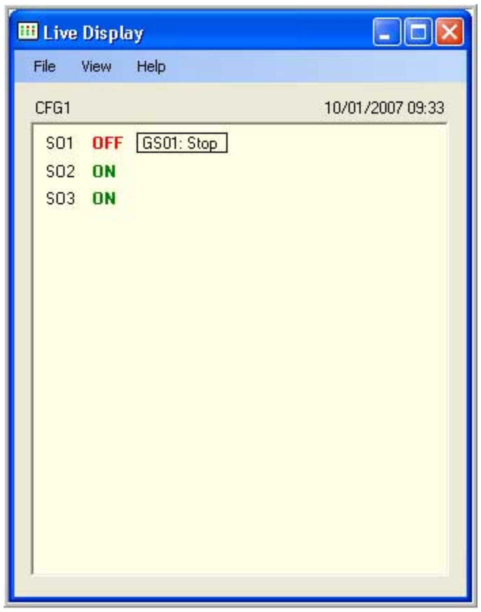


Figure 47. Live Display screen — PCI

7.3 Display Controller Information — Onboard Interface (OBI)

To display current information on the Controller's Onboard Interface screen (OBI), use the Controller's arrow buttons to step through the Run mode menu, as shown.

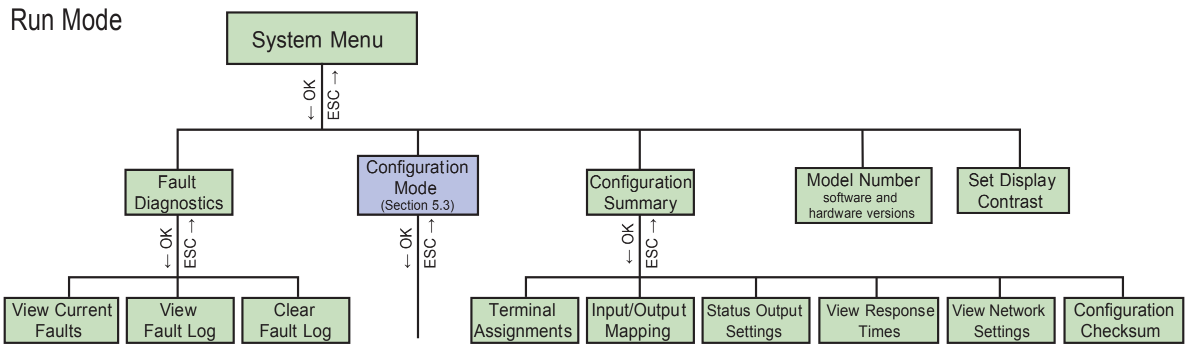


Figure 48. Run mode menu selections — OBI

7.3.1 Run Mode Screen—OBI

The OBI Run mode screen displays current information about the Safety Controller, including:

- The configuration name
- Safety Output status

- Input status
- System status
- XM card status

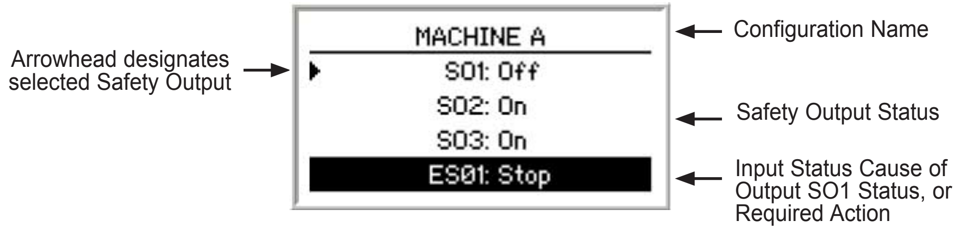


Figure 49. Run mode screen—OBI

Configuration Name: The top line of the display reads either the name of the configuration stored in the Safety Controller, if it has been confirmed, or *Configuration not confirmed*, if it has not.

Safety Output Status: Lines 2, 3, and 4 of the screen display the status of the three Safety Outputs. The selected output will have a small arrowhead to its left, on the screen. (The arrowhead scrolls through the Safety Outputs that are OFF, at 2-second intervals.) Line 5 of the display states the reason for the status of the selected Safety Output.

NOTE: Output faults are recoverable via a system reset (see section *System Resets and Lockout Conditions* on page 70).

Safety Output Status Message	Cause and/or Required Action
ON	The Safety Output is ON.
ON-Delay	The Safety Output will turn ON when the ON-delay time expires.
OFF	The Safety Output is OFF. Line 5 of the display indicates the reason the Safety Output is OFF.
OFF-Delay	The Safety Output will turn OFF when the OFF-delay expires. Line 5 of the display indicates the reason the Safety Output is in an OFF-delay.
Reset Needed	A manual reset operation needs to be performed. Line 5 of the display indicates the name of the manual reset input to press.
Fault	A problem has been detected with the Safety Output. See section *Fault Code Table* on page 79 to find additional information regarding the fault. If the fault is due to an external device monitor (EDM) fault, line 5 of the display indicates the name of the EDM.
Enable Mode	Line 5 of the display indicates Enable Mode if a Safety Output is in Enable mode.

Input Status: If a Safety Output is OFF or turning OFF, line 5 of the display indicates information about the input that is keeping the output OFF.

Line 5 also indicates when a manual reset operation needs to be performed.

NOTE:
- Line 5 changes to indicate each input when the status of more than one input must be displayed
- Press the Up arrow to pause the screen on the current input
- Press the Down arrow to change the last line to the next input (Press the Down arrow repeatedly to quickly cycle through the inputs)
- If more than one output is OFF, a small arrowhead indicates the Safety Output to which the input messages correspond, as shown in the preceding figure

Input Device Status Message	Cause and/or Required Action
Stop	The safety input is in a state that causes the Safety Output to turn OFF.

Input Device Status Message	Cause and/or Required Action
Test	A start-up test needs to be completed on the safety input. To perform the test, cycle the input (Run-Stop-Run) to turn the Safety Output ON.
Deactivate	A two-hand control input or an enabling device needs to be cycled (Run-Stop-Run) before the Safety Output will turn ON.
Fault	A problem has been detected with an input that controls the output.
Timed Out	The Safety Output is in enable mode and the enabling device active time limit has expired. Cycle the enabling device to turn the output back ON, or turn the enabling device OFF and perform a system reset to exit Enable mode.
Test Active	An AVM test is running. The output will turn ON when the test is complete.

When a Safety Output is ON, no input information is displayed unless a mapped input is muted, bypassed, or in a fault condition.

Status Output: Line 5 of the screen displays Mute Lamp Fault when a mute lamp fault exists.

System Status: Line 5 of the screen displays System Reset Needed whenever a system reset is needed to turn the Safety Outputs ON. However, when a fault condition exists, the fault must be corrected before the system reset operation will turn the Safety Outputs ON.

External Memory Card (XM Card) Status: The status of the XM card is temporarily displayed when it is inserted while the Run mode screen is active. Remove and replace the correct XM card as necessary.

XM Card Message	Cause
XM matches the active configuration	The configuration stored on the card is the same as the Safety Controller's configuration.
XM does not match the active configuration	The configuration stored on the XM card is different from the Safety Controller's configuration.
XM has no configuration	The XM card does not have a configuration stored in it.

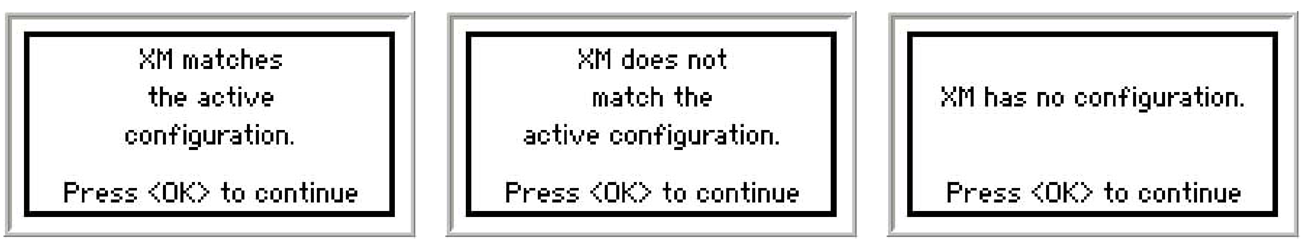


Figure 50. XM Card status message screens—OBI

7.4 Manual Reset

A manual reset operation is valid when all safety inputs mapped to the Safety Output are in the Run state when the manual reset is performed; see section *Reset Signal Requirements* on page 32.

When a single manual reset device is mapped to two or more Safety Outputs, one of which has an OFF-delay, then the manual reset will not be able to turn ON either Safety Output until the OFF-delay time has expired.

If a safety input device configured for manual reset changes from the Run state to Stop and back to Run, then any Safety Outputs to which that device is mapped will turn OFF and remain OFF until a valid manual reset is performed.

7.5 System Resets and Lockout Conditions

A system reset is necessary under the following conditions:

- Recovering from a lockout condition
- Starting the Controller after a new configuration has been downloaded
- Recovering from an output fault
- Entering Run mode after power-up, when configured for manual power-up
- Exiting Enable mode
- Recovering from an AVM fault
- Recovering from a two-hand control input fault

A system reset is used to clear lockout conditions not related to safety inputs. A lockout condition is a response where the Controller will turn 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.

The reset device (a button or switch) connects to a dedicated input terminal on the Safety Controller, labeled SR. The reset signal type can be configured to be either monitored (default) or non-monitored (see *Reset Signal Requirements* on page 32).

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.

7.6 Reset Signal Requirements

Both manual (latch) reset and system reset signals 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 0.3 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 0.3 seconds. After the reset, the reset signal can be either high or low. This is called a leading-edge event.

8 System Checkout

8.1 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 73 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[6]). 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[6] 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[6] 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[6] 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.

8.2 Commissioning Checkout Procedure

Before proceeding, verify that:

- The safety output terminal strip is not connected to the Safety Controller; unplug the 7-pin connector so that the safety outputs SO1 (A and B), SO2 (A and B) and SO3 (A and B) are not connected to the machine)
- 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.

8.2.1 Verifying System Operation

The commissioning checkout procedure must be performed by a Qualified Person[7]. 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 *Input Device and Safety Category Reference* on page 86 and the appropriate standards).

The commissioning checkout procedure is performed on two occasions:

1. When the Controller is first installed, to ensure proper installation

[6] See *Glossary* on page 120 for definitions.
[7] See *Glossary* on page 120 for definitions.

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 72)

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.

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 37 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.

Figure 51. Safety Output terminal block

8.3 Initial Setup, Commissioning and Periodic Checkout Procedures

NOTE: If any of the status outputs are mapped to functions within the configuration, monitor the function of each status output as the associated operation is tested.

1. Make sure that the indicators for indicators for the safety outputs (SO1, SO2, and SO3) of the Safety Controller and for the associated output devices can be observed and verified to operate correctly and without a risk of injury. Do not apply power to the Safety Controller or to the guarded machine.
2. Safety System and Safeguarding Device Checkout
   a. Verify that the guarded machine is compatible with this safeguarding system, as described in section *Appropriate Application* on page 25.
   b. Verify the installation and perform the checkout procedures for the external safety/safeguarding systems and devices connected to the Safety Controller inputs as described by the appropriate manuals. Do not proceed until all checkout procedures are completed successfully and all problems have been corrected.
   c. Verify that:
      - Access to any dangerous parts of the guarded machine is not possible from any direction not protected by the safeguarding system, hard (fixed) guarding, or supplemental safeguarding
      - Supplemental safeguarding and hard (fixed) guarding, as described by the appropriate safety standards, are in place and functioning properly
   d. Verify that all Reset switches are mounted outside and in full view of the guarded area, out of reach of anyone inside the guarded area, and the means of preventing inadvertent use are in place.
   e. Examine the electrical wiring connections between the Safety Controller's OSSD outputs and the guarded machine's control elements to verify that the wiring meets the requirements stated in *External Device Monitoring (EDM)* on page 37.
3. Verify that all Two-Hand Control devices, enabling devices, muting sensors, and bypass switches are in the inactive (Stop) state.

   NOTE: In all cases, outputs associated with a Two-Hand Control or a Bypass device should not turn on at power-up. In addition, bypass or enabling devices in the active (Run) state at power-up will not function until they are seen as Off first.

4. Ensure that all other input devices are in the active (Run) state.
5. Power-Up and Reset Functions:
   a. Ensure that no individual is exposed to the hazardous motion/situation of the guarded machine during the checkout procedure. Observe the SO status indicators or the messages on the front panel display to verify whether a safety output is On or Off.

b. Apply power to the Safety Controller and all input devices that require power, but not to the guarded machine.
c. Verify that the configuration file is appropriate for the application. At a minimum, have a copy of the Configuration Summary from the PC Interface software available for reference during the checkout procedure.
d. Verify that status outputs configured for a monitored mute lamp (if used) turn on after power-up.

6. Power-Up Configuration (see “System Settings” in the Configuration Summary). In all cases, safety outputs associated with a Two-Hand Control do not turn on at power-up. Enabling devices and bypass functions are not available at power-up —they must begin in a Stop state (Off):
   - If configured for Normal Power-Up (default): Verify that safety outputs associated only with device inputs configured for automatic reset turn on
   - If configured for Automatic Power-Up: Verify that all safety outputs turn on within 5 seconds (outputs with a configured On-delay may extend this time)
   - If configured for Manual Power-Up:
     1. Verify that all safety outputs remain Off.
     2. Wait at least 10 seconds after power-up and then apply a system reset.
     3. Verify that safety outputs turn on, even if an associated non-safety input is configured for a manual reset.
7. Reset Configuration
   - If configured for Automatic Reset: Verify that the corresponding Safety Output indicator is On Green, indicating that the safety output(s) is On (assuming that other inputs configured for manual reset are not associated with the safety output). If a Red status indicator begins to flash at any time, refer to *Troubleshooting* on page 79 for more information.
   - If configured for Manual Reset: Verify that the Green status LED is flashing to indicate that a reset is being requested, and that the message “Reset Needed” appears on the Diagnostic Display. If the Red status indicator begins to flash at any time, refer to *Troubleshooting* on page 79 for more information.

> NOTE: If a monitored manual reset has been configured, perform a reset by closing the Reset input for at least ¼ second, but not longer than 2 seconds, and then reopening the contact. Verify that the Green status indicator comes On steady.

   a. Verify that all reset switches are:
      - Mounted in full view of the guarded area
      - Outside of the guarded area
      - Out of reach of anyone inside the guarded area
      - Protected from inadvertent use
   b. Actuate each (non-safety input) manual reset device to turn on remaining outputs not associated with a Two-Hand Control device.
   c. Verify that all safety outputs not associated with Two-Hand Control devices are now On. Exception: An output associated only with an enabling device will remain Off.

If a particular function or device is not part of the application, skip that step and proceed to the next check or to the final step.

8. Two-Hand Control Functions
   a. Make sure that all inputs are in the On-state associated with safety outputs and activate each Two-Hand Control device to turn On the remaining outputs.
   b. Verify that the associated safety output remains Off unless both hand controls are activated within 0.5 seconds of each other.
   c. Verify that when one hand is removed and replaced, the safety output turns Off and remains Off.
9. Emergency Stop and Rope-Pull Functions
   a. While the outputs are on, individually actuate and re-arm each E-stop and/or rope-pull device, one device at a time.
   b. Verify that each associated safety output turns Off with the proper Off-delay, where applicable.
   c. As the E-stop or rope-pull device is returned to the Run state (armed):
      - If configured for Manual Reset or if associated with a Two-Hand Control device: verify that the safety output remains Off
      - If configured for Automatic Reset (assuming that another device is not holding it Off): verify that the safety output turns On
10. Apply a manual reset and/or activate the Two-Hand Control device as necessary to turn the output(s) back On.
11. Verify that each associated safety output turns On with the proper On-delay, where applicable.

12. Other Stopping Device Functions. Repeat the preceding three steps for each device type below, as applicable:
    a. Verify operation of all gate switches.
    b. Verify operation of all optical sensors.

   c. Verify operation of all protective stops (for example, other safety/safeguarding devices not listed).
   d. Verify operation of all On/Off inputs.

If Mute, Bypass and/or Enabling Device functions are not used, proceed to the final step in this procedure.

13. Mute Functions
   a. While the outputs are On, initiate a mute cycle by activating the mute enable input (if used) and then activate each mute sensor of a pair within 3 seconds.
   b. Verify that the mute lamp, if used, turns On.
   c. Generate a stop command from the safeguarding device that has been muted.
      a. Verify that the associated safety outputs remain On (Green status indicator remains On).
      b. If a time limit (backdoor timer) is associated with the mute, verify that the associated safety outputs turn Off when the mute timer expires.
   d. Repeat above steps for each muting sensor pair.
   e. Verify proper operation with each associated muted device
   f. Generate a stop command from the non-muted safeguarding device(s), one at a time.
   g. Verify that the associated safety outputs turn Off while the input is muted.

> NOTE: The mute function will end when an associated output turns Off for any reason. In order to complete this test with the other non-muted safeguarding devices, a new mute cycle must be initiated for each one.

14. Directional Muting Option
   a. If 2 Mute Sensor Pairs have been configured and mapped to a mutable safety input, such as light screen, a setting of the mutable safety input in the PC Interface provides the option for Directional Muting.

      Check the "Enable directional muting" box in the PC Interface. Select sensor pair 1.
   b. Verify that all mute sensors and the light screen are clear, and the safety outputs are On.
   c. Block sensor pair 1 (the one selected in the PC Interface), followed by the light screen, and sensor pair 2.
   d. Verify, that the mute lamp, if used, turns On.
   e. If a time limit (backdoor timer) is associated with the mute, verify that the associated safety outputs turn Off when the mute timer expires.
   f. Repeat the test in the *wrong direction* (mute sensor pair 2, then the light screen, then mute sensor pair 1), and verify that the mute does not take place: the safety output(s) turn(s) Off as soon as the light screen is blocked.
   g. Repeat the steps above for all devices with directional muting.
   h. Mute an input device that is configured for directional muting.
   i. While the safety output(s) are On, generate a Stop command from a non-muted safeguarding device(s) mapped to the same safety output(s).
   j. Verify that the associated safety output(s) turns Off, even though an input is muted.

15. Mute on Power-Up Option
   a. Turn the Safety Controller power Off.
      a. Activate the mute enable inputs (if used).
      b. Activate an appropriate muting sensor pair for starting a mute cycle.
      c. Ensure all input devices are in their Run (active) state (not including Two-Hand Control devices).
      d. Verify that all enabling devices and bypass switches are in the Stop (inactive) state.
   b. Verify proper operation at power-up.

> NOTE: In all cases, safety outputs associated with a Two-Hand Control device will not turn On at power-up. The Mute on Power-Up feature does not apply to mutable Two-Hand Control devices.

- If configured for Auto Power-Up:
   1. Verify that all safety outputs turn On.
   2. Verify that the mute status output (if used) turns On.
- If configured for Normal Power-Up:
   1. Verify that all safety outputs associated with only auto-reset devices or mutable manual-reset devices turn On.
   2. Verify that the mute status output (if used) turns On.
- If configured for Manual Power-Up:
   1. Verify that all safety outputs remain Off.

2. Wait at least 10 seconds after power-up and apply a system reset.
3. Verify that all safety outputs turn On.
4. Verify that the mute status output (if used) turns On.

c. Generate a stop command from the safeguarding device that has been muted.

   Verify that the associated safety outputs remain On (for example, the input is muted); the Green status indicator should remain On.

16. Mute-Dependent Override Option

a. Select *Enable Mute-Dependent Override Function* (default) for a bypass input.
b. Clear all mute sensors and the light screen.
c. Verify that the safety output(s) are On.
d. Block the light screen.
e. Verify that the safety output(s) turn Off.
f. Block one of the mute sensors.
g. Start the bypass by closing the bypass input.
h. Verify that the safety output(s) turn On.
i. Clear the light screen and all mute sensors.
j. Verify that the safety output(s) remain On.
k. Open the bypass input.
l. Verify that the safety output(s) remain On.

17. Bypass Function (with Mute)

a. Verify that each safety input, if it is both mutable and can be bypassed, is in the Stop state.

   If the Safety Controller is still muting, the associated safety outputs should remain On. Even if the timer expires and the outputs turn Off, go to the next step.
b. Activate one or both mute sensors in a mute sensor pair. If there are two mute sensor pairs, at least one sensor in one of the pairs must be activated.

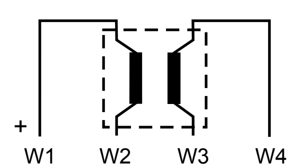
   Verify that the mute lamp, if used, is flashing.
c. Verify that when the bypass switch is in the Run state:
   - The associated safety outputs turn On.
   - The mute lamp, if used, is now steady On.
   - The associated safety outputs turn Off when the bypass timer expires.
d. Verify that when the bypass switch is in Stop state and goes back into Run state: The associated safety outputs turn On.
e. Verify that when all other non-bypassed inputs associated with the same output are in a Stop state, one at a time: The associated safety outputs turn OFF while the input is bypassed.

18. Safety Mat Device Checkout

Before connecting the mat to the Safety Controller, verify that the mat and the wiring to the mat does not exceed the maximum resistance specification:

1. Measure the resistance between wires connected to the same surface of the mat (see diagram):

   W1 and W2:______A______ ohms
   W3 and W4:______B______ ohms



2. While stepping on the mat, measure the resistance between W1 and W3. Repeat the measurement while stepping in various locations around the mat. Choose the location with the highest reading and record the following measurements:

   W1 and W3:______C______ ohms
   W2 and W4:______D______ ohms
   W2 and W3:______E______ ohms
   W1 and W4:______F______ ohms
3. If all measurements (A through F) are less than 20 ohms, the mat and leadwire resistance is acceptable and no further calculations are needed.
4. If A and B are both less than 300 ohms, the leadwire resistance is acceptable.
5. Calculate the mat resistance: $R = E + F - (A + B + C + D) / 2$
6. If $R < 20$ ohms, the mat resistance is acceptable.

19. Bypass Function (without Mute)
    a. Verify that when the safety input to be bypassed is in the Stop state: The associated safety outputs are Off.
    b. Verify that when the bypass input is in the Run state:
        - The associated safety outputs turn On.
        - The associated safety outputs turn Off when the bypass timer (backdoor timer) expires.
    c. Verify that when the bypass switch is in the Stop state and goes back into the Run state: The associated safety outputs turn On.
    d. Generate a stop command from the non-bypassed safeguarding device(s), one at a time. Verify that the associated safety output(s) turns Off while the input is bypassed.
20. Cancel OFF-delay Function
    a. Configure a delayed output and check the box *"Allow output to remain ON when off delay is cancelled"* in the Advanced Setting menu. Turn the delayed output ON. Start the delay time by generating a stop command from a safety input, mapped to the delayed safety output.
        - If the safety input is a latch input, perform the following steps:
            1. Close the safety input.
            2. Push the Reset button.
            3. Activate the Cancel Delay Input.
        - If the safety input is a trip input, perform the following steps:
            1. Close the safety input.
            2. Activate the Cancel Delay Input.
    b. Verify that the delayed safety output stays closed, after the delay time has expired.
    c. Configure a delayed output and do not check the box *"Allow output to remain On when off delay is cancelled"* (turn the output Off immediately after a Cancel Off-Delay signal) in the Advanced Setting menu.
    d. Turn the delayed output On.
    e. Start the delay time by generating a stop command from a safety input, mapped to the delayed safety output.
    f. Close the safety input again during the Off-delay time.
        - If the safety input is configured for manual reset: Verify that the delayed output turns Off immediately and remains Off (a reset signal during the delay time is ignored).
        - If the safety input is configured for auto reset: Verify that the delayed safety output turns Off immediately for 500 ms, then turns back On.
21. Enabling Device Function
    a. Verify that all inputs associated with the same output as the enabling device are in the Run state to turn the output(s) On. The enabling device is to remain in the Stop state. Verify that the associated safety outputs are On.
    b. Verify that when the enabling device is in the Run state: The associated safety outputs remain On and the LCD displays *ENABLE MODE*.
    c. Verify that when the enabling device is in the Stop state: The associated safety outputs turn Off.
    d. Verify that when the enabling device is in the Run state:
        a. The associated safety outputs turn On.
        b. The associated safety outputs turn Off when the enabling device timer expires.
    e. Verify that when the enabling device is in the Stop state and goes back into the Run state: The associated safety outputs turn On.
    f. Verify that when all E-stop and rope-pull inputs associated with the same outputs are in the Stop state, one at a time (repeat step for each device, as needed): The associated safety outputs turn Off while in Enable mode.
    g. Verify that the enabling device is in the Stop state and then apply a system reset.
        a. Verify that the LCD no longer displays *ENABLE MODE*.
        b. Verify that the Safety Controller is back to normal operation.
22. System (Final) Checkout

WARNING: Do not continue checkout until all problems are corrected.

The operation of the Safety Controller with the guarded machine must now be verified before the combined system may be put into service. To do this, a Qualified Person must perform the following checks.

Remove power from the Safety Controller.

Reinstall the safety output terminal strip to the Safety Controller. This is a permanent connection.

a. Verify that all wiring complies with NEC and local wiring codes.
b. Apply power to the guarded machine and verify that the machine does not start up.

c. Apply power to the Safety Controller and apply resets as needed to turn the safety outputs On.
d. Generate a stop command from each of the safety devices or safeguards connected to the input terminals of the Safety Controller and verify for each input device that:
    a. The safety outputs and status outputs operate as expected (for example, On-delays, Off-delays, etc.). Use the configuration summary to verify operation.
    b. It is not possible for the guarded machine to be put into motion.
e. Initiate machine motion of the guarded machine and, while it is moving, generate a stop command from each of the safety devices or safeguards. Do not attempt to insert anything into the dangerous parts of the machine. Upon issuing the stop command, verify that the dangerous parts of the machine come to a stop.
f. Upon reset of the safety device or safeguard and/or the Controller, verify that the machine does not automatically restart, and that the initiation devices must be engaged to restart the machine.
g. Test the machine stopping response time, using an instrument designed for that purpose, to verify that it is the same or less than the overall system response time specified by the machine manufacturer. A Banner Applications Engineer may be able to recommend a suitable instrument.

Important: If any of these checks fail, do not attempt to use the system until the reason for the failure(s) is identified and corrected.

9 Troubleshooting

9.1 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.

9.2 Repairs and Warranty Service

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

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.

9.3 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

When a fault is detected, a message describing the fault displays in the Fault Diagnostics menu. An additional message may also be displayed to help remedy the fault. The following troubleshooting table summarizes the faults and suggests additional checks to find the cause of the problem. The following sections describe how to recover from a lockout and how to access fault information, using either the PC Interface or the Onboard Interface.

A network user's guide, available on *www.bannerengineering.com*, may be helpful if a problem with network communications occurs.

9.3.1 Fault Code Table

Fault Code	Displayed Message	Additional Message	Further Steps and Checks
0.0	Input Fault	Cycle Input	• Check for unstable input signal • Turn input OFF to clear the fault indication

Fault Code	Displayed Message	Additional Message	Further Steps and Checks
1.1	Output Fault	Check for Shorts	A safety output appears ON when it should be OFF. • Check for short to 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 46)
1.2	Output Fault	Check for Shorts	A safety output is sensing a fault to another voltage source while the output is ON. • Check for short between safety outputs • Check for short to external voltage source • Check load device compatibility (too much capacitance?) • 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 46)
1.3 – 1.4	Internal Fault		Internal failure – Contact Banner Factory (see *Repairs and Warranty Service* on page 79)
1.5	Output Fault	Check Output Wiring	A safety output appears ON prematurely. • 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 46)
1.6	Internal Fault		Internal failure – Contact Banner Engineering (see *Repairs and Warranty Service* on page 79)
1.7	Output Fault	Check for Shorts	An overload is detected on the safety outputs . • Check each output terminal for a short to ground or overload condition (a fault on only one output may cause other outputs to indicate a fault) • Verify system power supply rating with system load requirements
1.8	Internal Fault		Internal failure – Contact Banner Factory (see *Repairs and Warranty Service* on page 79)
1.9	AVM Input 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
1.10	AVM Input Fault	Perform System Reset	An AVM input associated with this safety output was not closed when the safety output was commanded to turn ON. • The AVM may be disconnected; check the wiring • Perform a System Reset to clear the fault and cause another test to occur
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	Further Steps and Checks
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	Check Terminal xx	Internal failure – Contact Banner Engineering (see *Repairs and Warranty Service* on page 79).
2.8 – 2.9	Input Fault	Check Terminal xx	Input stuck high. • Check for shorts to other inputs or other voltage source • 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 source
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 shorts to other inputs or other voltage source
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. • 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 open prior to turning ON the safety outputs. • Check for a stuck-ON contactor or relay • Check for an open wire

Fault Code	Displayed Message	Additional Message	Further Steps and Checks
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) open 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
3.6	EDMxx Fault	Check Terminal xx	• Check for a short to ground
3.7	EDMxx Fault	Check Terminal xx	• Check for shorts between inputs
4.1	Supply Voltage Low	Check 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 sending a backup copy of the configuration using the PC Interface or an XM card • Or, erase and recreate the configuration using the on-board user interface
4.3 – 4.11	Internal Fault		Internal failure – Contact Banner Engineeing (see *Repairs and Warranty Service* on page 79).
4.12	Configuration Timeout	Check Configuration	Safety Controller was left in Configuration mode for more than one hour without pressing any keys.
4.13	Configuration Timeout	Check Configuration	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	Configuration was not confirmed after being edited. • Confirm configuration using the Onboard Interface or the PC Interface
4.15 – 4.19	Internal Fault		Internal failure – Contact Banner Factory (see *Repairs and Warranty Service* on page 79)
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 – 4.33	Internal Fault		Internal failure – Contact Banner Engineering (see *Repairs and Warranty Service* on page 79).
5.1	Mute Lamp Fault	Check Lamp and Wiring	The monitored status output voltage should be low when the lamp is OFF and is sensing a high, indicating an open in the mute lamp circuit.
5.2	Mute Lamp Fault	Check for Shorts	The monitored status output voltage should be high when the lamp is ON and is sensing a low, indicating a short in the mute lamp circuit.
5.3	Internal Fault		Internal failure – Contact Banner Engineering (see *Repairs and Warranty Service* on page 79).
6.xx	Internal Fault		Invalid configuration data. Possible internal failure. • Try to load a new configuration using the PC Interface, Onboard Interface, or XM card

9.4 Recovering from a Lockout

To recover from a lockout condition:

- Follow the recommendation in the fault display
- Follow the recommended steps and checks listed in the *Fault Code Table* on page 79
- 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 79).

9.5 Fault Diagnostics

The first step in diagnosing faults via the PCI is to open the Live Display screen (see *Display Controller Information — PC Interface (PCI)* on page 68).

The Live Display screen shows in real time, the status of each safety output, which device caused an output to turn off, if any, and basic information about the Safety Controller model and the configuration.

9.5.1 Fault Log—PCI

While the Controller is powered up and connected to the PC, every fault that occurs is stored in the fault log. The PCI displays real-time fault information via the Fault Log screen shown in the following figure. The fault information includes the following information about each fault; expand the size of the window as needed to see all the faults.

- Date and time of the fault
- Device name
- General description of the fault, and
- Fault code (for lookup table reference).

Additional code information can be displayed, should factory applications assistance be required.

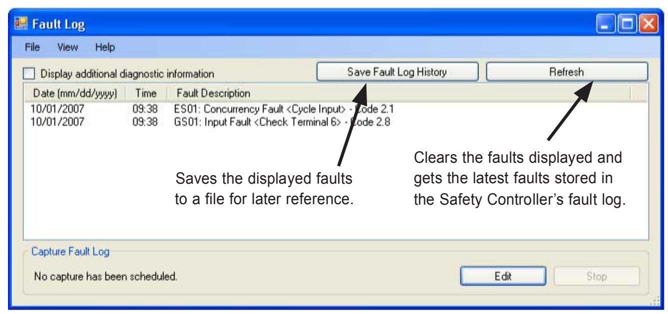


Figure 52. Fault Log screen—PCI

9.5.2 Fault Log Recording—PCI

To determine the cause of a persistent fault, compile an extended record of the faults and save it to a file. Select Edit in the Fault Log screen to establish the times at which the fault data record starts and stops. The Schedule Fault Log Capture menu will then appear.

The menu settings at right show that any fault that occurs from Friday, June 29, 2007 at 11:00 pm until Saturday, June 30, 2007 at 6:00 am will be recorded to a user-designated file for future reference.

Figure 53. Schedule Fault Log Capture menu

NOTE: The selected start and stop times must be later than the time at which this selection is made; the fault log capture will not capture past faults.

9.6 Fault Diagnostics—OBI

Troubleshooting the Controller and connected I/O devices is easy using the Onboard Interface. Any event that causes a safety output to turn OFF or stay OFF (either for fault or input stop events) will be immediately detected and displayed on the Controller's display. Further information about current and past faults can be accessed using the Fault Diagnostics menu. To get to the Fault Diagnostics menu, press OK from the Run mode menu. Select Fault Diagnostics and press OK.

The Diagnostics menu provides three choices:

- View fault conditions that currently exist
- View faults that have been stored in the fault log
- Clear the fault log

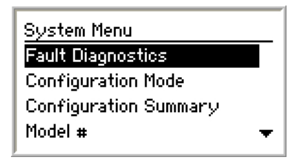


Figure 54. Select Fault Diagnostics—OBI

9.6.1 View Current Faults—OBI

To view current fault conditions, select View Current Faults using the up/down arrow buttons and press OK.

The screen shows the fault conditions that currently exist, one at a time. Use the left/right arrow keys to view all of the faults. (Shortcut: To view current faults when the Run mode screen is displayed, simply press OK three times.)

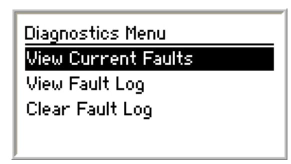


Figure 55. View current faults—OBI

- The top line of the Current Fault menu indicates which device has the fault
- The second and third lines provide a brief description of the fault
- The fourth line provides a suggestion for correcting the fault
- The fifth line provides the fault code. Use the *Fault Code Table* on page 79 to obtain more information about the fault and additional suggestions for correcting it

Use the left and right arrows (< and >) buttons to access fault information for all faulty devices.

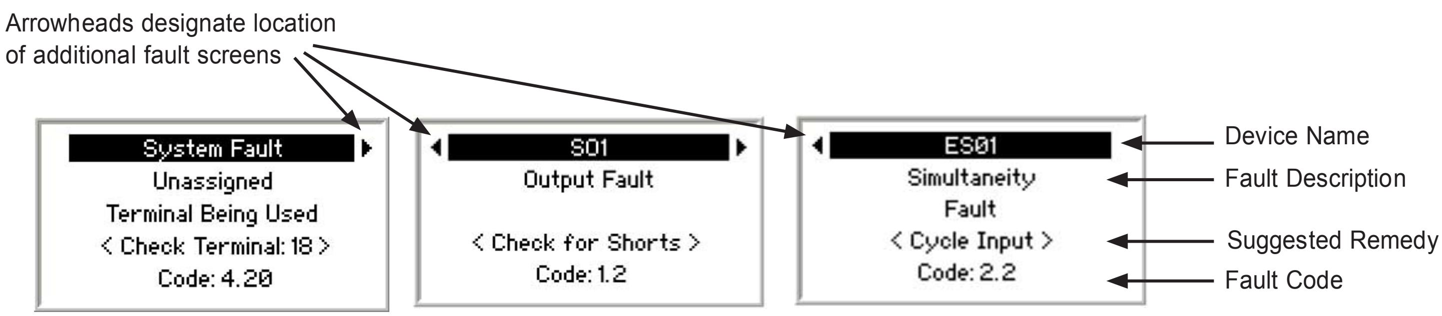


Figure 56. Current Fault screens—OBI

9.6.2 View Fault Log—OBI

The Safety Controller keeps a record of the last ten faults that have occurred. The faults are viewable from the View Fault Log menu. To view the fault log, select View Fault Log in the Diagnostics menu and press OK.

The screen shows the first fault stored in the fault log. Use the left/right arrow keys to view additional faults in the fault log.

- The top line of the fault log screen indicates which device had the fault
- The second and third lines provide a brief description of the fault

- The fourth line displays how long ago the fault occurred. For instance, a time of 01:30:23 indicates the fault occurred one hour, thirty minutes, and 23 seconds previous to the View Fault Log menu's appearance on the screen. If a fault is added to the fault log while the fault log is being viewed, the time is displayed as New Fault. If a fault is older than twenty-four hours, the time is displayed as > 24 hours
- The fifth line provides the fault code. Use the *Fault Code Table* on page 79 to obtain more information about the fault and additional suggestions for correcting it

NOTE: Removing power from the Safety Controller will clear the fault log, in addition to the method described next.

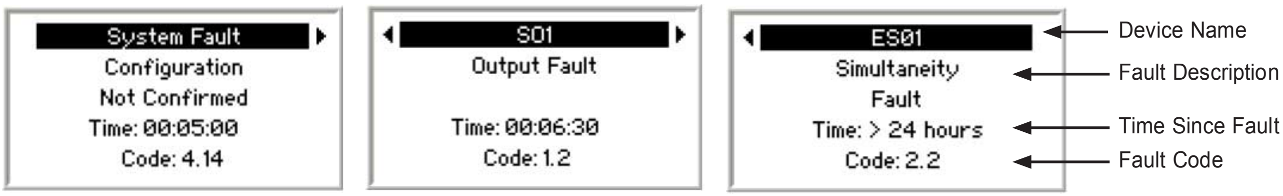


Figure 57. Fault Log screens—OBI

9.6.3 Clear Fault Log—OBI

To clear the fault log, select Clear Fault from the Diagnostics menu and press OK.

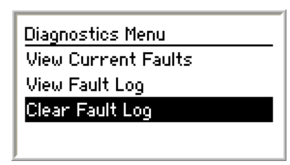


Figure 58. Clearing the fault log—OBI

When the fault is cleared, press OK to return to the Fault Diagnostics menu, then press ESC twice to return to the Run mode menu.

Figure 59. Fault log is cleared—OBI

10 Input Device and Safety Category Reference

For ease in finding information about them, the specific device types discussed are presented in the following order.

Follow the device manufacturer's installation, operation, and maintenance instructions and all relevant regulations. If there is any question about the device(s) that are to be connected to the Safety Controller, contact a Banner Applications Engineer for assistance.

10.1 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.

10.1.1 Safety Circuit Integrity Levels

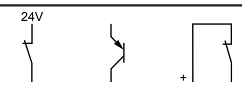
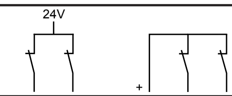
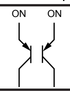
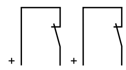
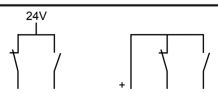
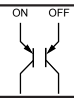
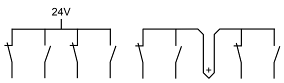
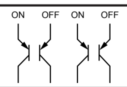
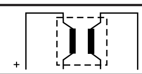
The safety circuits in International and European standards have been segmented into categories, depending on their ability to maintain their integrity in the event of a failure. The most recognized standard that details safety circuit integrity levels is ISO 13849-1, which establishes five levels: Categories B, 1, 2, 3, and 4 (most strict).

In the United States, the typical level of safety circuit integrity is called *control reliability*. Control reliability typically incorporates redundant control and self-checking circuitry and is relatively similar to ISO 13849-1 Categories 3 and 4 (see CSA Z432 and ANSI B11.19).

Perform a risk assessment to determine the appropriate category to make sure that the expected risk reduction is achieved to implement the requirements described by ISO 13849-1. This risk assessment must also take into account the national regulations, such as U.S. control reliability or European "C" level standards, to comply with the mandated minimum levels of performance.

The following sections deal only with Category 2, Category 3, and Category 4 applications, as described by ISO 13849-1 (1999). The following figure provides a snapshot of the possible safety categories that can be achieved for each device type, depending on the selected circuit option.

Refer to the text sections following, as well as the appropriate standards, for further information.

Circuit Symbol	E-Stop	Safety Gate	Optical Sensor	Two-Hand Control	Rope Pull	Protect. Stop	Safety Mat	Enabling Device
	Cat. 2	Cat. 2	Cat. 2	—	Cat. 2	Cat. 2	—	—
	Cat. 3	Cat. 2 Cat. 3	Cat. 2 Cat. 3	Type IIIa Cat. 1 Type IIIb Cat. 3	Cat. 3	Cat. 2 Cat. 3	—	Cat. 2 Cat. 3
	Cat. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3 Cat. 4	Type IIIa Cat. 1	Cat. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3 Cat. 4	—	Cat. 2 Cat. 3 Cat. 4
	Cat. 4	Cat. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3 Cat. 4	Type IIIa Cat. 1 Type IIIb Cat. 3	Cat. 4	Cat. 2 Cat. 3 Cat. 4	—	Cat. 2 Cat. 3 Cat. 4
	—	Cat. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3 Cat. 4	—	Cat. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3 Cat. 4	—	Cat. 2 Cat. 3 Cat. 4
	—	Cat. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3 Cat. 4	—	Cat. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3 Cat. 4	—	Cat. 2 Cat. 3 Cat. 4
	—	Cat. 3 Cat. 4	—	Type IIIc Cat. 4	—	—	—	Cat. 3 Cat. 4
	—	Cat. 3 Cat. 4	—	Type IIIc Cat. 4	—	—	—	Cat. 3 Cat. 4
	—	—	—	—	—	—	Cat. 2 Cat. 3	—

NOTES
- Cat. B or 1 is assumed when not using safety-rated devices.
- All safety input device contacts are shown in the ON/active state (for example, E-stop in the armed state, safety gate in the closed state, light screen in the clear state, etc.)
- Cat. B/1, 2, 3 and 4 are per ISO 13849-1, except for two-hand control.
- Two-hand categories are per ISO 13851.

Figure 60. Input devices, circuit options, and their potential safety categories

Important: Complementary (2 or 3 terminals) and Complementary (PNP device): In the actuated condition (for example, S1 closed/S2 open), a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time, see *Safety Input Device Properties* on page 27.

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 Solid State Outputs

The Safety Controller will not detect shorts between inputs or from an input to +24 V if the input signals on these terminals are coming from input devices with Solid State Outputs.

The user is responsible to use a device that can detect these shorts.

> 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.

10.1.2 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.

10.2 Protective (Safety) Stop

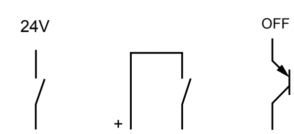
A Protective (Safety) Stop is designed for the connection of miscellaneous devices (not otherwise listed on the “Add Safety Device” screen) that could include safeguarding (protective) devices and complementary equipment. This stop function is a type of interruption of operation that allows an orderly cessation of motion for safeguarding purposes. The function can be reset or activated either automatically or manually.

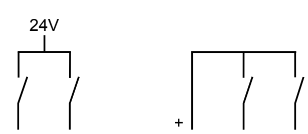
10.2.1 Protective (Safety) Stop Requirements

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 86). 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.

10.2.2 Protective (Safety) Stop Hookup Options

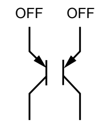
The device is shown in the Off (Stop) state.

Single-Channel (1 terminal, 2 terminals, or PNP device)	
This circuit typically meets ISO 13849-1 Category 2 requirements, depending on the safety rating and the installation of the device. At a minimum, a safety-rated device must be used to achieve Category 2. The 1-terminal and the PNP device circuits cannot detect a short circuit to another source of power. The two-terminal circuit uses pulse monitoring and can detect a short circuit to another source of power. Fault Exclusion must be used to achieve a higher level of safety circuit integrity.	

Dual-Channel (2 or 3 terminals)	
This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements, depending on the safety rating and the installation of the device. The Dual Channel 3-terminal hookup uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal circuits can detect a short between channels when the contacts are open for more than 2 seconds.	

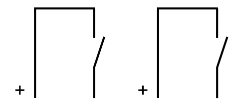
Dual-Channel (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating, installation, and the fault detection (such as short circuit) capabilities of the device. The Safety Controller does not provide short circuit detection in this configuration.



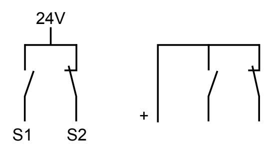
Dual-Channel (4 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements, depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels or to another source of power.



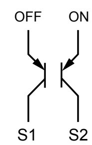
Complementary (2 or 3 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time.



Complementary (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



10.3 Interlocked Guard or Gate

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

10.3.1 Safety Circuit Integrity Levels

The application requirements for interlocked guards or gates vary for the level of control reliability or safety category per ISO 13849-1. 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 86 for guidance if the requirements as described by ISO 13849-1 need to be implemented.

In addition to the requirements stated in this section, the design and installation of the interlocking device should comply with ANSI B11.19 or ISO14119.

10.3.2 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.

Positive-Opening Safety Interlocking Switches

Safety interlock switches must satisfy several requirements. Each switch must provide electrically isolated contacts: at minimum, one normally closed (N.C.) contact from each individually mounted switch. The contacts must have positive-opening (direct-opening) design, as described by IEC 60947-5-1, with one or more normally closed contacts rated for safety. Positive-opening operation causes the switch to be forced open, without the use of springs, when the switch actuator is disengaged or moved from its home position (visit *www.bannerengineering.com* for examples).

In addition, the switches must be mounted in a positive mode to move/disengage the actuator from its home position and open the normally closed contact when the guard opens.

Magnetically Operated Safety Interlocking Switches

In higher levels of safety performance the design of a dual-channel magnetic switch typically uses complementary switching in which one channel is open and one channel is closed at all times. This provides redundancy (two contacts) and diversity (different principles of operation) to minimize the possibility of the loss of the switching function due to common mode failures, such as secondary magnetic fields. The circuitry or the Safety Controller that is monitoring the magnetic switch detects and responds to a failure that results in the loss of the complementary state (for example, a short circuit between the channels, or a short circuit to other sources of power).

Coded and non-coded magnetic switches affect the ability of the switch to be defeated and to withstand common mode failures. Non-coded switches are easily defeated by the presence of a simple magnetic field and should be mounted in a concealed position. A coded magnetic switch that uses alternating magnetic poles should be used in applications that require higher levels of safety performance.

The switch and its magnet must be mounted a minimum distance from any magnetized or ferrous materials for proper operation. If either the switch or magnet is mounted on a material that can be magnetized, the switching distance will be affected. This distance is stated by the manufacturer.

Monitoring Series-Connected Safety Interlock Switches

When monitoring two individually mounted safety switches (as shown in the Category 4 circuit figure), a faulty switch will be detected if it fails to switch when the guard opens. In this case, the Controller de-energizes its safety outputs (OSSDs) and disables its reset function until the input requirements are met, such as the replacement of the faulty switch. However, when multiple safety interlock switches are series-connected, the failure of one switch in the system may be masked or not be detected at all (refer to Category 3 and 4 circuit figures).

Series-connected safety interlock switch circuits may not meet OSHA Control Reliability or ISO 13849 Safety Category 4 requirements because of the potential of an inappropriate reset or a potential loss of the safety stop signal. Those requirements are not met due to the typical inability to fault exclude the failure of the safety interlock switch. A multiple connection of this type should not be used in applications where loss of the safety stop signal or an inappropriate reset can lead to serious injury or death. The following scenarios assume two positive-opening safety switches on each guard, both connected in series to switches of a second guard:

1. Masking of a failure. If a guard is opened but the switch fails to open, the redundant safety switch will open and cause the Controller to de-energize its outputs. If the faulty guard is then closed, both Controller input channels also close, but because one channel did not open, the Controller will not reset. However, if the faulty switch is not replaced and a second functional guard is cycled (opening and then closing both of the Controller's input channels), the Controller considers the failure to be corrected. With the input requirements apparently satisfied, the Controller allows a reset. This system is no longer redundant and, if the second switch fails, may result in an unsafe condition, such as the accumulation of faults resulting in loss of the safety function.
2. Non-detection of a failure. If a functional guard is opened, the Safety Controller de-energizes its outputs (a normal response). But if then a faulty guard is opened and closed before the functional guard is re-closed, the faulty guard is not detected. This system is no longer redundant and may result in a loss of safety if the second safety switch fails to switch when needed.

The systems in either scenario do not inherently comply with the safety standard requirements of detecting single faults and preventing the next cycle. It is important to periodically check the functional integrity of each interlocked guard individually in multiple-guard systems using series-connected safety interlock switches. Operators, maintenance personnel, and others associated with the operation of the machine must be trained to recognize such failures and be instructed to correct them immediately.

To verify series-connected safety interlock switch functionality:

Open and close each safeguard separately while verifying that the Controller outputs operate correctly throughout the check procedure. Follow each safeguard closure with a manual reset, if needed. If a contact set fails, the Controller will not enable its reset function. If the Controller does not reset, a switch may have failed; that switch must be immediately replaced.

This check must be performed and all faults must be cleared, at a minimum, during periodic checkouts. Do not use the series connection of the safety interlock switches if the application cannot exclude these types of failures and such a failure could result in serious injury or death.

Series Connection and Safety Circuit Integrity Considerations

Category 2 Interlocked Guard Circuit

A single-channel interlocked guard application typically provides a Category 2 level of circuit performance because a short circuit could cause a loss of safety function. The principle of fault exclusion must be incorporated into the design and installation to either eliminate, or reduce to an acceptable (minimal) level of risk, the possibility of faults that can result in a loss of the safety function.

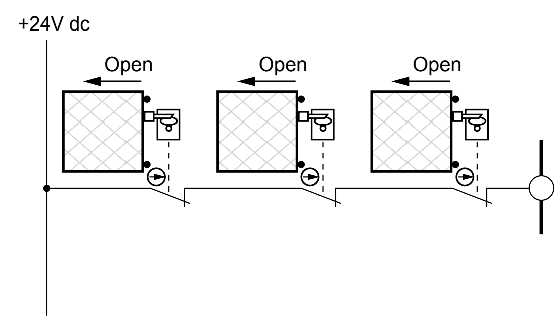


Figure 61. Category 2 Interlocked Guard Circuit

Category 3 Interlocked Guard Circuit

A dual-channel hookup switching +24V dc is typically a Category 3 application because a single failure does not result in a loss of safety. Loss of the switching action in one channel is detected by the actuation of opening and closing the guard, allowing the monitoring function of the safety inputs to detect the discrepancy between the channels. However, a short circuit between input channels or Safety Outputs may not be detected. It should be noted that an accumulation of faults may cause a loss of the safety function. The principle of fault exclusion must be incorporated into the design and installation to either eliminate, or reduce to an acceptable (minimal) level of risk, the possibility of undetected faults or catastrophic or common mode failures that could result in the loss of safety function.

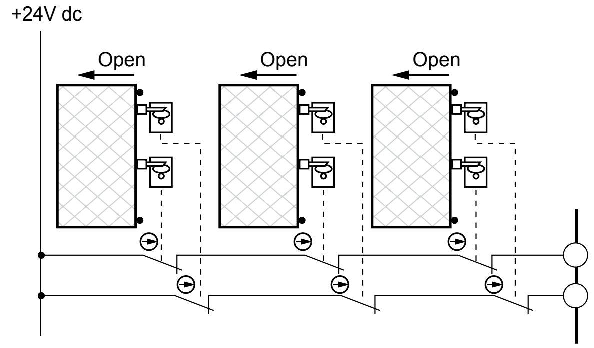


Figure 62. Category 3 Interlocked Guard Circuit

Category 4 Interlocked Guard Circuit

The self-monitoring safety inputs can be interfaced to achieve a Category 4 level of safety. The principle of fault exclusion must be incorporated into the design and installation to either eliminate, or reduce to an acceptable (minimal) level of risk, the possibility of catastrophic or common mode failures that could result in loss of the safety function.

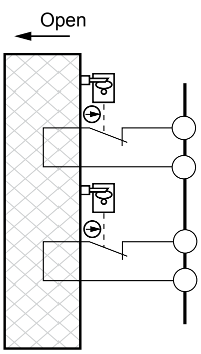
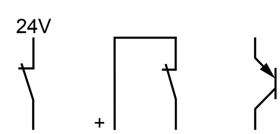


Figure 63. Category 4 Interlocked Guard Circuit

Interlock Switch Hookup Options

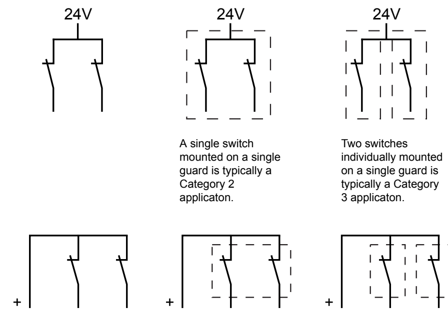
All figures show the guard (gate) in the closed (Run) state.

The safety contact is considered to be the normally closed contact that is of a positive-opening design (unless otherwise noted), normally marked with the  symbol.

Single-Channel (1 terminal, 2 terminals, or PNP device)	
This circuit typically meets ISO 13849-1 Category 2 requirements, depending on the safety rating and the installation of the device. At a minimum, a safety-rated device must be used to achieve Category 2. The 1-terminal and the PNP device circuits cannot detect a short circuit to another source of power. The two-terminal circuit uses pulse monitoring and can detect a short circuit to another source of power. Fault Exclusion must be used to achieve a higher level of safety circuit integrity.	

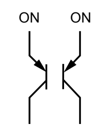
Dual-Channel (2 or 3 terminals)

This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements, depending on the safety rating and the installation of the device. The Dual Channel 3-terminal hookup uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal circuits can detect a short between channels when the contacts are open for more than 2 seconds.



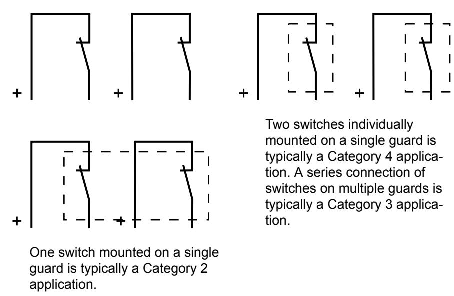
Dual-Channel (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating, installation, and the fault detection (such as short circuit) capabilities of the device. The Safety Controller does not provide short circuit detection in this configuration.



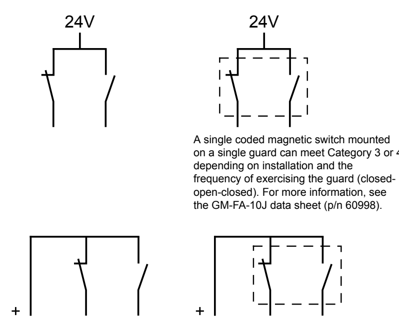
Dual-Channel (4 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements, depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels or to another source of power.



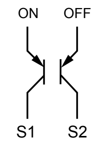
Complementary (2 or 3 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



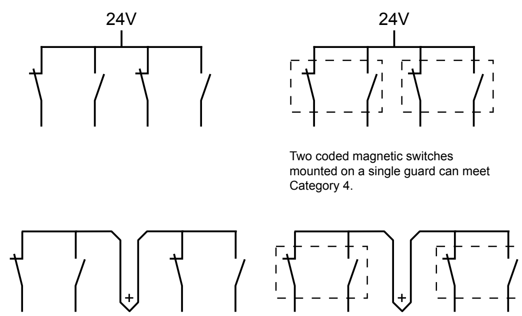
Complementary (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



2x Complementary (4 or 5 terminals)

This circuit meets ISO 13849-1 Category 3 or Category 4 requirements depending on the safety rating and the design and installation of the enabling device. This circuit can detect a short circuit between channels. In the guard closed condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time.



NOTE: Coded magnetic switches typically use this hookup option.

2x Complementary (PNP device)

This circuit meets ISO 13849-1 Category 3 or Category 4 requirements depending on the safety rating design and installation of the enabling device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. *Safety Input Device Properties* on page 27.

10.4 Optical Sensor

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

10.4.1 Safety Circuit Integrity Levels

The application requirements for optical safeguarding vary for the level of control reliability or safety category per ISO 13849-1. 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 86 for guidance if the requirements as described by ISO 13849-1 need to be implemented.

In addition to the requirements stated in this section, the design and installation of the optical safeguarding device must comply with ANSI B11.19 or IEC61496 (all parts).

10.4.2 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.

> 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.

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. For the purpose of the calculation, the Safety Controller default response is 0.010 seconds, plus any additional closed-to-open debounce time. If the debounce time is adjusted, the time in excess of 6 ms (default closed-to-open debounce time) must be added to the stated response. See *Response and Recovery Times* on page 23 and *Run Mode* on page 61, and *Onboard Interface (OBI) Overview* on page 59 for instructions on accessing device-specific response times.

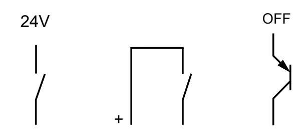
If the application includes a pass-through hazard (a person could pass through the optical device beams and stand undetected on the hazard side), other safeguarding may be required, and manual reset should be selected (see *Input Device Resets* on page 31).

10.4.3 Optical Sensor Hookup Options

The device is shown in the actuated, in the Normally Open (Off) state.

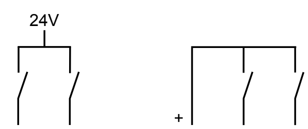
Single-Channel (1 terminal, 2 terminals, or PNP device)

This circuit typically meets ISO 13849-1 Category 2 requirements, depending on the safety rating and the installation of the device. At a minimum, a safety-rated device must be used to achieve Category 2. The 1-terminal and the PNP device circuits cannot detect a short circuit to another source of power. The two-terminal circuit uses pulse monitoring and can detect a short circuit to another source of power. Fault Exclusion must be used to achieve a higher level of safety circuit integrity.



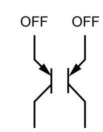
Dual-Channel (2 or 3 terminals)

This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements, depending on the safety rating and the installation of the device. The Dual Channel 3-terminal hookup uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal circuits can detect a short between channels when the contacts are open for more than 2 seconds.



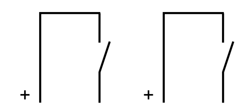
Dual-Channel (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating, installation, and the fault detection (such as short circuit) capabilities of the device. The Safety Controller does not provide short circuit detection in this configuration.



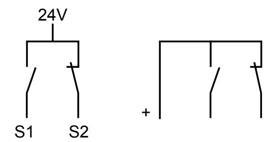
Dual-Channel (4 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements, depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels or to another source of power.



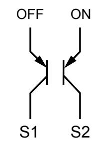
Complementary (2 or 3 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time.



Complementary (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



10.5 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.

Using a two-hand control system makes the operator, in effect, a "hostage" while the hazard is present, thus limiting or preventing exposure to the hazard. 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 97).

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

See *Two-Hand Control (THC)* on page 33 for more information.

> 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. See *Two-Hand Control Hookup Options* on page 98.

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

When used in a single-cycle or single-stroke mode, the machine control must provide an anti-repeat feature so that the operator must release the two-hand control actuators after each machine cycle, before a new cycle can be initiated. In addition to the anti-repeat of the machine control, the Safety Controller input(s) can also be used to halt a machine cycle and help in providing Anti-Repeat Control.

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.

10.5.1 Two-Hand Control Safety Distance (Minimum Distance)

Both hand controls must be located far enough away from the nearest hazard point that the operator cannot reach the hazard with a hand or other body part before the hazardous motion ceases. This is the “separation distance” (“safety distance”), and may be calculated as follows.

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

U.S. Applications

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.

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

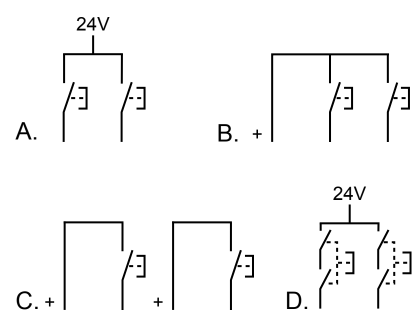
C
: the added distance due to the depth penetration factor equals 250 mm, per ISO 13855. The ISO 13855 C factor may be reduced to 0 if the risk of encroachment is eliminated, but the safety distance must always be 100 mm or greater

10.5.2 Two-Hand Control Hookup Options

The device is shown not actuated (Off state). See ISO 13851 for a complete explanation of “Type” designations and ISO 13849-1 Category requirements.

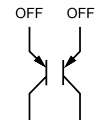
Dual-Channel (2, 3, or 4 terminals)

This circuit is a Type IIIa Two-Hand Control circuit as described by ISO 13851, and typically meets ISO 13849-1 Category 1 requirements. Type IIIb and Category 3 may be achieved if redundant contacts from each hand control are used in each channel, for example, two each in series (as shown in image D), or with a 3-terminal hookup that uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal hookups can detect a short between channels when the contacts are open if the short is present for more than 2 seconds. The 4-terminal circuit can detect a short circuit between channels or to another source of power (image C).



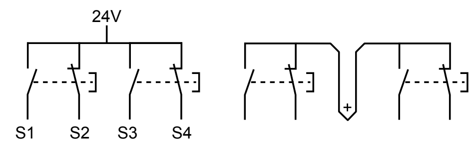
Dual-Channel (PNP device)

This circuit is a Type IIIa Two-Hand Control circuit as described by ISO 13851, and typically meets ISO 13849-1 Category 1 requirements. The Safety Controller does not provide short circuit detection between channels in this configuration.



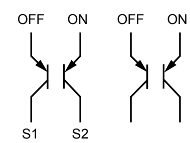
2x Complementary (4 or 5 terminals)

This circuit is a Type IIIc Two-Hand Control circuit as described by ISO 13851, and typically meets ISO 13849-1 Category 4 requirements. In the actuated condition (S1 closed/S2 open), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. Select this option if using Banner Self-checking Touch Button models STBVR81... See *Safety Input Device Properties* on page 27.



2x Complementary (PNP device)

This circuit is a Type IIIc Two-Hand Control circuit as described by ISO 13851, and typically meets ISO 13849-1 Category 4 requirements. In the actuated condition (S1 On/S2 Off), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. Select this option if using Banner Self-checking Touch Buttons models STBVP6... See *Safety Input Device Properties* on page 27.



10.6 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 100).

> 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.

10.6.1 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.

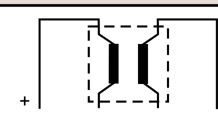
The four-wire connection between the interconnect cables and the sensor must withstand dragging or carrying the sensor by its cable without failing in an unsafe manner, such as broken connections due to sharp or steady pulls, or continuous flexing. If such connection is not available, an alternative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

10.6.2 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.	

10.6.3 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).

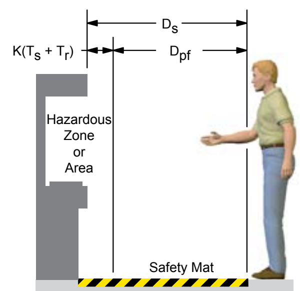


Figure 64. Determining safety distance for the safety mat

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

10.7 Emergency Stop Push Buttons

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

10.7.1 Safety Circuit Integrity Levels

The application requirements for emergency stop buttons vary for the level of control reliability or safety category per ISO 13849-1. 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 86 for guidance if the requirements as described by ISO 13849-1 need to be implemented.

In addition to the requirements stated in this section, the design and installation of the interlocking device must comply with In addition to the requirements stated in this section, the design and installation of the Emergency Stop device must comply with ANSI NFPA79 or ISO 13850.

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.

10.7.2 Emergency Stop Push Button Requirements

As shown in the following circuit figures, the 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.

Safety Circuit Integrity Levels and Multiple E-Stop Buttons

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 86 for guidance if the requirements as described by ISO 13849-1 need to be implemented.

In addition to ANSI NFPA 79 and IEC/EN 60204-1, the design and the installation of the emergency stop device (switch, button, or rope-pull) must be such that the possibility of a catastrophic failure of the device resulting in the loss of the safety function is excluded. The device must comply with ISO 13850 requirements such that the fault exclusions of ISO 13849-2 are applicable. Electromechanical devices that have contacts designed in accordance to IEC 60947-5-1 Annex K and that are installed according to manufacturer's instructions are expected to open when the emergency stop device is actuated.

WARNING: Multiple Switching Devices

Whenever two or more devices are connected to the same safety module (controller):

- Contacts of the corresponding pole of each switch must be connected together in series. *Never connect the contacts of multiple switches in parallel.* Such a parallel connection defeats the switch contact monitoring ability of the Module and creates an unsafe condition which may result in serious injury or death.
- Each device must be individually actuated (engaged), then released (or re-armed) and the safety module reset. This allows the module to check each switch and its wiring to detect faults.

This check must be performed during the prescribed checkouts. Failure to test each device individually in this manner may result in undetected faults and create an unsafe condition which may result in serious injury or death.

Category 2 E-Stop Circuit

A single-channel emergency stop application typically provides a Category 2 level of circuit performance, because a short circuit could cause the loss of the safety function. The principle of fault exclusion must be incorporated into the design and installation to either eliminate, or reduce to an acceptable (minimal) level of risk, the possibility of undetected faults or failures that result in a loss of the safety function.

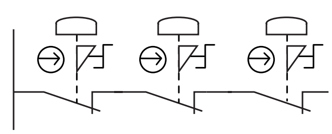


Figure 65. Category 2 E-stop circuit

Category 3 E-Stop Circuit

A dual-channel hookup switching +24V dc is typically a Category 3 application, because a single failure does not result in a loss of safety. A loss of the switching action in one channel is detected by the actuation of the E-stop button, the opening of the second channel, and the monitoring function of the safety inputs. However, a short circuit between input channels or safety outputs may not be detected. Note that an accumulation of faults may cause the loss of the safety function.

The principle of fault exclusion must be incorporated into the design and installation to either eliminate, or reduce to an acceptable (minimal) level of risk, the possibility of undetected faults or catastrophic failures that result in a loss of the safety function.

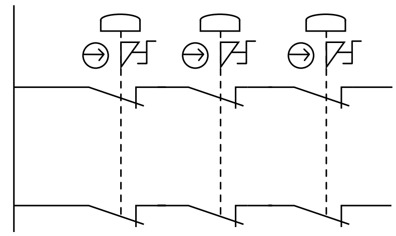


Figure 66. Category 3 E-stop circuit

Category 4 E-Stop Circuit

The self-monitoring safety inputs can be interfaced to achieve a Category 4 application. The principle of fault exclusion must be incorporated into the design and installation to either eliminate, or reduce to an acceptable (minimal) level of risk, the possibility of catastrophic failures or faults that result in a loss of the safety function.

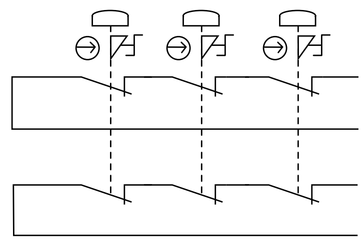
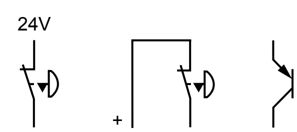
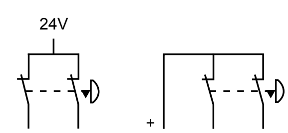
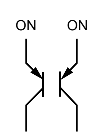


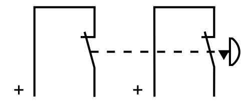
Figure 67. Category 4 E-stop circuit

Emergency Stop Hookup Options

The device is shown in the armed (Run) state.

Single-Channel (1 terminal, 2 terminals, or PNP device)
This circuit typically meets ISO 13849-1 Category 2 requirements, depending on the safety rating and the installation of the device. At a minimum, a safety-rated device must be used to achieve Category 2. The 1-terminal and the PNP device circuits cannot detect a short circuit to another source of power. The two-terminal circuit uses pulse monitoring and can detect a short circuit to another source of power. Fault Exclusion must be used to achieve a higher level of safety circuit integrity. 
Dual-Channel (2 or 3 terminals)
This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements, depending on the safety rating and the installation of the device. The Dual Channel 3-terminal hookup uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal circuits can detect a short between channels when the contacts are open for more than 2 seconds. 
Dual-Channel (PNP device)
This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating, installation, and the fault detection (such as short circuit) capabilities of the device. The Safety Controller does not provide short circuit detection in this configuration. 

Dual-Channel (4 terminals)
This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements, depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels or to another source of power.



10.8 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 102 for additional information.

It is recommended to use rope pull emergency stop switches that have the capability not only to react to a pull in any direction, but also to a slack or a break of the rope. Typically, this is accomplished by separate contacts within the switch. When the rope is properly tensioned, both contacts of the switch are closed. When the rope is pulled, the positive-break contacts open. If the rope breaks or goes slack, the second set of contacts opens (see *Rope/Cable Pull Hookup Options* on page 105).

Some rope pull emergency stop switches provide a latching function that requires a manual reset after actuation. If using a switch that does not provide a latching function after the rope is released, a separate latching circuit is required, which can be provided by the Safety Controller.

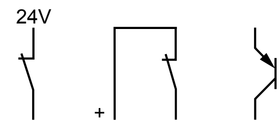
10.8.1 Rope/Cable Pull Installation Guidelines

- The wire rope should be easily accessible 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
- The rope should be free of friction at all supports. Pulleys are recommended.
- Use pulleys when routing the rope around a corner, or whenever direction is changed, even slightly
- Never run rope through conduit or other tubing
- Never attach weights to the rope
- Temperature affects rope tension. The rope expands (lengthens) when temperature increases, and contracts (shrinks) when temperature decreases. Significant temperature variations require frequent checks of the tension adjustment.
- Do not exceed the manufacturer’s recommended maximum rope length
- Mount the switch securely on a solid, stationary surface
- The anchor point for rope must be solid and stationary, and be able to withstand the constant tension of the rope
- Each rope pull emergency stop installation should be tested and inspected for proper operation at suitable intervals as determined by the user’s risk assessment, based upon severity of the operating environment and the frequency of switch actuations
- Pulleys and other moving parts associated with the rope should be periodically lubricated

10.8.2 Rope/Cable Pull Hookup Options

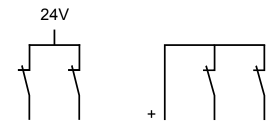
The device is shown in the armed (Run) state.

Single-Channel (1 terminal, 2 terminals, or PNP device)
This circuit typically meets ISO 13849-1 Category 2 requirements, depending on the safety rating and the installation of the device. At a minimum, a safety-rated device must be used to achieve Category 2. The 1-terminal and the PNP device circuits cannot detect a short circuit to another source of power. The two-terminal circuit uses pulse monitoring and can detect a short circuit to another source of power. Fault Exclusion must be used to achieve a higher level of safety circuit integrity.



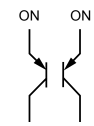
Dual-Channel (2 or 3 terminals)

This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements, depending on the safety rating and the installation of the device. The Dual Channel 3-terminal hookup uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal circuits can detect a short between channels when the contacts are open for more than 2 seconds.



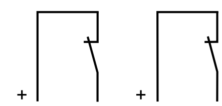
Dual-Channel (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating, installation, and the fault detection (such as short circuit) capabilities of the device. The Safety Controller does not provide short circuit detection in this configuration.



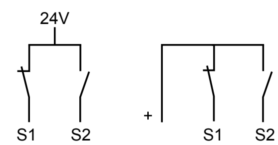
Dual-Channel (4 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements, depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels or to another source of power.



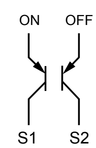
Complementary (2 or 3 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



Complementary (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



10.9 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.

See section *Enabling Devices* on page 34 for more information.

10.9.1 Enabling Device Guidelines

Depending on the application, the use of the enabling device may require supervision and allow only limited machine operation when the individual actuating the device is exposed to a hazardous situation. When the enabling device is in use, the control of the machine motion must be prevented from other sources that would override the function of the enabling device. Simply actuating the enabling device must not create a hazard.

An enabling device allows a hazardous situation when continuously actuated in one position only. In any other position, the hazard must be eliminated and the start function inhibited.

Many standards require the use of three-position devices due to an individual's reaction to either release or tighten the grip in an emergency situation.

- Position #1: the Off function of the switch (actuator is not operated)
- Position #2: the enabling function (actuator is operated in its midpoint)
- Position #3: the Off function of the switch (actuator is operated past its midpoint)

The release or compression past the midpoint-enabled position (Position #2) of the device must initiate an immediate stopping of hazardous motion or situation. It is required that the enabling device is released and re-actuated before the machine motion is reinitiated.

Two-position types (if allowed) are:

- Position #1: the Off function of the switch (actuator is not operated)
- Position #2: the enabling function (actuator is operated)

The stop function must be either a functional stop Category 0 or a Category 1 (see ANSI NFPA79 Section 9). The design and installation of the enabling device must consider the ergonomic issues (force, posture, etc.) of sustained activation. A visual confirmation that the device is active may be required.

Only trained and qualified individuals are allowed to operate the enabling device if it is bypassing other safeguards. Safe work procedures must include, but are not limited to, the use of the device, the associated hazards, and the task requiring the use of the device.

If more than one individual is safeguarded by the use of the enabling device, all individuals must have their own device. Each enabling device must be concurrently operated before machine motion can be initiated.

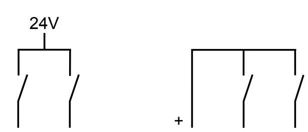
The method to return the machine to production mode must be located outside the hazardous area, where it cannot be reached from within that area and is guarded against unintended operation. In addition, the reset switch operator must have the full view of the entire guarded area and verify that the area is clear of individuals during the reset procedure.

10.9.2 Enabling Device Hookup Options

The device is shown in the actuated position (Stop state).

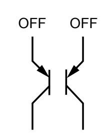
Dual-Channel (2 or 3 terminals)

This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements, depending on the safety rating and the installation of the device. The Dual Channel 3-terminal hookup uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal circuits can detect a short between channels when the contacts are open for more than 2 seconds.



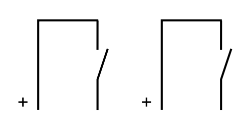
Dual-Channel (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating, installation, and the fault detection (such as short circuit) capabilities of the device. The Safety Controller does not provide short circuit detection in this configuration.



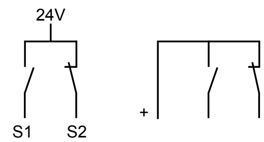
Dual-Channel (4 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements, depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels or to another source of power.



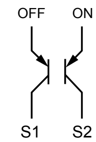
Complementary (2 or 3 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time.



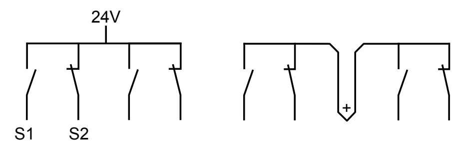
Complementary (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



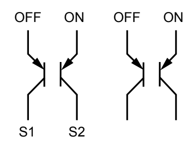
2x Complementary (4 or 5 terminals)

This circuit meets ISO 13849-1 Category 3 or Category 4 requirements depending on the safety rating and the design and installation of the enabling device. This circuit can detect a short circuit between channels. In the guard closed condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



2x Complementary (PNP device)

This circuit meets ISO 13849-1 Category 3 or Category 4 requirements depending on the safety rating design and installation of the enabling device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. *Safety Input Device Properties* on page 27.



10.10 Bypass Switches (Bypassing Safeguards)

The Safety Controller may be used to monitor switches that initiate the bypassing of a safeguarding device.

Bypassing or overriding a safeguarding device is the manual interruption or suspension of the normal function of a safeguard under supervisory control. 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.

See *Bypass Function* on page 36 for more information.

10.10.1 Requirements of Bypassing Safeguards

Requirements to bypass a safeguarding device include[8]:

- 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

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

- 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.

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.

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.

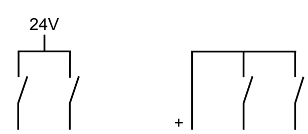
> **WARNING: Limit Use of Bypass Function**
>
> The Bypass function is not intended for production purposes; it is to be used only for temporary or intermittent actions, such as to clear the defined area of a safety light screen if material becomes "stuck". When Bypass is used, it is the user's responsibility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

10.10.2 Bypass Switch Hookup Options

The device is shown in the not actuated (Off) state.

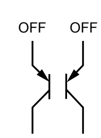
Dual-Channel (2 or 3 terminals)

This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements, depending on the safety rating and the installation of the device. The Dual Channel 3-terminal hookup uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal circuits can detect a short between channels when the contacts are open for more than 2 seconds.



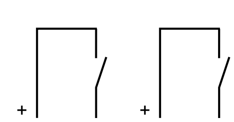
Dual-Channel (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating, installation, and the fault detection (such as short circuit) capabilities of the device. The Safety Controller does not provide short circuit detection in this configuration.



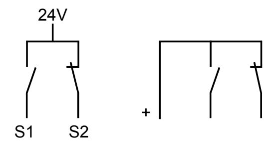
Dual-Channel (4 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements, depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels or to another source of power.



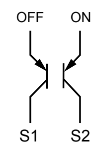
Complementary (2 or 3 terminals)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time.



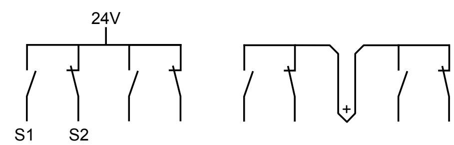
Complementary (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



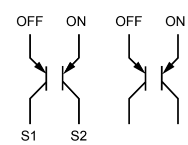
2x Complementary (4 or 5 terminals)

This circuit meets ISO 13849-1 Category 3 or Category 4 requirements depending on the safety rating and the design and installation of the enabling device. This circuit can detect a short circuit between channels. In the guard closed condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. See *Safety Input Device Properties* on page 27.



2x Complementary (PNP device)

This circuit meets ISO 13849-1 Category 3 or Category 4 requirements depending on the safety rating design and installation of the enabling device. This circuit can detect a short circuit between channels. In the actuated condition (S1 Off/S2 On), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time. *Safety Input Device Properties* on page 27.



10.11 Mute Sensor Pair

10.11.1 Muting Function

OSHA and ANSI 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.

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

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 the 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.

See *Mute Function* on page 34 for more information.

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 (per OSHA 1910.217(c)(3)(iii)(d), and ANSI B11.19).

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.

10.11.2 Muting Function Requirements

The beginning and the end of a mute cycle must be triggered by outputs from either pair of muting devices, depending on the application. The mute device pairs both must have normally open contacts, or have PNP outputs, both of which fulfill the Muting Device Requirements. These contacts must close (conduct) when the switch is actuated to initiate the mute, and must open (not conduct) when the switch is not actuated and in a power-off condition.

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.

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), 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.

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.

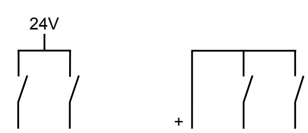
10.11.3 Muting Device Hookup Options

The Controller provides configuration options for the muting devices. One or two pairs of muting devices (typically sensors or switches) must be used; these pairs are designated M1-M2 and M3-M4. In the circuit diagrams below, it is assumed that each contact or output is being generated by an individual device for category 3 and category 4.

To meet category 4 requirements for the category 3 hookups shown, design or otherwise eliminate the possibility of a short circuit between muting sensors (input channels); see *Fault Exclusion* on page 88.

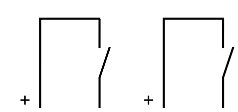
Dual-Channel (2 or 3 terminals)

This circuit typically meets ISO 13849-1 Category 2 or Category 3 requirements, depending on the safety rating and the installation of the device. The Dual Channel 3-terminal hookup uses pulse monitoring and can detect a short circuit to another source of power. Both 2- and 3-terminal circuits can detect a short between channels when the contacts are open for more than 2 seconds.



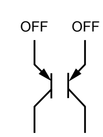
Dual-Channel (4 terminals)

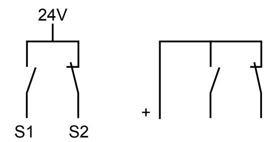
This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements, depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels or to another source of power.

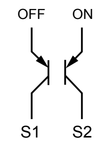


Dual-Channel (PNP device)

This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating, installation, and the fault detection (such as short circuit) capabilities of the device. The Safety Controller does not provide short circuit detection in this configuration.



Complementary (2 or 3 terminals)	
This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. In the actuated condition (S1 open/S2 closed), as shown, a short across the closed contact may cause the response time to increase based on the debounce time. In this situation, the response time may be longer than specified, based on the selected debounce time.	

Complementary (PNP device)	
This circuit meets ISO 13849-1 Category 2, 3, or 4 requirements depending on the safety rating and the installation of the device. This circuit can detect a short circuit between channels. See *Safety Input Device Properties* on page 27.	

10.11.4 Mute Enable (ME)

The Mute Enable input is a non-safety-rated input. When the input is closed, 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

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) 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 timing requirement for the closed-open-closed is similar to the manual reset function. Initially, the input needs to be active (closed) for longer than 1/4 second, then open for longer than 1/4 second, but not longer than 2 seconds, and then must re-close to reset the simultaneity timer. The function can reset the timer only once per mute cycle (all mute inputs M1-M4 must open before another reset can occur).

10.11.5 Mute Lamp Output (ML)

Some applications require that a lamp (or other means) is used to indicate when the safety device, for example, a light screen, is muted; the Safety Controller provides this through the status outputs. If a monitored output signal is required (see Warning below), status outputs O9 and O10 can be configured for a monitored output. The monitored output prevents the initiation of a mute after an indicator failure is detected. If the application requires compliance with UL 61496, Lamp Monitoring must be selected and the lamp used must meet applicable requirements.

> WARNING:
>
> Indication that the safety device is muted must be provided and be readily observable.
>
> Failure of this indication should be detectable and prevent the next mute, or operation of the indicator should be verified at suitable intervals.
>
> Lamp monitoring must be selected if the application requires compliance with UL 61496.

10.11.6 Muting Time Limit (Backdoor Timer)

The muting time limit (Backdoor Timer) 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 timer begins when the second muting device makes the simultaneity requirement (within 3 seconds of the first device), and allows a mute to continue for the predetermined time. 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 mapped OSSD outputs turn Off and must be manually reset (if the input device is configured for manual reset).

WARNING: Muting Time Limit

An infinite time for the backdoor timer (disabling) 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.

10.11.7 Mute on Power-Up

If selected (see *Mute Function* on page 34), the Mute on Power-Up function initiates a mute when:

- Power is applied
- The Mute Enable input is closed (if configured)
- The safety device inputs are active (closed)
- Either M1-M2 or M3-M4 (but not all four) are closed

If Normal or Automatic Power-Up mode is configured and all other mut conditions are satisfied, a mute event will start immidiately.

If Manual Power-Up mode is configured and all other mute conditions are satisfied, the first valid system reset will result in a mute event

WARNING: Mute on Power-Up

The Mute on Power-Up function should be used only in applications where:

- Muting the System (M1 and M2 closed) when power is applied is required, and
- Using it does not, in any situation, expose personnel to any hazard.

10.11.8 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.

10.11.9 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 114), 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.

10.11.10 Mute Timing Sequences

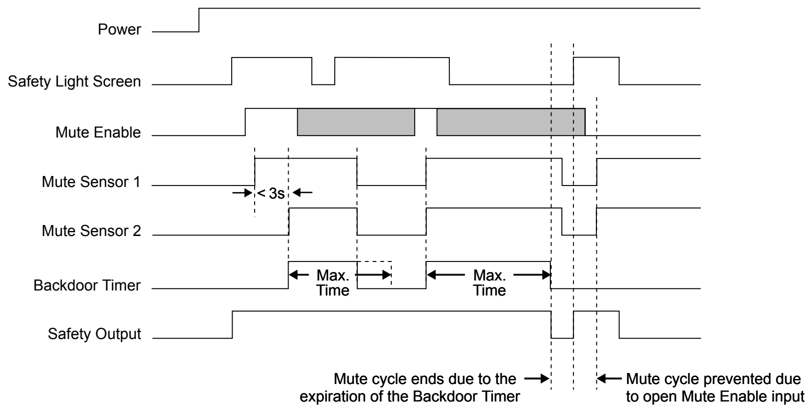


Figure 68. Timing logic: two mute sensors, mute enable, safety light screen, and limited mute time. Mutable safety device configured for Auto Reset.

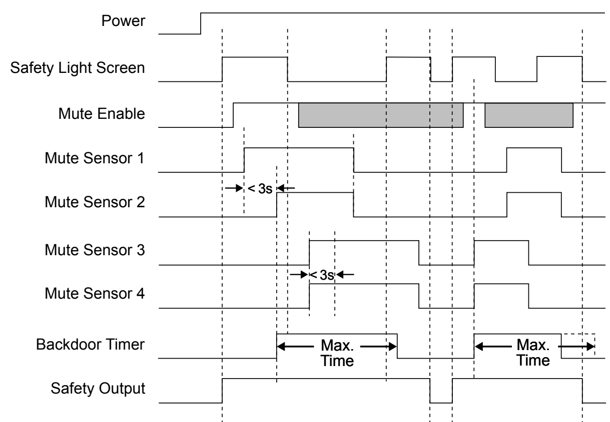


Figure 69. Timing logic: four mute sensors, mute enable, safety light screen, and limited mute time. Optical screen configured for Auto Reset.

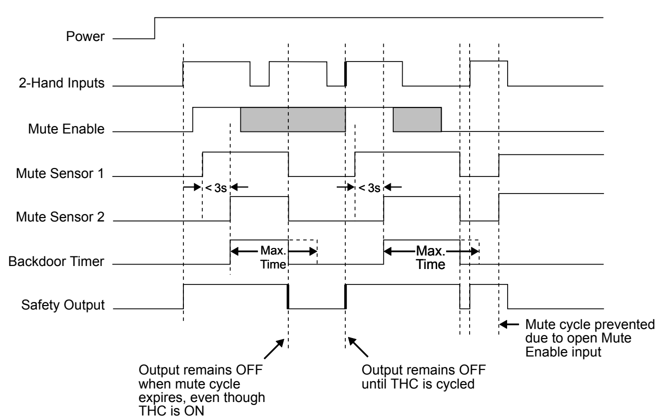


Figure 70. Timing logic: two mute sensors, ME, two-hand control, and limited mute time

NOTE: When a two-hand control is muted the outputs remain On until one of the mute sensors opens, another safety input device causes a stop, the mute time limit (backdoor timer) expires, a lockout occurs, or the Module loses power. Both hand control actuators must be released in order to start another cycle.

11 Ethernet Reference

The Industrial EtherNet Guide provides details and examples to aid in the setup and connection to your PLC. Contact Banner Engineering for this guide and the EDS files for the SC22-3E controller.

Information on Ethernet functionality can also be found in the following sections of this manual:

Ethernet-Compatible Model on page 9: Description of supported Ethernet protocols

Personal Computer Interface (PCI) on page 14: Accessing Ethernet functionality

Virtual Status Outputs on page 17: See Warning

SC22-3 Safety Controller Starter Kit Models on page 21: SC22-3E model options and accessory Ethernet cordsets

Network Interface (Model SC22-3E only) on page 23: Network Interface specifications

Virtual Status Outputs on page 49 : Detailed description, including the Auto Configure function

Configuration Tools on page 50: Descriptions of PCI icons and fields

Build a Configuration on page 51: Examples of the Ethernet support documents

11.1 Ethernet Setting Access

To access the Ethernet settings, click on the Network Settings icon of the PCI and check the Enable Network Interface box (see figure below). By default, the Safety Controller communicates using Modbus/TCP and EtherNet/IP.

IP Address. The factory default IP address for the Safety Controller is: 192.168.0.254

Subnet Mask. The factory default Subnet Mask for the Safety Controller is: 255.255.255.0

Gateway Address. By default, the Safety Controller Gateway Address is disabled.

Link Speed and Duplex Mode Options. The following speed and duplex options are available. The factory default setting is Auto Negotiate; other options, available by drop-down list, are:

- 100 Mbps / Full Duplex
- 100 Mbps / Half Duplex
- 10 Mbps / Full Duplex
- 10 Mbps / Half Duplex

Reset Advanced Network Settings. This will cause the advanced network settings to revert back to the factory default settings.

Ethernet TCP. Default port: 502 (TCP502); Device ID: 1

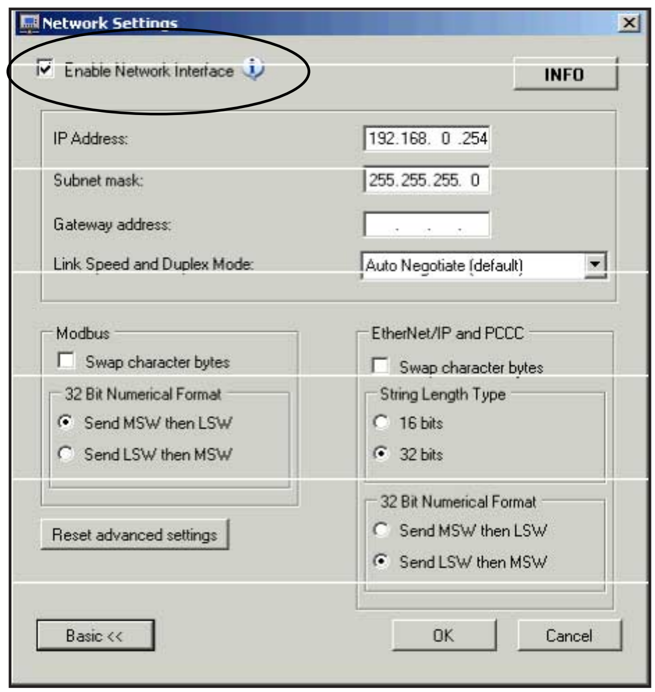


Figure 71. Ethernet Settings Menu (advanced view shown)

11.2 EtherNet/IP Assembly Objects

Input (T->O) Assembly Objects

The following Instance IDs are supported:

- Instance ID 100 (0x64) with a size (data length) of four 16-bit words. Instance ID 100 is used to access basic information about the Virtual Status Outputs.
- Instance ID 101 (0x65) with a size (data length) of forty-two 16-bit words. Instance ID 101 is used to access advanced information (inclusive of the basic information) about the Virtual Status Outputs.

- Instance ID 102 (0x66) with a size (data length) of one hundred forty 16-bit words. Instance ID 102 is used to access fault log information (it provides no Virtual Status Output information). The format of the fault log information starts with a time stamp and may be found in the appropriate Fault Log Support file (see section *Support Files* on page 117).

Output (O->T) Assembly Object

The Output Assembly Object is not implemented. However, some EtherNet/IP clients require one. If this is the case, use Instance ID 112 (0x70) with a data length of two 16-bit words.

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.

11.3 Support Files

During installation of the PCI, the following support files are copied to the computer's Program Files directory (C:\Program Files\Banner Engineering\Banner SC\Network Tables), in both .csv and .pdf formats. These files contain network communication information and fault diagnostic information. To access the files, use your computer's navigation tools (for example, "My Computer" or Windows Explorer).

Any references in this section to files are referring to these support files. All of these files are also available on *www.bannerengineering.com*.

- Fault Index Table (applies to all protocols)
- MB Fault Log
- MB System Info
- EIP Fault Log
- EIP Fault Log Explicit Messages
- EIP System Info Explicit Messages
- PCCC Fault Log
- PCCC System Info

An additional file is included with a .eds format. This file is a simple text file used by network configuration tools to help identify products and easily commission them on a network.

11.3.1 Retrieving Current Fault Information

To retrieve information via network communications about a fault that currently exists, use the following procedure:

1. Read the *Fault Flag* location.
   If this location is set, then a fault exists.
2. Read the *Fault Index* location.

   The number in this location provides an index value used with a *Fault Index Table* file that contains fault diagnostic information.
3. Access the data in the *Fault Index Table* file using the *Fault Index* number.

   The data in the file provides a specific fault number, a short fault description, a longer fault description, and a remedy.

11.3.2 Retrieving Fault Log Information

To retrieve information via network communications about faults contained in the fault log, the following procedure may be used:

1. Read the number in the *Seconds Since Power-up* location in the appropriate System Info file. The number indicates, in seconds, how long the Safety Controller has been ON.
2. Compute the real time that the Safety Controller powered up (hour, minute, second) by using the *Seconds Since Power-up* number with a real time reference.
3. Read the number in the *Time Stamp* location in the *Fault Log* file. The number indicates, in seconds, when the fault happened, relative to a power-up.
4. Compute the real time when the fault occurred by using the *Time Stamp* number with the power-up time of the Safety Controller, computed in Step 2.
5. Read the *Fault Index* location in the *Fault Log* file. The number provides an index value used with a *Fault Index Table* file that contains fault diagnostic information.
6. Access the data in the *Fault Index Table* file using the *Fault Index* number. The data in the file provides a specific fault number, a short fault description, a longer fault description, and a remedy.

11.4 Table Row and Column Descriptions

The following are table row and column descriptions (listed in alphanumeric order) for the register maps found on the PCI, the computer, and the Banner website.

3X/4X (Modbus/TCP)

This column lists the offset for a 30000 Input register or a 40000 Holding register.

Corresponds to Virtual Output # (Fault Log File)

In the Fault Log file, this provides another way to link the fault to an input, output, or system via a Virtual Status Output (if assigned). If, for example, VSO7 is assigned to track a gate switch which has a fault in the wiring, this number will be 7. If Virtual Status Outputs are not assigned, this number will be 0.

Data Type

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 String Format 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

Date Code Format (System Info File)

YYWWL - Two ASCII characters for the year, followed by two characters for the week indicating the date of manufacture. This is followed by a letter code for the manufacturing location. See “String Format” below for more details.

Fault Flag (Advanced View)

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 (Advanced View)

If the Fault Flag bit is set for this virtual output, this index number provides a pointer to a particular fault code and message in the Fault Index Table which is provided in a .csv or .pdf file on the CD that came with the Safety Controller.

Function

The function that determines the state of that virtual output. This function is assigned during configuration of the virtual outputs using the PCI software.

Name of I/O/system (Fault Log File)

If the fault is system related, the name “System” or “Internal” will be used. Otherwise, the name of the input or output associated with the fault will be given. Refer to “String Format” below for more details.

Operating Mode (System Info File)

0	Reserved
1	Reserved
2	Manual Power-up Mode — waiting for System Reset
3	Normal Operating Mode (including if I/O faults are present)
4	Configuration Mode
5	Waiting for System Reset (exiting Configuration Mode)
6	System Lockout

REG:BIT

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

Reserved

Banner has reserved these registers for internal use.

Seconds Since Power-up (System Info File)

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

SO1/2/3 is OFF Due to… (Advanced View)

A bit will be set high if the input device associated with this virtual output is a reason why the output is off.

String Format (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 PCI, you may click Advanced to change this setting to a 16 bit length which corresponds to the standard CIP “String”. Note, however, that 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”. The advanced network settings option in the PCI also allows you to “Swap” characters so that it reads correctly.

String Format (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”. The advanced settings option in the PCI allows you to “Swap” characters so that it reads correctly.

While the string length is provided, it is usually not required for Modbus/TCP systems. Note that if you use string length for Modbus/TCP, the length format corresponds to the settings used for Ethernet/IP.

Time Stamp (Fault Log File)

This is the time since power up, in seconds, when the fault occurred. To use this information, such as for fault analysis, refer to section *Support Files* on page 117.

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.

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.

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. In this manual, either the input device or the device signal is said to be in the Run state.

S

Safety-Rated Device
A device that is designed to an applicable safety standard and when properly applied, reduces the level of risk.

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. If ‘Start up Test’ has been selected for a safety light screen and the light screen is clear at power up, it would be necessary to cycle the light screen one time (from On to Off and back to On), even if the Controller has been configured for auto power up.

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
The term used to describe a manual system reset operation required for one or more Safety Outputs to turn On after Controller power-up, when configured for manual power-up, and lockout (fault detection) situations.

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