SAFETY CONTROLLER

Type

Models SC22-3 & SC22-E

For use with E-stop Buttons, Gate Switches, Safety Light Screens including Point & Grid, Two-Hand Control, Non-Safety Devices, Safety Mats/Edges, Muting Sensors, Bypass Switches & Live Man Pendants

Instruction Manual

European UK English Version

CE pending

more sensors, more solutions

135369 Rev. B 04.2009

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1 GENERAL SAFETY

WARNING BEFORE PROCEEDING FURTHER READ THIS GENERAL SAFETY CHAPTER FIRST.

This Chapter details all the necessary safety information relating to the *SC22-3 & SC22-3E Safety Controllers* and its intended use.

WARNING

IT IS THE RESPONSIBILITY OF THE QUALIFIED PERSON WHO CONFIGURES, INSTALLS, OR MAINTAINS THE SAFETY CONTROLLER TO:

- **CAREFULLY READ, UNDERSTAND AND FOLLOW THE INFORMATION IN THIS MANUAL**
- **PERFORM A RISK ASSESSMENT OF THE SPECIFIC MACHINE GUARDING APPLICATION**
- **DETERMINE WHAT SAFEGUARDING DEVICES AND METHODS ARE APPROPRIATE AS PER THE REQUIREMENTS DEFINED IN ISO 13849-1 AND EN 945-1 AND THAT ARE REFERENCED IN THE SAFETY CONTROLLER MANUAL**
- **CREATE AND CONFIRM EACH SAFETY CONTROLLER CONFIGURATION AND THEN VERIFY THAT THE ENTIRE SAFEGUARDING SYSTEM (INCLUDING INPUT DEVICES AND OUTPUT DEVICES) IS OPERATIONAL AND WORKING AS INTENDED**
- **PERIODICALLY RE-VERIFY AS NEEDED, THAT THE ENTIRE SAFEGUARDING SYSTEM IS WORKING AS INTENDED**

FAILURE TO FOLLOW ANY OF THESE RECOMMENDATIONS CAN POTENTIALLY CREATE A DANGEROUS CONDITION THAT MAY LEAD TO SERIOUS INJURY OR DEATH.

1.1 SAFETY NOTICES

In order to install and operate the product in a safe and efficient way, safety notices are displayed on the product and throughout this Instruction *Manual*.

The Safety Notices comply with ISO 7010 and ISO 3864-2.

All Cautions and Warnings contain signal words, which call attention to safety messages and designate the degree of hazard seriousness.

Table 1 on page 1 gives a breakdown of safety notices that may be used in this document.

Table 1 Safety Notice Breakdown

Description	Example	Definition
WARNING	WARNING	A signal word accompanied by a safety shape that indicates a potentially hazardous situation. If not avoided, the action could result in serious injury or death. A WARNING is highlighted in yellow.
CAUTION	CAUTION	A signal word accompanied by a safety shape that indicates a potentially hazardous situation or unsafe practice. If not avoided, the action may result in minor or moderate personal injury or equipment damage. A CAUTION is highlighted in yellow.
CAUTION	CAUTION	A signal word that indicates a situation or unsafe practice, which if not avoided may result in equipment damage. A CAUTION is highlighted in yellow.

Table 1 Safety Notice Breakdown

Description	Example	Definition
General Warning		Indicates a general hazard. Details about this hazard appear in the safety notice explanation.
High Voltage		Indicates a high voltage hazard.

1.1.1 Warnings

This type of notice WARNING is posted, preferably, prior to or as near as possible to the information they are applicable to throughout the *Manual* (see Table 1 on page 1 for breakdown). In cases where identical notices are duplicated, a cross reference is used at the relevant position in the text or graphic to direct the reader to the applicable notice.

There are two different types used:

- A general WARNING is indicated by the symbol (see example warning on page 3)
- An Electrical Shock Hazard WARNING indicated by the symbol (see example warning on page 4)

The User must read the relevant WARNING appertaining to the event before proceeding further.

1.1.2 Cautions

These type of notices CAUTION CAUTION are posted, preferably, prior to or as near as possible to the information they are applicable to throughout the *Manual* (see Table 1 on page 1 for breakdown). In cases where identical notices are duplicated, a cross reference is used at the relevant position in the text or graphic to direct the reader to the applicable notice.

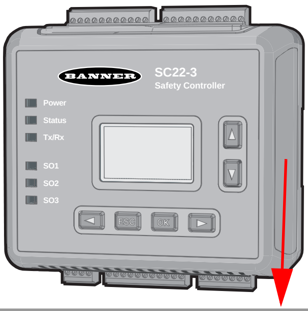
1.1.3 Notes

☛ *A note is posted where the information is purely advisory and is non-mandatory. They are written and positioned close to the information they are applicable to.*

1.2 PRODUCT SAFETY LABELLING INFORMATION

Table 2 on page 2 lists the safety labels used on the product together with their descriptions and locations.

Table 2 Label Identification Safety Controller

SYMBOL	LOCATION/MEANING
Yellow background ⚠ WARNING	Located on *Safety Controller* left side panel. Indicates the following important information:  ⚠ **WARNING** **Correct use of this control device is an essential part of proper machine control. Always follow the instructions in the *Manual*. Failure to follow all instructions or warnings could lead to serious bodily injury or death.** CONFIGURABLE SAFETY CONTROLLER **BANNER ENGINEERING CORP., USA** **www.bannerengineering.com • +1 763 544 3164**

1.3 SAFETY STANDARDS

☛ *The list of standards below is included as a convenience for users of this Banner product. Inclusion of these standards does not imply that the product complies specifically with any standard, other than those listed in the Specifications (block 3.2.1 on page 20) and Declaration of Conformity (appendix A3.1 on page 117) in this Manual.*

ISO 7010 (2003)

Graphical symbols -- Safety colours and safety signs -- Safety signs used in work places and public areas

ISO 3864-2 (2004)

Graphical symbols -- Safety colours and safety signs -- Part 2: Design principles for product safety labels

ISO 12100-1 (2003) & -2 (2003)(EN 292-1 & -2)

Safety of Machinery – Basic Concepts, General Principles for Design

ISO 13849-1 (2006)(EN 954-1)

Safety-Related Parts of Control Systems

ISO 13850 (2006) (EN418)

Emergency Stop Devices, Functional Aspects – Principles for Design

ISO 13851 (2002)(EN 574)

Two-Hand Control Devices – Functional Aspects – Principles for Design

ISO 13852 (1996)(EN 294)

Safety Distances - Upper Limbs

ISO 13853 (1998) (prEN 811)

Safety Distances - Lower Limbs

ISO 13855 (2002)(EN 999)

The Positioning of Protective Equipment in Respect to Approach Speeds of Parts of the Human Body

ISO 14119 (1998) (EN 1088)

Interlocking Devices Associated with Guards – Principles for Design and Selection

ISO 14121-1 (2007)(EN 1050)

Principles of Risk Assessment

IEC 60204-1 (2005-10)

Electrical Equipment of Machines Part 1: General Requirements

IEC 61496-1 (2004-02), & IEC 61496-2 (2006-04)

Electro-sensitive Protection Equipment

IEC 60529 (2001-02)

Degrees of Protection Provided by Enclosures

IEC 60947-5-1 (2003-11)

Low Voltage Switch Gear – Electro-mechanical Control Circuit Devices

IEC 60947-5-5

Low Voltage Switchgear - Electrical Emergency Stop device with mechanical latching function

IEC 60947-1 (2004-03)

Low Voltage Switch Gear – General Rules

2006/42/EC

Safety of Machinery

1.4 INGRESS PROTECTION RATINGS

The *Safety Controller* meets the following Ingress Protection IP class as per *IEC 60529*:

- IEC IP20*

*The *Safety Controller* must be installed inside an enclosure rated IEC IP54 or better for IP20 rating.

1.5 ELECTRICAL SAFETY

WARNING

SHOCK HAZARD - DISCONNECT POWER

ALWAYS DISCONNECT POWER FROM THE SAFETY CONTROLLER AND THE GUARDED MACHINE BEFORE MAKING ANY CONNECTIONS OR REPLACING ANY COMPONENT.

PROPER ELECTRICAL CONNECTION

ELECTRICAL CONNECTION MUST BE MADE BY qualified persons AND MUST COMPLY WITH LOCAL ELECTRICAL STANDARDS. DO NOT MAKE CONNECTIONS TO THE SYSTEM OTHER THAN THOSE DESCRIBED IN CHAPTER 4 OF THIS MANUAL. DOING SO COULD RESULT IN SERIOUS INJURY OR DEATH.

The *Safety Controller* has been designed to meet with the Electrical Safety Standards as detailed in DOC.

1.6 CONDITIONS OF EQUIPMENT USE

Important . . .
read this before proceeding!

IT IS THE RESPONSIBILITY OF THE MACHINE DESIGNER, CONTROLS ENGINEER, MACHINE BUILDER AND/OR MAINTENANCE ELECTRICIAN TO APPLY AND MAINTAIN THIS PRODUCT IN FULL COMPLIANCE WITH ALL APPLICABLE REGULATIONS AND STANDARDS. THE PRODUCT CAN PROVIDE THE REQUIRED SAFEGUARDING FUNCTION ONLY IF IT IS PROPERLY INSTALLED, PROPERLY OPERATED, AND PROPERLY MAINTAINED. THIS MANUAL ATTEMPTS TO PROVIDE COMPLETE INSTALLATION, OPERATIONAL, AND MAINTENANCE INSTRUCTION. READING THE MANUAL COMPLETELY IS HIGHLY RECOMMENDED. PLEASE DIRECT ANY QUESTIONS REGARDING THE APPLICATION OR USE OF THE PRODUCT TO THE BANNER ENGINEERING APPLICATIONS DEPARTMENT AT THE PHONE NUMBER OR ADDRESS SHOWN ON THE BACK COVER. FOR MORE INFORMATION REGARDING U.S. AND INTERNATIONAL INSTITUTIONS THAT PROVIDE SAFEGUARDING APPLICATION AND SAFEGUARDING PRODUCT PERFORMANCE STANDARDS, SEE THE LIST ON THE INSIDE OF THE BACK COVER.

USE OF WARNINGS

WARNINGS ARE INTENDED TO REMIND THE MACHINE DESIGNER, CONTROL ENGINEER, MACHINE BUILDER, MAINTENANCE ELECTRICIAN, OR END USER HOW TO AVOID MIS-APPLICATION OF THIS PRODUCT AND EFFECTIVELY APPLY THE SAFETY CONTROLLER TO MEET THE VARIOUS SAFEGUARDING APPLICATION REQUIREMENTS. READING AND ABIDING BY THE WARNINGS IS HIGHLY RECOMMENDED.

WARNINGS

READ BLOCK 1.6 CAREFULLY BEFORE INSTALLING THE SYSTEM

THE *BANNER* SAFETY CONTROLLER ARE AN ACCESSORY DEVICE THAT IS TYPICALLY USED IN CONJUNCTION WITH A MACHINE. 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 SAFEGUARDED.

IF ALL MOUNTING, INSTALLATION, INTERFACING, AND CHECKOUT PROCEDURES ARE NOT FOLLOWED PROPERLY, THE SAFETY CONTROLLER CANNOT PROVIDE THE PROTECTION FOR WHICH IT WAS DESIGNED. THE USER HAS THE RESPONSIBILITY TO ENSURE THAT ALL LOCAL, STATE, AND NATIONAL LAWS, RULES, CODES, OR REGULATIONS RELATING TO THE INSTALLATION AND USE OF THIS CONTROL SYSTEM IN ANY PARTICULAR APPLICATION ARE SATISFIED. EXTREME CARE SHOULD BE TAKEN TO ENSURE THAT ALL LEGAL REQUIREMENTS HAVE BEEN MET AND THAT ALL TECHNICAL INSTALLATION AND MAINTENANCE INSTRUCTIONS CONTAINED IN THIS MANUAL ARE FOLLOWED. READ ALL OF THE safety information in chapter 1 OF THIS MANUAL CAREFULLY BEFORE INSTALLING THE SYSTEM. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN SERIOUS BODILY INJURY OR DEATH. THE USER HAS THE SOLE RESPONSIBILITY TO ENSURE THAT THE *BANNER* SAFETY CONTROLLER IS INSTALLED AND INTERFACED TO THE SAFEGUARDED MACHINE BY A qualified person as specified in block 1.8.2 on page 4 IN ACCORDANCE WITH THIS MANUAL AND APPLICABLE SAFETY REGULATIONS.

NOT A STAND ALONE POINT-OF-OPERATION GUARDING

THE **Safety Controller** IS NOT A STAND ALONE POINT-OF-OPERATION, AS DEFINED BY EUROPEAN SAFETY STANDARDS. IT IS THEREFORE NECESSARY TO INSTALL POINT-OF-OPERATION, SUCH AS SAFETY LIGHT SCREENS AND/OR FIXED GUARDS, TO PROTECT PERSONNEL FROM HAZARDOUS MACHINERY. FAILURE TO PROPERLY INSTALL POINT-OF-OPERATION SAFEGUARDING ON HAZARDOUS MACHINERY, AS INSTRUCTED BY THE APPROPRIATE INSTALLATION MANUALS, CAN RESULT IN A DANGEROUS CONDITION WHICH COULD LEAD TO SERIOUS INJURY OR DEATH.

USER RESPONSIBILITY FOR APPLICATION SAFETY

THE APPLICATION EXAMPLES DESCRIBED IN appendix A3 DEPICT GENERALIZED SAFEGUARDING SITUATIONS. EVERY SAFEGUARDING APPLICATION HAS A UNIQUE SET OF REQUIREMENTS. EXTREME CARE IS URGED TO ENSURE THAT ALL LEGAL REQUIREMENTS ARE MET AND THAT ALL INSTALLATION INSTRUCTIONS ARE FOLLOWED. IN ADDITION, ANY QUESTIONS REGARDING SAFEGUARDS SHOULD BE DIRECTED TO THE Corporate Office as listed on page 127.

1.6.1 Safety Controller Interfacing

Safety Controller interfacing is dependent on the type of machine and the safeguards that are to be interfaced with the *Controller*. The *Controller* is generally interfaced with safeguards that may be used only on machinery that is capable of stopping motion immediately upon receiving a *Stop* signal and at any point in its machine cycle. It is the user's responsibility to verify whether the *Safeguarding* is appropriate for the application and is installed as instructed by the appropriate installation *Manuals*.

If there is any doubt about whether or not your machinery is compatible with this *Controller*, contact Corporate Office as listed on page 127.

1.7 SECURITY PROTOCOL

The *Safety Controller* must be mounted inside a lockable enclosure or cabinet IP rated IP54 or better, both to protect the *Controller* from environmental conditions and in order to prevent access by unauthorized personnel, if required by applicable standards.

The key (or combination) to the enclosure should be kept in the possession of a qualified person as specified in block 1.8.2 on page 4 and only they should have access to the configuration switches.

1.8 DESIGNATED & QUALIFIED PERSONS

1.8.1 Designated Person

A **Designated Person** (designated person on page 123) is identified and designated in writing, by the employer, as being appropriately trained and able to perform the specified checkout procedures on the *Safety Controller*.

1.8.2 Qualified Person

A **Qualified Person** (qualified person on page 125) by possession of a recognised degree or certificate of professional training, or by extensive knowledge, training and experience, has successfully demonstrated the ability to solve problems relating to the implementation of this safety system.

1.9 SAFETY INPUTS

WARNING

FAILURES AND FAULTS

THE *Safety Controller* CAN BE INTERFACED WITH *Input Devices* AT DIFFERING LEVELS OF INTEGRITY AS DESCRIBED IN appendix A2. THE USER MUST CONDUCT A RISK ASSESSMENT TO DETERMINE THE APPROPRIATE LEVEL OF INTEGRATION. THE USER ALSO MUST ELIMINATE OR MINIMIZE THE POSSIBILITY OF FAILURES AND FAULTS THAT COULD RESULT IN THE LOSS OF THE SAFETY FUNCTION(S).

Safety Input devices allow for the cessation of motion, for an otherwise hazardous situation, by controlling the *Safety Output* 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).

For a *Safety Output* to turn *ON*, all of its controlling *Safety Inputs* must be in their *Run* state. A few special *Safety Input* functions can, under pre-defined circumstances, temporarily suspend the *Safety Input Stop* signal to keep the *Safety Output ON* (e.g. 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 that control of the safety function. Once such a failure or fault is detected, the *Safety Controller* locks out until the problem is fixed.

Other input configurations do not have this detection capability. It is recommended that in all circumstances the installation of the *Safety Controller* and its associated safety and *Safeguarding Devices* be installed to eliminate or minimize the possibility of failures and faults that could result in the loss of the safety function(s).

Methods to eliminate or minimize 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
- 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-drive components, installed and mounted in a positive mode

For further information see block 2.5 on page 8

1.9.1 Signals Run & Stop States

Dual channel Safety Inputs 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. Others have a complementary circuit structure where *Single channel* is at 24 V dc and the other is at 0 V dc when the device is in the *Run* state. For the sake of clarity, instead of referring to a *Safety Input* as being *ON* (e.g. 24 V dc) or *OFF* (e.g. 0 V dc), this *Manual* adopts the *Run* state/*Stop* state convention.

1.10 RESETS

WARNING

RESET SWITCH LOCATION

The System Reset push button must be accessible only from outside, and in full view of, the hazardous area. Manual Reset switches must also be out of reach from within the safeguarded space, and must be protected against unauthorized or inadvertent operation (e.g. through the use of rings or guards). If any areas are not visible from the Manual Reset switch(es), additional means of Safeguarding must be provided. Failure to do so could result in serious bodily injury or death.

Two *Manual Reset* types are available:

1.10.1 Manual Reset

Used to manually *Reset* a *Safety Output* that has turned *OFF* in response to a *Stop* signal from *Safety Input* configured for *(Latch* mode) *Manual Reset*. The *Manual Reset* signal type can be configured to be either monitored or non-monitored (the default setting is monitored). For further information see block 2.4.1 on page 8 and block 7.3 on page 69.

1.10.2 System Reset

Used to recover from a fault condition or to restart the *Controller* after a new configuration has been altered. This *Manual Reset* device (a button or switch) connects to a dedicated input terminal on the *Safety Controller*, labelled *SR* & *Sys Res*. The *Manual Reset* signal type can be configured to be either monitored or non-monitored (the default setting is monitored). For further information see block 2.4.1 on page 8 and block 7.4 on page 69.

1.11 MUTING

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 Inputs*:

- *Gate Switches* (Interlocking)
- *Optical Sensors*
- *Two-Hand Controls*
- *Safety Mats*

(E-stop buttons, rope pulls, protective stops, enabling devices, external device monitoring, and bypass switches are said to be “non-mutable” devices or functions)

At least two mute sensors are required for each muting operation. One or two pairs of mute sensors can be *Mapped to* one or more *Safety Inputs* so that their assigned *Safety Output* can remain *ON* to complete the operation (see block 2.5.4 on page 10 and appendix A2.11 on page 112 for more information).

1.12 DISCLAIMER INFORMATION

WARNING

IMPORTANT... READ THIS BLOCK BEFORE PROCEEDING!

WHETHER OR NOT ANY PARTICULAR SAFETY CONTROLLER INSTALLATION MEETS ALL APPLICABLE REQUIREMENTS DEPENDS UPON FACTORS THAT ARE BEYOND THE CONTROL OF *BANNER ENGINEERING CORP.* THESE FACTORS INCLUDE THE DETAILS OF HOW THE SAFETY CONTROLLER IS APPLIED, INSTALLED, WIRED, OPERATED, AND MAINTAINED. IT IS THE RESPONSIBILITY OF THE PURCHASER AND USER TO APPLY THIS SAFETY CONTROLLER IN FULL COMPLIANCE WITH ALL RELEVANT APPLICABLE REGULATIONS AND STANDARDS. SAFETY CONTROLLER CAN ONLY SAFEGUARD AGAINST ACCIDENTS WHEN THEY ARE PROPERLY INSTALLED/INTEGRATED INTO THE MACHINE, PROPERLY OPERATED, AND PROPERLY MAINTAINED. *BANNER ENGINEERING CORP.* HAS ATTEMPTED TO PROVIDE COMPLETE APPLICATION, INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS.

THE USER HAS THE RESPONSIBILITY TO ENSURE THAT ALL LOCAL, STATE, AND NATIONAL LAWS, RULES, CODES, AND REGULATIONS RELATING TO THE USE OF THIS *Safeguarding* SYSTEM IN ANY PARTICULAR APPLICATION ARE SATISFIED.

EXTREME CARE IS URGED TO ENSURE THAT ALL LEGAL REQUIREMENTS HAVE BEEN MET AND THAT ALL INSTALLATION AND MAINTENANCE INSTRUCTIONS CONTAINED IN THIS *Manual* ARE FOLLOWED.

FOR A LIST OF EUROPEAN & INTERNATIONAL STANDARDS APPERTAINING TO THIS EQUIPMENT, REFER TO DOC.

1.13 EQUIPMENT NOISE LEVELS

The Safety Controller does not generate noise and is therefore in compliance with:

- IEC 61000-6-1
- EN 55011 (CISPR11)

1.14 EQUIPMENT VIBRATION LEVELS

For shock and vibration levels, the *Safety Controller* is in compliance with:

- IEC 61496-1

1.15 EQUIPMENT RADIATION LEVELS

1.15.1 Electromagnetic Immunity Levels

For electro-magnetic levels, the *Safety Controller* is in compliance with IEC 61496-1.

1.16 DESIGN & TESTING

The *Safety Controller* was designed for up to *Category 4* PL (Performance Level) “e” (ISO 13849-1) and SIL (Safety Integrity Level) 3 (IEC 61508 and IEC 62061) *Safeguarding* applications. It has been extensively tested to ensure that it meets IEC and ISO product performance requirements for both safety functionality and operational reliability. This self-checking *Safety Controller* incorporates:

- *Redundant* micro controllers
- *Redundant* input signal detection circuitry
- *Redundant Safety Output* control circuitry

It should be noted that the safety circuit performance (e.g. categories) of a specific *Safety Input* or *Output* will be primarily determined by the devices and their interconnection to the *Safety Controller*. See appendix A2 for further information.

1.17 MINIMUM SAFETY DISTANCES

☛ ***The following information is only applicable to CE certified installations.***

1.17.1 Minimum Safety Distance for Optical Sensors

This information is detailed in appendix A2.4.3.

1.17.2 Minimum Safety Distance for Two-Hand Controls

This information is detailed in appendix A2.5.1.

1.17.3 Minimum Safety Distance for Safety Mats

This information is detailed in appendix A2.6.4.

1.18 EXTERNAL DEVICE MONITORING

⚠ WARNING

EDM Configuration

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

Notice Regarding External Device Monitoring Connection

It is strongly recommended that at least one N.C., forced-guided monitoring contact of each MPCE or external device be wired in order to monitor the state of the MPCEs (as shown in figure 31, figure 32, figure 32, figure 33 and figure 34). If this is done, proper operation of the MPCEs are verified. MPCE monitoring contacts must be used in order to maintain control reliability.

The *Safety Controller’s Safety Output* 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 N.C. when the device is turned *OFF*. This capability permits the *Safety Controller* to detect if the devices under load are responding to the *Safety Output*, or if the Normally Open (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 in three ways: *Single channel*, *Dual channel*, or no monitoring. *Single channel* and *Dual channel EDM* are used when the Output Signal Switching Device (OSSD) *Outputs* directly control the de-energizing of the MPCEs or external devices.

For further information see block 2.5.6 on page 11 and block 4.9.1 on page 33.

2 OVERVIEW

The *Banner Safety Controller* (the *Safety Controller* or the *Controller*) is an easy-to-use, configurable, 24 V dc Safety Module designed to monitor multiple safety and *Non-Safety Input* and control up to three independent Machine Primary Control Elements (MPCEs). It provides 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 Inputs* as E-stop buttons, gate interlocking switches, safety light curtains, and other *Safeguarding Devices*. It also can be used in place of safety PLCs (Programmable Logic Controller) and other safety logic devices when they are excessive for the application.

Configurations are created using an integral LCD (Liquid Crystal Display) and push-button interface or using a PC connected to the *Safety Controller* via a USB (Universal Serial Bus) 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 FEATURES

The *Banner Safety Controller* includes the following features:

- Easy-to-use *Controller* with fully configurable *Inputs* and *Outputs*
- ISO 13849-1 *Category 2*, *Category 3*, or *Category 4* Control Reliability *Input Device* connection
- Manages several safety related functions
- Twenty two *Inputs* for safety and *Non-Safety Input* devices or functions
- Three *Dual channel Safety Outputs* with selectable *ON* and *OFF* delay
- Ten Status *Outputs* track input and output status, mute status, lockout, fault conditions and *Reset* needed
- Simple configuration procedure using PC interface *(PCI)* or on-board controller interface *(OBI)* maps each *Input Device* to any of three *Safety Outputs*
- Configurations password protected and confirmed before use, to ensure safety integrity
- Configurations transferable to multiple *Safety Controllers* and can be e-mailed as attachments
- 24 V dc operation
- Complies with SIL 3 (Safety Integrity Level) as per IEC 62061, IEC 61508, & *Category 4* performance Level "e" as per ISO 13849-1
- Live display and fault log provide "real-time" status information and historical fault tracking
- *Wiring Diagrams*, *Ladder Logic Diagrams* and *Configuration Summaries* can be printed or exported as .pdf or .dxf files

2.3 APPLICATIONS

The Safety Controller can be used wherever safety modules are used (see Figure 1 on page 7). 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

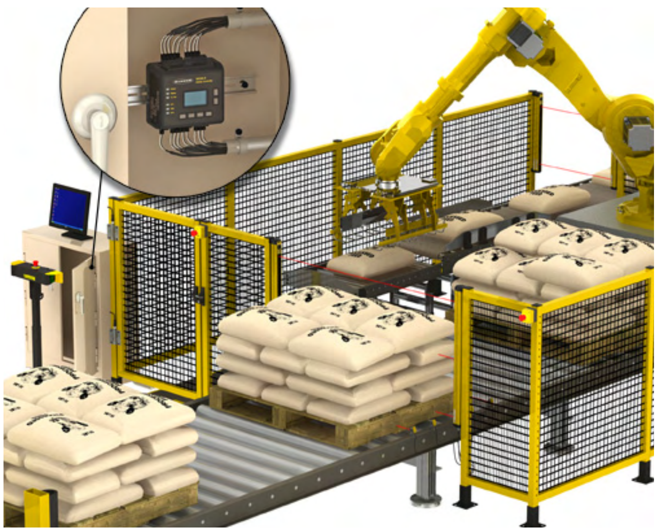


Figure 1 Typical Safety Controller Application

2.4 RESET ADDITIONAL INFORMATION

2.4.1 Automatic Reset & Manual Reset Inputs Mapped to 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 Inputs* must be in their *Run* state. If one or more of these *Safety Inputs* 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* (see Figure 2 on page 8).

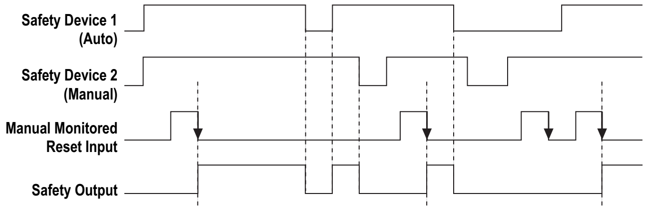


Figure 2 Auto & Manual Monitored Reset Safety Inputs Mapped to Same Safety Output (Safety Output has no Delay) Timing Logic

2.4.2 Safety Inputs with Common Manual Reset Mapped to Same Safety Output

If two *Safety Inputs*, each configured for *Manual Reset*, are *Mapped to* the same *Safety Output*, then only one valid *Manual Reset* operation is required to manually *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 Figure 3 on page 8).

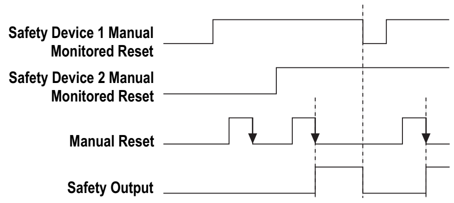


Figure 3 Safety Inputs with a Common Reset, Mapped to the Same Safety Output, Timing Logic

See block 7.3 on page 69 for more information about *Resets*.

2.5 SAFETY INPUTS & NON-SAFETY INPUTS

The *Safety Controller* has 22 input terminals that can be used to monitor either *Safety Input* or *Non-Safety Input* 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 24 V dc. The function of each input circuit depends on the type of device connected to it. This function is established when the *Controller* is configured.

Refer to chapter 4 and appendix A2 for the following:

- General and specific information about *Input Devices* — the requirements
- Connection options and appropriate warnings and cautions
- Additional installation information (e.g. *Minimum Safety Distances)*

appendix A2 contains connection and other useful information about integrating the following devices:

- *Protective Stop* (Safety) — appendix A2.2 on page 91
- *Optical Sensor* — appendix A2.4 on page 96
- *Gate Switch* (or Interlock Guard) — appendix A2.3 on page 92
- *Two-Hand Control* — appendix A2.5 on page 98
- *Safety Mat* (Edges) — appendix A2.6 on page 101
- *E-Stop* — appendix A2.7 on page 104
- *Rope Pull* (Cable) — appendix A2.8 on page 106
- *Enabling Device* (Pendants) — appendix A2.9 on page 108
- *Bypass Switch* — appendix A2.10 on page 110
- *Mute Sensor* — appendix A2.11 on page 112

For further information about connecting any devices to the *Safety Controller*, contact Corporate Office as listed on page 127.

2.5.1 Internal Logic

The *Controller's* internal logic is designed so that a *Safety Output* can turn *ON* only if all the controlling *Safety Input* signals and the *Controller's* self-check signals are in the *Run* state and report that there is no fault condition. Table 3 on page 8 illustrates the internal logic.

Table 3 Safety Input Internal Logic

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

Table 3 on page 8 illustrates the logic for two *Safety Inputs* that are *Mapped to* control *Safety Output 1*. If any of the *Safety Inputs* are in the *Stop* state, the *Safety Output* is *OFF*. When both *Safety Inputs* and the *Controller* are in the *Run* state, then *Safety Output 1* will turn *ON*.

2.5.2 Two-Hand Control

The *Two-Hand Control* function requires that each control actuation should be activated within 0,5 seconds of each other in order to produce a *Run* signal to start a machine cycle. *Two-Hand Control* devices are always the last input (in time) to turn the *Safety Output ON*. If one or more of the other controlling *Safety Input* devices are configured for *Manual Reset* and are used to stop the machine, a *Manual Reset* must be performed before the *Two-Hand Control* device can cycle the machine again. See appendix A2.5 on page 98 for more information.

2.5.2.1 Two-Hand Control Activation on Power-up Protection

The *Controller's Two-Hand Control* logic does not permit the assigned *Safety Output* to turn *ON* when power is initially supplied while each *Two-Hand Control* actuation is in the *Run* state. Each *Two-Hand Control* actuation must change to its *Stop* state and return to the *Run* state before the *Safety Output* can turn *ON* (see Figure 4 on page 9).

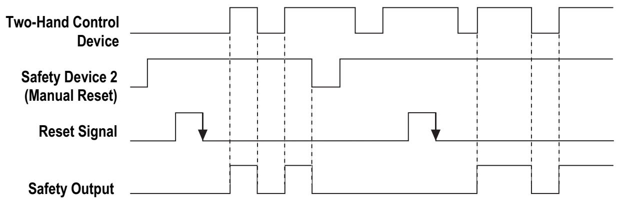


Figure 4 Two-Hand Control Device & Manual Reset Safety Input Timing Logic

A two-hand control device does not have a *Manual Reset* option.

2.5.3 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 hazardous motion. **This *Enabling Device* must have ultimate hazard turn *OFF* or *Stop* authority when being used.** The *Enabling Device* is sometimes referred to as the 'live man pendant.'

An *Enabling Device* can be *Mapped to* one or more *Safety Output(s)*. When the Enable signal goes from the *Stop* state to the *Run* state, the *Controller* goes into *Enable Mode*. In this mode, the associated *Safety Outputs* 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)* are ignored while the *Controller* is in *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. See appendix A2.9 on page 108 for more information.

2.5.3.1 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* turn *OFF*. In order to start a new *Enable* mode cycle with the time limit *Manual Reset* set to its original time limit value, the enabling device must switch from *ON* to *OFF*, and back to *ON* (see figure 5).

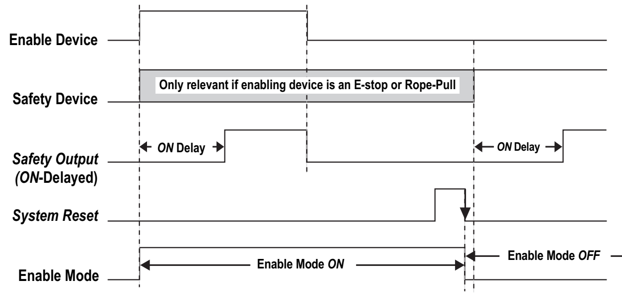


Figure 5 Enabling Device & Enable Mode Timing Logic

All *ON* and *OFF* delay times associated with the *Safety Output* that are controlled by the *Enabling Device* function are honoured during the *Enable* mode.

2.5.4 Mute Functions

2.5.4.1 Mute Enable

The optional *Mute Enable ME* function can be configured to ensure that a mute function is permitted only at the appropriate time. If an *ME Input Device* has been *Mapped to* a mutable *Safety Input*, this *Safety Input* can be muted only if the *ME* switch is in the *Enable* state (24 V dc) at the time the *Mute Cycle* is started. After the *Mute Cycle* starts, the *ME* input can be turned *OFF*. An *ME Input Device* can be *Mapped to* one or more mutable *Safety Inputs* (see figure 6).

Refer to appendix A2.11 on page 112 for more information about *Mute Enable* conditions.

☛ *Mute Enable is not a Safeguarding function but rather a machine logic function.*

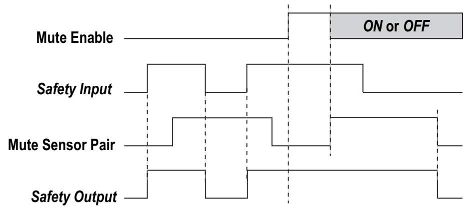


Figure 6 Timing Diagram for One Mute Sensor Pair with Mute Enable

2.5.4.2 Muting 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*. Other *Safety Input* devices that are also muted are affected only by their own mute time limit setting. The *Muting Time Limit* can be disabled. When disabled, the time limit for the mute function for that *Safety Input* device is infinite.

2.5.4.3 Mute on Power-up function

⚠ 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 MUST NOT, IN ANY SITUATION, EXPOSE PERSONNEL TO ANY HAZARD**

If configured, the *Mute on Power-up* function initiates a *Mute Cycle* after power is applied to the *Safety Controller* providing the muted *Safety Inputs* are active *(Run* state or *Closed)* and either M1-M2 or M3-M4 (but not all four) are signalling a muted condition (e.g. *Run* state or *Closed)* (see warning above).

Mute on Power-up Enabled

When the *Mute on Power-up* option is enabled, the *Controller* goes into a *Mute Cycle* if the conditions for a valid *Mute Cycle* are satisfied at power-up. Specific valid mute signal conditions must be present for a *Mute Cycle* to be initiated and maintained.

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) results 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 utilisation of this function is the result of a *Risk Assessment* and is required by that particular machine operation.

2.5.5 Bypass Switch Function

⚠ WARNINGS

MUTE AND BYPASS SWITCH

MUTE AND BYPASS OPERATIONS MUST BE DONE IN A WAY THAT MINIMIZES PERSONNEL RISK. THE FOLLOWING RULES AND METHODS MUST BE IMPLEMENTED 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 (NO LONGER THAN NEEDED) MUTE AND BYPASS FUNCTION TIME LIMITS**

USE OF MUTE AND BYPASS SWITCH FUNCTIONS

FAILURE TO FOLLOW THESE RULES COULD LEAD TO AN UNSAFE CONDITION THAT COULD RESULT IN SERIOUS INJURY OR DEATH. REFER TO appendix A2.10 on page 110 AND appendix A2.11 on page 112 FOR MORE INFORMATION.

The *Bypass Switch* safety device is a manually activated and temporary suspension of one or more *Stop* signals for *Safety Input(s)* when no immediate hazard is present.

Bypass Switches can be *Mapped to* one or more of the following *Safety Inputs*:

- *Gate Switches* (interlocking)
- *Optical Sensors*
- *Two-Hand Control* devices
- *Safety Mats*
- *Protective Stops*

When the *Bypass Switch* signal changes to the bypass *(Run)* state, it turns *ON* or keeps *ON* all the *Safety Outputs* that are controlled by the bypassed *Safety Inputs* only if all other non-bypassed *Safety Input* devices that are *Mapped to* these *Safety Outputs* are in the *Run* state (see Figure 7 on page 10).

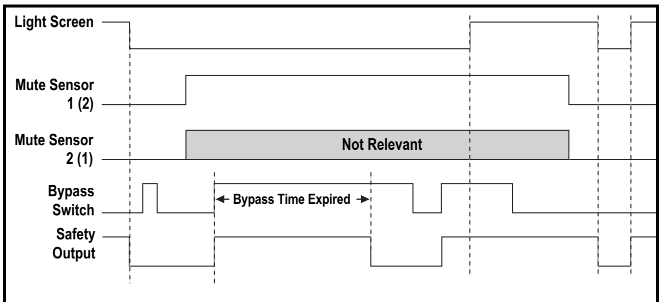


Figure 7 Light Screen with Mute Sensors & Bypass Switch Timing Logic

For further information on the *Bypass Switch* function refer to appendix A2.10 on page 110.

2.5.5.1 Bypass Switch Time Limit.

A *Bypass Switch* function time limit can be established to limit how long the *Safety Input* bypass is active. The time limit can be adjusted from 1 second to 30 minutes and cannot be disabled. Only one time limit can be set, and this limit applies to all *Safety Input* devices that are bypassed. At the end of the time limit, *Safety Output* control authority is handed back to the bypassed *Safety Inputs*.

2.5.5.2 Bypass with Mute.

If a mute sensor is *Mapped to* the *Safety Input* and the *Safety Input* is in the *Stop* state, at least one of the Mute sensors must be in the Mute *(Run)* state in order to start a new bypass cycle. If the conditions are right for bypass, the mute status output indicator (if configured) starts flashing at 1 Hz.

2.5.6 EDM

For further information see also block 1.18 on page 6 and block 4.9.1 on page 33.

2.5.6.1 Single channel Monitoring

For timing information refer to Figure 8 on page 11.

A series connection of closed monitor contacts that are forced-guided (mechanically linked) from each device controlled by the *Safety Controller*. The monitor contacts must be closed before the *Safety Controller Outputs* can be *System Reset* (either *Manual* or *Automatic)*. After a *System Reset* is executed and the *Safety Output* (OSSDs) 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 ms of the OSSD *Outputs* going from *ON* to *OFF*.

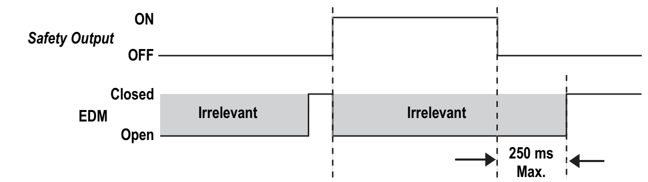


Figure 8 Timing for Single channel EDM Status with Respect to Safety Output

2.5.6.2 Dual channel Monitoring

For timing information refer to Figure 9 on page 11 and Figure 10 on page 11.

An independent connection of closed monitor contacts that are forced-guided (mechanically linked) from each device controlled by the *Safety Controller*. Both *EDM Inputs* must be closed before the *Safety Controller* can be *System Reset* and the OSSDs can turn *ON*. While the OSSDs are *ON*, the *Inputs* may change state (either both open, or both closed). If the *Inputs* remain in opposite states for more than 250 ms, a lockout occurs.

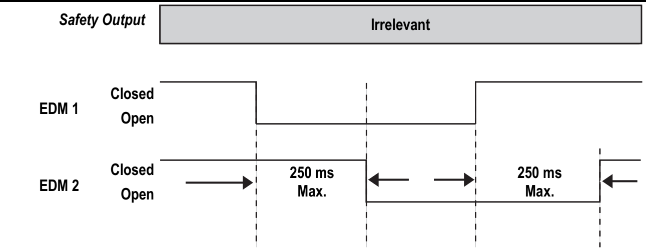


Figure 9 Timing for Dual channel EDM Between Channels

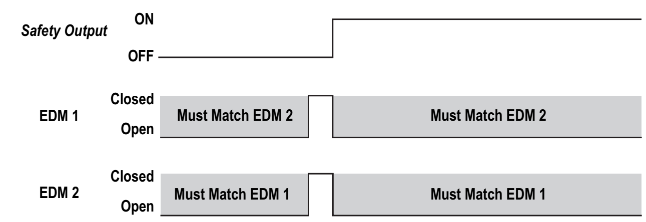


Figure 10 Dual channel EDM Status, with Respect to Safety Output

2.6 CONFIGURING THE SAFETY CONTROLLER

A configuration for the *Safety Controller* can be built up, using one of the two interfaces:

- Push buttons and display of the *OBI* on *Controller* itself

or

- *PCI* software program (included on the enclosed CD p/n 134534)

The process comprises three main steps:

Defining *Safeguarding* Application (Risk Assessment)

- Determining required devices
- Determining required level of safety

Building Configuration

- Selecting *Safety Input* types and circuit connections
- Mapping each *Safety Input*/*Non-Safety Input* to one or more *Safety Output(s)* or to other *Safety Input*/*Non-Safety Input* devices
- Setting optional *Safety Output ON*- or *OFF*-time delays
- Selecting *Non-Safety Input* types and circuit connections, if required
- Assigning status output signals, if required
- Creating *Configuration Name*, file name, date, author name, and notes

Confirming Configuration

- *Safety Controller* verifying that the desired configuration is valid
- User confirming that the configuration is as expected

2.6.1 Safety Outputs

WARNINGS

OSSD INTERFACING

TO ENSURE PROPER OPERATION, THE SAFETY CONTROLLER OUTPUT PARAMETERS AND MACHINE INPUT PARAMETERS MUST BE CONSIDERED WHEN INTERFACING THE SOLID-STATE SAFETY OUTPUT TO THE MACHINE INPUTS.

MACHINE CONTROL CIRCUITRY MUST BE DESIGNED SO THAT:

- THE MAXIMUM CABLE RESISTANCE VALUE BETWEEN THE SAFETY CONTROLLER SOLID-STATE SAFETY OUTPUT 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, AND
- THE SAFETY CONTROLLER'S SOLID-STATE SAFETY OUTPUT MAXIMUM LEAKAGE CURRENT, DUE TO THE LOSS OF 0 V, WILL NOT RESULT IN AN ON CONDITION

FAILURE TO PROPERLY INTERFACE THE SAFETY OUTPUT TO THE GUARDED MACHINE COULD RESULT IN SERIOUS BODILY INJURY OR DEATH.

INTERFACING OF BOTH OSSDS

BOTH OF THE OSSD 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) (E.G. 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.

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 WILL CREATE AN UNSAFE CONDITION.

SAFETY OUTPUT LEAD RESISTANCE

IN ORDER TO ENSURE PROPER OPERATION, THE RESISTANCE IN THE SAFETY OUTPUT WIRES SHOULD NOT EXCEED 10 OHMS. A HIGHER RESISTANCE THAN 10 OHMS MAY MASK A SHORT BETWEEN THE DUAL CHANNEL SAFETY OUTPUT AND COULD CREATE AN UNSAFE CONDITION THAT MAY LEAD TO SERIOUS BODILY INJURY OR DEATH.

CONNECTING SAFETY CONTROLLERS IN SERIES

A SAFETY OUTPUT FROM ONE SAFETY CONTROLLER CAN BE CONNECTED TO A SAFETY INPUT OF A SECOND SAFETY CONTROLLER. HOWEVER, THE SECOND SAFETY CONTROLLER SHOULD BE THE ONLY DEVICE TO WHICH THE OUTPUT FROM THE FIRST SAFETY CONTROLLER IS CONNECTED. IF A THIRD DEVICE IS ALSO CONNECTED TO THE SAME SAFETY OUTPUT (NOW USED AS THE SAFETY INPUT OF THE SECOND SAFETY CONTROLLER), THEN DURING A POWER TRANSITION OF THE SECOND SAFETY 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 SAFETY CONTROLLERS CORRECTLY COULD CREATE AN UNSAFE CONDITION THAT MAY LEAD TO SERIOUS BODILY INJURY OR DEATH.

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.

WARNING

Off-Delays

A SAFETY OUTPUT OFF-DELAY TIME WILL BE HONOURED EVEN IF THE SAFETY INPUT THAT CAUSED THE OFF-DELAY DELAY TIMER TO START SWITCHES 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, THEN ADDITIONAL SAFEGUARDING MEASURES MUST BE TAKEN TO PREVENT INJURIES.

NOTICE: *Safety Outputs* SO1, SO2 & SO3 are *Dual Channel Outputs*.

An individual Safety Output (e.g. SO1) 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 (i.e. Category 4), both the 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 MPCEs, resulting in a non-hazardous condition.

FSDs typically accomplish this when the OSSDs go to an OFF state (see Figure 31 on page 85 thru to Figure 34 on page 87).

The *Safety Outputs* (see Figure 12 on page 14) are designed to control Final Switching Devices (FSDs) and 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 *EDM*.

The *Safety Controller* has three independently controlled and *Redundant* solid-state *Safety Outputs*. The *Safety 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 *Safety Input* devices with both *Automatic* and *Manual Reset* operation.

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 OSSDs (see Figure 15 on page 19). 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* 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.

2.6.1.1 Functional Stops as per IEC 60204-1

The *Safety Controller* is capable of performing the 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, for example, machines need power for a braking mechanism to stop the hazardous motion.

2.6.1.2 OSSD Output Connections

The 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 MPCEs, resulting in a non-hazardous condition.

FSDs typically accomplish this when the *Safety Outputs* go to the *OFF* state. See Figure 15 on page 19.

Refer to the output specifications (table 4 on page 20) and WARNING above left before making OSSD connections and interfacing the *Safety Controller* to the machine.

2.6.1.3 Safety Output On-Delays & Off-Delays

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 REMAINS OFF WHILE THE DELAY TIME IS RUNNING.

AT THE END OF THE DELAY TIME, THE DELAYED OUTPUT ALSO TURNS OFF. BOTH OUTPUTS THEN REMAIN OFF FOR ABOUT 500 MS, BEFORE THEY TURN BACK ON. THIS HAPPENS EITHER AUTOMATICALLY, IF CONFIGURED FOR AUTOMATIC RESET, OR AFTER A VALID MANUAL RESET SIGNAL, IF CONFIGURED FOR MANUAL RESET.

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 ms to 5 minutes, in 100 ms increments (see Figure 11 on page 14 and Figure 12 on page 14.

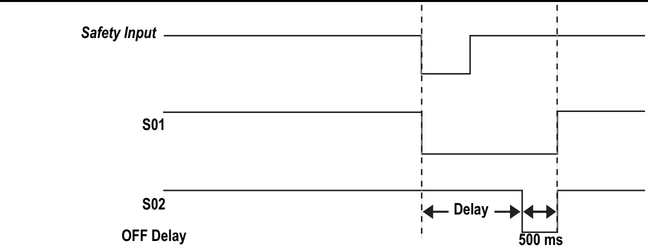
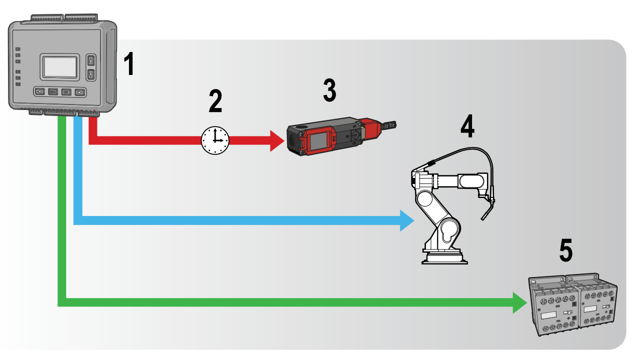


Figure 11 Safety Output with OFF Delay Timing Logic

Safety Output ON-delays are sometimes used when a machine operation must be delayed before a safe machine start-up is permitted. An example application would be a robot weld cell. See block 2.6.1 on page 13 for more information.



Index to figure
1. Safety Controller
2. *OFF*-Delay
3. Solenoid Locking Switch
4. Robot
5. Contactors

Figure 12 Safety Outputs

2.6.2 Status Outputs

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 COULD LEAD TO SERIOUS INJURY OR DEATH.

The *Safety Controller* has ten configurable status *Outputs* which are used to:

• Send non-safety status signals to PLCs

or

• To HMIs (Human Machine Interfaces)

or

• They may be used to power indicator lights

These *Outputs* can be configured to report on the status of *Safety Input* or *Non-Safety Input* devices, *Safety Outputs*, or the *Controller* itself. See block 4.10 on page 35 for more information.

Signal Convention

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

- An input is in the *Run* state
- A *Safety Output* is in the *ON* state (see note * on page 14)
- A Safety Output is in a logical ON state (ON or in an ON-delay (see note * on page 14)
- The system is in a lockout condition
- An I/O fault is present (see note on page 14)
- A system *Reset* is needed
- A *Safety Output* needs a *Reset* (see note on page 14)
- A *Safety Input* is muted
- Which Safety Input, of a defined group of Safety Inputs, turned OFF first

☛ *Only Safety Outputs that have Inputs Mapped to them can be Mapped to a status output.*

An I/O fault is a failure of one or more Safety Inputs, Safety Outputs or Status Outputs.

Only Safety Outputs Mapped to Inputs configured with Manual Reset logic can have a status output configured to indicate a Reset is needed.

2.6.2.1 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*, the *Controller* 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 to monitor a 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, block 3.2.1 on page 20).*

2.6.3 Virtual Status Outputs

WARNING

VIRTUAL STATUS OUTPUTS

THE VIRTUAL 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 VIRTUAL STATUS OUTPUT IS USED TO CONTROL A SAFETY-CRITICAL APPLICATION, A FAILURE TO DANGER IS POSSIBLE AND COULD LEAD TO SERIOUS INJURY OR DEATH.

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

2.6.4 I/O Mapping & the I/O Control Relationship

The term map or mapping 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 (see Figure 13 on page 15).

2.6.4.1 Safety Inputs & Non-Safety Inputs Mapped to Outputs

The following devices can be mapped directly to the *Safety Outputs*:

- *Emergency Stop* buttons
- *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*

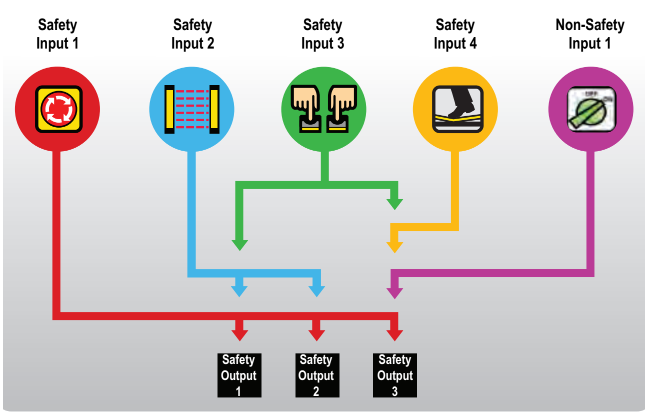


Figure 13 Input & Output Mapping

2.6.4.2 Inputs Mapped to Inputs

Muting sensors and bypass switches work in conjunction with certain *Safety Inputs* to temporarily suspend the *Stop* signal of a *Safety Input*. These sensors and switches are mapped directly to the *Safety Inputs*; they are then indirectly *Mapped to* the *Safety Output* that the muted *Safety Inputs* control (see block 1.11 on page 5).

2.7 SYSTEM SETTINGS

WARNINGS

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 PROVIDING 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.

CONTROLLER OPERATION ON POWER-UP

IT IS THE RESPONSIBILITY OF THE PERSON WHO CONFIGURES, INSTALLS, AND/OR MAINTAINS THE CONTROLLER TO ASSESS WHAT SAFEGUARDING DEVICES AND METHODS ARE APPROPRIATE FOR ANY GIVEN MACHINE OR APPLICATION AND TO BE AWARE THAT THE POWER-UP BEHAVIOUR OF THIS CONTROLLER MAY NOT BE OBVIOUS TO THE MACHINE OPERATOR.

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*

2.7.1 Settings Breakdown

2.7.1.1 Configuration Name

The *Configuration Name* identifies the configuration that will be used in a *Safety Controller* application. The *Configuration Name* can be displayed on the *Controller* and will be useful to be sure that the configuration in a *Controller* is the correct one.

2.7.1.2 Author's name

The *Author's name* may also be helpful when questions arise about configuration settings.

2.7.1.3 Power-up mode

Used for Operational Characteristics when Power Is Applied

The *Controller* provides three power-up modes to choose from to determine how the *Controller* will behave immediately after power is applied. These power-up modes are: *Normal*, *Automatic* and *Manual*.

After power is applied, when in *Normal* power-up mode (default):

- Only those *Safety Outputs* that have only *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*

After power is applied, when in *Automatic* power-up mode:

- 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 Switch 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* remain *OFF*

After power is applied, when in *Manual* power-up Mode:

- *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 *Reset* for a manual *Latch* 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*

2.7.2 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 signalling a muted condition (e.g. *active* or *closed)*. See also block 1.11 on page 5.

2.7.3 *Monitored System Reset*

A *Monitored System Reset* is enabled by default and requires an *OFF-ON-OFF* signal at the *System Reset* input, where the *ON*-duration must be between 0,3 s and 2 s (trailing edge *System Reset)*, in order to *Reset* the system.

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

2.8 INTERNAL LOGIC

See also block 2.5.1 on page 8.

2.8.1 Additional Logic Functions

Other logic functions are slight variations of the general *AND* logic rule set as follows:

- ***Two-Hand Control*** The machine initiation signal incorporating a 0,5 second actuation *Simultaneity Limit* and *Anti-Tie-Down Logic*, designed to prevent single-actuation machine cycle operation
- ***Safety Device Mute Enable*** The automatic suspension of one or more *Safety Input(s)* for *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 Switch*** The manually activated, temporary suspension of one or more *Safety Input(s)* for *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

The rules that apply to these special cases are explained in appendix A2.

2.9 PASSWORD OVERVIEW

To provide security, the *Safety Controller* requires use of a password in some cases. For information about changing a *Safety Controller's* password, refer to block 5.1.18 on page 50 *(PCI)* and block 6.3.3 on page 66 *(OBI)*.

☛ *If the password becomes lost, contact Corporate Office as listed on page 127.*

For Creating a Configuration:

- Via PC using *Controller PCI* program (no password required)
- Via *Safety Controller* password protected *OBI*

Confirming a Configuration:

- Via password protected *PCI* using PC connected to a powered-up *Controller*
- Via password protected *OBI* on a powered *Controller*

Sending a Confirmed Configuration to the Safety Controller:

- Via a direct connection between the PC and *Controller*, using SC-USB1 cable and password protected *PCI*
- Via password protected *PCI* PC, *XM Card* programming tool and *XM Card*

2.10 CONFIRMING A CONFIGURATION

Although a *Safety 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 *PCI*.

IMPORTANT: If any modification is made to a confirmed configuration, or if a configuration is edited during the confirmation process, the *PCI* and the *Safety Controller OBI* 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 reconfirming. The configuration code will be validated automatically each time it is downloaded to a *Safety Controller* and whenever the *Safety Controller* powers up. Configurations, confirmed or not, can be sent via email. Sending (down loading) a new confirmed configuration to a *Safety Controller* requires entry of the *Safety Controller* password.

2.11 PC INTERFACE 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

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 Diagrams* and *Ladder Logic Diagrams*. These diagrams provide I/O device wiring detail for the installer and a symbolic representation of the *Safety Controller's Safeguarding* logic for the use of the machine designer or controls engineer. Refer to block 5.1 on page 37, for further instruction on the use of this interface.

2.12 ON BOARD INTERFACE OVERVIEW

The *Safety Controller* On Board 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 the *Input Devices* themselves as well as between the *Input Devices* and the *Outputs*.

Figure 14 on page 18 gives a breakdown of all the *Run* mode and *Configuration* mode options available using the *OBI*.

To move through the menus, in most cases, the ***OK*** push button must be pressed to make a selection or move further down the menu tree. Pressing the ***ESC*** push button allows movement further up the tree. When a vertical list of options appears on the screen, the up/down arrow push buttons are used to highlight an option selected. The highlighted option is selected by pressing ***OK***. When a single option appears on the screen (for example, an *Input Device)* with an arrow running across the top of the screen, the left/right arrow push buttons are used to step through the selections. The option shown on the screen is selected when ***OK*** is pressed.

Refer to chapter 6, for further instruction on the use of this interface.

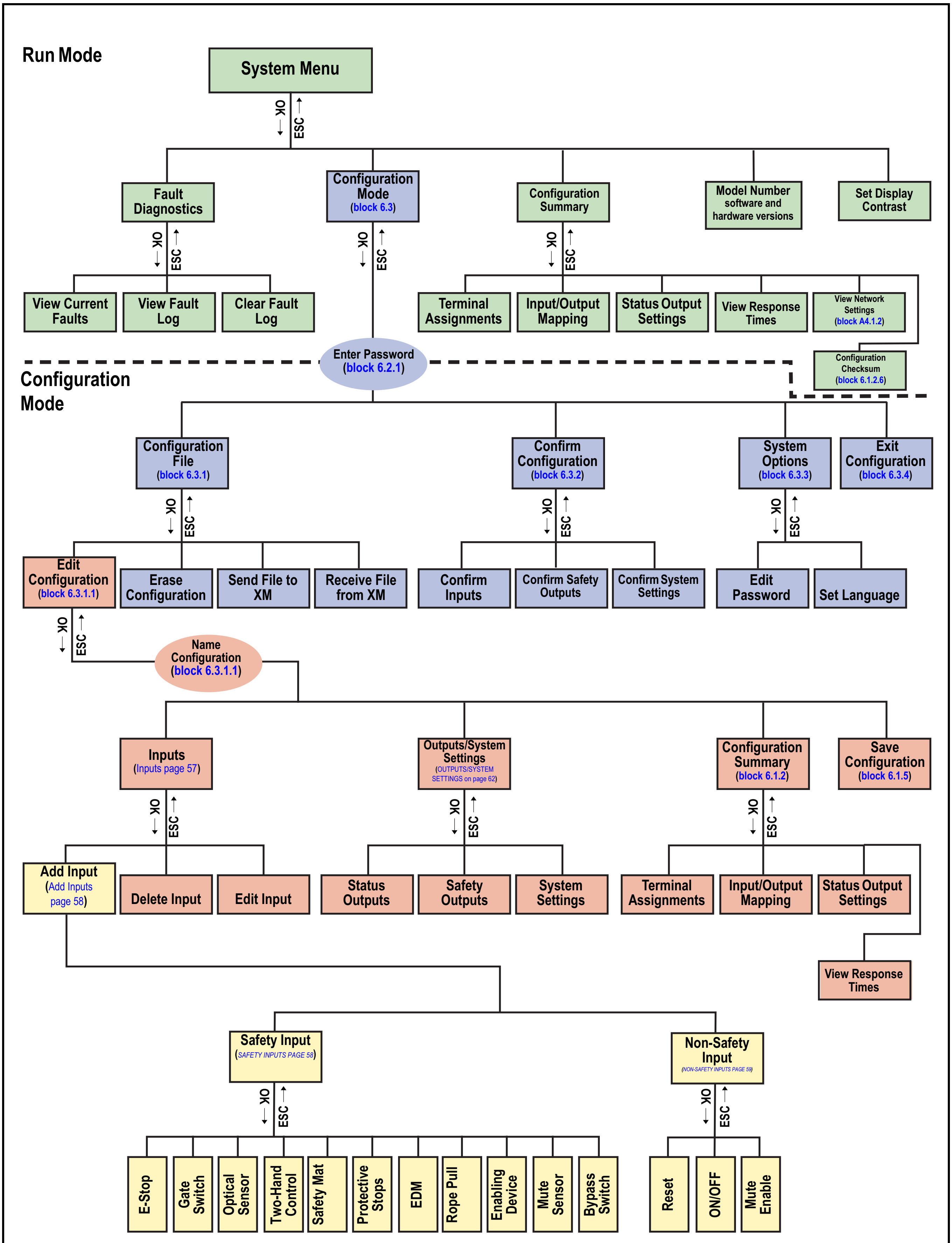


Figure 14 OBI Configuration Options

3 GENERAL INFORMATION

This Chapter details information of a general nature on the equipment.

3.1 PRODUCT

This block details product information such as CE and Product Identification Plates together with their location.

3.1.1 CE Marking / Product Identification Plate

The CE information is combined with Product Identification Information as shown in Figure 15 on page 19.

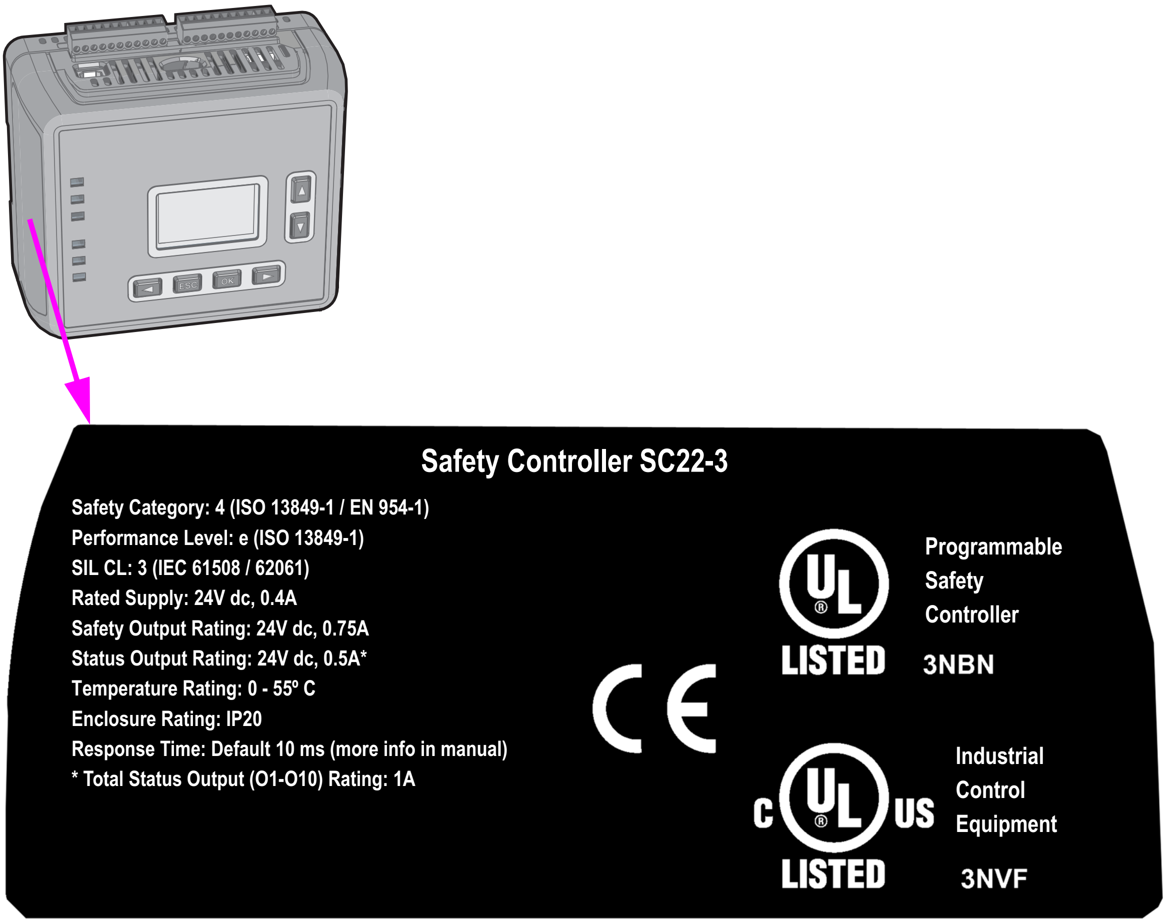


Figure 15 Safety Controller CE Marking / Production Identification Plate

3.1.2 Certificate of Adequacy

The *Safety Controller* Instruction *Manual* (Part No. 135369 Dated 06.03.08) satisfies the requirements of:
Machine Directive 2006/42/EC, Safety of Machinery, Block 1.7.4 - Instructions.

3.1.3 Declaration of Conformity

The *Safety Controller* is delivered with a *Declaration of Conformity* as shown in appendix A3.1 on page 117.

This declaration is delivered to the Customer to certify that the product complies with the CE-Norm.

3.2 TECHNICAL DATA

This block details the most important technical data for the product.

3.2.1 Specifications

Table 4 on page 20 lists the specifications for the *Safety Controller*.

Table 4 Safety Controller General Specifications

<table>
<tr><th>Nomenclature</th><th colspan="2">Value/Meaning</th></tr>
<tr><td>Power</td><td colspan="2">24 V dc, ± 20%
Model SC22-3: 0,4 A (Safety Controller only), 5,9 A (all Outputs ON @ full rated load)
Model SC22-3E: 0,4 A (Safety Controller only), 5,9 A (all Outputs ON @ full rated load)
The Safety Controller should be connected only to a SELV (safety extra-low voltage, for circuits without earth ground) or PELV (protected extra-low voltage, for circuits with earth ground) power supply.</td></tr>
<tr><td>Safety Input & Non-Safety Input
(22 terminals)</td><td colspan="2">Input ON threshold: > 15 V dc (guaranteed on), 30 V dc max.
Input OFF threshold: < 5 V dc (guaranteed off with any 1 fault), – 3 V dc min.
Input ON current: 8 mA typical @ 24 V dc, > 2 mA (guaranteed with 1 fault)
50 mA peak contact cleaning current @ 24 V dc
Sourcing current: 30 mA minimum continuous (3 V dc max. drop)
Input lead resistance: 300 Ohm max. (150 Ohm per lead)</td></tr>
<tr><td>Safety Outputs
(6 terminals, 3 Redundant Outputs)</td><td colspan="2">Model SC22-3 Rated output current: 0,75 A max. @ 24 V dc (1,0 V dc max. drop)
Model SC22-3E Rated output current: 0,75 A max. @ 24 V dc (1,0 V dc max. drop)
Output OFF threshold: 0,6 V dc typical (1,2 V dc max. guaranteed with 1 fault)
Output leakage current: 50 μA max. with open 0 V
Load: 0,1 μF max., 1 H max., 10 Ohm max. per lead</td></tr>
<tr><td>Status Outputs
(10 terminals)</td><td colspan="2">Rated output current: 0,5A @ 24 V dc (individual), 1,0 A @ 24 V dc (total of all Outputs)
O1 to O8 (General Purpose) Output OFF voltage: < 0,5 V dc (no load), 22 Kilaohms pull down to 0 V
O9 and O10 (General Purpose or Monitored Mute Lamp)
Output OFF voltage: Internal 94 Kilaohms pull up to V supply
Output ON/OFF threshold: 15 V dc ± 4 V dc @ 24 V dc supply
☛ For O9 and O10, if a short circuit or other fault condition causes the output to drop below this threshold while the output is ON, a lockout occurs. If an open circuit or other fault condition causes the output to rise above this threshold while the output is OFF, a lockout occurs.</td></tr>
<tr><td>Response and
Recovery Times</td><td colspan="2">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 (Automatic Reset)</td></tr>
<tr><td>Onboard LCD Information Display — Password Requirements</td><td>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)</td><td>Password is required:
Configuration mode (create/modify/confirm/download configurations)</td></tr>
<tr><td>Environmental Rating</td><td colspan="2">IEC IP20, for use inside IEC IP54 or better enclosure</td></tr>
<tr><td>Operating Conditions</td><td colspan="2">Temperature range: 0° to +55° C</td></tr>
<tr><td>Mechanical Stress</td><td colspan="2">Shock: 15 g for 11 ms, half sine, 18 shocks total (per IEC 61131-2)
Bump: 10 g for 16 ms, 6000 cycles total (per IEC 61496-1)
Vibration: 3,5 mm occasional / 1,75 mm continuous @ 5 Hz to 9 Hz, 1,0 g occasional and 0,5 g continuous @ 9 Hz to 150 Hz: (per IEC 61131-2) and 0,35 mm single amplitude / 0,70 mm peak-to-peak @ 10 Hz to 55 Hz (per IEC 61496-1), all @ 10 sweep cycles per axis</td></tr>
<tr><td>EMC</td><td colspan="2">Meets or exceeds all EMC requirements in IEC 61131-2, IEC 61496-1 (Type 4), and IEC 62061 Annex E, Table E.1 (increased immunity levels)</td></tr>
<tr><td>Removable Terminals</td><td colspan="2">Screw Terminals
Wire sizes: 0,20 mm² – 1,31 mm²
Wire strip length: 5,00 mm
Tightening torque: 0,23 Nm nominal
Tightening torque: 0,34 Nm maximum
Clamp Terminals
Wire size: 0,20 mm² – 1.31 mm²
Wire strip length: 9,00 mm
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.</td></tr>
</table>

Table 4 Safety Controller General Specifications

Nomenclature	Value/Meaning
Network Interface (Model SC22-3E only)	Ethernet 10/100 Base-T/TX, RJ45 modulator, 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	• SIL 3 as per IEC 62061 Safety of Machinery – Functional Safety of Safety-Related Electrical, Electronic and Programmable Electronic Control Systems • SIL 3 as per as per IEC 61508 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems • *Category 4* as per ISO 13849-1 (1999) / (EN954-1) (1999) • *Category 4 Performance Level* (PL) e per ISO 13849-1 (2006) • Complies with Machinery Directive 2006/42/EC • IEC 61131-2 Programmable Controllers, Part 2: Equipment Requirements and Tests • IEC 60204-1 Electrical Equipment of Machines: General Requirements • EN 954-1 Safety of Machinery. Safety Related Parts of Control Systems. General Principles. • ISO 13851 (EN574) Safety of Machinery – Two-Hand Control Devices – Functional Aspects and Design Principles • ISO 13850 (EN418) Emergency Stop Devices Also see DOC for a list of other applicable International Standards.
Agency Approvals	CE Approvals for model **SC22-3E** are pending.

3.2.2 Model/Type Numbering

For model and order numbers see block 8.4.1.1 on page 83.

Included with the *Safety Controller* are the following documents:

- European Instruction Manual (this document; for further break-down, see block 8.4.2 on page 84)
- Quick Start Guide (for order numbers, see block 8.4.2 on page 84)

3.2.3 Safety Controller Dimensions

Figure 16 on page 22 gives the dimensions for the *Safety Controller*.

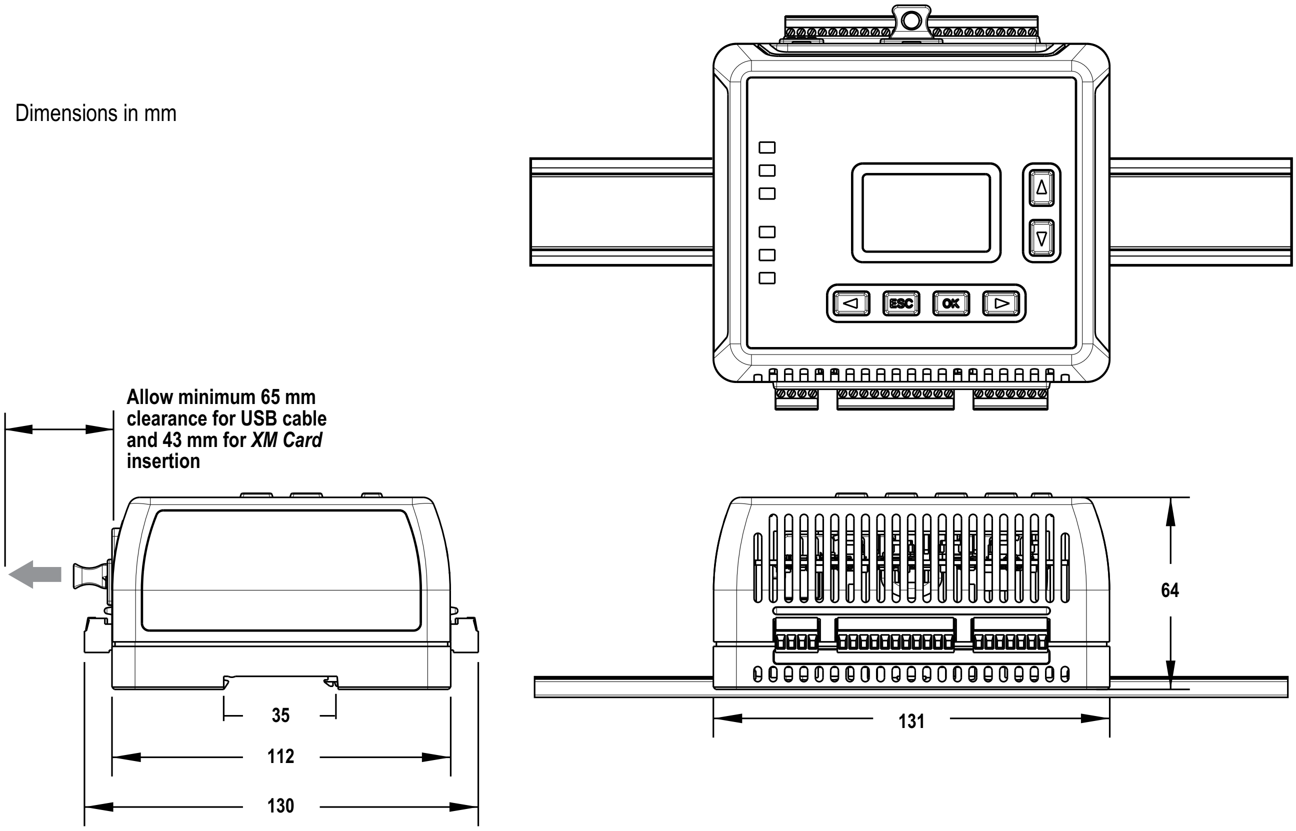


Figure 16 Safety Controller Dimensions

3.3 CUSTOMER SERVICE INFORMATION

For Customer service information refer to appendix A6 on page 127.

4 INSTALLATION - SYSTEM

WARNING

BEFORE CARRYING OUT ANY INSTALLATION OF THE SAFETY CONTROLLER, READ THE SAFETY INFORMATION CONTAINED IN CHAPTER 1.

4.1 INSTALLING THE SAFETY CONTROLLER

The Safety Controller mounts to a standard 35 mm DIN-rail track. It must be installed inside an enclosure rated 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.

For reliable operation, the user must ensure that the operating specifications are not exceeded. The enclosure must provide adequate heat dissipation, so that the air closely surrounding the Controller does not exceed its maximum operating temperature. Methods to reduce heat build-up include venting, forced air flow (e.g., exhaust fans), adequate enclosure exterior surface area, and spacing between the Safety Controller and other sources of heat. (See Specifications, “Operating Conditions” Table 4 on page 20)

The Safety Controller should be mounted in a convenient location that is free from heavy impulse force and high-amplitude vibration.

Electrostatic Discharge (ESD) can cause damage to electronic equipment. To prevent this, follow proper ESD handling practices such as:

- Wear an approved wrist strap or other approved grounding products.
- Touch a grounded object before handling the Controller.

See ANSI/ESD S20.20 (2007) for further information about managing ESD.

4.2 SAFETY CONTROLLER INTERFACING

Safety Controller interfacing is dependent on the type of machine and the safeguards that are to be interfaced with the *Controller*. The *Controller* is generally interfaced with safeguards that may be used only on machinery that is capable of stopping motion immediately upon receiving a *Stop* signal and at any point in its machine cycle. It is the user's responsibility to verify whether the *Safeguarding* is appropriate for the application and is installed as instructed by the appropriate installation Manuals.

If there is any doubt about whether or not your machinery is compatible with this *Controller*, contact Corporate Office as listed on page 127.

4.3 COMPONENTS

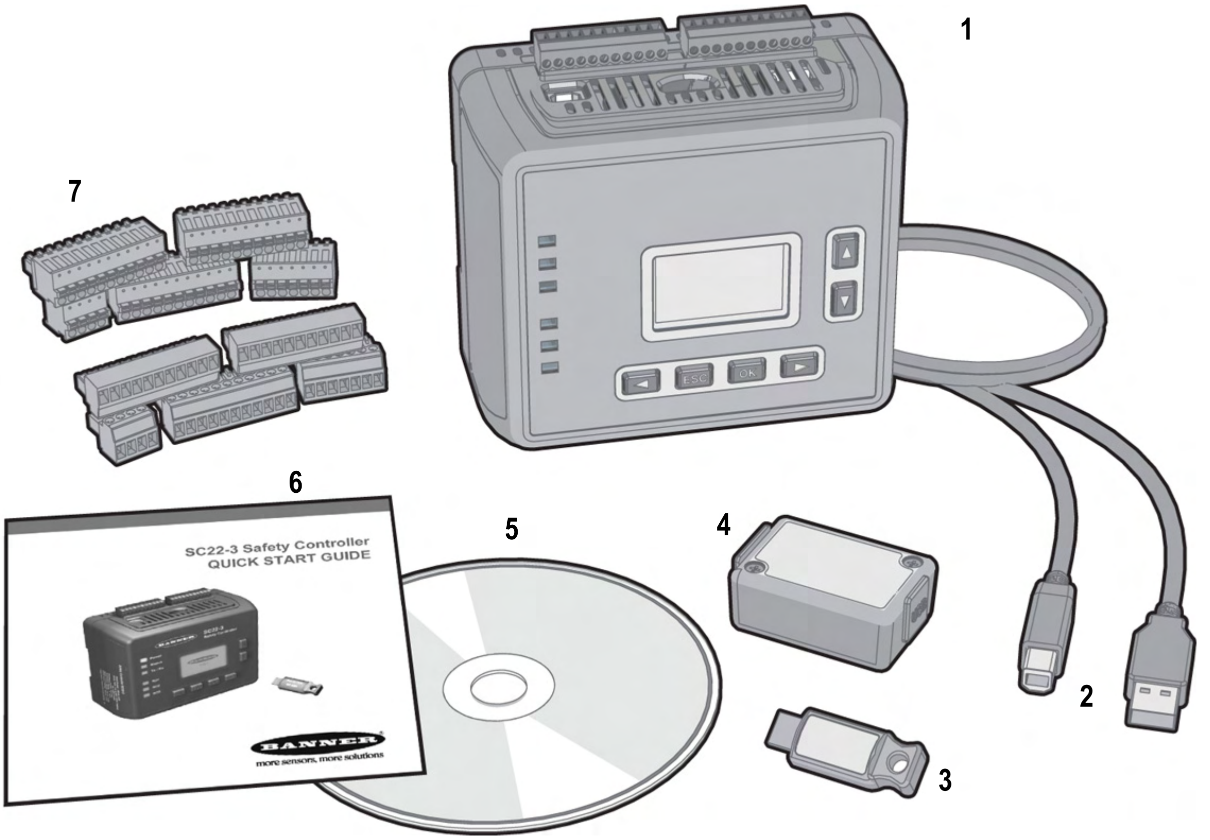
The *Safety Controller* Starter Kit (see block 8.4.1 on page 83 for further breakdown and replacement parts) includes the following (see Figure 17 on page 24):

- x1 *Safety Controller* (model SC22-3 or SC22-3E)
- x1 set of removable terminals (choose screw or clamp type)
- x1 SC-XM1 external memory card (*XM Card)*
- x1 USB A/B cable (some models)
- x1 SC-XMP *XM Card* programming tool (some models)
- x1 CD containing *PCI* software, Instruction Manual, and configuration tutorials (p/n 134534)
- x1 Quick Start Guide (p/n 133485)
- Standard US English Manual (Part No. 133487)*
- European Language Kit **

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

***Users please note that the Manual (133487) is NOT suitable for use within the EU. European users of the Safety Controller should use the European English version (this Manual 135369) or a translated equivalent.**

****For details contact your** corporate office as listed on page 127.



Index to figure

1. Safety Controller
2. USB A/B Cables
3. External memory card *(XM Card)*
4. SC-XMP *XM Card* programming tool (some models)
5. CD containing *PCI* software instruction *Manual* & configuration tutorials
6. Quick Start Guide
7. Removable Terminals

Figure 17 Safety Controller Kit Components

4.4 CONNECTING SAFETY CONTROLLER

4.4.1 Electrical Connection

1) Referring to appropriate Vendor Installation instructions in conjunction with *Safety Controller* configuration information contained in this Instruction Manual, connect supplied *Safety Controller* terminal blocks (shown in Figure 17 on page 24) to *Power Supply*, *Status Outputs*, *Safety Outputs* and *Inputs*.

4.4.2 USB Connections

The *Safety Controller* is connected to a PC by way of a USB A/B cable (Figure 18 on page 25). The cable is also used to connect the PC to the *SC-XMP Programming Tool* (Figure 19 on page 25 refers) in order to download a configuration to the *XM Card*.

1) Referring to Figure 18 on page 25, connect USB A/B cable to *Safety Controller* and PC with *PCI* configured software loaded.

Figure 18 PC to Safety Controller USB Port Connection

4.4.3 Ethernet Connections

Ethernet connections are made using an ethernet cable from the SC22-3E Ethernet port (see Figure 1-3) to a network switch or the user's control device. The SC22-3E supports use of either standard or crossover-style cables; see Section 2.1 for available models. Shielded cable may be needed in high-noise environments.

4.4.4 SC-XMP Programming Tool

The *SC-XMP Programming Tool* is a handy device that can be 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 an *Safety Controller*. It connects to the PC via the USB A/B cable and the PC's USB port (see Figure 19 on page 25).

1) Referring to Figure 19 on page 25, connect *SC-XMP Programming Tool*.
2) Plug in *XM Card*.

☛ *For Information on loading configuration to XM Card*, refer to *block 5.1.16 on page 50*.

Figure 19 PC to SC-XMP Programming Tool Connection

4.4.5 SC-XM1 External Memory XM Card

The model *SC-XM1 External Memory XM Stick* 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 Safety Controller* is shown connected to the Figure 19 on page 25.

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* (see block 5.1.16 on page 50)
- Send/Receive copy from/to *Safety Controller* to *XM Card*, using *OBI* (see block 6.3.1.2 on page 64 or block 6.3.1.3 on page 64)

☛ *A configuration can be stored permanently in an XM Card, if the "lock" function is performed.*
Configurations on an XM card do NOT contain any network settings. The PCI software must be used to change network settings

Figure 20 Safety Controller Connections

4.5 SAFETY DEVICE CONNECTION CONSIDERATIONS

WARNING

THE USER IS RESPONSIBLE FOR ENSURING THAT ALL LOCAL, STATE, AND NATIONAL LAWS, RULES, CODES, AND REGULATIONS RELATING TO THE USE OF THE SAFETY CONTROLLER IN ANY PARTICULAR APPLICATION ARE SATISFIED. EXTREME CARE IS URGED THAT ALL LEGAL REQUIREMENTS HAVE BEEN MET AND THAT ALL INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS CONTAINED IN THE SAFETY DEVICE MANUAL FROM THE MANUFACTURER AND IN THIS MANUAL ARE FOLLOWED.

The *Inputs* of the *Safety Controller* can be configured to interface with many types of safety devices, including *Safeguarding Devices* (e.g. Safety Light Screens), complementary protective equipment (e.g. Emergency Stop Push Buttons) and other devices that impact the safe use of a machine (e.g. 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.

4.6 SAFETY INPUT DEVICE PROPERTIES

Figure 21 on page 26 gives a breakdown of the *Safety Input* properties menu.

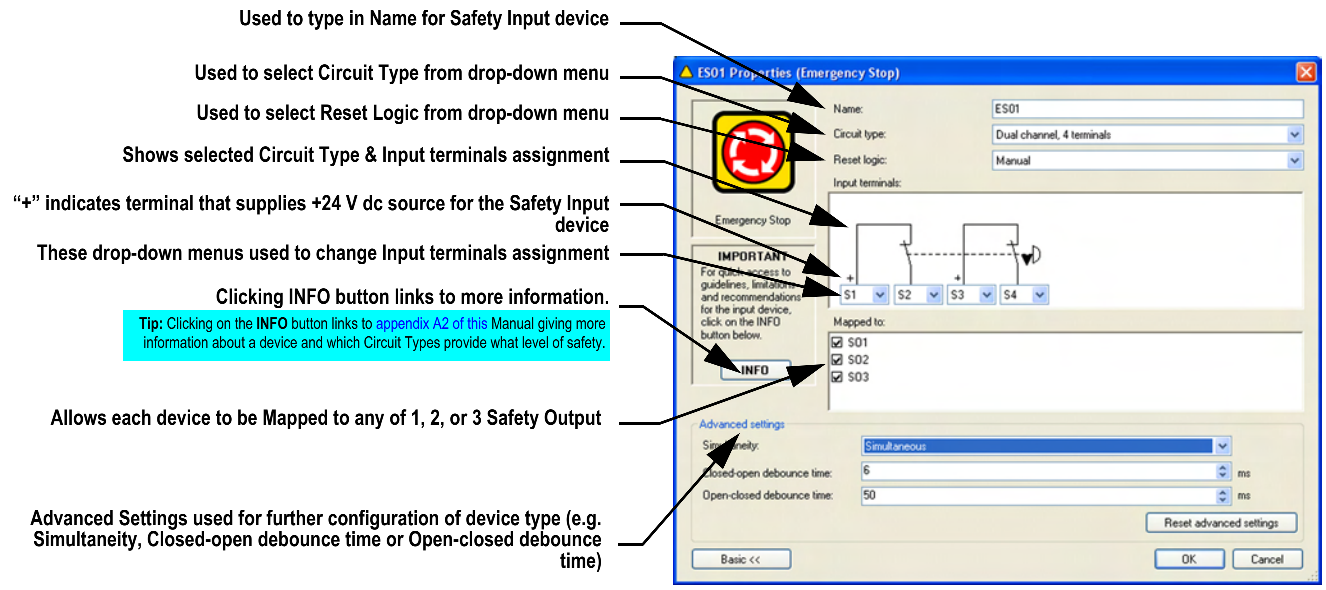


Figure 21 Safety Input Properties Breakdown

4.6.1 General

The *Controller* can be configured to accommodate many types of *Safety Inputs*. However, a number of device properties must be established (using either the *OBI* or *PCI)* so that the *Controller* can properly monitor their signals.

The *Safety Input* devices configurable properties breakdown is detailed in Table 5 below and block 4.6.2 thru' to block 4.6.11.

4.6.2 Name

This property is used for automatically configuring the Device *Name* by the *Controller* and can be changed by the user.

4.6.3 Circuit Type

This property is used to configure the circuit and signal convention options that can be selected to define the *Safety Input* device. Table 5 below shows a selection of the *Safety Input* devices and *Circuit Types* the *Safety Controller* can monitor. It also 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 as per ISO 13849-1; refer to* appendix A2 *for more information over safety circuit integrity levels.*

Table 5 Safety Controller Safety Input Device & Circuit Type Monitoring Breakdown

Configurable Properties	*Emergency Stop*	*Gate Switch*	*Optical Sensor*	*Two-Hand Control*	*Rope Pull*	*Protective Stop*	*Safety Mat*	*Enabling Device*	*Mute Sensor*	*Bypass Switch*	*External Device Monitoring*
Circuit Types:	7	13	10	7	10	10	1	10	7	10	2
Reset Logic:	*Auto/Manual*	*Auto/Manual*	*Auto/Manual*	*Auto*	*Auto/Manual*	*Auto/Manual*	*Auto/Manual*	*Auto*	*Auto*	*Auto*	—
Mapped to:	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/I	I/I	I/O
COS* **(Simultaneity): Simultaneous (S) / Concurrent (C)**	S/C	S/C	S/C	S	S/C	S/C	—	S/C	S	S/C	S
Debounce	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Start-up Test	—	Yes	Yes	—	—	—	—	—	—	—	—
Function Time Limit	—	—	—	—	—	—	—	Yes	Yes	Yes	—
Muteable	—	Yes	Yes	Yes	—	—	Yes	—	—	—	—
Bypassable	—	Yes	Yes	Yes	—		Yes	—	—	—	—

* Signal Change-of-state (block 4.6.7.1 on page 28)
S = Simultaneity
C = Concurrency

4.6.4 Reset Logic

This property is used for configuring both *Automatic* (*Trip* mode) or *Manual (Latch* mode) *Resets. Safety Inputs* 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 *System Reset* is performed. If a *Safety Input* is configured for *Automatic Reset* or *Trip* mode, the *Safety Output(s)* it controls turn back *ON* when the *Input Device* changes to the *Run* state (provided that all other controlling *Inputs* are also in the *Run* state). *System Reset* rules and types are discussed in block 1.10 on page 5.

4.6.5 Input terminals

This property is used for configuring input terminals to connect *Safety Input*/*Non-Safety Input* devices. The *Safety Controller* needs to know what device signal lines are to be connected to which wiring terminals, so that it can apply the proper signal monitoring methods, *Run* and *Stop* convention, timing rules, and fault rules. Although terminals are assigned automatically during the configuration process, the terminal assignments can be changed manually, using either the *OBI* or the *PCI* Interface.

4.6.6 Mapped to:

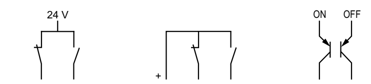
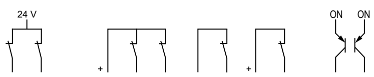
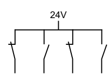
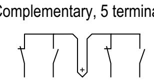
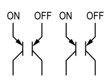
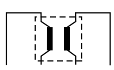
This property is used for configuring the logic control relationship between *Inputs* and *Outputs* or between *Inputs*

4.6.7 Advanced Settings

4.6.7.1 Signal Change-of-State (Simultaneity)

Two COS types *(Simultaneity* see Simultaneity) can be used when monitoring dual-channel safety *Input Device* signals for *Dual channel*; *Simultaneous* or *Concurrent*. The rules for each *Circuit Type* are listed in table 6 on page 28.

Table 6 Signal Change-of-State (COS)(Simultaneity) Types

Circuit Type	Circuit Symbol	Input Signal *Stop* State COS (Simultaneity) Timing Rules	Input Signal *Run* State COS (Simultaneity) Timing Rules
		The Safety Output turns OFF when[1]:	**The Safety Output turns ON when[2]:**
Dual channel A & B Complementary	Complementary, 2 terminals; Complementary, 3 terminals; Complementary, PNP switch 	At least 1 channel (A or B) input in the *Stop* state.	**Simultaneity** A and B are both in the *Stop* state and then both in the *Run* state within 3 s before *Outputs* turn *ON*. **Concurrency** A and B concurrently in the *Stop* state, then both in the *Run* state with no simultaneity, to turn *Outputs ON*.
Dual channel A & B	Dual channel, 2 terminals; Dual channel, 3 terminals; Dual channel, 4 terminal; Dual Channel, PNP 		
x2 Complementary A & B	2X Complementary, 4 terminals  2X Complementary, 5 terminals  2X Complementary, PNP switch 	At least 1 channel (A or B) within a pair of contacts in the *Stop* state.	**Simultaneity** A and B 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 in the *Run* state within 3 s (0,5 s for *Two-Hand Control)*. **Concurrency** A and B concurrently in the *Stop* state, then contacts within a channel in the *Run* state within 3 s. Both channels in the *Run* state with no simultaneity.
x2 Complementary A & B	Safety Mat 4 Terminals 	Input channels are shorted together, or At least 1 of the wires is disconnected, or one of the normally low channels is detected high, or one of the normally high channels is detected low	Each channel detects its own pulses.

☛ [1] *Safety Outputs turn OFF when one of the controlling Inputs is in the Stop state.*

[2] *Safety Outputs will only turn ON when all of the controlling Inputs are in the Run state and only after a Manual Reset has been performed, if any of these Safety Inputs are configured for Manual Reset and were in their Stop state.*

4.6.7.2 Closed-open debounce time / Open-closed debounce time

⚠CAUTIONS

Debounce and Response Time

Any changes in the Closed-open debounce time will affect the Safety Output Response Time (turn OFF). 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.)

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.

Any changes in the Open-closed debounce time affects the Safety Output reaction (turn ON time).

The configurable Debounce of an ON/OFF input and an Enabling Device input are not part of the calculated and confirmed Response Times.

This property is used for configuring the signal state transition time.

Closed-open debounce time

From 6 ms to 100 ms in 1 ms intervals

The *Closed-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 longer signal transition times. If the *Closed-open debounce time* is set too short under these harsh conditions, the system may detect a signal disparity fault and lock out. (Default setting is 6 ms).

Open-closed debounce time

From 10 ms to 500 ms in 1 ms intervals

The *Open-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 longer signal transition times. If the *Open-closed debounce time* is set too short under these harsh conditions, the system may detect a signal disparity fault and lock out. (Default setting is 50 ms.)

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

4.6.8 Enable startup test

This property is used for configuring an optional precautionary *Safety Input* test after each power-up.

4.6.9 Device Time Limit

This property is used for configuring the adjustable time limit within a function is allowed to operate.

4.6.10 Muting Sensor Pair

This property is used for configuring whether or not the device can be muted.

4.6.11 Bypass Switch

This property is used for configuring whether or not the device can be bypassed.

4.7 NON-SAFETY INPUT DEVICE PROPERTIES

The *Non-Safety Input* devices configurable properties breakdown is detailed in Table 7 below and block 4.7.1 thru' to block 4.7.3.

Table 7 Non-Safety Input devices

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

4.7.1 Manual Reset Devices

The *Manual Reset* is used to create a *System Reset* signal after a *Safety Input* 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* can turn *ON*. See caution on page 5.

4.7.2 ON/OFF Switch

The *ON/OFF* switch is used to provide a machine *ON* or *OFF* command. 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.

4.7.3 Mute Enable Switch.

The mute enable switch is used to signal the *Controller* when the mute sensors are permitted to perform a mute function. When the mute enable function is configured, the mute sensors will not be 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.

4.8 CONFIGURING THE SAFETY CONTROLLER

Building a configuration for the *Safety Controller* is a simple process, using one of two interfaces:

- The push buttons and display on the *Safety Controller* itself *(OBI)* or
- The *PCI* software program on the CD (p/n 134534) included in the *Safety Controller* Kit.

The process comprises three main steps:

a) Define the safeguarding application (risk assessment).
   - Determine the required devices.
   - Determine the required level of safety.

b) 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.

c) Confirm the configuration.
   - Controller verifies that the desired configuration is valid.
   - User confirms that the configuration is what is expected.

4.8.1 OBI

The *Safety Controller* can be configured using the *OBI* with its built-in push buttons and LCD screen. 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*. Refer to Figure 22 on page 30 and Table 8 on page 31 for *OBI* breakdown.

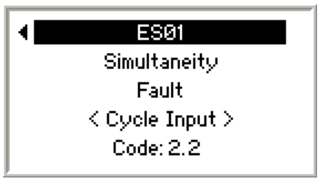
The display is used in conjunction with the six push buttons to:

- Create or modify password protected configurations
- Retrieve fault log information
- Review device wiring detail and I/O logic relationships and
- Display I/O device fault details and likely remedial steps
- Display configuration checksum

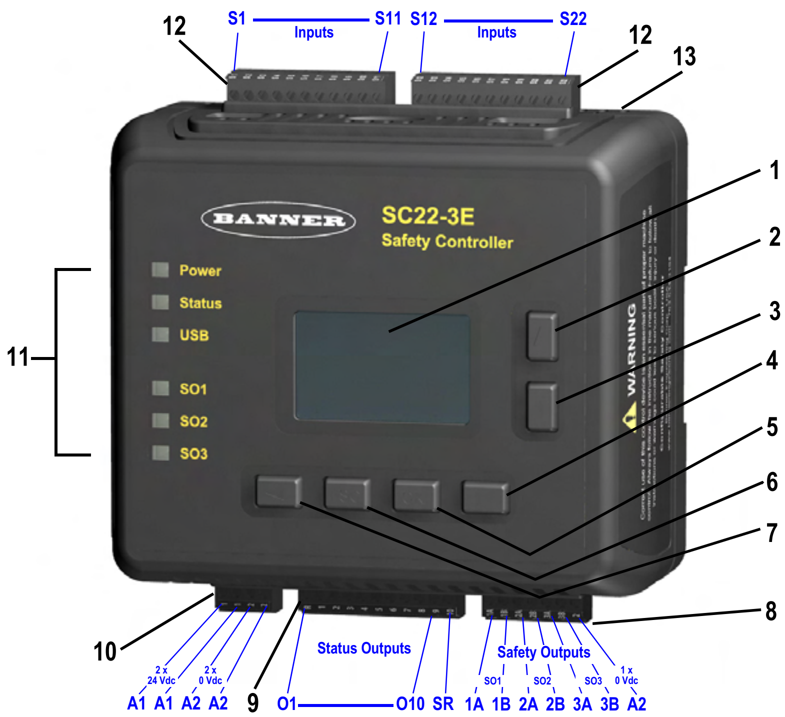
☛ *For more detailed information on OBI functions refer to chapter 6.*
The OBI cannot be used to change network settings; the PCI must be used for that function.

Accessing Fault Codes

The Fault codes are displayed in the last line of the *OBI Fault Diagnostics* menu (see screen 1). Refer to chapter 6 and block 8.3.3 on page 78 for more information.



Screen 1



Index to figure

1. Liquid Crystal Display
2. Moves cursor up or causes items within a list to be displayed as the cursor is moving up through the list. May also be used to make selection settings.
3. Moves cursor down or causes items within a list to be displayed as the cursor is moving down through the list. May also be used to make selection settings.
4. Moves cursor to the right or performs selection setting.
5. Enters or stores the item highlighted in the display as the intended selection or may be used to toggle a setting
6. Moves cursor to the pre-established point in the program to re-establish a menu reference point.
7. Moves cursor to the left or performs selection setting
8. Safety Output Terminal Connector
9. Status Output Terminal Connector
10. Power Supply Terminal Connector
11. Status Indicators
12. Safety Input Terminal Connectors
13. Ethernet connector indicators (yellow & green)

Figure 22 Onboard Interface Including Push Buttons, LCD Display, Status Indicators & Terminal Connectors

Table 8 Onboard Interface Status Indicator Breakdown

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

☛ *The OBI functions are detailed in chapter 6.*

4.8.2 PC Interface

The *Safety Controller* can also be configured using a Windows®-based computer and the PC Interface *(PCI)* program (screen 2). This user-friendly interface utilises icons and circuit symbols to simplify the selection of device properties during configuration. The configuration wiring and *Ladder Logic Diagrams* are automatically created as the configuration progresses.

Once a configuration is created, it can be:

• Stored to a computer file for archiving and future use

or

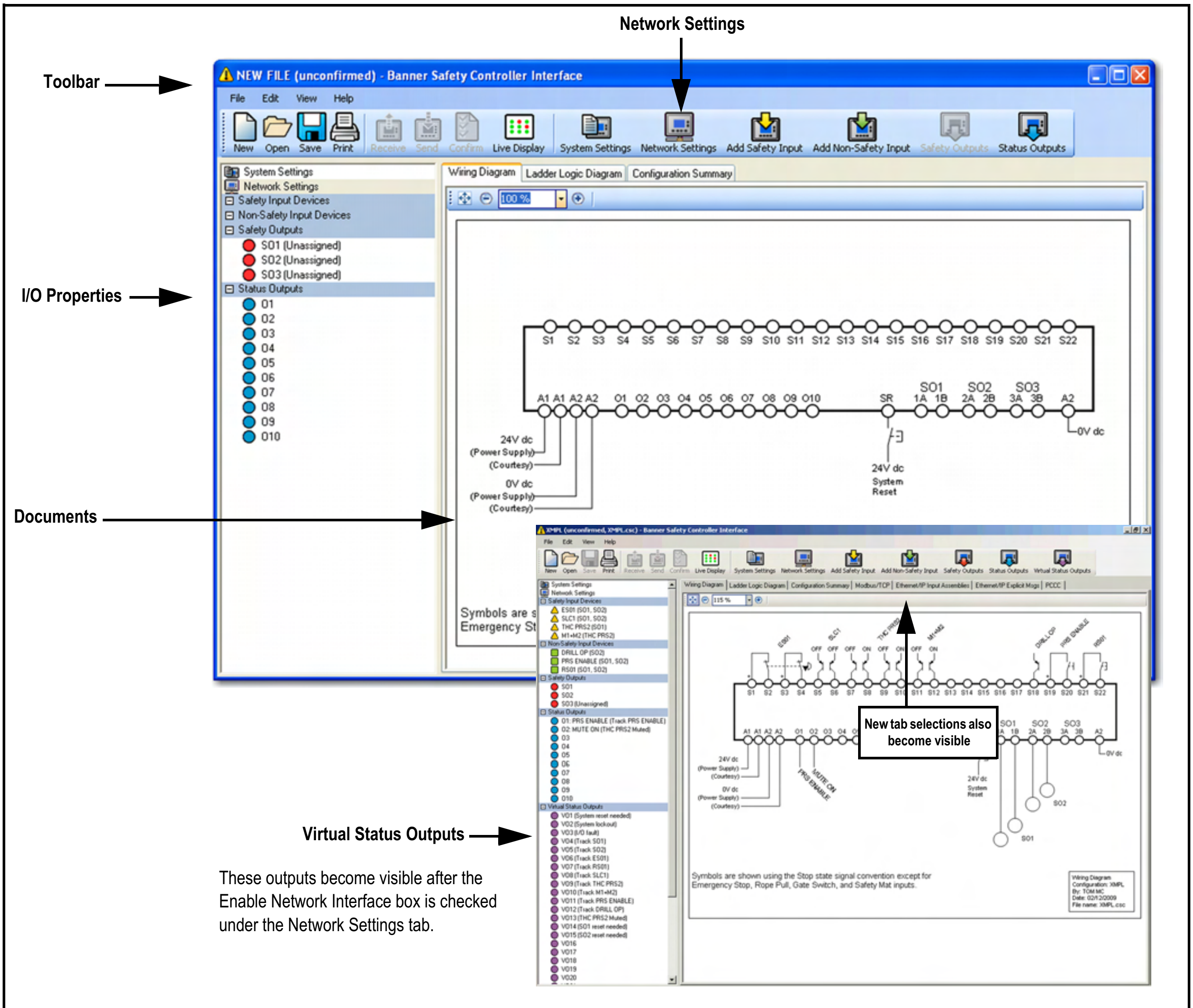
• E-mailed to a remote location as an attachment

or

• 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 *Safety Controller* using the live display, as well as monitor the fault log for troubleshooting purposes. The *PCI* functions are covered in more detail in chapter 5.

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 screen 2. The PC Interface network functions are covered in more detail in block 4.10 on page 35 and the Ethernet Reference, appendix A4 on page 119.



Screen 2

4.8.3 Defining Safeguarding Application

Risk Assessment

This includes:

- Determining required devices
- Determining required level of safety

4.8.4 Building the Configuration

This includes:

- Selecting *Safety Input* types and circuit connections
- Mapping each input to one or more *Safety Outputs*, or to other *Input Devices*
- Setting optional *Safety Output ON* or *OFF* time delays
- Selecting *Non-Safety Input* types and circuit connections, if required
- Assigning status output signals, if required
- Creating *Configuration Name*, *Author's name*, *Power-up mode* and *Monitored System Reset*

4.8.5 Confirming Configuration

This includes:

- Via *Safety Controller*, verifying that desired configuration is valid
- As User, confirming that configuration is what is expected

4.9 EDM, OSSD SAFETY OUTPUT & FSD CONNECTION

4.9.1 EDM

4.9.1.1 Single channel Monitoring

For connection information refer to Figure 29 on page 85.

4.9.1.2 Dual channel Monitoring

For connection information refer to Figure 30 on page 85.

4.9.1.3 No monitoring

If *No monitoring* is desired, simply do not select either *Single channel* or the *Dual channel* option. **If the Safety Controller does not use the *EDM* function in Category 3 or Category 4 applications, the user must ensure that any single failure or accumulation of failures of the external devices does not result in a hazardous condition and that successive machine cycles are prevented.**

4.9.2 FSD Interfacing Connections

FSDs can 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.

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

4.9.2.1 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 of a minimum of two N.O. contacts from forced-guided (mechanically linked) relays, which are monitored to detect certain failures such that the loss of the safety function does not occur (i.e. *EDM)*. 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 of them controlled by one separate *Safety Output* of the *Safety 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 arrests the hazard and prevents the next cycle from occurring.

Interfacing safety stop circuits must be wired so that the safety function can not 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 *Safety Controller*.

The N.O. *Outputs* from an interfacing module (see block 3.2.2 on page 21 for models) 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 Figure 15 on page 19).

Dual channel Control

Dual channel (or *Dual channel)* control has the ability to electrically extend the safe switching point beyond the FSD contacts. With proper monitoring (i.e., *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 *Single channel* to a secondary source of energy or voltage, or the loss of the switching action of one of the FSD *Outputs*. The result could 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 increases
- As the length or the routing of the interconnection wiring 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 *Single channel)* control, as mentioned, 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 can occur that would result in the loss of the safety function (e.g. a short-circuit to a secondary source of energy or voltage).

Thus, this method of interfacing should only be used 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 can not be achieved, then *Dual 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 can not 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 wiring
- 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

4.9.2.2 Safety Controller Connection to Interface Modules

For *Safety Controller* connection to Interface Modules refer to Figure 32 on page 86, Figure 33 on page 86 and Figure 34 on page 87.

4.9.3 DC Common Wire Installation

Current through loads will create a voltage drop due to the line resistance R_L of the DC common wire. The higher the DC common wire resistance (e.g. too small a wire cross sectional area or bad electrical connection), the higher the voltage created on this wire resistance. If this voltage exceeds 0,6 V, a *Safety Output* that has been switched *OFF*, might appear to be shorted to + voltage. This would create a fault in the *Controller* and the *Output* would turn *OFF* or remain *OFF*, resulting in a *Lockout* (see Fault Code 1.2 page 78).

To prevent this happening, all DC common wiring from the loads connected to the Safety Outputs should always be heavy wired (larger cross sectional area) and as short as possible to minimise resistance (see Figure 35 on page 87).

4.10 STATUS OUTPUTS

4.10.1 Status Output Signal Convention

Two signal conventions are selectable for the status *Outputs*. The default convention provides a 24 V 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 waits for a *Reset*, when the output waits for a *Reset* or during an active *Mute Cycle*. If the above conditions are not true, the signal output would show 0 V.

Signal Convention 2 is the reverse of Signal Convention 1, as shown in table 9 below.

Table 9 Signal Convention Breakdown

Tracked Function	Mapped Status Output(s) State	
	Signal Convention 1 (Default) 24 V dc = *Run* (Default)	Signal Convention 2 0 V dc = *Run*
Track Input **Input *Run*** **Input *Stop***	24 V dc 0 V dc	0 V dc 24 V dc
Track Output **Output *ON*** **Output *OFF***	24 V dc 0 V dc	0 V dc 24 V dc
System Lockout Status **System in Lockout** **System in *Run* mode**	24 V dc 0 V dc	0 V dc 24 V dc
I/O Fault **I/O fault exists** **No I/O fault exists**	24 V dc 0 V dc	0 V dc 24 V dc
System Waiting for Reset ***System Reset* required** ***System Reset* not required**	24 V dc 0 V dc	0 V dc 24 V dc
Output Waiting for Reset **Output *Reset* required** **Output *Reset* not required**	24 V dc 0 V dc	0 V dc 24 V dc
Mute Status **Input is muted** **No mute**	24 V dc 0 V dc	0 V dc 24 V dc
Track Input Group **Input that turned OFF first** **Other linked inputs**	24V dc 0V dc	0V dc 24V dc

4.10.2 Status Output Functionality

4.10.2.1 Track Input

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

4.10.2.2 Track Output

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

4.10.2.3 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.

4.10.2.4 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.

4.10.2.5 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.

4.10.2.6 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.
- 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

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

4.10.2.7 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).

4.10.2.8 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.

4.10.2.9 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.

4.10.3 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 (block 4.10 on page 35), 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 (see appendix A4 on page 119).

One feature of the Virtual Status Outputs Properties window is the Auto Configure function. This function 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. After Auto Configure has been used, Virtual Status Output configuration can be manually revised.

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, appendix A4 on page 119.

4.11 COMMISSIONING CHECKOUT

After power is connected to the *Safety Controller*, the *EDM* has been properly configured, and the *Safety Outputs* have been connected to the machine to be guarded, the operation of the *Safety Controller* with the guarded machine must be verified before the combined system may be put into service. To do this, a qualified person as specified in block 1.8.2 on page 4 must perform the Commissioning Checkout procedure detailed in block 8.2.5 on page 71.

4.12 SOFTWARE INSTALLATION

4.12.1 PCI Software Installation

4.12.1.1 System Requirements

The following are the system requirements for running the *PCI* software:

System Requirements	
Operating System	Windows® XP, Windows 2000 & Windows® Vista (PCI Software Version 1.1 and newer)
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 PC-GUI software, if not already on computer Adobe® Reader® for Windows® 7.0 or newer version
USB port	USB 1.1 or 2.0 type A port

4.12.1.2 Installing the Software

☛ *PCI* software may be installed from CD (supplied with *Safety Controller*) or alternatively, downloaded from the Banner Sales Force website (https://www.bannersalesforce.com/menu.php).

Instructions for getting started are also supplied with the Safety Controller in the form of a Quick Start Guide.

1) Insert CD into computer CD drive.

2) To install: Run setup.exe, or click *Install Software* on launch menu.
3) Restart computer for maximum functionality.
4) Remove CD from drive

On PC *restart*, the Banner *Safety Controller* icon  which starts the program appears on the PC desktop.

5 OPERATING INSTRUCTIONS - PCI

5.1 WORKING WITH THE PCI PROGRAM

The *Safety Controller PCI* is the primary tool for creating and managing configuration files for the *Safety Controller*. It is also used to retrieve, display and store both I/O and system status and fault information.

The following information details the steps needed to create a sample configuration, using the *Safety Controller's PCI*. The configuration is used to define the *Safety Input* and *Non-Safety Input* devices to be connected to the *Safety Controller*. It is also used to establish relationships between those *Safety Input*/*Non-Safety Input* devices and the *Safety Controller Safety Outputs*.

5.1.1 Installing PCI Software

Refer to block 4.12.1 on page 36.

5.1.2 Starting PCI Program

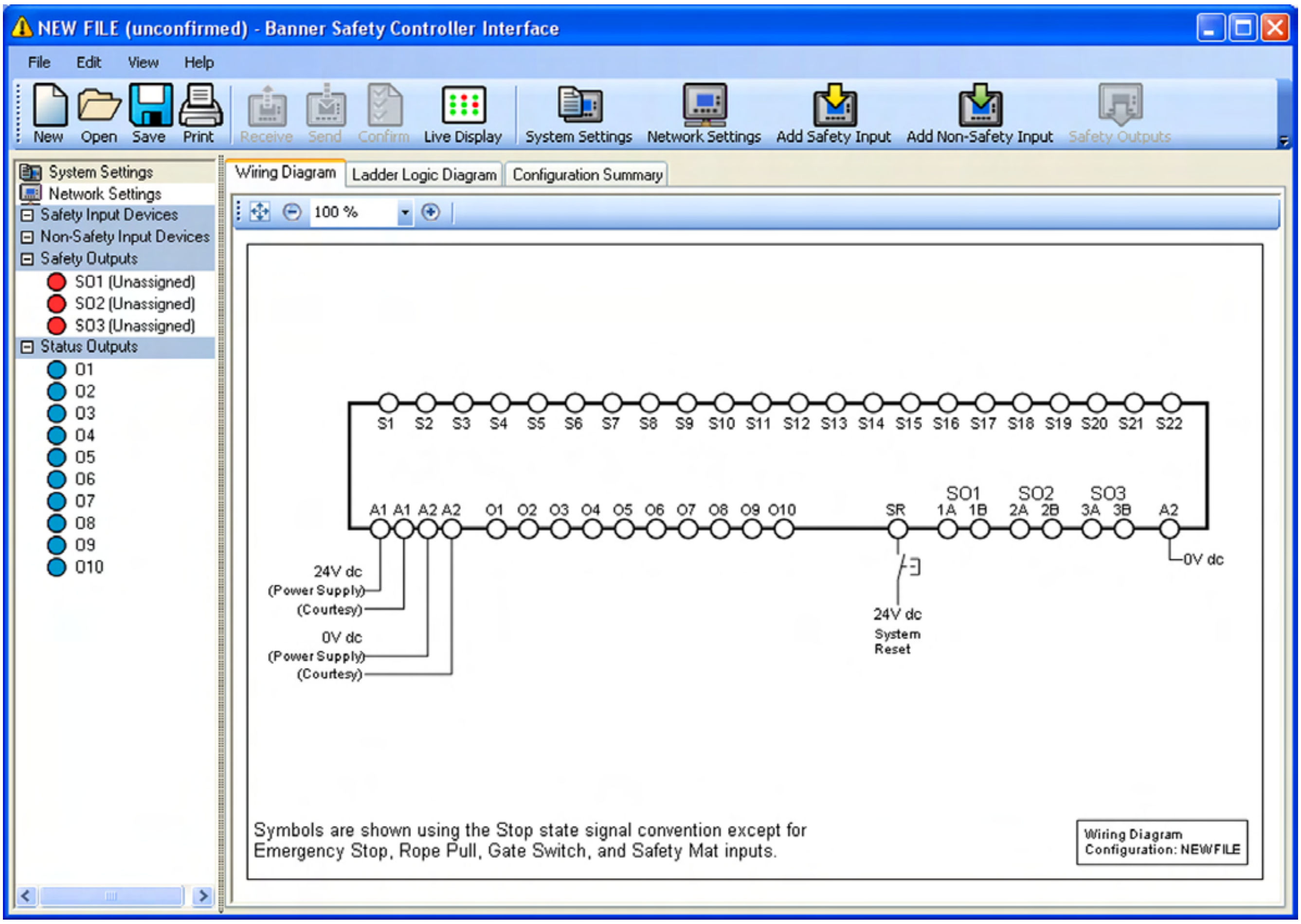
Proceed as follows:

1) From the PC Desktop, Double-click on *Banner Safety Controller* icon  or alternatively from the Start Menu, click on:

   <Start> <All Programs> <Banner Engineering> <Banner Safety Controller>

2)  Read and understand warning on Start-up page of program and click ***OK***.

A new un-named file is created as shown in screen 3 on page 38.



Screen 3

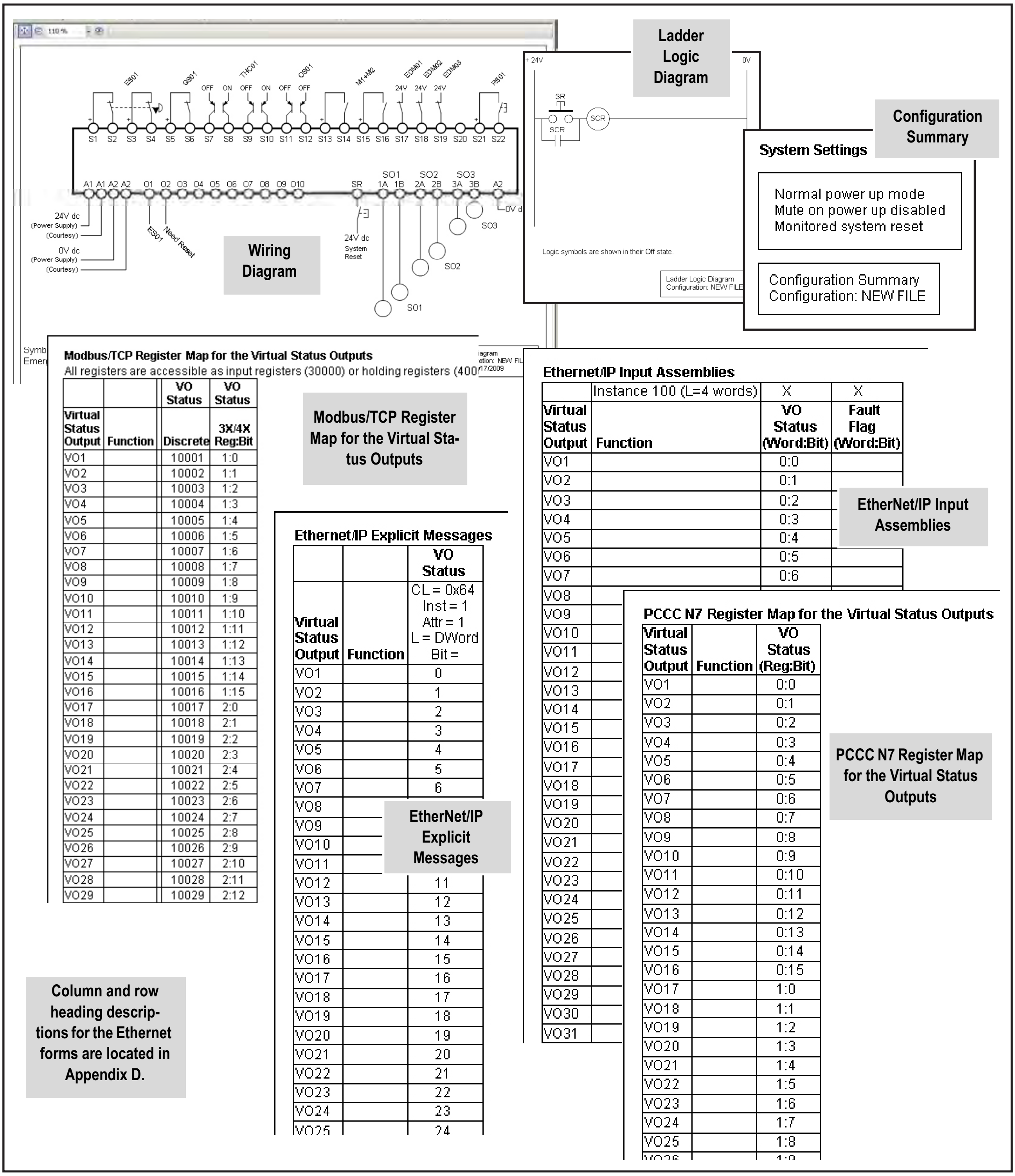
5.1.2.1 Type SC22-3E Ethernet Version Controllers Only

1) Click on button  . The popup menu screen 173 is shown.

For further information refer to appendix A4.1 on page 119.

5.1.2.2 Diagrams & Summaries

The support documents, if opened at this point, show basic information, and auto-populate as the configuration develops; see (screen 4).

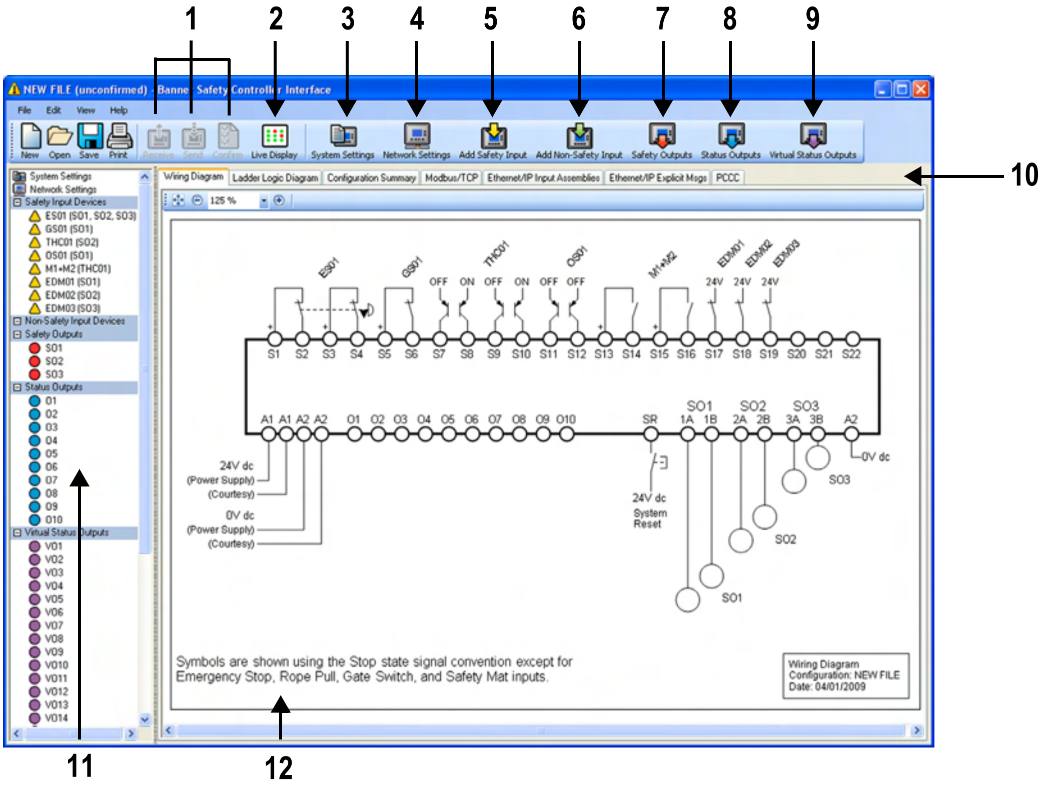


Screen 4

5.1.3 Configuration Tools

Screen 5 gives a breakdown of the tool bar and is used for creating and managing configuration files. In particular, the *Live Display* button permits the *PCI* to display real time *Run* mode data from a working *Safety Controller* via the USB connection.

The screen shows the status after the Enable Network Interface button has been checked, enabling the Virtual Status Outputs and the additional tabs above the support documents field.



Index to screen

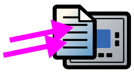
1. Send, receive & confirm buttons appear in colour when a powered *Safety Controller* or programming tool is connected to the PC
2. Access live display
3. Access network settings
4. *Add Safety Input* to configuration
5. *Add Non-Safety Input* to configuration
6. Access *Safety Output* settings
7. Access status output settings
8. Access system settings
9. *Access* virtual status output settings
10. Support document display buttons
11. I/O Properties - Double-click to access property settings
12. Support Documents Section

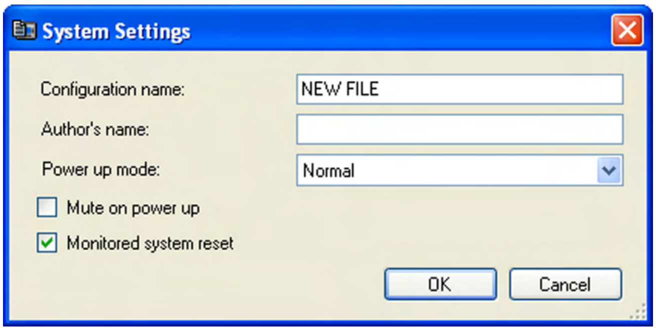
Screen 5

5.1.4 Creating a New Configuration

1) Double-click on *Banner Safety Controller* icon  .

At this stage the *Configuration Name* and *Author's name* can be filled in as well as the system settings.

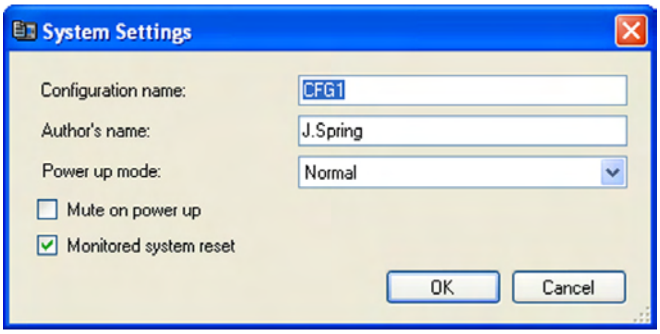
2) Double-click System Settings icon  . Screen 6 on page 41 is shown.



Screen 6

3) Fill in field for *Configuration Name* file using up to 16 alphanumeric characters.
4) Fill in field for *Author's name* box (up to 10 characters).
5) Keep or change the default system settings:

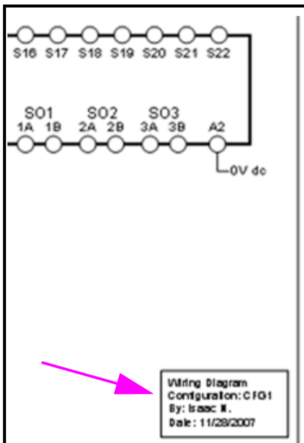
Power-up mode:	*Automatic*, *Manual*, or *Normal* (default), see block 2.6.4 on page 15
Mute on Power-up:	Checked ON or unchecked OFF (default), see block 2.6.4 on page 15
Monitored System Reset:	Unchecked OFF or Checked ON (default), block 1.10 on page 5



Screen 7

6) When complete, click **OK** (screen 7 on page 41).

Name details are now also shown on the main screen (screen 8 on page 41).



Screen 8

5.1.5 Adding *Safety Input* & *Non-Safety Input* Devices

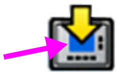
Table 10 on page 41 shows the *Safety Input* and *Non-Safety Input* devices that can be configured with the *Safety Controller*.

Table 10 Safety Input & Non-Safety Input Configurable Devices

Safety Inputs	**Non-Safety Input**
• *Emergency Stop* button • *Rope Pull* • *Gate Switch* (interlock) • *Optical Sensor* – single-/multiple-beam sensors, safety light curtain, area scanners, etc. • *Two-Hand Control* device • *Safety Mat* • *Protective Stop* – miscellaneous device • *Enabling Device* • *Mute Sensor* • *Bypass Switch* • *EDM*	• *Manual Reset* switch • *ON/OFF* switch • *Mute Enable* switch

Refer to appendix A2 for more information about each of the Safety Input device types.

To Add Safety Input:

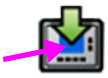
1) Click *Add Safety Input* icon  .Screen 9 is shown.

Screen 9 on page 42 displays the *Safety Input* device types the *Safety Controller* can accommodate.

Screen 9

2) Click on appropriate icon to select desired device and click **OK** (or double-click on the icon).

To Add Non-Safety Input:

3) Click *Add Non-Safety Input* icon  . Screen 10 on page 42 is shown.

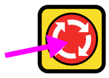
Screen 10

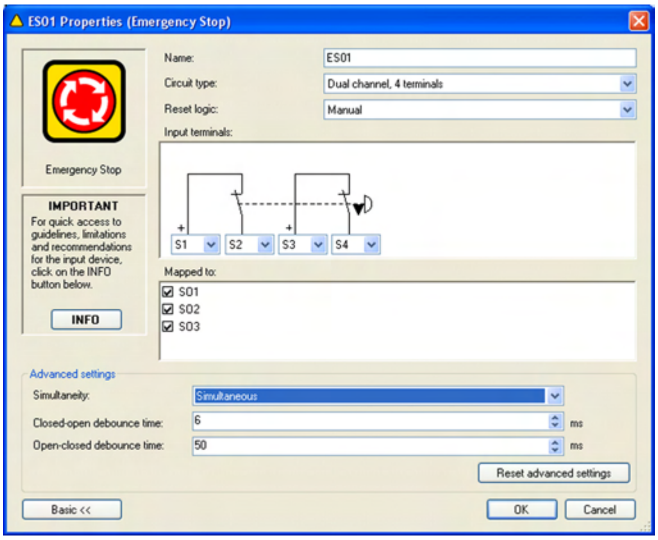
5.1.6 Selecting Safety Inputs

For background and properties breakdown refer to block 1.9 on page 4 and block 4.6 on page 26.

Once a *Safety Input* is selected, the Properties menu for that device is shown. This menu presents the properties that must be established for each type of *Safety Input*.

5.1.6.1 Adding Emergency Stop

1) From *Add Safety Input* menu (screen 9 on page 42) click on an appropriate icon  and click ***OK*** (or double-click on the icon). Screen 11 on page 42 is shown.



Screen 11

If the default settings are **NOT** to be used, proceed as follows:

2) Add *Name:* e.g. **ES01**.

☛ *Any Safety Input device can be renamed during the configuration process.*

3) Select appropriate *Circuit Type* for the designated device**:** e.g. *Dual channel, 4 terminal*.

The selected *Circuit Type* appears in the *Safety Input* terminals diagram with automatically assigned terminal numbers. The terminal numbers can be reassigned using the drop-down menu(s). The plus signs at **S1** and **S3** (see screen 11 on page 42) designate that these terminals supply the +24 V dc source for the device contacts.

☛ *For more information about safety circuit integrity levels and the capabilities of each Circuit Type see appendix A2.*

4) Set *Reset Logic:* e.g. *Manual*.
5) From drop down menu(s), select *Input terminals:* e.g. **S1**, **S2**, **S3** and **S4** (use the drop-down terminal number fields to change the terminal assignment, if needed).
6) Set *Mapped to:* Check or uncheck boxes to map each *Safety Input* to one or more *Safety Outputs***,** e.g. **SO1**, **SO2**, and **SO3** (at least one must be selected).

7) If the default settings are **NOT** to be used, click on:
Advanced Settings
Check/Uncheck box *Enable startup test*
Set *Simultaneity:*
Set *Closed-open debounce time:*
Set *Open-closed debounce time:*

8) On completion click **OK** to exit.

Because a *Manual Reset* signal was chosen for the E-stop button, when OK is selected and the **ES01** Properties menu closes, the **RS01** Properties Manual Reset screen appears automatically (screen 12 on page 43) to add a *Manual Reset Input Device* for that device. Any *Safety Input* which keeps the default *Manual Reset Logic* setting requires a *Manual Reset* for any *Safety Output Mapped to* that device. A separate *Manual Reset* may be assigned for each *Safety Output*.

☛ *If the Safety Input is a Muting Sensor Pair or a Bypass Switch, those Inputs should be Mapped to at least one of the other Safety Inputs.*

If the default settings are **NOT** to be used, proceed as follows:

9) *Name:* e.g. **RS01**.

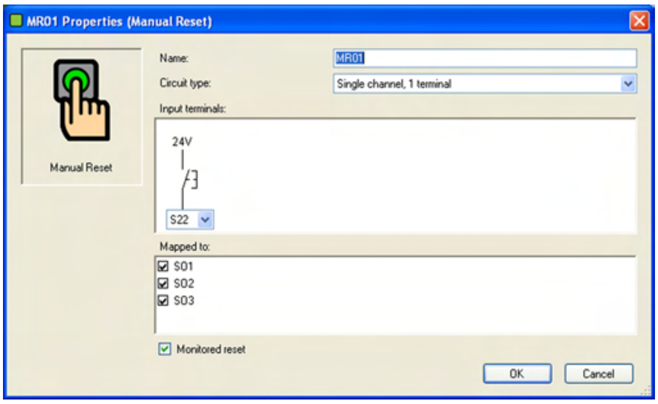
10) Select appropriate *Circuit Type:* e.g. *Single channel, 2 terminal***.**

11) From drop down menu(s), select *Input terminals:* e.g. **S21** and **S22**.

12) Check/Uncheck *Mapped to:* e.g. **SO1**, **SO2** and **SO3**.

13) Check/Uncheck *Monitored Reset*.

14) On completion click **OK** to exit.

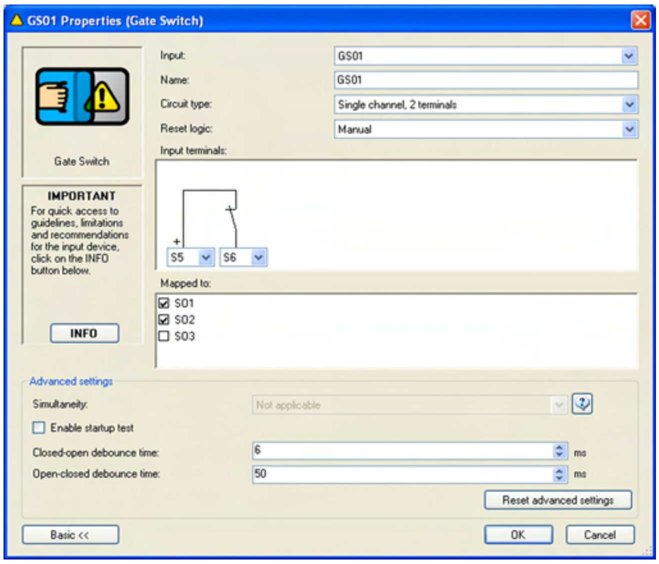


Screen 12

As the properties are selected, the *Wiring Diagram* also begins to populate with the selected *Safety Input(s).* Also the *Ladder Logic Diagram, Configuration Summary as well as Modbus/TCP, Ethernet/IP Input Assemblies, Ethernet/IP Explicit Msgs and PCCC listings (see* screen 4 on page 39).

5.1.6.2 Adding Gate Switch

1) From *Add Safety Input* menu (screen 9 on page 42) click on an appropriate icon  and click **OK** (or double-click on the icon). Screen 13 on page 43 is shown.



Screen 13

If the default settings are **NOT** to be used, proceed as follows:

2) Add *Name:* e.g. **GS01**.

3) Select appropriate *Circuit Type: Single channel, 2 terminal***.**

4) Set *Reset Logic:* e.g. *Manual*.

5) From drop down menu(s), select *Input terminals:* e.g. **S5**, **S6**.

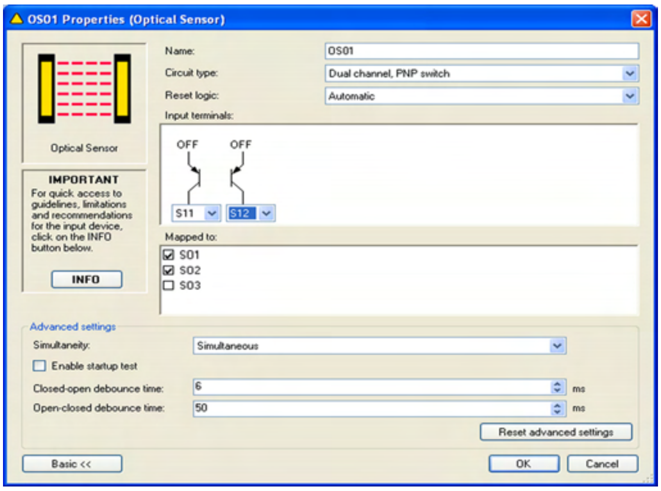
6) Set *Mapped to:* e.g. **SO1** and **SO2**.

7) If the default settings are **NOT** to be used, click on:
Advanced Settings
Check/Uncheck box *Enable startup test*
Set *Simultaneity:*
Set *Closed-open debounce time:*
Set *Open-closed debounce time:*

8) On completion click **OK** to exit.

5.1.6.3 Adding Optical Sensor

1) From *Add Safety Input* menu (screen 9 on page 42) click on an appropriate icon  and click **OK** (or double-click on the icon). Screen 14 on page 44 is shown.



Screen 14

If the default settings are **NOT** to be used, proceed as follows:

2) Add *Name:* e.g. **OS01**.

3) Select appropriate *Circuit Type: Dual Channel, PNP*.

4) Set *Reset Logic:* e.g. *Automatic*.

5) From drop down menu(s), select *Input terminals:* e.g. **S11** and **S12**.

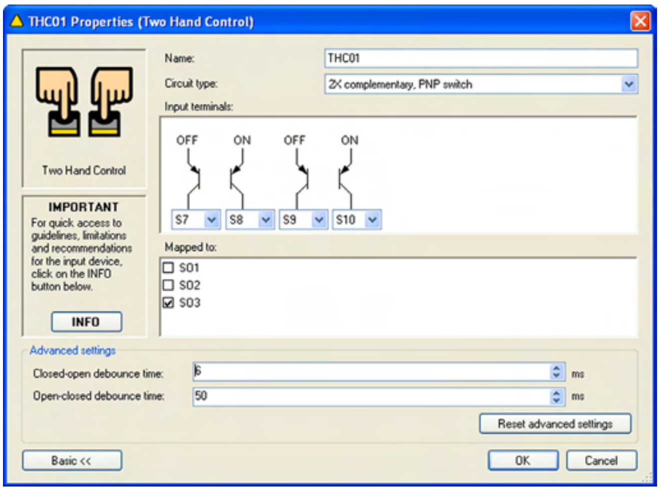
6) Set *Mapped to:* e.g. **SO1** and **SO2**.

7) If the default settings are **NOT** to be used, click on:
Advanced Settings
Check/Uncheck box *Enable startup test*
Set *Simultaneity:*
Set *Closed-open debounce time:*
Set *Open-closed debounce time:*

8) On completion click **OK** to exit.

5.1.6.4 Adding Two-Hand Control

1) From *Add Safety Input* menu (screen 9 on page 42) click on an appropriate icon  and click **OK** (or double-click on the icon). Screen 15 on page 44 is shown.



Screen 15

If the default settings are **NOT** to be used, proceed as follows:

2) Add *Name:* e.g. **THC01**.

3) Select appropriate *Circuit Type: 2X Complementary, PNP switch*.

4) From drop down menu(s), select *Input terminals:* e.g. **S7**, **S8**, **S9** and **S10**.

5) Set *Mapped to:* e.g. **SO3**.

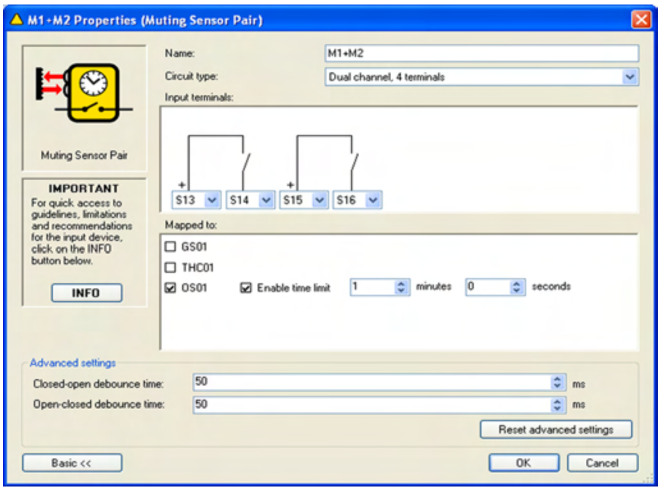
6) If the default settings are **NOT** to be used, click on:
Advanced Settings
Set *Closed-open debounce time:*
Set *Open-closed debounce time:*

7) On completion click **OK** to exit.

☛ *The Reset Logic is set to Automatic for Two-Hand Control devices. There are no other reset options.*

5.1.6.5 Adding Muting Sensor Pair

1) From *Add Safety Input* menu (screen 9 on page 42) click on an appropriate icon  and click **OK** (or double-click on the icon). Screen 16 on page 45 is shown.



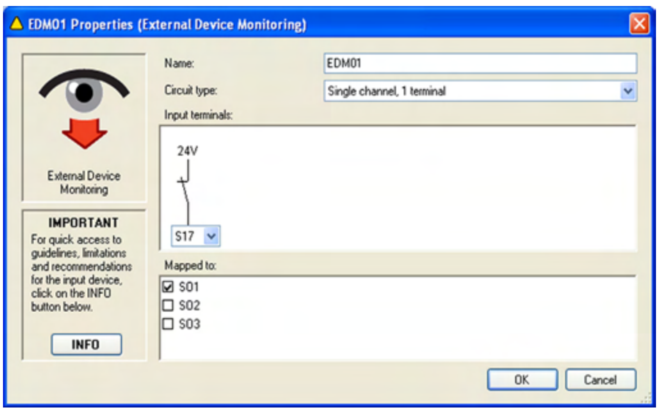
Screen 16

If the default settings are **NOT** to be used, proceed as follows:

2) Add *Name:* e.g. **M1+M2**.
3) Select appropriate *Circuit Type: Dual channel, 4 terminal*.
4) From drop down menu(s), select *Input terminals:* e.g. **S13**, **S14**, **S15** and **S16**.
5) Set *Mapped to:* e.g. **OSO1**.
6) If the default settings are **NOT** to be used, click on:
Advanced Settings
Set *Closed-open debounce time:*
Set *Open-closed debounce time:*
7) On completion click **OK** to exit.

5.1.6.6 Adding External Device Monitoring

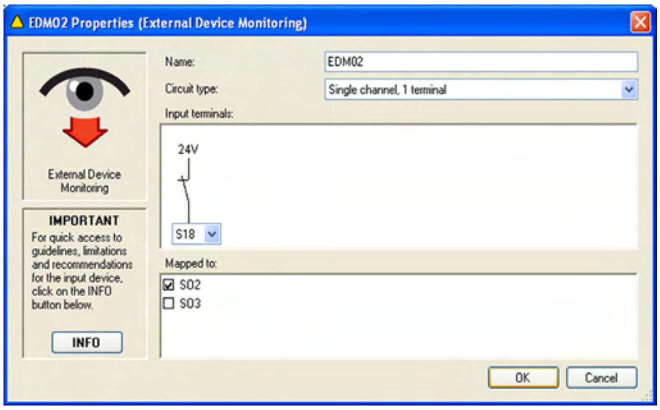
1) From *Add Safety Input* menu (screen 9 on page 42) click on an appropriate icon  and click **OK** (or double-click on the icon). Screen 17 on page 45 is shown.



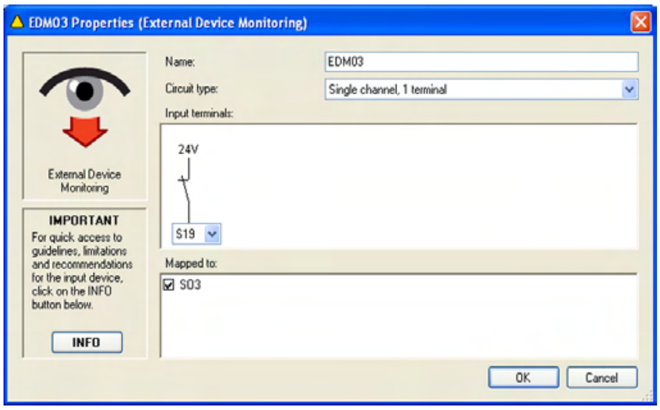
Screen 17

If the default settings are **NOT** to be used, proceed as follows:

2) Add *Name:* e.g. **EDM01**.
3) Select appropriate *Circuit Type: Single channel, 1 terminal*.
4) From drop down menu(s), select *Input terminals:* e.g. **S17**.
5) Set *Mapped to:* e.g. **SO1**.
6) On completion click **OK** to exit.
7) Add two more *External Device Monitoring Safety Inputs*, one for each *Safety Output* as shown in screen 18 on page 45 and screen 19 on page 45, as follows:
   - Name them **EDM02** and **EDM03**
   - Use *Circuit Types Single channel, 1 terminal* for each
   - Assign *Input terminals* **S18** to **EDM02** and **S19** to **EDM03** *Mapped to* **SO2** for **EDM02** and to **SO3** for **EDM03**



Screen 18



Screen 19

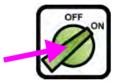
5.1.7 Add Non-Safety Input devices

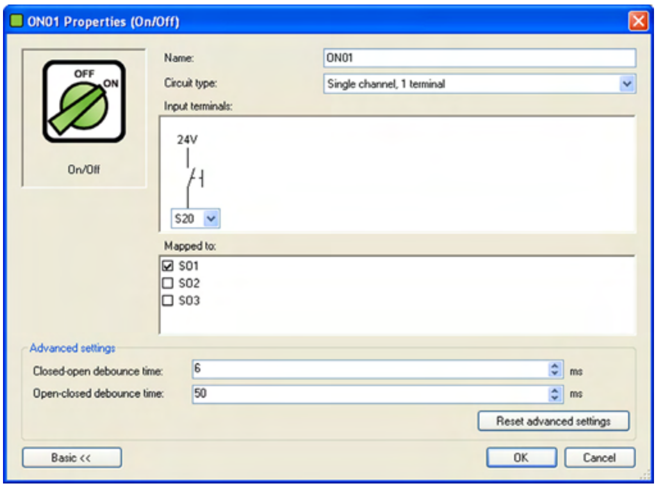
For properties breakdown refer to block 4.7 on page 29.

Once a *Non-Safety Input* device is selected the Properties menu for that device is shown (screen 20 on page 46). This menu presents the properties that must be established for each type of *Non-Safety Input*. The user-defined properties, depending on the device, include:

- *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
- *Mapped to* — Establishes relationships between *Non-Safety Input* devices and *Outputs*

5.1.7.1 Adding ON/OFF Switch

1) From *Add Non-Safety Input* menu (screen 9 on page 42) click on an appropriate icon  and click OK (or double-click on icon) as shown in screen 20 on page 46.



Screen 20

If the default settings are not used, proceed as follows:

2) Add *Name:* e.g. ON01.

☛ *Any Non-Safety Input device can be renamed during the configuration process.*

3) Select appropriate *Circuit Type:* for the designated device.

The selected *Circuit Type* appears in the *Wiring Diagram* with automatically assigned terminal numbers.

☛ *See* appendix A2 *for more information about safety circuit integrity levels and the capabilities of each Circuit Type.*

4) From drop down menu(s), select *Input terminals:* e.g. **S20**.

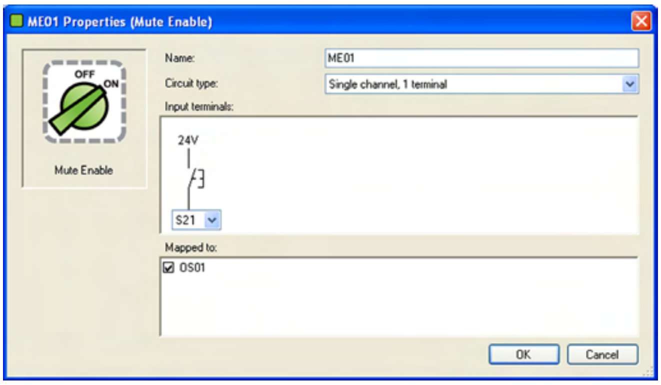
5) Set *Mapped to:* e.g. **SO1**.

6) If default settings are NOT to be used:
Advanced Settings
Set *Closed-open debounce time:*
Set *Open-closed debounce time:*

7) On completion click ***OK*** to exit.

5.1.7.2 Adding Mute Enable Switch

1) From *Add Non-Safety Input* menu (screen 9 on page 42) click on an appropriate icon  and click OK (or double-click on icon) as shown in screen 21 on page 46.



Screen 21

If the default settings are not used, proceed as follows:

2) Add *Name:* e.g. **ME01**.

☛ *Any Non-Safety Input device can be renamed during the configuration process.*

3) Select appropriate *Circuit Type: Single channel, 1 terminal*.

The selected *Circuit Type* appears in the *Wiring Diagram* with automatically assigned terminal numbers.

4) From drop down menu(s), select *Input terminals:* e.g. **S20**.

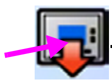
☛ *See* appendix A2 *for more information about safety circuit integrity levels and the capabilities of each Circuit Type.*

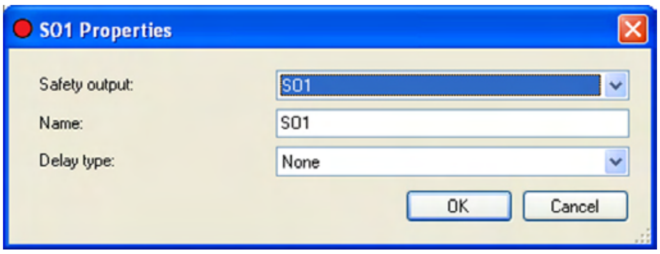
5) *Mapped to:* Check or uncheck boxes to map each *Non-Safety Input* to one or more *Safety Output* (at least one must be selected).

6) On completion click ***OK*** to exit.

5.1.8 Assigning Safety Output(s)

The *Safety Output(s)* are assigned individually for each safety output.

1) Click *Safety Output* icon . Screen 22 is shown.
2) From drop-down menu select *Safety Output:* e.g. **SO1**.
3) Type in *Name:* e.g. **SO1**.
4) Select *Delay Type: None, On-Delay* or *Off-Delay* (for info refer to block 2.6.1.3 on page 14).
5) On completion click ***OK*** to exit.

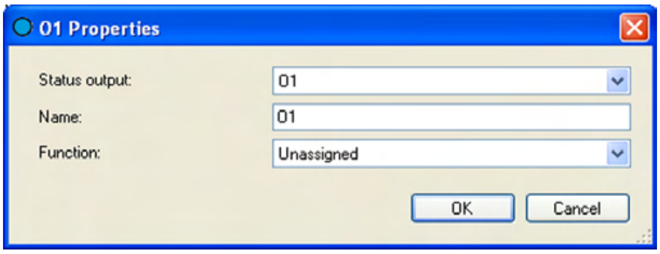


Screen 22

5.1.9 Configuring Status Outputs

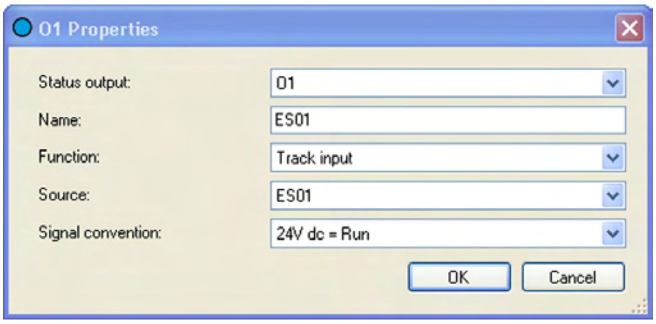
The *Safety Controller* has 10 configurable *Status Outputs* (for more info refer to block 2.6.2 on page 14 and block 4.10.1 on page 35).

1) Click *Status Output* icon . Screen 23 is shown.



Screen 23

2) From drop-down menu select *Status Output:* e.g. **O1**.
3) type in *Name:* e.g. **ESO1**.
4) Select a *Function:* (for info refer to block 2.6.2 on page 14 and block 4.10.1 on page 35).
5) Select a *Source:* e.g. **ESO1**.
6) Select a *Signal Convention...:* e.g. *24V dc = Run*. Screen 24 is shown.

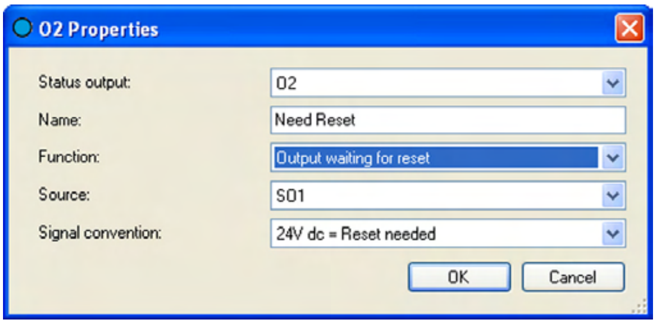


Screen 24

7) On completion click ***OK*** to exit.

Add an additional *Status Output*

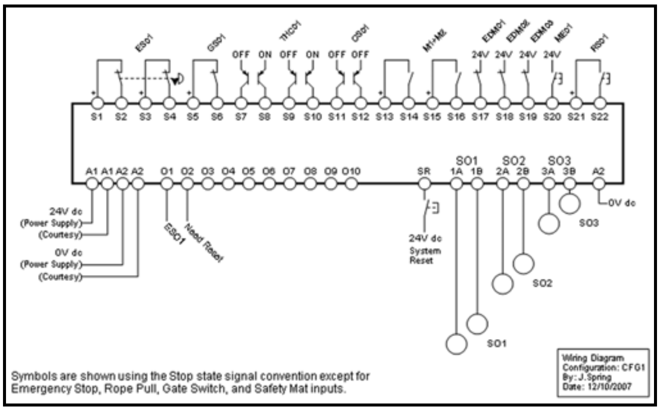
8) Click *Status Output* icon . Screen 25 is shown.
9) From drop-down menu select *Status Output:* e.g. **O2**.
10) type in *Name:* e.g. **Need Reset**.
11) Select a *Function: Output waiting for reset*.
12) Select a *Source:* e.g. **SO1**.
13) Select a *Signal Convention...:* e.g. *24V dc = Run*. Screen 25 is shown.



Screen 25

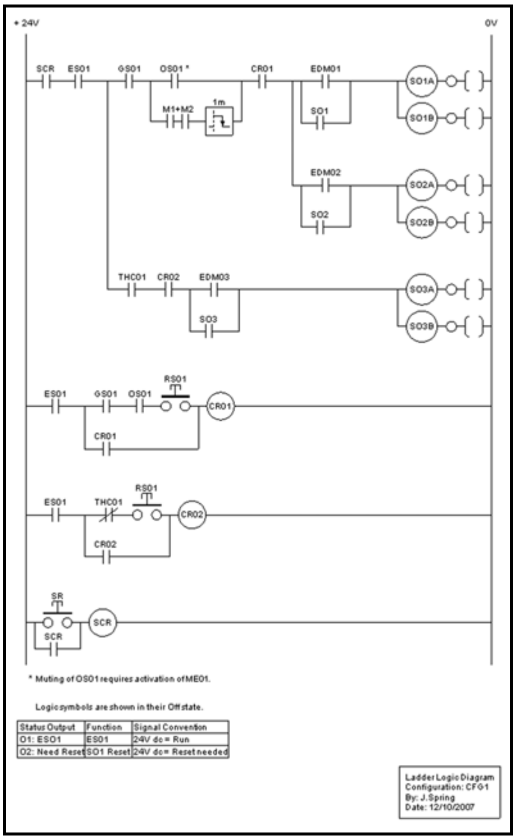
14) On completion click ***OK*** to exit.

The *Wiring Diagram* should be as shown in Screen 26.



Screen 26

The *Ladder Logic Diagram* should be as shown in screen 27.



Screen 27

5.1.10 Confirming Configuration

The new configuration must be confirmed before it can be used in a *Safeguarding* application and the *Safety Controller* has to be connected to the PC via the USB cable.

The confirmation process has two parts:

Configuration 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).

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.

5.1.10.1 Configuration Validation

To confirm a configuration **CFG1**, follow the steps below:

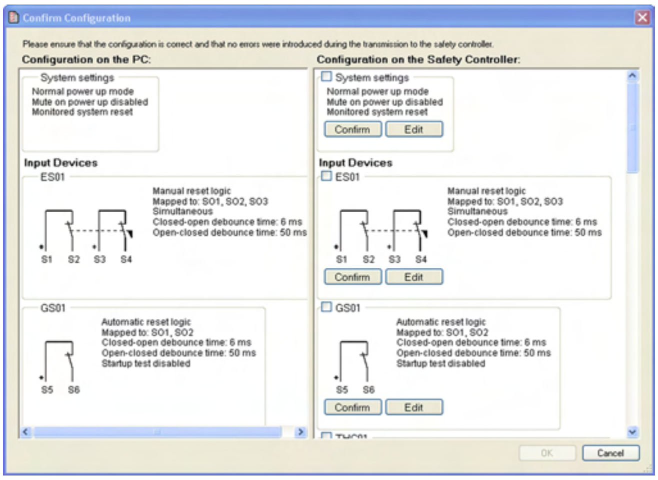
1) Save configuration file to the PC.
   Click on *File* > *Save.*
   Name configuration file e.g. **CFG1** and select a file location on your computer.
   Click *Save.*
2) Using USB cable connect *Safety Controller* to PC (see block 4.4.2 on page 25).
3) Apply 24V dc power to *Safety Controller*.
4) Check that *Receive*, *Send* and *Confirm* buttons (Receive Send Confirm) in the *PCI* tool bar go active by changing from gray scale to full colour.
5) Click on *Confirm* Confirm button.

☛ *The Controller used during the confirmation process may have an existing (either factory default or user-defined) configuration. Any configuration already loaded in the Controller is overwritten (and therefore lost) during this confirmation process. It is the user's responsibility to save existing configurations, as required.*

6) At *Save Configuration* pop-up menu, select *Yes* to save configuration or *No* to proceed to overwrite *Controller's* existing configuration.
7) At *Confirm Configuration* pop-up menu (screen 29), enter password (factory default is 0000) and click ***OK***.
8) At pop-up warning message asking whether to continue, select *Yes*.

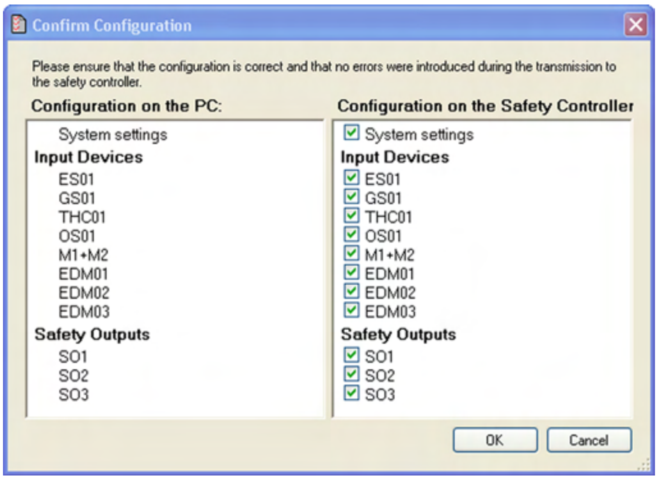
☛ *Wait a few seconds for Configuration Validation process to complete.*

The *Configuration Verification* screen then appears (see screen 28).



Screen 28

9) Verify that properties in right-hand column match those in left-hand column. For each device, as you determine that its properties are correct, either click on *Confirm* or click in corresponding checkbox. A check mark appears in box and section compresses to a list, as shown in screen 29.



Screen 29

5.1.10.2 Editing Configuration

If the columns do not match, or a different circuit is required:

1) Select *Edit* for device to be changed (screen 28 refers).

The Properties menu for the device opens (e.g. screen 13).

2) Make necessary change(s).
3) On completion click ***OK*** to exit.
4) At message asking whether any other devices are to be edited or to continue with confirmation process, click required selection.

☛ *If any device properties are changed while in the Manual Verification stage of the confirmation, the Controller proceeds to re-validate the code.*

If the columns match, and no further changes are required:

5) At screen 28 select *Confirm* for each device.

The verification screen (screen 29) shows the summary that is created after each property has been verified.

To review a confirmed device property:

6) At screen 29, un-check checkbox and *Device properties* pop-up menu re-appears. Perform *Edits* as necessary.
7) On completion of *Manual Verification*, click ***OK*** to exit.

On completion of verification process, the *Confirm Configuration* pop-up menu (screen 29) is again displayed.

8) Click on *Close*.
9) Perform a *System Reset* (see block 5.1.11 on page 49).

The Controller activates the new configuration and functions as per the new parameters.

5.1.10.3 Configuration Checksum

To be notified

5.1.11 System Reset

Under certain conditions the *Safety Controller* requires a *System Reset* for the following reasons:

• To place the *Controller* into *Run* mode after it has been configured

• To recover from certain conditions (e.g. *Lockouts*)

To perform a *System Reset*, either:

1) Provide a 24V dc signal on *System Reset* input (***SR***) (screen 26 refers).

or

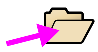
2) Cycle power.

When the configuration is successfully confirmed, the *Controller* switches to *Run* mode.

5.1.12 Editing an Existing Configuration

To edit an existing configuration:

1) At PC double-click on *Banner Safety Controller* program icon  .

2) From menu, click on *File*, then *Open* or click  icon to browse for configuration file to be changed. Make changes as described in block 5.1 on page 37.

5.1.13 Receiving a Configuration from *Safety Controller*

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

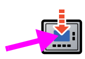
1) Connect *Safety Controller* to PC.
2) At PC double-click on *Banner Safety Controller* program icon.

3) Apply a 24V dc power supply to *Controller*.
4) From tool bar click on *Receive* button  .
5) If configuration is not already confirmed, *Confirm Configuration* as shown in screen 29.

5.1.14 Sending a Configuration to the *Safety Controller*

To send a configuration from the *PCI* to a *Safety Controller:*

1) Using USB cable, connect *Safety Controller* to PC.
2) Apply a 24V dc power to the *Controller*.
3) At PC double-click on *Banner Safety Controller* program icon.

4) From tool bar click on *Send* button  .

5.1.15 Opening a Configuration from the XM Card

Both confirmed and unconfirmed configurations can be sent to or received from the *XM Card*. Proceed as follows:

1) Using USB cable, connect *SC-XMP Programming Tool* to PC.
2) Insert *XM Card* into *SC-XMP Programming Tool* (Figure 19 on page 25 refers).
3) At PC double-click on *Banner Safety Controller* program icon .
4) From menu click on ***File*** then ***Open*** .

A message appears when the operation is complete.

5.1.16 Sending a Configuration to the XM Card

Both confirmed and unconfirmed configurations can be sent to or received from the *XM Card*. Proceed as follows:

1) Using USB cable connect *SC-XMP Programming Tool* to PC (Figure 19 on page 25 refers).
2) Insert *XM Card* into *SC-XMP Programming Tool* (Figure 20 on page 25).
3) At PC double-click on *Banner Safety Controller* program icon .
4) From menu, click on *File*, *Open* or click icon to browse for configuration file.
5) From menu click on *File* then *Send to XM Card*.

A message appears when the operation is complete.

5.1.17 Locking the XM Card

CAUTIONS

IT IS IMPORTANT TO NOTE THAT THIS OPERATION CANNOT BE UNDONE. ONCE THE *XM Card* IS LOCKED, ANOTHER CONFIGURATION CAN NEVER BE STORED ON IT.

This operation is useful when the *XM Card* and its configuration are used on another *Banner Safety Controller* or for storing and archiving a configuration.

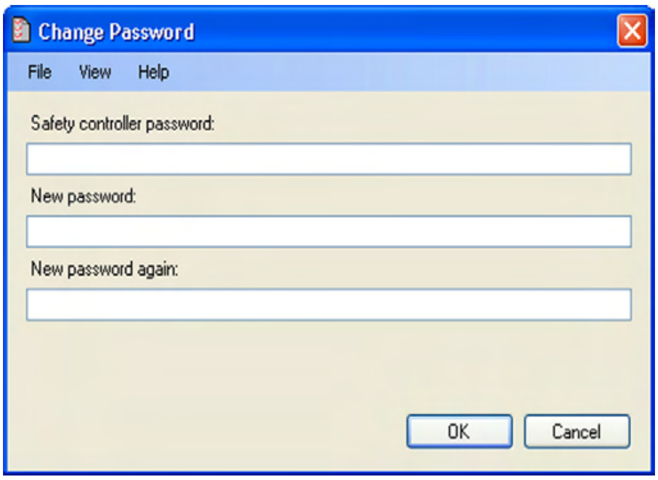
To lock the *XM Card* so that the stored configuration cannot be changed:

1) Insert *XM Card* into *SC-XMP Programming Tool* (Figure 19 on page 25).
2) Verify that correct file is stored on *XM Card*.
3) From menu, click on, *Lock XM Card* (upper left of tool bar).

A message appears when the operation is complete.

5.1.18 Changing Password Using PCI

1) Using USB cable, connect PC to *Banner Safety Controller* (Figure 20 on page 25).
2) Ensure power supply to *Safety Controller* is ***ON*** (power LED green).
3) At PC double-click on *Banner Safety Controller* program icon .
4) From menu click on *File* then *Change Safety Controller Password*. Screen 30 is shown.



Screen 30

5) Fill in fields as appropriate. Click ***OK***.

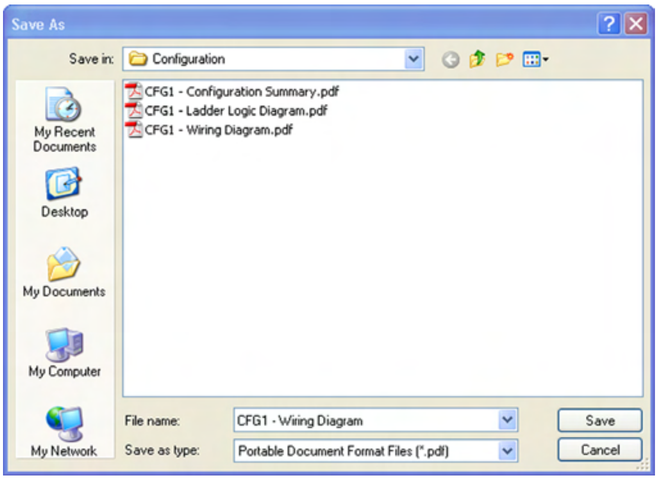
The *Entering Configuration Mode* screen is shown, saying, “Are you sure you want to do this? All safety *Outputs* will be turned off.” Clicking *Yes*, all safety *Outputs* turn *OFF*, together with the machine or system the *Safety Controller* is monitoring.

6) Clicking ***Yes***. Screen 30 re-shown.
7) Clicking ***Close***. The password is now changed.
8) Record password for safekeeping.

☛ *If the password becomes lost, contact Corporate Office as listed on page 127.*

5.1.19 Exporting Documents

The configuration documents (wiring diagram, ladder logic diagram, configuration summary, and network register maps) can be exported in different formats (see Screen 31).



Screen 31

To export a configuration file:

1) At PC double-click on *Banner Safety Controller* program icon  .
2) Open configuration file to be saved.
3) From menu click on *File* then *Export*.
4) Select the configuration document to be exported.
5) Verify file name is correct and select *Save As* type file option (.pdf or .dxf) as required.
6) Select *Done*.

5.1.20 Printing Options

To print a configuration file:

1) At PC double-click on *Banner Safety Controller* program icon  .
1) Open configuration file to be printed.
2) From menu click on *File* then ***Print***.
3) Select configuration document *(Wiring Diagram*, *Ladder Logic Diagram* and *Configuration Summary)* as required.
4) When *Page Setup* menu appears, select page and printer choices then click ***OK***.

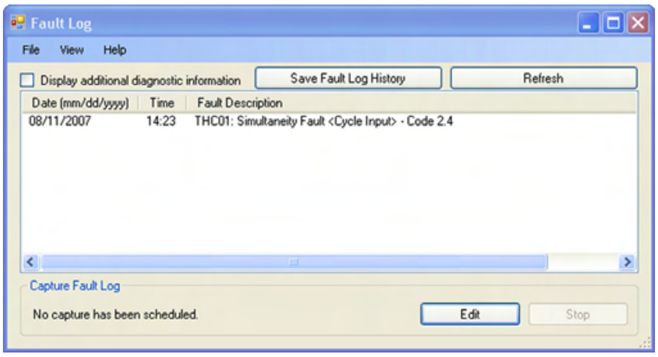
☛ *Wiring Diagrams, Ladder Logic Diagrams and Configuration Summaries typically fit the page better when "landscape" is selected. Other documents fit better on "portrait."*

5.1.21 Accessing Fault Log

To access the Controller's internal *Fault Log* using the *PCI:*

1) Using USB cable, connect PC to *Banner Safety Controller* (Figure 20 on page 25).
2) Apply a 24V dc power supply to Controller.
3) Click on *View* menu in the *PCI* tool bar.
4) Select *Fault Log*.

Screen 32 is shown and displays any I/O or system faults detected by the *Safety Controller*.

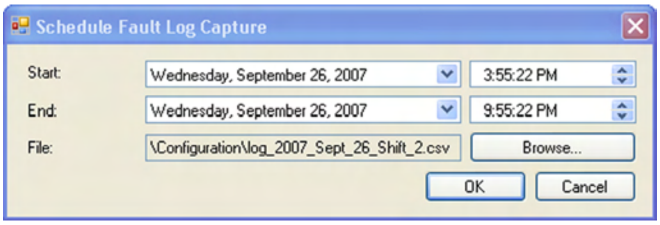


Screen 32

5.1.22 Scheduled Fault Log Capture

Controller I/O and system fault information can be recorded to a computer file. To set up a recording period to capture fault data from a *Safety Controller*, via the *Fault Log* menu.

1) Using USB cable, connect PC to *Banner Safety Controller* (Figure 20 on page 25).
2) Apply a 24V dc power supply to *Safety Controller*.
3) Click on *View* menu.
4) Select *Fault Log*.
5) Select *Edit* button. Screen 33 is shown.



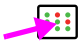
Screen 33

6) Using drop-down fields set *Start* and *End* times.
7) Click on *Browse* for *File* location.
8) Click ***OK***.

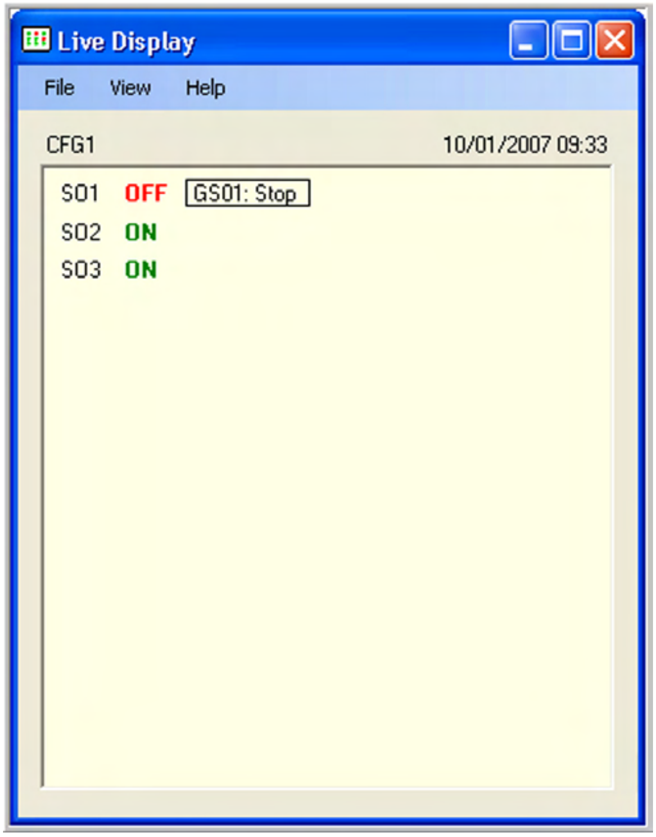
The fault data is stored as an Excel file to this file location.

5.1.23 Live Display

To access live *Controller* information from the *PCI:*

1) Using USB cable, connect PC to *Banner Safety Controller* (Figure 20 on page 25).
2) Apply a 24V dc power supply to the *Controller*.
3) From Tool bar click on *Live Display* button  or open *View* and select *Live Display*.

The Live Display screen is shown.



Screen 34

6 OPERATING INSTRUCTIONS - OBI

For an overview of the *OBI*, refer to block 2.12 on page 17. The *Safety Controller OBI* is a tool for creating and managing configuration files for the *Safety Controller*, using the built-in features of the *Controller* itself. The *OBI* is also used to retrieve, display and store both I/O, system status and fault information.

The following information details the steps needed to create a sample configuration, using the *Safety Controller's OBI*. The configuration is used to define the *Safety Input* devices to be connected to the *Safety Controller* and to establish relationships between those *Safety Input* devices and the *Controller Safety Outputs*.

☛ *To Enter Run mode a password is **NOT** required. To Enter Configuration Mode specifically a password **IS** required.*

6.1 RUN MODE

A breakdown of the *Run* mode is shown in Figure 23 on page 53.

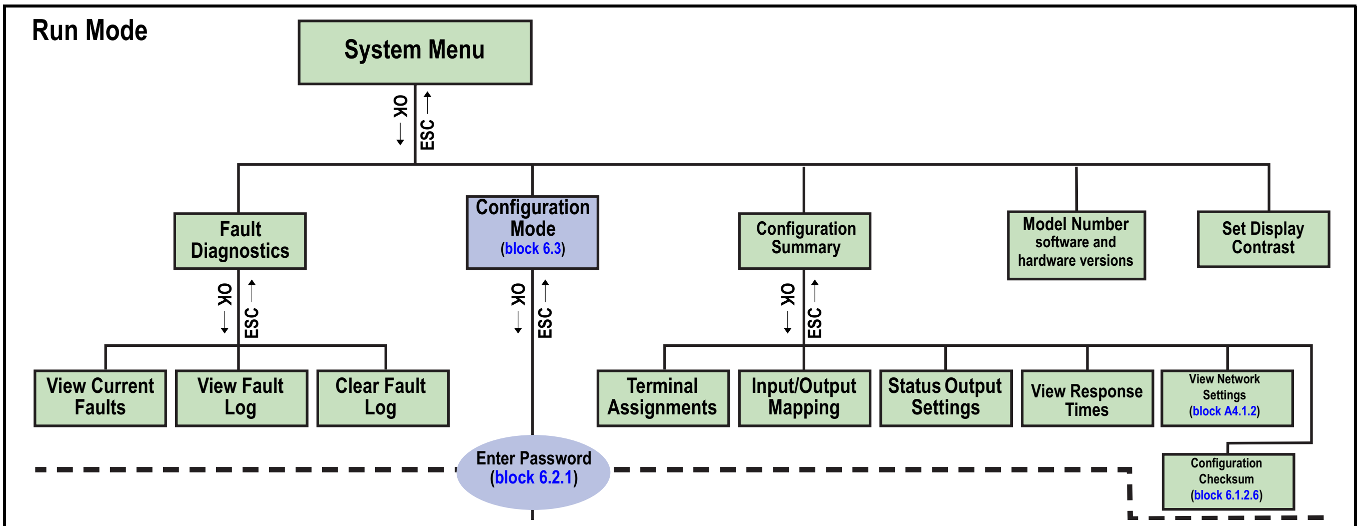
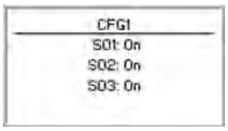


Figure 23 Safety Controller OBI Run Mode Options

To enter *Safety Controller Run* mode:

1) Connect *Safety Controller* to safety system as appropriate.
2) Connect a 24 V dc power supply to *Safety Controller*.

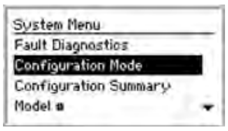
Controller boots up to initial screen 35.



Screen 35

3) From *Run* mode, press ***OK*** to view *System Menu* (screen 36).

This menu provides the ability to read *Fault Diagnostics* information, enter *Configuration Mode* to create or edit a configuration, read the *Configuration Summary*, read the *Safety Controller Model Number*, and *Set Display Contrast* itself.

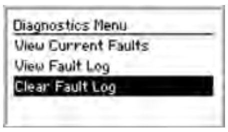


Screen 36

4) Using up/down arrow buttons, highlight selection required then press ***OK*** to select.

6.1.1 Fault Diagnostics Screen

1) From *System Menu* (screen 36) select *Fault Diagnostics.* Screen 37 is shown.
2) At screen 37, use this screen to *View Current Faults*, *View Fault Log*, or *Clear Fault Log*. For more information refer to block 8.3.3.3 on page 81.



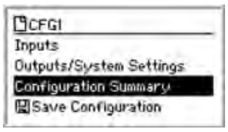
Screen 37

6.1.2 Configuration Summary

The *Configuration Summary* provides viewing only screens to review:

- *Terminal Assignments* for each input device in the current configuration
- *Input/Output Mapping* relationships between *Input Devices* and between *Input Devices* and *Safety Outputs*
- *Status Output Settings* (to change the current settings, see OUTPUTS/SYSTEM SETTINGS on page 62)
- *View Response Times* for each input mapped to the safety output and used to calculate safety distance (see block 6.1.2.4 on page 54)
- *Network Settings* - configured for current network communication (see block 6.1.2.5 on page 54)
- *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 (see block 6.1.2.6 on page 54)

1) At screen 38, scroll down menu and choose *Configuration Summary* then press ***OK***. Screen 39 is shown.

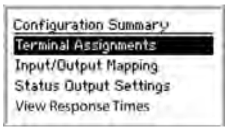


Screen 38

6.1.2.1 Terminal Assignments

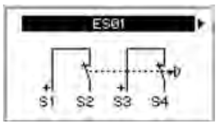
For overview refer to block 4.6.4 on page 28.

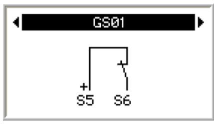
1) At screen 39, scroll down menu and choose *Terminal Assignments* then press ***OK***. Screen 40 then shows *Terminal Assignments* for first input.

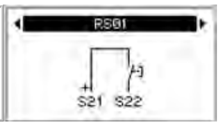


Screen 39

2) Use left/right arrow buttons to view *Terminal Assignments* for other *Inputs* (screen 41 and screen 42). On completion, press either ***OK*** or ***ESC*** to exit.





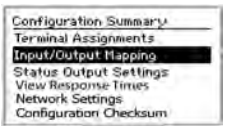


Screen 40 **Screen 41** **Screen 42**

6.1.2.2 Input/Output Mapping

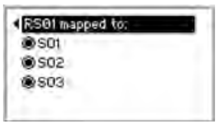
For overview refer to block 4.6.6 on page 28.

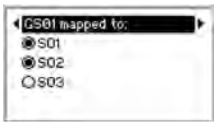
1) At screen 43, scroll down menu and choose *Input/Output Mapping* then press ***OK***. Screen 44 then shows *Input/Output Mapping* for first input.

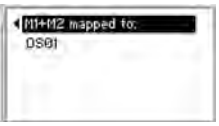


Screen 43

2) Use left/right arrow buttons to view *Input/Output Mapping* for other *Inputs* (screen 45 and screen 46). On completion, press either ***OK*** or ***ESC*** to exit.





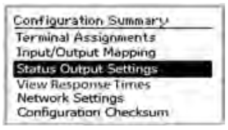


Screen 44 **Screen 45** **Screen 46**

6.1.2.3 Status Output Settings

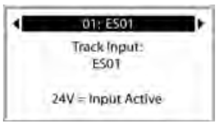
This option is used for displaying the configured *Status Outputs*. Proceed as follows:

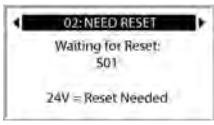
1) At screen 47, scroll down menu and choose *Status Output Settings* then press ***OK***. Screen 48 then shows *Status Output Settings* for first input.

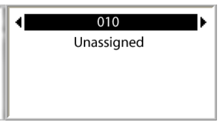


Screen 47

2) Use left/right arrow buttons to view *Status Output Settings* for other *Inputs* (screen 49 and screen 50). On completion, press either ***OK*** or ***ESC*** to exit.





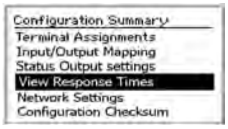


Screen 48 **Screen 49** **Screen 50**

6.1.2.4 View Response Times

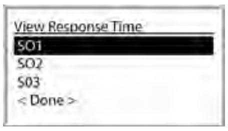
This option allows viewing of the *Response Times* for each input mapped to the output. *Response Times* can be used to calculate *Minimum Safety Distances* (see appendix A2.4.2 on page 96 for more information). To view this option:

1) At screen 51, scroll down menu and choose *View Response Times* then press ***OK***. Screen 40 then shows *Terminal Assignments* for first input.



Screen 51

2) Use up/down arrow buttons to view *Response Times* for *Safety Outputs* (screen 52). On completion, scroll down to **< *Done* >** to exit.



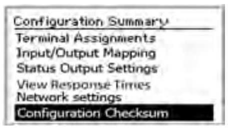
Screen 52

6.1.2.5 Network Settings (type SC22-3E Controllers only)

Refer to block A4.1.2 on page 119.

6.1.2.6 Configuration Checksum

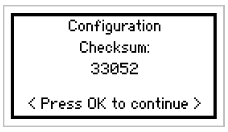
1) At screen 53, scroll down menu and choose *Configuration Checksum*. Screen 54 is shown



Screen 53

2) At screen 54 press ***OK***.

Information is then displayed of configuration programs that are currently loaded in the Safety Controller.



Screen 54

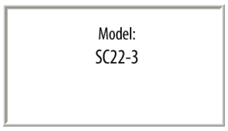
6.1.3 Model # (Number)

Select this screen to see the *Controller* model number, and software and hardware versions. This can be useful when an Applications help call is needed.

1) From *System Menu* (screen 36), select *Model #.* Screen 55 is shown.

Details of *Model #* is shown at screen 55.

2) Using up/down arrows, highlight selection required then press ***OK*** to select.



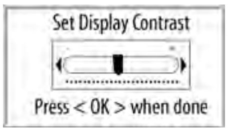
Screen 55

6.1.4 Set Display Contrast

This screen is used to adjust the brightness of the Controller display screen background and images for ambient conditions.

1) From *System Menu* (screen 36), select *Set Display Contrast.* Screen 56 is shown.

2) At screen 56, select this screen to adjust the brightness of the Controller display screen background and images for ambient conditions.



Screen 56

3) Using left/right arrow buttons adjust contrast level (left for lighter, right for more saturated). When contrast is correct, press ***OK***.

6.1.5 Save Configuration

Initial configuration changes are stored in a temporary memory location. To make the configuration changes permanent (save the configuration in non-volatile memory):

1) Select *Save Configuration* and press ***OK***.

If it is not required to save changes while at *Edit Configuration* menu:

2) Press ***ESC*** push button and select ***Yes*** when prompted.

When configuration is saved or if ***ESC*** is pressed, display returns to the *Configuration Mode* menu.

6.2 ENTERING CONFIGURATION MODE

6.2.1 Entering Controller Password

Before the *Configuration Mode* can be accessed, a password must be entered. The default password is 0000.

For instructions on changing the password, refer to block 6.3.3.2 on page 66.

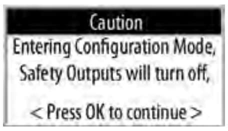
1) At screen 57, Using left/right arrow buttons, select password digit position.

2) Using up/down arrows, select digit (value) for each position (choices 0-9).

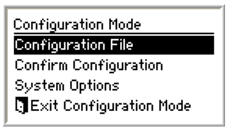
Screen 57

3) When password is entered, press ***OK*** to enter *Configuration* mode. Screen 57 is shown.

4) After reading the Caution shown in screen 58 press ***OK***. Screen 59 is then shown.



Screen 58



Screen 59

6.3 CONFIGURATION MODE

The *Configuration Mode* is used to create or edit a configuration.

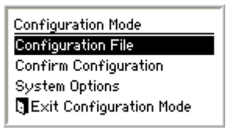
A breakdown of the *Configuration Mode* itself is shown in Figure 24 on page 56.

To enter *Configuration Mode:*

1) From *Run* mode display (screen 35), press ***OK*** to display main *System Menu* (screen 36).
2) At *System Menu*, press Down arrow button until *Configuration Mode* is highlighted on display (screen 36), then press ***OK***. Screen 60 is shown.
3) At screen 60, use this selection to enter following menus:

- *Configuration File* (to *Edit Configuration)*
- *Confirm Configuration*
- *System Options*
- *Exit Configuration Mode*

For more information refer to block 8.3.3 on page 78.



Screen 60

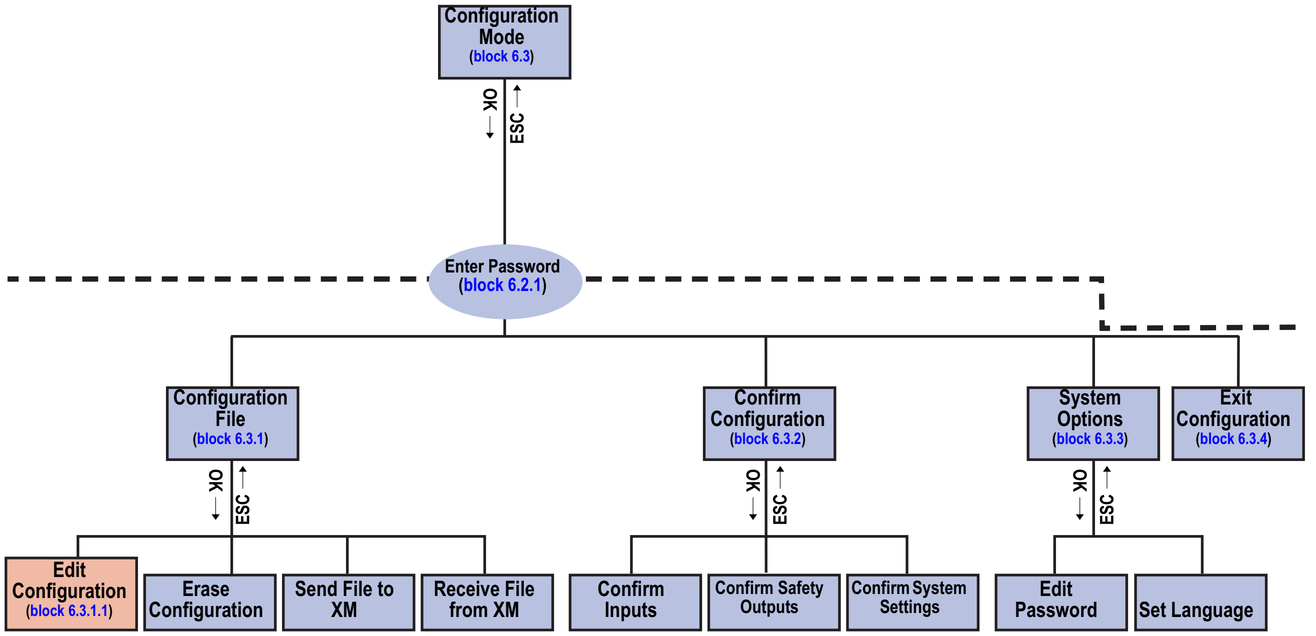


Figure 24 Safety Controller OBI Configuration Mode Options

6.3.1 Configuration File

1) From *Configuration Mode* (screen 60), select *Configuration File.* Screen 61 is shown in block 6.3.1.1 on page 57.

The following functions are in the *Configuration File* menu:

- *Edit Configuration*
- *Erase Configuration*
- *Send File to XM*
- *Receive File from XM*

6.3.1.1 Edit Configuration

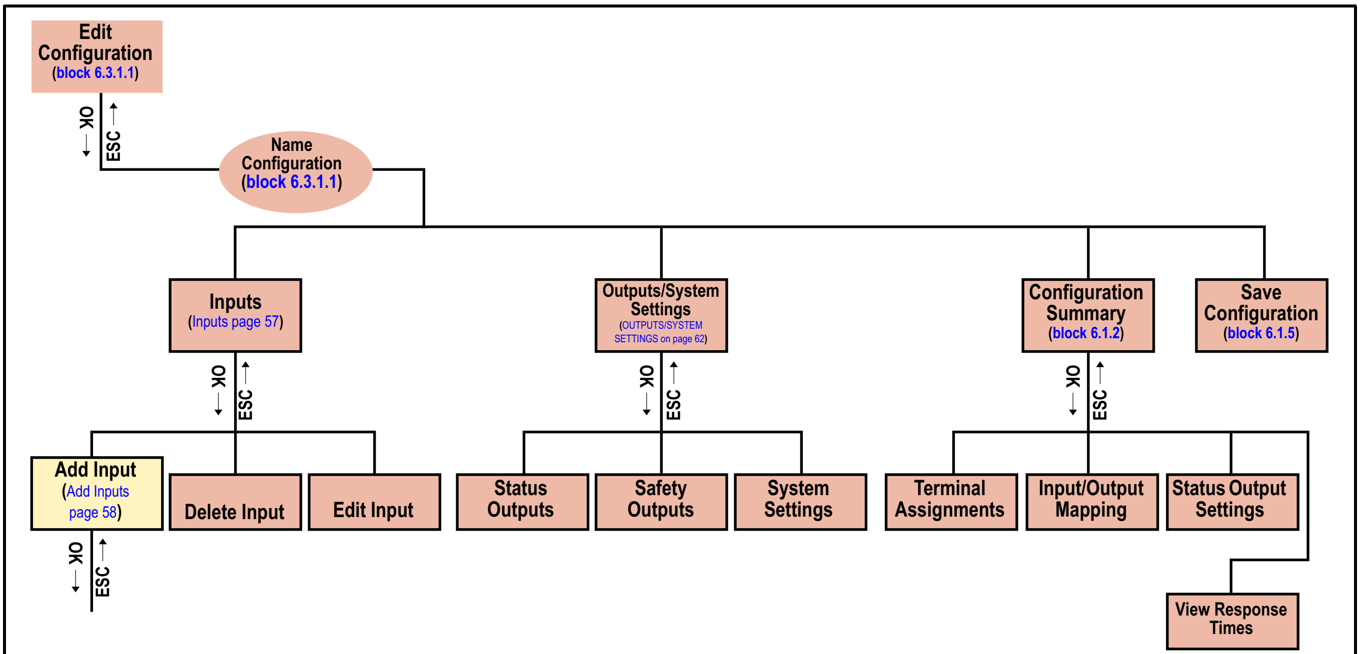
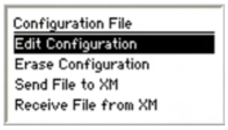


Figure 25 Safety Controller OBI Edit Configuration Mode Options

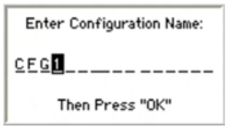
1) At screen 61, using up/down arrow buttons, highlight *Edit Configuration* required then press ***OK*** to select. Screen 62 is shown.



Screen 61

NAME CONFIGURATION

2) At screen 62, *Enter Configuration Name*. Using up/down arrow buttons, select character to be changed (up to 16 characters, choices A-Z, 0-9, -, +, or space). Press ***OK***. Screen 63 is shown.

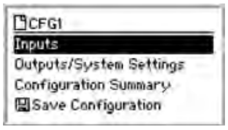


Screen 62

Inputs

☛ *Refer also to OBI Configuration Options in Figure 14 on page 18.*

3) At screen 63, use up/down arrow buttons to select *Inputs*. Press ***OK***. Screen 64 is shown.



Screen 63

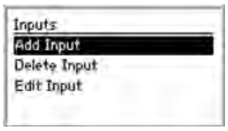
From the *Inputs* menu, *Add Input*, *Delete Input* or *Edit Input* may be selected as follows:

ADD INPUT

From this menu a *Safety Input* or *Non-Safety Input* can be selected.

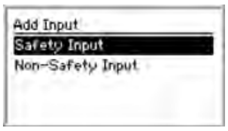
Safety Inputs

4) At screen 64, use up/down arrow buttons to select *Add Input*. Press ***OK***. Screen 65 is shown.



Screen 64

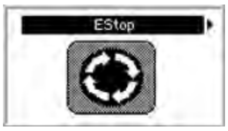
5) At screen 65, use up/down arrow buttons to select a *Safety Input*. Press ***OK***. Screen 66 is shown.



Screen 65

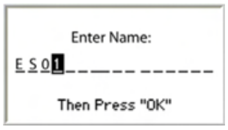
Emergency Stop (ES01) Example Menu Breakdown

6) At screen 66, use left/right arrow buttons to select a *Safety Input*, e.g. *EStop*. Press ***OK***. Screen 67 is shown.



Screen 66

7) At screen 67, *Enter Name*; use up/down arrow buttons to select the character to be changed (up to 16 characters, choices A-Z, 0-9, -, +, or space). Press ***OK***. Screen 68 is shown.

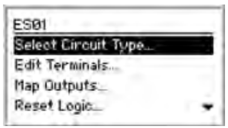


Screen 67

< Select Circuit Type... >

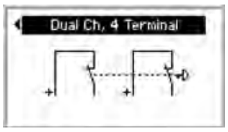
For overview refer to block 4.6.3 on page 27.

8) At screen 68, use up/down arrow buttons to select *Select Circuit Type....* Press ***OK***. Screen 69 is shown.



Screen 68

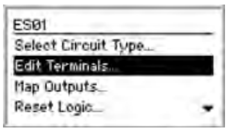
9) At screen 69, use left/right arrow buttons to select, e.g. *Dual channel, 4 terminal*. Press ***OK***. Screen 70 is shown.



Screen 69

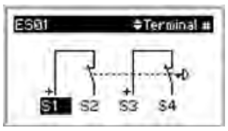
< Edit Terminals >

10) At screen 70, use up/down arrow buttons to select, *Edit Terminals*. Press ***OK***. Screen 71 is shown.



Screen 70

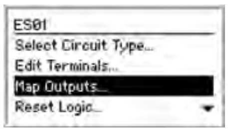
11) At screen 71, to *Edit Terminals,* use left/right arrow button to select terminal assignment to be changed. Use up/down arrow buttons to change terminal assignments. Press ***OK***. Screen 72 is shown.



Screen 71

< Map Outputs >

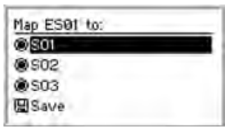
12) At screen 72, use up/down arrow buttons to select *Map Outputs*. Press ***OK***. Screen 73 is shown.



Screen 72

13) At screen 73, to *Map Outputs,* Use up/down arrow buttons to highlight an output.

14) Remove or add input mapping by selecting output and pressing **OK**.



Screen 73

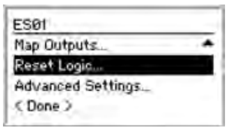
☛ *A filled-in circle next to an output indicates the input is mapped to that output. An open circle indicates the input is not mapped to that output.*

15) Map *E-Stop* to all three safety *Outputs*, and using up/down arrow buttons select *Save* and press ***OK***. Screen 74 is shown.

< Reset logic.. >

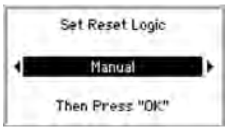
For overview refer to block 4.6.4 on page 28.

16) At screen 74, use up/down arrow buttons to select *Reset logic...* Press ***OK***. Screen 75 is shown.



Screen 74

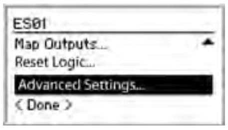
17) At screen 75, *Set Reset Logic* using left/right arrow buttons to select *Manual* from *Manual* or *Auto*. Press ***OK***. Screen 76 is shown.



Screen 75

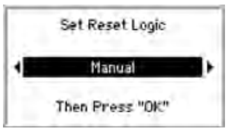
<Advanced Settings...>

18) At screen 76, use up/down arrow buttons to select *Advanced Settings....* Press ***OK***. Screen 77 is shown.



Screen 76

19) At screen 77, if necessary, choose from *Advanced Settings...* using up/down arrow buttons to make selections for *Simultaneity* or *Debounce Time* (see block 4.6.7 on page 28 for information on these settings). Press ***ESC*** to go back to *ES01* Screen 78.



Screen 77

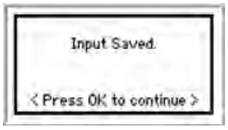
< Saving Settings >

This function used for saving the configured parameters. Proceed as follows:

20) At screen 78, use up/down arrow buttons to scroll down to < *Done* >. Press ***OK***. Screen 79 is shown.

Screen 78

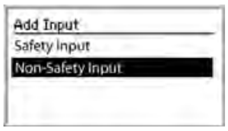
21) At screen 79, press ***OK*** to return to *Inputs* screen (Screen 64).



Screen 79

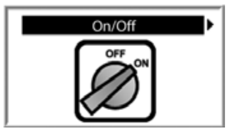
Non-Safety Inputs

22) At screen 80, use up/down arrow buttons to select *Non-Safety Input*. Press ***OK***. Screen 81 is shown.



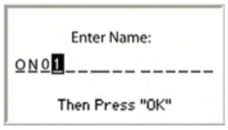
Screen 80

23) At screen 81, use left/right arrow buttons to select a *Non-Safety Input*
e.g. *ON/OFF* Switch. Press ***OK***. Screen 82 is shown.



Screen 81

24) At screen 82, *Enter Name*; use up/down arrow buttons to select the character to be changed (up to 16 characters, choices A-Z, 0-9, -, +, or space). Press ***OK***. Screen 68 is shown.



Screen 82

☛ *The Screens for* step 8) thru to step 21) *are almost identical.*

25) Repeat step 8) thru to step 21).

ADDING ADDITIONAL SAFETY INPUT DEVICES

The steps required to add other *Safety Input* devices are similar to those just completed.

1) Create following *Safety Input* devices, with properties as shown in table 11 on page 59:
   Gate Switch, GS01
   Two Hand Control, THC01
   Reset Input, RS01
   Optical Sensor, OS01
   External Device Monitors; EDM01, EDM02, and EDM03
   Mute Sensor Pair, M1+M2

Table 11 Breakdown of Additional Safety Input Devices

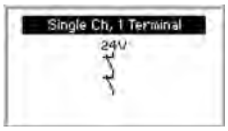
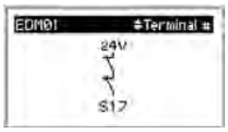
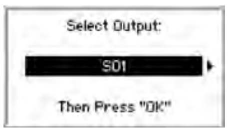
Function	Screen
External Device Monitoring – EDM01	
Circuit Type: *Single channel, 1 terminal*	 **Screen 83**
Terminals: S17	 **Screen 84**
Mapped to: SO1	 **Screen 85**

Table 11 Breakdown of Additional Safety Input Devices

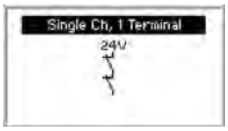
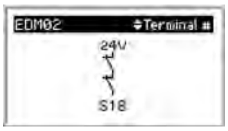
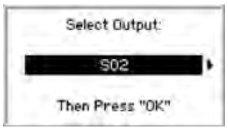
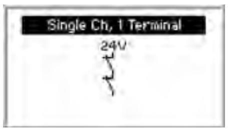
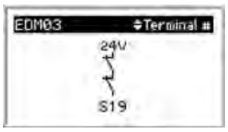
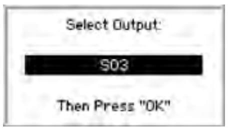
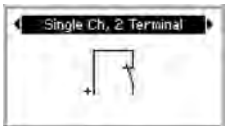
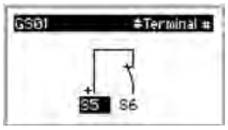
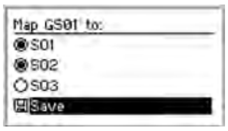
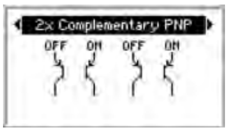
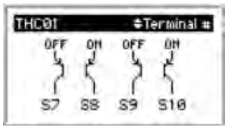
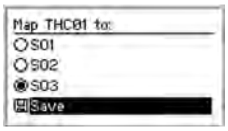
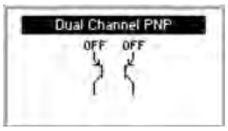
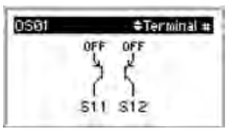
Function	Screen
External Device Monitoring – EDM02	
Circuit Type: *Single channel, 1 terminal*	 **Screen 86**
Terminals: S18	 **Screen 87**
Mapped to: SO2	 **Screen 88**
External Device Monitoring – EDM03	
Circuit Type: *Single channel, 1 terminal*	 **Screen 89**
Terminals: S19	 **Screen 90**
Mapped to: SO3	 **Screen 91**
Gate Switch – GS01	
Circuit Type: *Single channel, 2 terminal*	 **Screen 92**
Terminals: S5 & S6	 **Screen 93**
Mapped to: SO1, SO2	 **Screen 94**
Auto Reset Logic:	 **Screen 95**
Two-Hand Control – THC01	
Circuit Type: *2X Complementary, PNP switch*	 **Screen 96**
Terminals: S7, S8, S9 & S10	 **Screen 97**
Mapped to: SO3	 **Screen 98**
Optical Sensor – OS01	
Circuit Type: *Dual Channel, PNP*	 **Screen 99**
Edit Terminals: S11 & S12	 **Screen 100**

Table 11 Breakdown of Additional Safety Input Devices

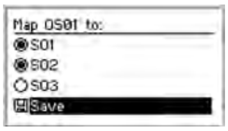
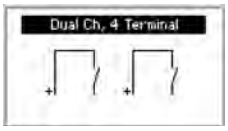
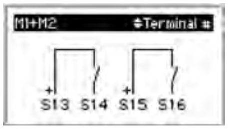
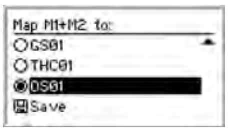
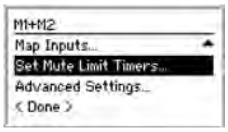
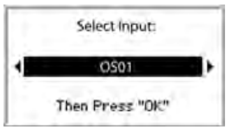
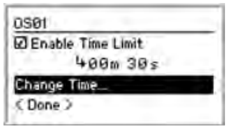
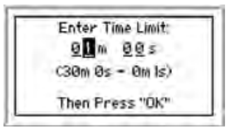
Function	Screen
Mapped to: SO1 & SO2	 **Screen 101**
Auto Reset Logic:	 **Screen 102**
Mute Sensor – M1 + M2 The next input is different than the previous *Inputs* added and is therefore covered in more detail. 1) After selecting *add a Mute Sensor* and entering its name, set *Circuit Type* and the terminal assignments as follows:	
Circuit Type: *Dual channel, 4 terminal*	 **Screen 103**
Edit Terminals: 13, 14, 15 & 16	 **Screen 104**
Instead of mapping to an output, *Mute Sensor Inputs* are mapped to the *Inputs* they mute. Only certain types of *Input Devices* can be muted. The *Safety Controller* creates a list of the *Inputs* in the current configuration that can be muted. 2) From *Mute Sensor* Properties menu select *Map Inputs* and press ***OK***. Screen 105 is shown. 3) At screen 105, using up/down arrow buttons, select **OS01** from list of *Inputs* and press ***OK***. The circle to the left of *OS01* fills in to indicate that mute senor pair M1+M2 is mapped to OS01.	 **Screen 105**
☛ *In this case, the Mute Sensor pair is being mapped to only OS01, but the Mute Sensor pair can be mapped to more than one input.* 4) Select ***Save*** and press ***OK*** to complete input mapping process.	

Table 11 Breakdown of Additional Safety Input Devices

Function	Screen
Set Mute Limit Timers The *Set Mute Limit Timers* defines the maximum amount of time an input can be muted. 1) At screen 106, *M1+M2* Properties menu, select *Set Mute Limit Timers* and press ***OK***. screen 107 is shown.	 **Screen 106**
2) At screen 107, *Select Input*, and press ***OK***. Screen 108 is shown.	 **Screen 107**
☛ *If the box in front of Enable Time Limit is not checked, highlight it and then check it by pressing **OK** to enable the time limit.* 3) At screen 108, using up/down arrow buttons, select *Change Time...* and press ***OK***. Screen 109 is shown.	 **Screen 108**
4) At screen 109, change value to 1 minute. Use the left/right arrow buttons to select the digit to be changed and the up/down arrow buttons to change the digit (0-9) and press ***OK***. 5) At screen 108, select **<Done>** and press ***OK***.	 **Screen 109**
When all necessary *Safety Inputs* have been added in turn, press ***ESC*** to exit to screen 63.	

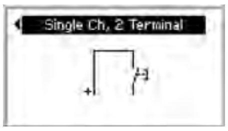
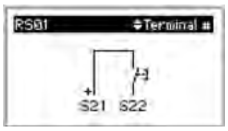
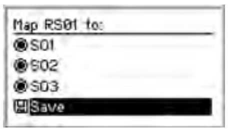
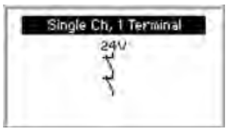
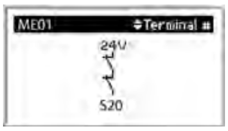
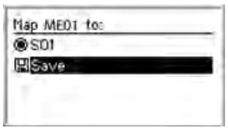
ADDING ADDITIONAL NON-SAFETY INPUT DEVICES

The steps required to add other *Non-Safety Input* devices are similar to those just completed.

1) Create following *Input Devices*, with properties as shown in table 11 on page 59:

- Reset Input, RS01
- Mute Enable

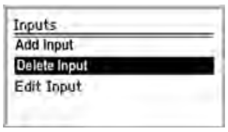
Table 12 Additional Safety Input Device Breakdown

Function	Screen
Reset – RS01	
Circuit Type: *Single channel, 2 terminal*	 Screen 110
Terminals: S21 and S22	 Screen 111
Mapped to: SO1, SO2, and SO3	 Screen 112
Mute Enable – ME01	
Circuit Type: *Single channel, 1 terminal*	 Screen 113
Terminals: S20	 Screen 114
Mapped to: SO1, SO2, and SO3	 Screen 115
When all necessary *Non-Safety Inputs* have been added in turn, press ***ESC*** to exit to screen 63.	

Delete Input

To delete an input:

1) From screen 116 select *Delete Input* and follow the prompts.

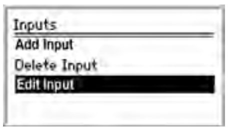


Screen 116

Edit Input

To edit an input:

1) From screen 117 select *Edit Input* and follow the prompts to select another Input.



Screen 117

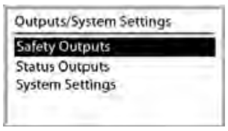
Outputs/System Settings

SAFETY OUTPUTS

This option is used to edit the *Safety Outputs* if necessary.

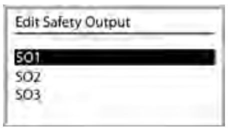
1) At screen 63, select *Outputs/System Settings***.** Screen 118 is shown.

2) At screen 118, using up/down arrow buttons, select *Safety Outputs* and press ***OK***. Screen 119 is shown.



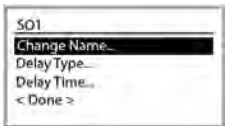
Screen 118

3) At screen 119, select *Safety Output* to edit and press ***OK***. Screen 120 is shown.



Screen 119

4) At screen 120, edit *Change Name...*, *Delay Type* and *Delay Time* as necessary. On completion select < *Done* >.



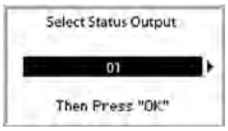
Screen 120

STATUS OUTPUTS

This option is used to configure individually the *Status Outputs*.

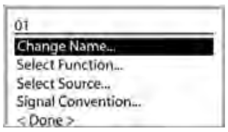
1) At screen 118, select *Status Outputs***.** Screen 121 is shown.

2) At screen 121, using left/right arrow buttons, select each *Status Output* in turn to edit (O1 to O10), and press ***OK***. Screen 122 is shown.



Screen 121

The *Status Output* properties menu appears and is used to edit the following indications:



Screen 122

Change Name...

Select Function...

Select Source...

Signal Convention...

For further breakdown of these indications refer to Figure 26 on page 63.

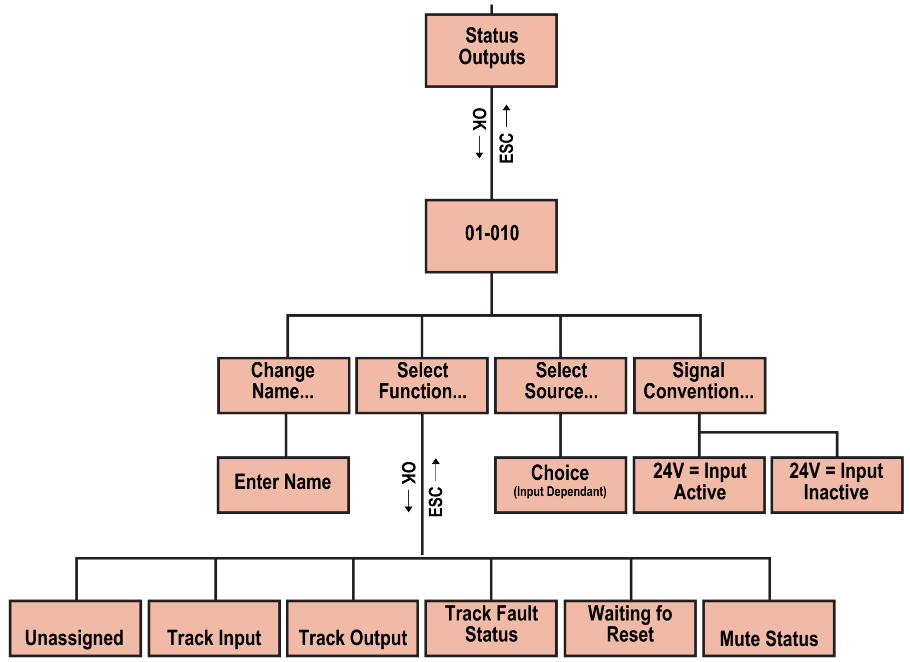
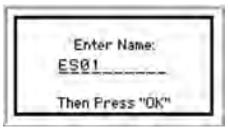


Figure 26 Editing OBI Status Outputs - Options

Change Name...

3) At screen 122, scroll down menu to select *Change Name...* and press ***OK***. Screen 123 is shown.

4) At screen 123, using left/right arrow buttons, move to each character in turn (up to 10 characters).



Screen 123

5) At screen 123, using up/down arrow buttons, change character(s) as necessary (choices A-Z, 0-9, -, +, or space). Press ***OK*** when done.

When the display returns to the *Status Output* properties menu, the top line of the display displays the new name.

Select Function...

6) At screen 122, scroll down menu to *Select Function...*

7) Use left/right arrow buttons to select a function, then press ***OK***.

The display returns to the *Status Output* Properties menu.

Select Source...

8) At screen 122, scroll down menu to choose *Select Source...* and press ***OK***.

9) Use the left/right arrow buttons to select device and press ***OK***.

The display returns to the *Status Output* Properties menu.

Signal Convention...

10) At screen 122, scroll down menu to choose *Signal Convention...* and press ***OK***.

11) Use left/right arrow buttons to toggle between options and press ***OK***.
Options are: *24V = Input Active* and *24V = Input Inactive* (e.g. if *Track Input* is selected; see block 4.10.1 on page 35 for more information).

12) Select **<*Done*>** and press ***OK*** to save the settings for this output.

The display returns to the *Outputs/System Settings* menu.

13) Repeat step 1) thru to step 12) to configure additional *Status Outputs* in the same way.

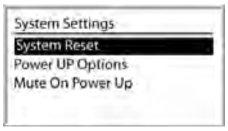
14) When last *Status Output* is configured, press ***ESC*** to return to the *Edit Configuration* menu.

SYSTEM SETTINGS

This menu is used to set *System Reset*, *Power-up Option* and *Mute on Power-up*.

System Reset

1) At screen 124, scroll down menu to choose *System Reset* and press ***OK***.



Screen 124

2) Use left/right arrow buttons to toggle between *Monitored* or *Non-Monitored*, and press ***OK***.

Power-up Option

3) At screen 124, scroll down menu to choose *Power-up Option* and press ***OK***.

Use the left/right arrows to select *Normal*, *Auto*, or *Manual*, and press ***OK***.

Mute on Power-up

4) At screen 124, scroll down menu to choose *Mute on Power-up* and press ***OK***.

5) Use left/right arrows to toggle between *OFF* or *ON*, and press ***OK***.

Configuration Summary

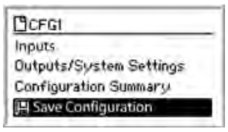
For detailed instructions refer to block 6.1.2 on page 54.

Save Configuration

While making the configuration changes they are stored in a temporary memory location.

To make the configuration changes permanent:

1) At screen 125, select *Save Configuration* and press ***OK***.



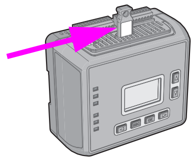
Screen 125

☛ *If it is not required to save the changes while at the Edit Configuration menu, press* ***ESC*** *and select* ***Yes*** *when prompted to exit without saving changes yes/no.*

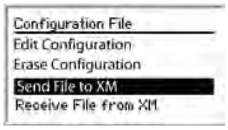
6.3.1.2 Send File to XM

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*.

1) Insert the *XM Card* into *Controller's* XM port as shown.



2) At *Controller* screen 126, select *Send File to XM* and follow prompts as appropriate.



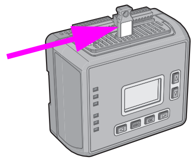
Screen 126

If *XM Card* is not empty, the *Controller* prompts to overwrite the current configuration on the *XM Card* YES/NO (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.

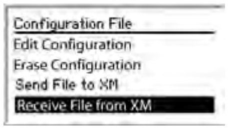
6.3.1.3 Receive File from XM

This selection is used to receive a configuration from the XM card.

1) Insert the *XM Card* into Controller's XM port.



2) At *Controller* screen 127, select *Receive File from XM* and follow prompts as appropriate.



Screen 127

The *Controller* prompts to overwrite the current configuration in the *Controller* YES/NO (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.

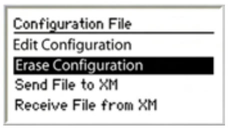
6.3.1.4 Erase Configuration

This selection is used to remove the current configuration from the *Safety 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 (as detailed in* *block 6.3.1.2 on page 64**) before erasing it from the Controller.*

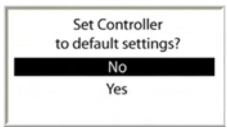
To perform an Erase:

1) At screen 128, using up/down arrow buttons, highlight *Erase Configuration* then press ***OK*** to select. Screen 129 is shown.



Screen 128

2) At screen 129, using up/down arrow buttons, set default requirements Yes/No. To exit Press ***OK***.

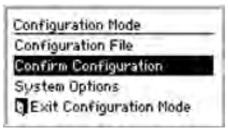


Screen 129

6.3.2 Confirm Configuration

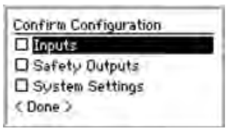
Before configuration can be used in a *Safeguarding* application, it must be confirmed. To *Confirm Configuration:*

1) Select *Confirm Configuration* and press ***OK***. Screen 131 is shown.



Screen 130

The safety-critical configurations for the *Inputs*, *Safety Outputs* and system settings must now be reviewed. An unchecked box in the *Confirm Configuration* menu indicates the safety-critical settings have not yet been confirmed. Screen 131 refers.

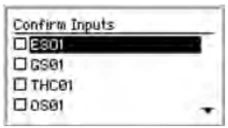


Screen 131

6.3.2.1 Confirm Configuration of Inputs

From Screen 131 *Confirm Configuration* menu, select *Inputs* and press ***OK***. Screen 132 is shown.

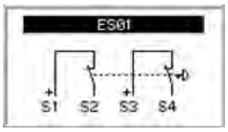
1) At screen 132, *Confirm* by selecting e.g. ***E-Stop ES01***, then press ***OK***. Screen 133 is shown.



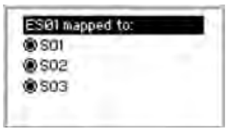
Screen 132

The next series of menus lists the safety-critical configurations for this input.

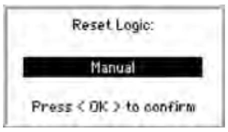
2) Review safety-critical configurations for each setting of this input at following screens, screen 133, screen 134, screen 135, screen 136 and screen 137 and then press ***OK***:



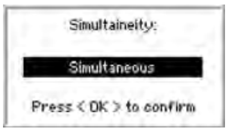
Screen 133



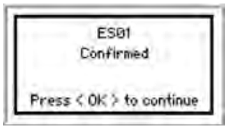
Screen 134



Screen 135



Screen 136

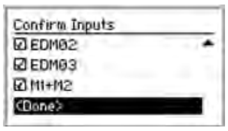


Screen 137

3) Repeat confirmation process for each of the *Inputs*.

When all *Inputs* have been confirmed, Screen 138 is shown.

4) To continue *Confirm Configuration*, select **<*Done*>** and press ***OK***.

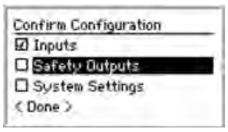


Screen 138

6.3.2.2 Confirm Configuration of Outputs

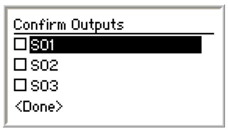
1) From Screen 131 select *Confirm Configuration* menu, and press ***OK***. Screen 139 is shown.

2) At screen 139, select *Safety Outputs*, then press ***OK***. Screen 140 is shown.



Screen 139

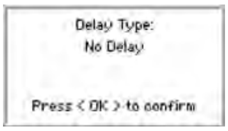
3) Confirm *Safety Output* SO1's configuration by selecting ***SO1*** and then press ***OK***.



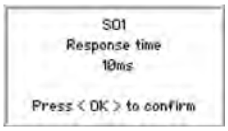
Screen 140

The next series of menus lists the safety-critical configurations for SO1.

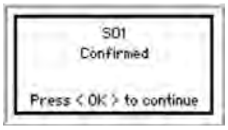
4) Review safety-critical configurations for S01 of this *Safety Output* at following screens, screen 141, screen 142 and screen 143 then press ***OK***.



Screen 141



Screen 142



Screen 143

5) Repeat confirmation process for SO2 and SO3.

When all *Safety Outputs* have been confirmed, Screen 138 is shown.

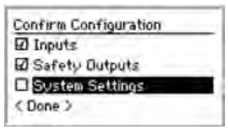
6) To continue *Confirm Configuration*, select **<*Done*>** and press ***OK***.

6.3.2.3 Confirm Configuration of System Settings

1) From Screen 131 select *Confirm Configuration* menu, and press ***OK***. Screen 144 is shown.

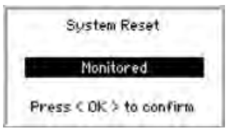
2) At screen 144, select *System Settings*, then press ***OK***. Screen 140 is shown.

The next series of menus lists the safety-critical *System Settings*.

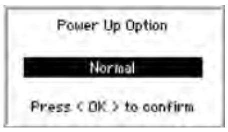


Screen 144

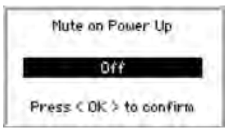
3) Review safety-critical configurations for *System Settings* at following screens, screen 145, screen 146 and screen 147 then press ***OK***.



Screen 145



Screen 146



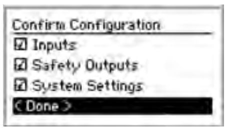
Screen 147

6.3.2.4 Final Confirmation Step

When all of the safety-critical configurations settings have been confirmed then and only then can the configuration be used in a *Safeguarding* application.

☛ *If any changes are made to the configuration, the confirmation process must be repeated.*

1) At screen 148 exit *Confirm Configuration* menu by selecting **< *Done* >** and pressing ***OK***.

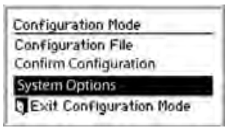


Screen 148

6.3.3 System Options

This function is used to *Edit Password* and *Set Language*.

1) At screen 149, select *System Options*. Screen 150 is shown.

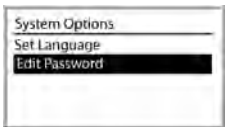


Screen 149

6.3.3.1 Edit Password

This function allows the password to be edited 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) At screen 150, select *Edit Password*. Screen 151 is shown.



Screen 150

2) At screen 151, using left/right arrow buttons, select password digit position. Using up/down arrows select digit (value) for each position (choices 0-9).

Screen 151

3) When password is entered, press ***OK*** and record the new password in a file for safekeeping and later reference.

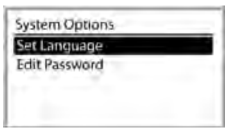
6.3.3.2 Set Language

This screen is used to determine what language appears on the display. Choices are:

English	French	Japanese
German	Italian	
Spanish	Portuguese	

Highlight the correct language to select it, then press OK.

1) At screen 152, select ***Edit Password***.
2) Select language as appropriate and when finished press ***OK***.



Screen 152

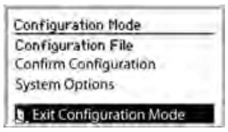
☛ *Language can also be changed immediately following power-up. A screen appears automatically, and the language selection can be changed at that time. If nothing is changed, the screen times out after 5 seconds and continues to Run mode in the language that was selected before the Controller was last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

6.3.4 Exit Configuration Mode

This function is used to return to *Run* mode.

1) At screen 153, select *Exit Configuration Mode*.

Controller prompts whether to *Confirm Configuration Yes/No* before exiting and then returns to *System Menu*.



Screen 153

7 OPERATING INSTRUCTIONS — GENERAL

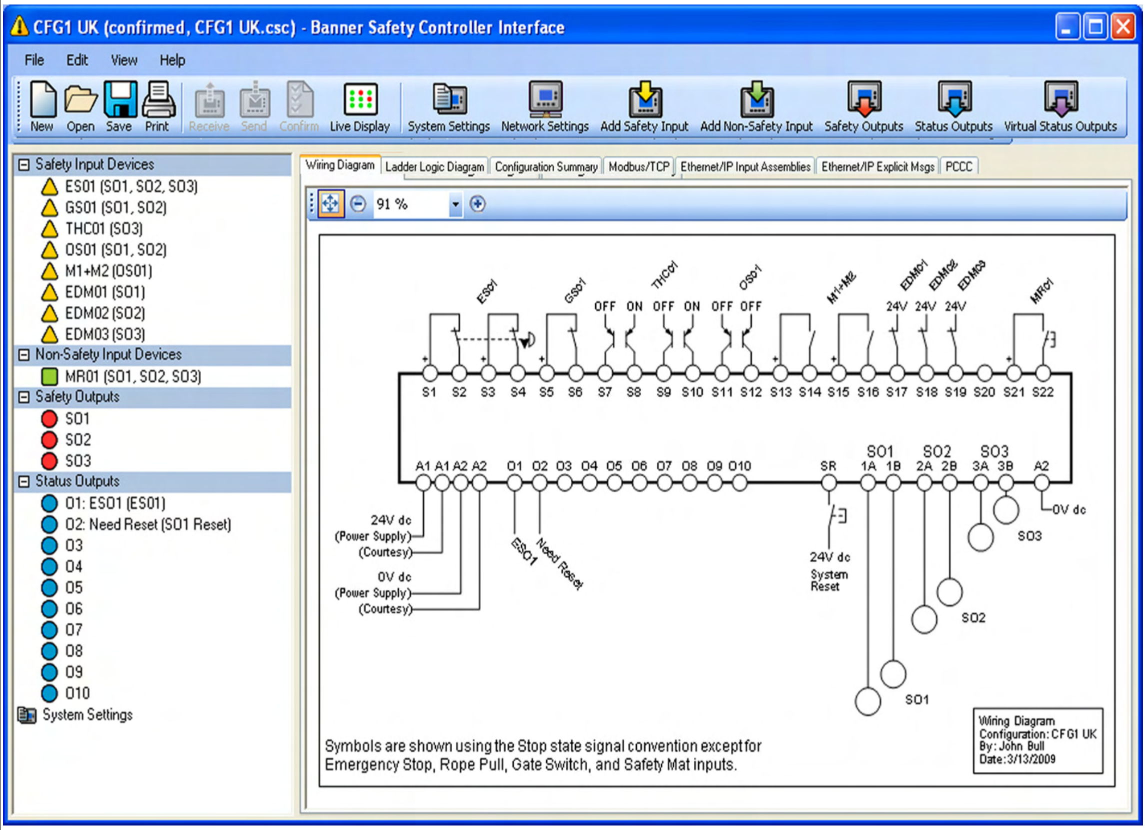
7.1 DISPLAYING CONTROLLER INFORMATION — PCI

To display real-time *Run* mode information on the PC:

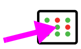
1) Referring to block 4.4.2 on page 25, connect *Controller* to PC, via USB cable.
2) From the PC Desktop, Double-click on *Banner Safety Controller* icon .

or alternatively
From the Start Menu, click on:
<Start> <All Programs> <Banner Engineering> <Banner Safety Controller>

3) ⚠ Read and understand warning on Start-up page of program and click ***OK***. Screen 154 is shown.



Screen 154

4) At screen 154 on page 67, click on icon *Live Display* button  Screen 155 on page 67 is shown.

The *Live Display* (screen 155 on page 67) continually updates *Run* mode data and displays it as shown. It 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.

Screen 155

For further *PCI* information, refer to chapter 5.

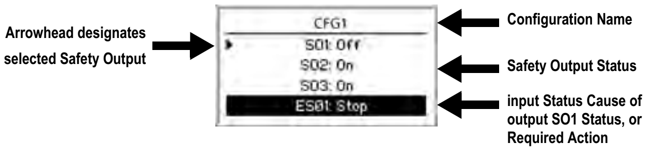
7.2 DISPLAYING CONTROLLER INFORMATION — OBI

7.2.1 Run Mode

For a breakdown of the *Run* mode refer to Figure 23 on page 53.

The *Controller OBI Run* mode example (screen 156 on page 68) displays current information about the *Safety Controller*, including:

- *Configuration Name*
- *Safety Output* status
- input status
- *System* status
- *XM Card OBI* status



Screen 156

7.2.1.1 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.

7.2.1.2 Safety Output Status

Lines 2, 3, and 4 of screen 156 on page 68 give status of x3 *Safety Outputs*. Selected *Safety Output* is indicated by a small arrowhead as shown (the arrowhead scrolls through the *Safety Outputs* that are *OFF*, at 2-second intervals). Line 5 of display gives reason for status of selected *Safety Output*. Table 13 on page 68 gives a breakdown of the *Safety Output* status messages.

☛ *Output faults are recoverable via a System Reset (see block 7.4 on page 69).*

Line 5 of screen displays *Mute Lamp Fault* when a *Mute Lamp Fault* exists.

Table 13 Safety Output Status Message Breakdown

Safety Output Status Message	Cause and/or Required Action
ON	*Safety Output* is *ON*.
ON-Delay	*Safety Output* turns *ON* when *ON*-delay time expires.
OFF	*Safety Output* is *OFF*. Line 5 of display indicates reason *Safety Output* is *OFF*.
OFF-Delay	The *Safety Output* turns OFF when OFF-delay expires. Line 5 of display indicates reason *Safety Output* is in an OFF-delay.
Reset Needed	A *Manual Reset* operation needs to be performed. Line 5 of display indicates name of *Manual Reset* input to press.
Fault	A problem has been detected with *Safety Output*. See troubleshooting table (block 8.3.3 on page 78) to find additional information regarding fault. If fault is due to an *EDM* fault, line 5 of display indicates name of *EDM*.
Enable Mode	Line 5 of display indicates *Enable Mode* if a *Safety Output* is in *Enable Mode*.

7.2.1.3 Input Status

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

Line 5 also indicates when a *Manual Reset* operation needs to be performed.

☛ *Line 5 changes to indicate each input when status of more than one input must be displayed.*
Press Up arrow button to pause screen on current input.
Press Down arrow button to change last line to next input (Press Down arrow button repeatedly to quickly cycle through Inputs).
If more than one output is OFF, a small arrowhead indicates Safety Output to which input messages correspond (see screen 156 on page 68).

No input information is displayed when a *Safety Output* is *ON*, unless a mapped input is muted, bypassed, or in a fault condition.

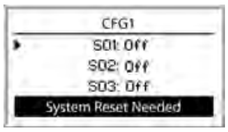
Table 14 on page 68 gives a breakdown of the *Input Device* status messages.

Table 14 Input Device Status Message Breakdown

Input Device Status Message	Cause and/or Required Action
Stop	*Safety Input* is in a state that causes *Safety Output* to turn *OFF*.
Test	A start-up test needs to be completed on *Safety Input*. To perform test, cycle input (Run-Stop-Run) to turn *Safety Output ON*.
Deactive	A two-hand control input or an enabling device needs to be cycled (Run-Stop-Run) before *Safety Output* turns *ON*.
Fault	A problem has been detected with an input that controls output.
Timed Out	*Safety Output* is in *Enable Mode* and enabling device active time limit has expired. Cycle enabling device to turn output back *ON*, or turn enabling device *OFF* and perform a *System Reset* to exit *Enable Mode*.

7.2.1.4 System Status

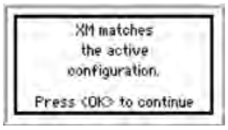
Line 5 of screen 157 on page 68 displays *System Reset Needed* whenever a *System Reset* is needed to turn *Safety Outputs ON*. However, when a fault condition exists, fault must be corrected before *System Reset* operation turns *Safety Outputs ON*.



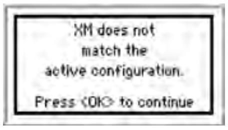
Screen 157

7.2.1.5 XM Card OBI Status

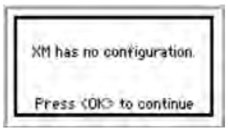
The status of *XM Card* is temporarily displayed (screen 158, screen 159 and screen 160) when it is inserted while *Run* mode screen is active. Correct *XM Card* should be removed or replaced as necessary.



Screen 158



Screen 159



Screen 160

Table 15 on page 69 gives a breakdown of the *XM Card* Status Messages.

Table 15 XM Card Status Message Breakdown

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

7.3 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 block 1.10 on page 5 for *Reset* timing requirements.

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* is 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 turn *OFF* and remain *OFF* until a valid *Manual Reset* is performed.

7.4 SYSTEM RESET & LOCKOUT CONDITIONS

⚠ 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.

CHECKING 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 COULD RESULT IN SERIOUS BODILY INJURY OR DEATH.

SYSTEM SWITCH LOCATION

THE MANUAL SYSTEM RESET PUSH BUTTON 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 (E.G. 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 COULD RESULT IN SERIOUS BODILY INJURY OR DEATH.

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*

A *System Reset* is used to clear *Lockout* conditions not related to *Safety Inputs*. A *Lockout* condition is a response where the *Controller* turns *OFF* all affected *Safety Outputs* when a safety-critical fault is detected. Recovery from this condition requires all faults to be remedied and a *System Reset* performed. A *Lockout* will re-occur 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*, labelled SR. The *Reset* signal type can be configured to be either *Monitored* or *Non-Monitored* (the default setting is *Monitored)*. See block 7.5 on page 70 for *Reset* timing requirements.

7.5 RESET SIGNAL REQUIREMENTS

Both *Manual Reset (Latch)* and *System Reset* signals can be configured for *Monitored* or *Non-Monitored* operation, as follows:

7.5.1 Monitored Reset

Requires the *Reset* signal to transition from low (0 V dc) to high (24Vdc) and then back to low. The high state duration must be 0,3 s to 2 s. This is said to be a *trailing edge trip event*.

7.5.2 Non-Monitored Reset

Requires only that the *Reset* signal transitions from low (0V dc) to high (24 Vdc) and stays high for at least 0,3 seconds. After the *Reset*, the *Reset* signal can be either high or low. This is said to be a *leading-edge trip event*.

8 MAINTENANCE

8.1 PREVENTIVE MAINTENANCE

8.2 SYSTEM CHECKOUT

WARNINGS

PERIODIC CHECKOUTS

The commissioning, periodic and daily safety system checks must be performed by appropriate personnel at the appropriate times (as described in block 8.2.1 on page 71) 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.

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 Safety Controller and the guarded machine until the defect or problem has been corrected (see chapter 8). Attempts to use the guarded machine under such conditions could result in serious bodily injury or death.

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 could result in serious bodily injury or death.

8.2.1 Schedule of Check-outs

Verifying the configuration and proper functioning of the *Safety Controller* includes the verification of each *Safety Input* 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 checked to verify that they turn *ON* and *OFF* as expected. Other *Inputs* mapped to the same *Safety Outputs* as the one that is being tested, must be in their ON-state during the test.

A comprehensive test must be used to verify the operation of the Safety Controller and the functionality of the intended configuration. The checklist in block 8.2.2 on page 71 is generic and 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 check-outs. A similar, simplified daily checkout checklist should be made for the operator (or Designated Person as specified in block 1.8.1). It is highly recommended to have copies of the *Wiring Diagrams* and *Ladder Logic Diagrams* and the *Configuration Summary* available to assist in the checkout procedures.

8.2.2 Commissioning Checkout

A Qualified Person as specified in block 1.8.2 on Page 4 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.

8.2.3 Periodic (6 Monthly) Checkout

A Qualified Person as specified in block 1.8.2 on Page 4 must also perform a safety system re-commissioning 6 monthly or at periodic intervals based on the appropriate local or national regulations.

8.2.4 Daily Operational Checks

A Designated Person as specified in block 1.8.1 must also check the effectiveness of the protective devices as per the device manufacturers' recommendation each day that the safeguarded machine is in service.

8.2.5 Commissioning Checkout Procedure

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.

8.2.5.1 Commissioning Pre-Checks

Verify pre-checks as follows:

1) ❑ Verify power has been removed from machine, and no power is available to machine controls or actuators.
2) ❑ Referring to Figure 27 on page 71, verify that 7-pin connector is unplugged from *Safety Controller* to ensure that *Safety Outputs* SO1 (A and B), SO2 (A and B) and SO3 (A and B) are not connected to machine.

Figure 27 Safety Output Terminal Block

☛ *Permanent connections will be made at a later point in this checkout.*

8.2.5.2 Verifying System Operation

The commissioning checkout procedure must be performed by a Qualified Person as specified in block 1.8.2 on Page 4 (see also warning on page 71). 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* (per Appendix A and the appropriate standards).

The commissioning checkout procedure is performed on two occasions:

- When the *Controller* is first installed to ensure proper installation
- Whenever any maintenance or modification is performed on the System or on the machinery being guarded by the System, to ensure continued proper *Controller* function (see block 8.2.1 on page 71 for a schedule of required check-outs)

8.2.5.3 Procedure

1) ❑ Verify that *Safety Output* leads are isolated (i.e. not shorted together and not shorted to power or ground).
2) ❑ Verify that, if used, *EDM* connections have been connected to a +24V dc via the *N.C.* monitoring contacts of device(s) connected to *Safety Outputs* as described in block 4.9 on page 33 and Figure 31 on page 85, Figure 32 on page 86, Figure 33 on page 86 and Figure 34 on page 87.
3) ❑ Verify that proper *Controller* configuration file for required application has been uploaded to *Safety Controller*.
4) ❑ Verify that *Safety Controller* has been connected to *Safety Systems* **only** (do **not** connect to guarded machine at this stage) in accordance with instructions detailed in this manual and that it complies with safety standards and local wiring codes.

This procedure allows the *Controller* and the associated *Safety Systems* to be checked out before permanent connections are made to the guarded machine.

8.2.6 Initial Setup & Commissioning/Periodic Check-outs

☛ *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) ❏ Configure machine so that indicators for *Safety Outputs* (SO1, SO2, and SO3) of *Safety Controller* and for the associated *Output Devices* can be observed and verified to operate correctly and without risk of injury.

Do not apply power to the *Safety Controller* or to the guarded machine at this stage.

8.2.6.1 Safety System & Safeguarding Device Checkout

1) ❏ Verify that guarded machine is of a type and design compatible with this *Safeguarding* system, as described on chapter 2.

2) ❏ Verify installation and perform checkout procedures for the external safety/*Safeguarding* systems and devices connected to the *Safety Controller Inputs* as described by appropriate manuals. **Do not proceed until all checkout procedures are completed successfully and all problems have been corrected.**

3) ❏ Verify that access to any dangerous parts of guarded machine is not possible from any direction not protected by *Safeguarding* system, fixed guarding, or supplementary *Safeguarding* and that supplementary *Safeguarding* and fixed guarding as described by appropriate safety standards are in place and functioning properly.

4) ❏ Verify that all *Reset* switches are mounted outside and in full view of guarded area, out of reach of anyone inside guarded area and that means of preventing inadvertent use is in place.

5) ❏ Examine electrical wiring connections between *Safety Controller OSSD Outputs* and guarded machine's control elements to verify that wiring meets requirements stated in block 4.9 on page 33.

6) ❏ Verify that all *Two-Hand Control* devices, *Enabling Devices*, Mute Sensors and *Bypass Switches* are in inactive *(Stop)* state.

☛ *In all cases, Outputs associated with a Two-Hand Control device should not turn ON at power-up. Also, Bypass Switches or Enabling Devices in the active (Run) state at power-up will not function until they are seen as OFF first.*

7) ❏ Ensure that all other *Input Devices* are in the active *(Run)* state.

8.2.6.2 Power-up & Reset Functions

1) ❏ Ensure that no individual is exposed to the hazardous motion/situation of the guarded machine during the checkout procedure.

2) ❏ Observe the SO status indicators or the messages on the front panel display to verify whether a safety output is *ON* or *OFF*.

3) ❏ Apply power to *Safety Controller* and all *Input Devices* that require power, but **NOT** to guarded machine.

4) ❏ Verify that configuration file (e.g. revision level) is appropriate for application. At a minimum, have a copy of Configuration Summary from PC Interface software available for reference during the checkout procedure.

5) ❏ Verify that status *Outputs* configured for a monitored mute lamp (if used) turn *ON* briefly (i.e. flash) after power-up.

SET POWER-UP OPTION CONFIGURATION

☛ *Before carrying out step 1, step 2 and step 3 refer to the System Settings in the Configuration Summary.*

1) ❏ **If configured for Normal (default)**, verify that *Safety Outputs* associated only with *Input Devices* configured for *Automatic Reset* turn *ON*.*

2) ❏ **If configured for Automatic**, verify that all *Safety Outputs* turn *ON** within 5 seconds (*Outputs* with a configured *ON*-delay may extend this time).

3) ❏ **If configured for Manual**:

- Verify that all *Safety Outputs* remain *OFF*
- Wait at least 10 s after power-up, then perform a *System Reset* (for further information on *Resets* see block 7.3 on page 69 & block 1.10 on page 5)
- Verify that *Safety Outputs* turn *ON** even if an associated *Non-Safety Input* is configured for a *Manual Reset*

*In all cases, *Safety Outputs* associated with a *Two-Hand Control* will not turn ON at power-up. *Enabling Devices* and *Bypass Switches* are not available at power-up. They must begin in a *Stop* state *(OFF)*.

RESET CONFIGURATION

1) ❑ **If configured for** *Automatic Reset*, verify that corresponding *Controller Safety Output* indicator shows green SO1 or SO2 or SO3 indicating that *Safety Output(s)* is *ON* (assuming that other *Inputs* configured for *Manual Reset* are not associated with the *Safety Output*; see Manual Reset).

   If *Controller* red status indicator begins to flash at any time, refer to block 8.3.3 on page 78 for troubleshooting information.

2) ❑ **If configured for** *Manual Reset*,

   - Verify that *Controller* green status LED is flashing to indicate that a *Reset* is being requested, and that message *System Reset Needed* appears on the *Diagnostic Display*. If *Controller* red status indicator begins to flash at any time, refer to block 8.3.3 on page 78 for troubleshooting information

☛ *If a "monitored manual reset" has been configured, perform a reset by closing the Reset input for at least 0,25 s, but not longer than 2 s, and then reopening the contact. Verify that Controller green status indicator comes ON steady* .

3) ❑ Verify that all *Reset* switches are mounted in full view of guarded area but outside it and out of reach of anyone inside guarded area and that means of preventing inadvertent use is in place.

4) ❑ Actuate each *(Non-Safety Input) Manual Reset* device to turn *ON* remaining *Outputs* not associated with a *Two-Hand Control* device.

5) ❑ 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 function or device as detailed in block 8.2.6.3, block 8.2.6.4 or block 8.2.6.5 is not part of the application, skip that block and proceed to next relevant check or to block 8.2.6.11 on page 76.

8.2.6.3 Two-Hand Control Functions

1) ❑ Ensure all *Inputs* are in *ON*-state associated with *Safety Outputs* and activate each *Two-Hand Control* device to turn *ON* remaining *Outputs*.

   - If both *Two-Hand Controls* are **NOT** activated within 0,5 s of each other, verify that associated *Safety Output* remains *OFF*
   - Verify that when one hand is removed and replaced, *Safety Output* turns *OFF* and remains *OFF*

8.2.6.4 E-Stop & Rope Pull Functions

1) ❑ While *Outputs* are *ON*, individually actuate and re-arm each *E-Stop* and/or *Rope Pull* device one at a time.

   - Verify that each associated *Safety Output* turns *OFF* with proper *OFF*-delay, where applicable

2) ❑ 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*, verify that *Safety Output* remains *OFF*.

   If configured for *Automatic Reset* (assuming that another device is not holding it *OFF)*, verify that *Safety Output* turns *ON*.

3) ❑ Apply a *Manual Reset* and/or activate *Two-Hand Control* device as necessary to turn *Output(s)* back *ON*.

   - Verify that each associated safety output turns *ON* with proper *ON*-delay, where applicable

8.2.6.5 Other Stopping Device Functions

1) ❑ Repeat step 1), step 2) and step 3) in block 8.2.6.4 on page 74 for each device type below, as applicable:

   ❑ Verify operation of all *Gate Switches*.

   ❑ Verify operation of all *Optical Sensors*.

   ❑ Verify operation of all *Safety Mats*.

   ❑ Verify operation of all *Protective Stops* (i.e. other safety/*Safeguarding Devices* otherwise not listed).

   ❑ Verify operation of all *ON/OFF Inputs*.

If *Mute Sensor*, *Bypass Switch* and/or *Enabling Device* functions are not used, proceed to block 8.2.6.11 on page 76.

8.2.6.6 Mute Functions

1) ❑ While *Outputs* are *ON*, initiate a *Mute Cycle* by activating *Mute Enable* input (if used) and then activate each *Mute Sensor* of a *Muting Sensor Pair* within 3 s.

   - Verify that Mute Lamp, if used, turns *ON*

2) ❑ Generate a stop command from *Safeguarding Device* that has been muted.

   - Verify that associated *Safety Outputs* remain *ON (Controller* green status indicator remains *ON*)
   - If a *Muting Time Limit* (backdoor timer) is associated with the mute, verify that associated *Safety Outputs* turn *OFF* when *Muting Time Limit* expires

3) ❑ Repeat step 1) and step 2) for each *Muting Sensor Pair*.

   - Verify proper operation with each *Mute Sensor* of a *Muting Sensor Pair*

4) ❑ Generate a stop command from non-muted one at a time.

   - Verify that associated *Safety Outputs* turn *OFF* while muted input is muted.

*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.

8.2.6.7 Mute on Power-Up Option

1) ❑ Turn power *OFF* to *Safety Controller*.
   - Activate *Mute Enable Inputs* (if used)
   - Activate an appropriate *Muting Sensor Pair* for starting a *Mute Cycle*
   - Ensure all *Input Devices* are in their *Run* (active) state (not including *Two-Hand Control* devices)
   - Verify that all *Enabling Devices* and *Bypass Switches* are in *Stop* (inactive) state
2) ❑ Verify proper operation at *Power-up*.
3) ❑ If *Power-up* is configured for *Auto:*
   - Verify that all *Safety Outputs* turn *ON**
   - Verify that *Output* for mute status (if used) turns *ON*
4) ❑ If *Power-up* is configured for *Normal:*
   - Verify that all *Safety Outputs* associated with *Automatic Reset* devices only or mutable *Manual Reset* devices turn *ON**
   - Verify that output for *Mute Status* (if used) turns *ON*
5) ❑ If *Power-up* is configured for *Manual:*
   - Verify that all *Safety Outputs* remain *OFF*
   - Wait at least 10 s after *Power-up* and then apply a *System Reset* (see block 7.4 on page 69)
   - Verify that all *Safety Outputs* turn *ON**
   - Verify that output for *Mute Status* (if used) turns *ON*

*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.

6) ❑ Generate a *Stop* command from *Safeguarding Device* that has been muted.
   - Verify that associated *Safety Outputs* remain *ON* (i.e. input is muted) and green status indicator also remains *ON*

8.2.6.8 Bypass Switch Function (with Mute)

1) ❑ Verify that each *Safety Input*, if it is both mutable and can be bypassed, is in *Stop* state:
   - If *Safety Controller* is still muting, associated *Safety Outputs* should remain *ON*. Even if timer expires and *Outputs* turn *OFF*, go to the next step
2) ❑ Activate one or both *Mute Sensors* in a *Muting Sensor Pair*. If there are two *Muting Sensor Pairs*, at least one sensor in one of the pairs must be activated:
   - Verify that Mute Lamp, if used, is flashing
3) ❑ Verify that when *Bypass Switch* is in *Run* state:
   - Associated *Safety Outputs* turn *ON*
   - Mute Lamp, if used, is now steady *ON*
   - Associated *Safety Outputs* turn *OFF* when *Bypass Switch* timer expires
4) ❑ Verify that when *Bypass Switch* is in *Stop* state and goes back into the *Run* state:
   - Associated *Safety Outputs* turn *ON*
5) ❑ Verify that when all other non-bypassed *Inputs* associated with same output are in a *Stop* state, one at a time:
   - Associated *Safety Outputs* turn *OFF* while input is bypassed

8.2.6.9 Bypass Switch Function (without Mute)

1) ❑ Verify that when *Safety Input* to be bypassed is in *Stop* state:
   - Associated *Safety Outputs* are *OFF*
2) ❑ Verify that when *Bypass Switch* is in *Run* state:
   - Associated *Safety Outputs* turn *ON*
   - Associated *Safety Outputs* turn *OFF* when bypass timer (backdoor timer) expires
3) ❑ Verify that when *Bypass Switch* is in *Stop* state and goes back into the *Run* state:
   - Associated *Safety Outputs* turn *ON*
4) ❑ Generate a stop command from non-bypassed , one at a time:
   - Verify that associated *Safety Output(s)* turns *OFF* while input is bypassed

8.2.6.10 Enabling Device Function

1) ❑ Verify that all *Inputs* associated with same output as *Enabling Device* are in *Run* state to turn output(s) *ON*. *Enabling Device* should remain in *Stop* state:
   - Verify that associated *Safety Outputs* are *ON*
2) ❑ Verify that when *Enabling Device* is in *Run* state:
   - Associated *Safety Outputs* remain *ON* and LCD displays *Enable Mode*
3) ❑ Verify that when *Enabling Device* is in the *Stop* state:
   - Associated *Safety Outputs* turn *OFF*
4) ❑ Verify that when *Enabling Device* is in *Run* state:
   - Associated *Safety Outputs* turn *ON*
   - Associated *Safety Outputs* turn *OFF* when *Enabling Device* timer expires
5) ❑ Verify that when *Enabling Device* is in *Stop* state and goes back into *Run* state:
   - Associated *Safety Outputs* turn *ON*
6) ❑ Verify that when all *E-Stop* and *Rope Pull Inputs* associated with same *Outputs* are in *Stop* state, one at a time (repeat step for each device, as necessary):
   - The associated *Safety Outputs* turn *OFF* while in *Enable Mode*
7) ❑ Verify that *Enabling Device* is in *Stop* state and then apply a *System Reset* (see block 7.4 on page 69):
   - Verify that LCD no longer displays *Enable Mode*
   - Verify that *Safety Controller* is back to normal operation

8.2.6.11 System (Final) Checkout

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 as specified in block 1.8.2 on page 4 must perform the following checks.

Remove power from *Safety Controller*.

1) ❏ Remove power from *Safety Controller*.
2) ❏ Referring to Figure 27 on page 71, refit *Safety Output* 7-pin connector terminal strip to *Safety Controller Safety Outputs* SO1 (A and B), SO2 (A and B) and SO3 (A and B) to enable connection of machine control circuit. **This is a permanent connection.**
3) ❏ Verify that all wiring complies with EU standards and local wiring codes.
4) ❏ Apply power to guarded machine and verify that machine does not start up.
5) ❏ Apply power to *Safety Controller* and apply *Resets* (block 7.4 on page 69 refers) as necessary to turn safety *Outputs ON*.
6) ❏ Generate a stop command from each of safety devices or safeguards connected to input terminals of Safety Controller and verify for each *Input Device* that:
   - ❏ *Safety Outputs* and *Status Outputs* operate as expected (e.g. *On-Delays*, *Off-Delays*, etc.). Use *Configuration Summary* to verify operation.
   - ❏ It is not possible for guarded machine to be put into motion.
7) ❏ Initiate machine motion of guarded machine and while it is moving, generate a *Stop* command from each of safety devices or safeguards. Do not attempt to insert anything into dangerous parts of machine. Upon executing stop command, verify that dangerous parts of machine come to a stop.
8) ❏ Upon *Reset* of safety device or safeguard and/or *Controller*, verify that machine does not automatically restart and that initiation devices must be engaged to restart machine.
9) ❏ Test machine stopping response time, using an instrument designed for that purpose, to verify that it is same or less than overall system response time specified by machine manufacturer (Corporate Office as listed on page 127 may be able to recommend a suitable instrument).

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

8.3 CORRECTIVE MAINTENANCE

8.3.1 Cleaning

1) Disconnect power to the *Controller*.
2) Using a soft lint free cloth that has been dampened with a mild detergent and warm water solution, clean polycarbonate enclosure and display as required.

8.3.2 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:

- Supply voltage is within 24V dc +/- 20%
- *Safety Controller's* plug-in terminal blocks are fully inserted (Figure 27 on page 71 refers)
- Wire connections to each individual terminal are secure
- High-voltage noise sources, high-frequency noise sources or any high-voltage power lines are not routed near *Controller* or alongside wires that are connected to *Controller*
- Proper transient suppression is applied across the output loads (see warning on page 13)

The *Safety Controller* has no internal field-replaceable parts. If the *Controller* is not operating properly, please contact Corporate Office as listed on page 127. In case of a non-recoverable fault, do not open the housing of the *Controller* and do not attempt to disassemble the *Controller* in anyway. Contact Corporate Office as listed on page 127.

An applications engineer will attempt to remotely troubleshoot the Controller from the reported description of the problem. If it is concluded that the *Controller* or a component is defective and must be returned to Banner, an RMA (Return Merchandise Authorization) number will be issued, and shipping instructions will be forwarded. The *Controller* should be packaged carefully. Damage which occurs during return shipping is not covered by warranty.

8.3.3 Troubleshooting

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 is displayed in the *Fault Diagnostics* menu. An additional message may also be displayed to help remedy the fault.

The troubleshooting table 16 on page 78 summarizes the faults and suggests additional checks to find the cause of the problem. The following blocks describe how to recover from a *Lockout* and how to access fault information, using either the *PCI* or the *OBI*.

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

Table 16 Diagnostic Display Breakdown

Fault Code	Displayed Message	Initial Check	Further Steps & Checks
0.0	Input Fault	Cycle Input	• Check for unstable input signal • Turn input *OFF* to clear the fault indication
1.1	Output Fault	Check for shorts	A *Safety Output* appears *ON* at power-up when it should be *OFF*. • Check for short to external voltage source • Check DC common wire size connected to the *Safety Output* loads. The wire must be heavy-gauge wire or 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 block 4.9.3 on page 34).
1.2	Output Fault	Check for shorts	A *Safety Output* is sensing a fault to another voltage source. • Check for short between *Safety Outputs* • Check for short to external voltage source • Check load device compatibility (too much capacitance) • Check DC common wire size connected to the *Safety Output* loads. The wire must be heavy-gauge wire or 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 block 4.9.3 on page 34).
1.3 – 1.4	Internal Fault	—	Internal failure – Contact Banner Corporate Office as listed on page 127.
1.5	Output Fault	Check Output Wiring	A *Safety Output* appears ON prematurely. • Check DC common wire size connected to the *Safety Output* loads. The wire must be heavy-gauge wire or 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 block 4.9.3 on page 34).
1.6	Internal Fault	—	Internal failure – Contact Banner Corporate Office as listed on page 127.
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 Corporate Office as listed on page 127.
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 wiring • Check input signals • Consider adjusting *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 wiring • Check input signal timing
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 wiring • Check input signals • Check power supply providing input signals • Consider adjusting *Debounce* times

Table 16 Diagnostic Display Breakdown

Fault Code	Displayed Message	Initial Check	Further Steps & Checks
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 wiring • Check input signal timing
2.7	Internal Fault	Check Terminal xx	Internal failure – Contact Banner Corporate Office as listed on page 127.
2.8 – 2.9	Input Fault	Check Terminal xx	Input stuck high. • Check for shorts to other *Inputs* or other voltage source • Check *Input Device* compatibility
2.10	Input Fault	Check Terminal xx	Check for short between *Inputs*.
2.11 – 2.12	Input Fault	Check Terminal xx	Check for short to ground.
2.13	Input Fault	Check Terminal xx	Input stuck low. • Check for short to ground
2.14	Input Fault	Check Terminal xx	Missing test pulses. • Check for short to other *Inputs* or other voltage source
2.15	Open Lead	Check Terminal xx	Check for open lead.
2.16 – 2.18	Input Fault	Check Terminal xx	Missing test pulses. • Check for short to other *Inputs* or other voltage source
2.19	Open Lead	Check Terminal xx	Check for open lead.
2.20	Input Fault	Check Terminal xx	Missing test pulses. • Check for short to ground
2.21	Open Lead	Check Terminal xx	Check for open lead.
2.22 – 2.23	Input Fault	Check Terminal xx	Check for unstable signal on the input.
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 open wire
3.2	EDMxx Fault	Check Terminal xx	*EDM* contact(s) failed to close within 200 ms after the *Safety Outputs* turned *OFF*. • Check for slow or stuck-*ON* contactor or relay • Check for open wire
3.3	EDMxx Fault	Check Terminal xx	*EDM* contact(s) open prior to turning *ON* the *Safety Outputs*. • Check for stuck-*ON* contactor or relay • Check for open wire
3.4	EDMxx Fault	Check Terminal xx	*EDM* contact pair mismatched for longer than 200 ms. • Check for slow or stuck-*ON* contactor or relay • Check for open wire
3.5	EDMxx Fault	Check Terminal xx	Check for unstable signal on the input.
3.6	EDMxx Fault	Check Terminal xx	Check for short to ground.
3.7	EDMxx Fault	Check Terminal xx	Check for short between *Inputs*.
4.1	Supply Volt-age 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 configuration with backup copy obtained and transferred from *PCI* or *XM Card* or • Erase and recreate configuration using *OBI*
4.3 – 4.11	Internal Fault	—	Internal failure – Contact Banner Corporate Office as listed on page 127.
4.12	Configura-tion Timeout	Check Configuration	*Safety Controller* was left in *Configuration Mode* for more than one hour without pressing any keys.

Table 16 Diagnostic Display Breakdown

Fault Code	Displayed Message	Initial Check	Further Steps & Checks
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	Check Configuration	Configuration was not confirmed after being edited. • Confirm configuration using the *OBI* or the *PCI*
4.15 – 4.19	Internal Fault	—	Internal failure – Contact Banner Corporate Office as listed on page 127.
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 wiring
4.21 – 4.32	Internal Fault	—	Internal failure – Contact Banner Corporate Office as listed on page 127.
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 circuit in the Mute Lamp.
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 Corporate Office as listed on page 127.
6.xx	Internal Fault	—	Invalid configuration data. Possible internal failure. • Try to load a new configuration using the *PCI*, *OBI* or XM card

8.3.3.1 Recovering from a Lockout

To recover from a *Lockout* condition perform one or more of the following steps:

1) At *Safety Controller* display, perform ON SCREEN fault display recommendation (e.g. Cycle Input).
2) Follow recommendations listed in troubleshooting table 16 on page 78 under *Further Steps and Checks*.
3) Perform a *System Reset* (block 7.4 on page 69 refers).
4) Cycle power and perform a *System Reset* (block 7.4 on page 69 refers) if necessary.

If these steps do not remedy the *Lockout* condition, contact Banner Corporate Office as listed on page 127.

8.3.3.2 Fault Diagnostics via PCI

When diagnosing faults via the *PCI:*

1) Ensure PC is connected to *Safety Controller* via supplied USB cable, supplied *Safety Controller* software program is loaded and *Safety Controller* hardware has been recognised by the PC.
2) Referring to instructions detailed in block 5.1.2 on page 38, open *PCI* program.
3) Referring to block 5.1.23 on page 52, open *Live Display* screen.

The *Live Display* screen displays information in real time (see screen 34 on page 52) as follows:

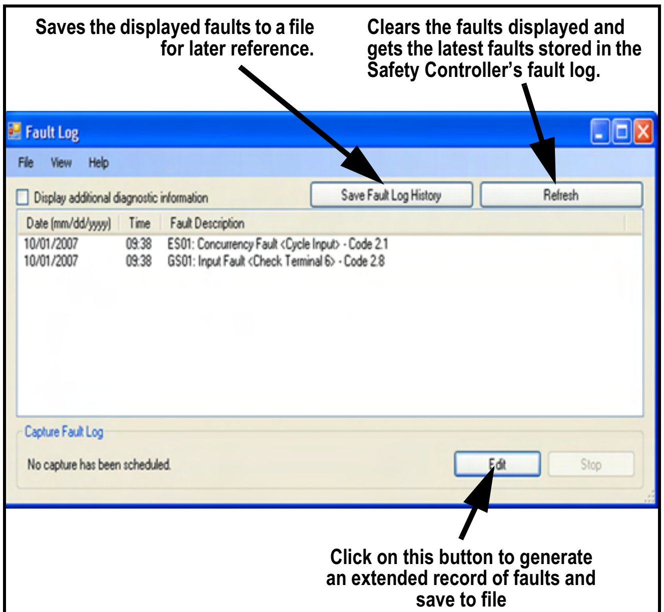
- Status of each *Safety Output*
- Which device caused an output to turn *OFF* if any
- Basic information about *Controller* model and configuration

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 screen 161.

To access the *Fault Log:*

1) Open *PCI* program
2) From Tabular, click on View then *Fault Log*. Screen 161 is displayed.



Screen 161

The *Fault Log* 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 looking up table reference)

Should factory applications assistance be required, additional code information can be displayed.

Fault Log Recording — PCI

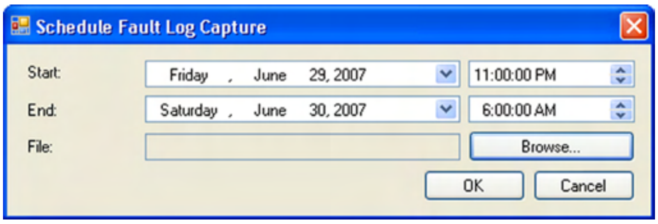
To determine the cause of a persistent fault, an extended record of faults can be compiled and saved to file.

To access this function:

1) Open *Fault Log* as previously described.
2) In *Fault Log* (screen 161), click *Edit* button. The Schedule Fault Log Capture menu screen 162 is then displayed.

In screen 162, the menu settings 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.

☛ *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.*



Screen 162

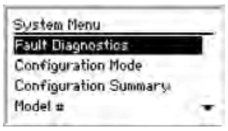
8.3.3.3 Fault Diagnostics via OBI

Fault diagnosing the *Safety Controller* and associated I/O devices can also be carried out using the *OBI*.

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 *Safety Controller's* display. Further information about current and past faults can be accessed using the *Fault Diagnostics* menu.

To access *Safety Controller Fault Diagnostics* menu:

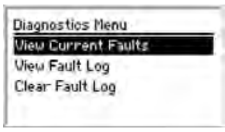
1) From *Run* mode menu press *OK*. Screen 163 is displayed.
2) At screen 163, select *Fault Diagnostics* and press *OK*. Screen 164 is displayed.



Screen 163

At screen 164 the *Diagnostic Menu* provides three choices:

- *View Current Faults*
- *View Fault Log*
- *Clear Fault Log*



Screen 164

View Current Faults

To view current fault conditions:

3) Using up/down arrow buttons, select *View Current Faults* and press ***OK***.

Screen shows fault conditions that currently exist, one at a time (screen 165).

4) Use left/right arrow keys to view all faults (screen 166 and screen 167) (short-cut: To view current faults when the *Run* mode screen is displayed, simply press ***OK*** three times).

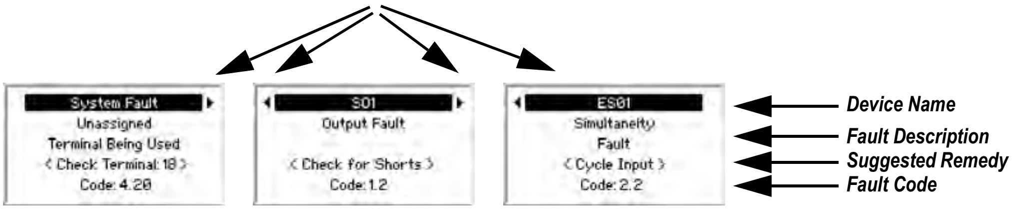
A breakdown of the *View Current Faults*, shown in screen 165, screen 166 and screen 167, is as follows:

- Top line indicates which device has the fault
- Second and third lines provide a brief description of the fault
- Fourth line provides a suggestion for correcting the fault
- Fifth line provides the fault code

Use the fault code and information in block 8.3.3 on page 78 and table 16 on page 78 to obtain more information about the fault and additional suggestions for correcting it.

5) Use left/right arrow buttons to access fault information for all faulty devices.

Arrowhead designates location of additional fault screens



Screen 165 **Screen 166** **Screen 167**

View Fault Log

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 *Fault Log:*

1) From *Diagnostic Menu* (screen 164), using up/down arrow buttons, select *View Fault Log* and press ***OK***.

Screen shows first fault stored in the *Fault Log* (screen 168).

2) Use left/right arrow keys to view additional faults in the *Fault Log* (screen 169 and screen 170).
   - Top line of *Fault Log* screen indicates which device had the fault
   - Second and third lines provide a brief description of the fault
   - Fourth line displays how long ago the fault occurred. For instance, a time of 01:30:23 indicates 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 it 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)*
   - Fifth line provides the *Fault Code*. Use the *Fault Code* and information in table 16 on page 78 to obtain more information about the fault and additional suggestions for correcting it

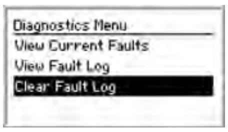
☛ *Removing power from Safety Controller will clear the Fault Log, in addition to the method described in* Clear Fault Log.

Screen 168 **Screen 169** **Screen 170**

Clear Fault Log

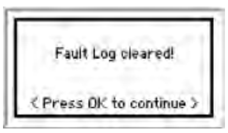
To *Clear Fault Log:*

1) From *Diagnostic Menu* (screen 171), select *Clear Fault Log* and press ***OK***. Screen 172 is displayed.



Screen 171

2) When fault is cleared, indicated by screen 172, press ***OK*** to return to *Diagnostic Menu* menu, then press ***ESC*** twice to return to the *Run* mode menu.



Screen 172

8.4 SPARE PARTS, SPECIAL TOOLS & MATERIAL

8.4.1 Spare Parts

This block details Spare Parts information for the *Safety Controller*.

8.4.1.1 Safety Controller Starter Kit

Kits include the Safety Controller model SC22-3 or SC22-3E:

- Set of plug-on terminal blocks (screw or cage-clamp type, depending on model)
- USB A/B cable (for direct connection between PC and 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)
- User CD (includes software interface, online manual, ethernet references and configuration tutorials)
- Quick Start Guide

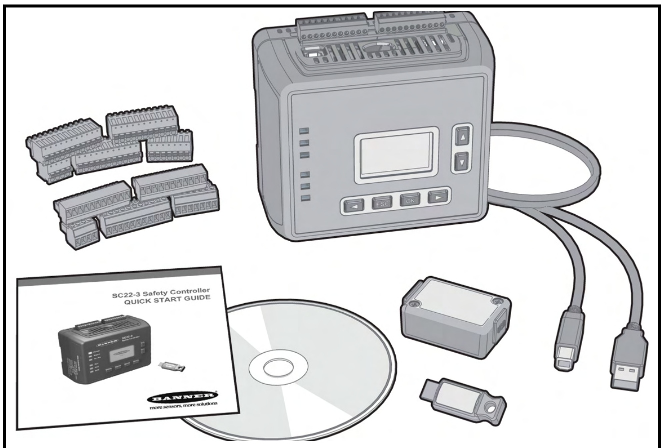


Figure 28 Safety Controller Starter Kit

Figure 28 on page 83 and Table 17 on page 83 gives information on the kits.

Table 17 Safety Controller Starter Kit

Kit Model	Order Part No.	Terminal Type	Safety Outputs	Status Outputs	Safety Output Rating	USB A/B Cable	XM Card	XM Card Programming Tool	Communication Protocol
SC22-3-S	30 772 59	Screw	6 PNP Terminals (3 pairs)	10 Status	0,75 A each output	–	Yes	–	–
SC22-3-C	30 779 13	Clamp							
SC22-3-SU1	30 779 14	Screw				1,8 m		Yes	
SC22-3-CU1	30 779 15	Clamp							
SC22-3E-S	30 833 67	Screw		10 Status plus 32 Virtual Status	0,5 A each output	–		–	EtherNet/IP & Modbus/ TCP
SC22-3E-C	30 833 68	Clamp							
SC22-3E-SU1	30 833 69	Screw				1,8 m		Yes	
SC22-3E-CU1	30 833 70	Clamp							

Table 18 Replacement Parts/Accessories

Model	Description	Order Part No.
SC22-3	Replacement Controller (without Terminals)	30 797 15
SC-XM1	External memory card (XM card)	30 761 77
SC-XM1-5	Bulk pack of 5 XM memory cards	TBA*
SC-XMP	USB programming tool for XM card	30 777 08
SC-TS1	Screw terminal blocks (1 set for 1 Safety Controller)	30 778 12
SC-TC1	Cage clamp terminal blocks (1 set for 1 Safety Controller)	30 778 13
SC-TC1SC-USB1	USB A/B cable	TBA*
–	CD including PCI program and instruction manual	134534
SC22-3	Replacement Controller (without Terminals)	30 797 15
–	CD including PCI program and instruction manual	134534

***To be allocated**

Table 19 Ethernet Cordsets

Model				Length
Shielded		Cat5e Crossover		
Model	Order Part No.	Model	Order Part No.	
STP07	30 699 85	**STPX07**	30 699 87	2,1 m
STP25	30 699 86	**STPX25**	30 699 88	7,6 m
STP50	TBA*	**STPX50**	30 77 971	15,5 m
STP75	30 779 76	**STPX75**	30 753 20	23 m

8.4.1.2 Interface Modules

SC-IM9 series

SC-IM9 series *Interface Modules* are for use only with the *Safety Controller* and have:

- Dry contacts for use with higher ac/dc voltage and current with a 10 A output
- DIN-mount housing
- Removable (plug-in) terminal blocks for *OSSD Outputs* (screw terminal block supplied)
- Measures approx. 72 mm H, 170 mm D, and 45 mm, 90 mm, or 140 mm W depending on model

☛ *EDM is required to be wired separately to the N.C. contacts to comply with ISO 13849-1 categories control reliability (see block 4.9 on page 33).*

Table 20 on page 84 gives information on the various modules.

Table 20 Interface Modules Series SC-IM9

Type No.	Description	Supply Voltage	Inputs (Safety Controller Outputs)	Safety Outputs	Output Rating	EDM Contacts	Order Part No
SC-IM9A	For use with x1 *Safety Controller Safety Output*	24V dc *(Controller supplied)*	x2 (SO1)	x3 *N.O.*	10 amps	x1 *N.C.* as per *Output* (2 contacts in series)	30 778 14
SC-IM9B	For use with x2 *Safety Controller Safety Outputs*		x4 (SO1 and SO2)	Total of 6 (x3 *N.O.* as per output)			30 778 15
SC-IM9C	For use with x 3SC22-3 *Safety Outputs*		x6 (SO1, SO2 & SO3)	Total of 9 (x3 *N.O.* as per output)			30 778 23
See datasheet p/n 131845 for more information							

IM-T-9 series

IM-T-9 series interface modules have:

- 6A output
- 22,5 mm DIN-mount housing
- Removable (plug-in) terminal blocks
- Low current rating of 1 V ac/dc @ 5 mA
- High current rating of 250 V ac/dc @ 6A

☛ *EDM is required to be wired separately to the N.C. contacts to comply with ISO 13849-1 categories control reliability (see block 4.9 on page 33).*

Table 21 on page 84 gives information on the various modules.

Table 21 Interface Modules Series IM-T-9

Type No.	Supply Voltage	Inputs	Safety Outputs	Output Rating	EDM Contacts	Aux. *Outputs*	Order Part No
IM-T-9A	24V dc	x2 *(Dual channel* connection)	x3 *N.O.*	6 A	x2 *N.C.*	—	30 614 25
IM-T-11A			x2 *N.O.*			x1 *N.C.*	30 614 24

8.4.1.3 Mechanically Linked Contactors

Provides an additional 10 A or 16 A carrying capability to any safety system. If used, two contactors as per safety output pair (e.g. 2 x SO1) are required. The *N.C.* contacts are to be used in an *EDM* circuit (see Figure 31 on page 85).

Table 22 on page 84 gives information on the various versions.

Table 22 Mechanically Linked Contactors

Type No.	Supply Voltage	Inputs	Outputs	Output Rating	Order Part No
11-BG00-31-D-024	24V dc	x2 *(Dual channel* connection)	x3 *N.O.* + x1 *N.C.*	10 A	30 696 82
11-BF16C01-024				18 A	30 696 87

8.4.2 Documentation

Table 23 on page 84 details the documentation applicable to the *Safety Controller*.

Table 23 Documentation Order Numbers

Order Part No.	Description
135369	Instruction Manual (European version UK English)
135453	Instruction Manual (European version French)
135454	Instruction Manual (European version German)

Table 23 Documentation Order Numbers

Order Part No.	Description
135455	Instruction Manual (European version Italian)
133485	Quick Start Guide (English)

A1 WIRING DIAGRAMS

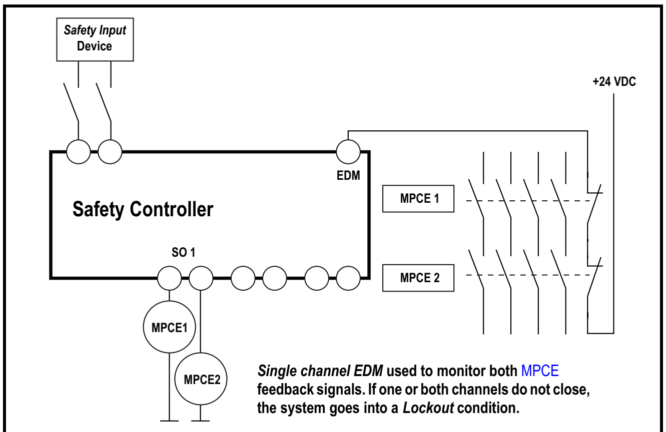


Figure 29 Single channel EDM Connection

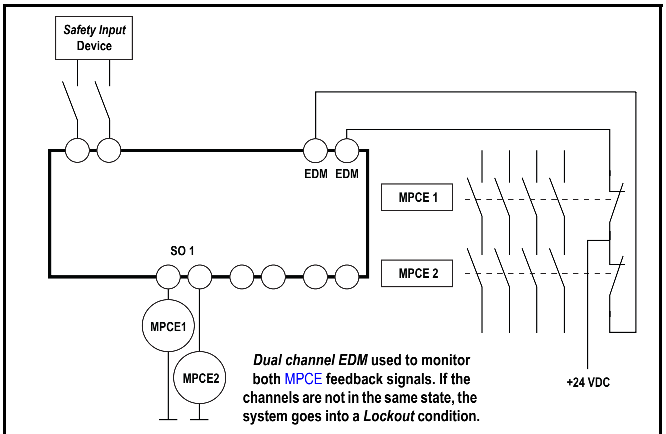


Figure 30 Dual channel EDM Connection

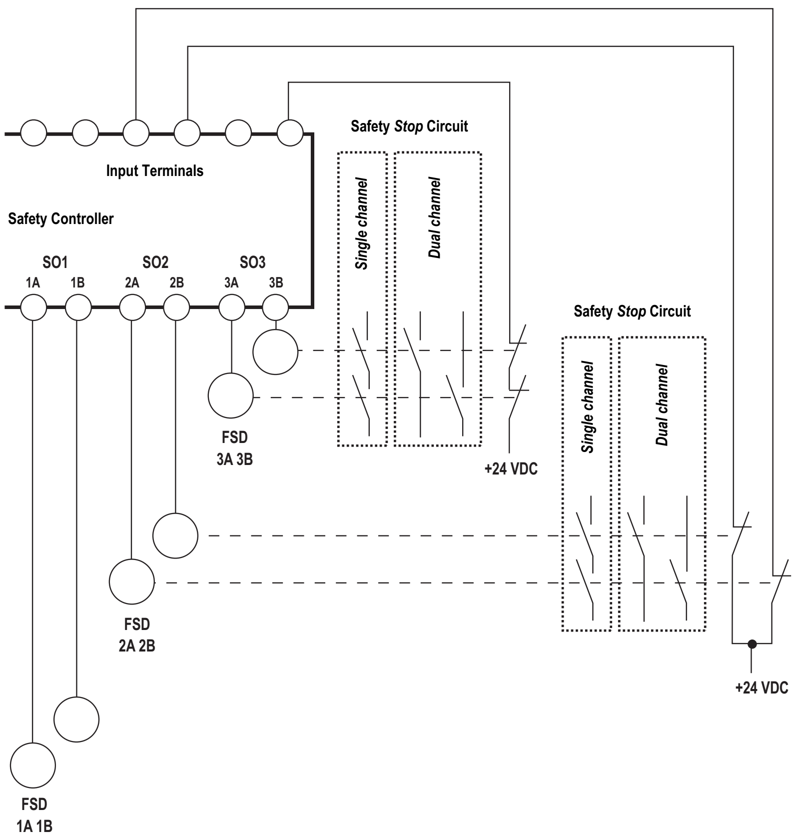


Figure 31 Generic Connection Showing Single channel, Dual channel, & No EDM options

WARNINGS

REFER TO USE OF TRANSIENT SUPPRESSORS warning on page 13.

REFER TO OSSD INTERFACING warning on page 13.

REFER TO SHOCK HAZARD warning on page 3.

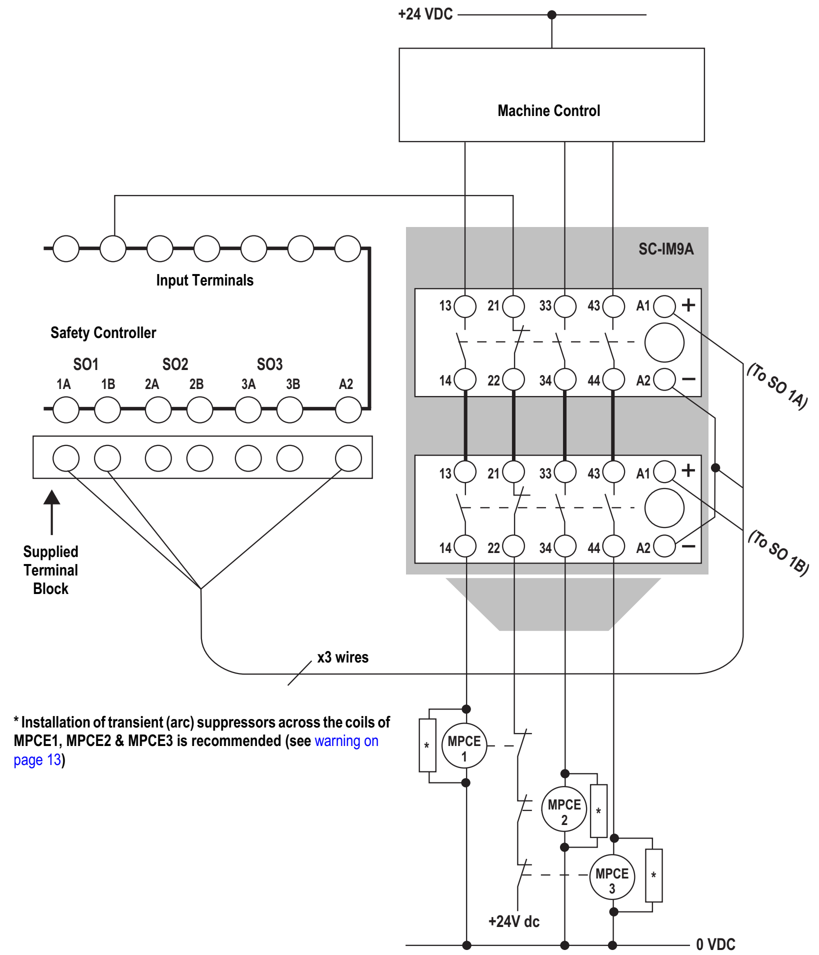
REFER TO PROPER WIRING warning on page 13.

This 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 *Dual channel EDM* configured
- *Safety Output* SO3 is shown with *Single channel EDM* configured

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

See also block 1.18 on page 6 on *EDM* and block 4.9.2 on page 34 on interfacing safety stop circuits.



WARNINGS

REFER TO USE OF TRANSIENT SUPPRESSORS warning on page 13.

REFER TO OSSD INTERFACING warning on page 13.

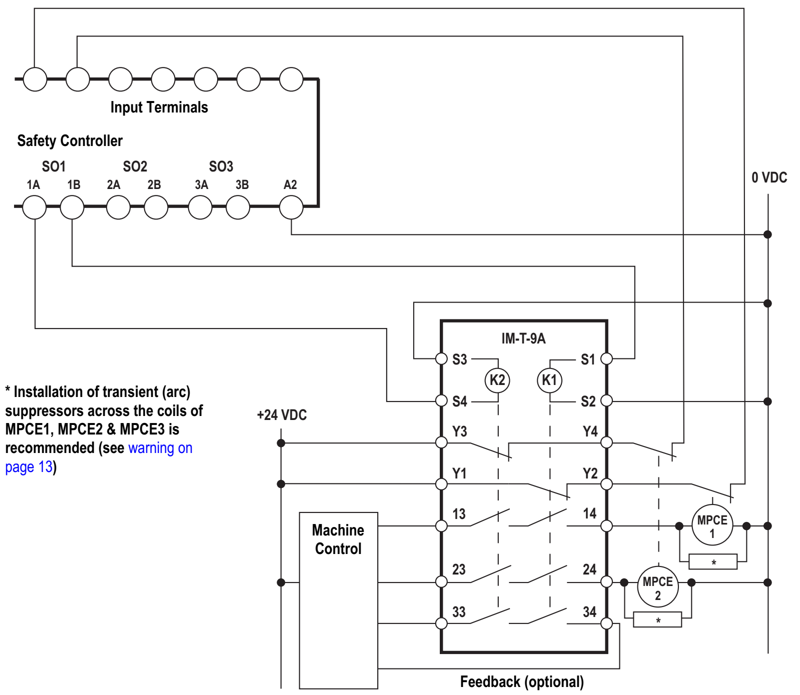
REFER TO SHOCK HAZARD warning on page 3.

REFER TO PROPER WIRING warning on page 13.

The SC-IM9A Interface Module is shown as *Single channel EDM* connection. The SC-IM9B and SC-IM9C modules are connected in the same manner using individual *Single channel EDM* circuits (terminals 21/22 on each pair of contactors).

For interfacing safety stop circuits, see also block 1.18 on page 6 on *EDM* and block 4.9.2 on page 34.

Figure 32 Single channel EDM Connection to SC-IM9A Interface Module



WARNINGS

REFER TO USE OF TRANSIENT SUPPRESSORS warning on page 13.

REFER TO OSSD INTERFACING warning on page 13.

REFER TO SHOCK HAZARD warning on page 3.

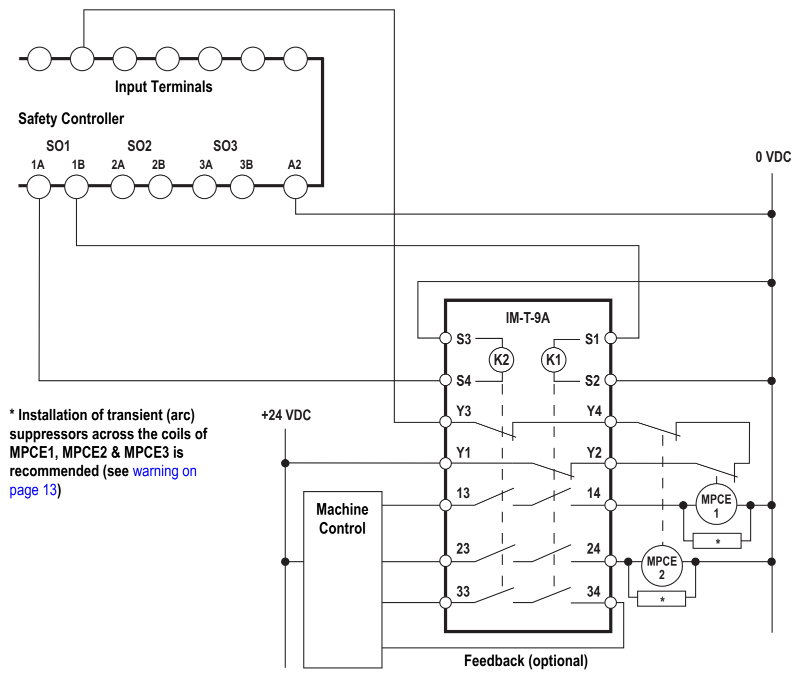
REFER TO PROPER WIRING warning on page 13.

The IM-T-9A interface module is shown as *Dual channel* EDM connection. 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.

For interfacing safety stop circuits, see also block 1.18 on page 6 on *EDM* and block 4.9.2 on page 34.

Figure 33 Dual channel EDM Connection to IM-T-9A Interface Module



WARNINGS

REFER TO USE OF TRANSIENT SUPPRESSORS warning on page 13.

REFER TO *OSSD* INTERFACING warning on page 13.

REFER TO SHOCK HAZARD warning on page 3.

REFER TO PROPER WIRING warning on page 13.

The IM-T-9A interface module depicted in this figure is shown in *Single channel* EDM connection. 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.
See also block 1.18 on page 6 on *EDM* and block 4.9.2 on page 34 on interfacing safety stop circuits.

Figure 34 Single channel EDM Connection to IM-T-9A Interface Module

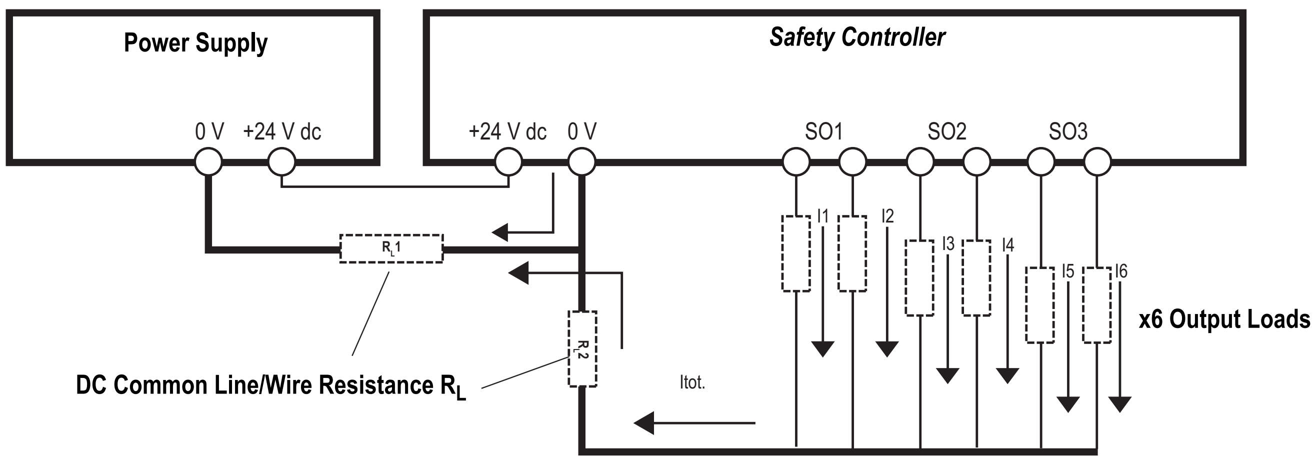


Figure 35 DC Common Wire Installation

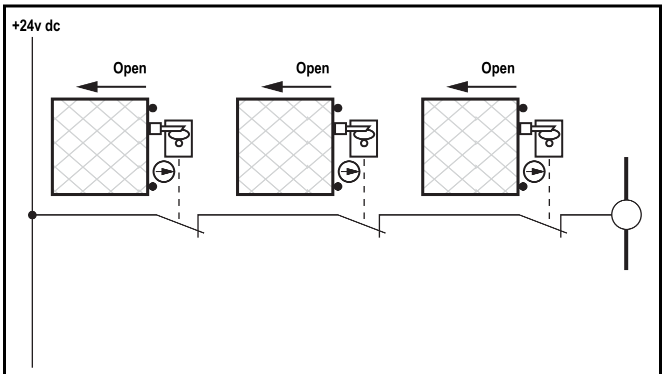


Figure 36 Category 2 Circuit - Gate Switch

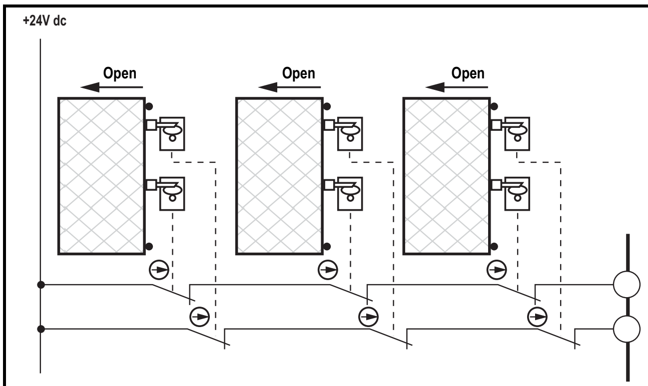


Figure 37 Category 3 Circuit - Gate Switch

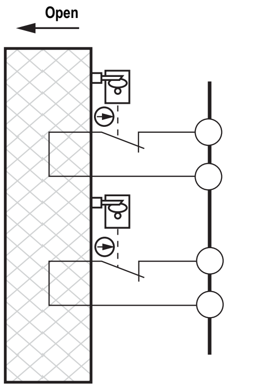


Figure 38 Category 4 Circuit - Gate Switch

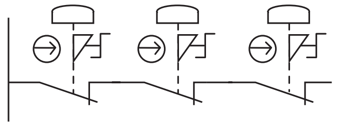


Figure 39 Category 2 Circuit E-Stop

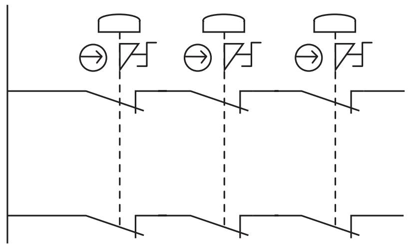


Figure 40 Category 3 Circuit E-Stop

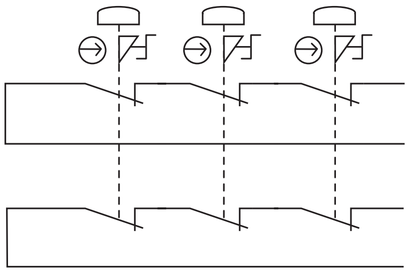


Figure 41 Category 4 Circuit E-Stop

A2 INPUT DEVICE & SAFETY CATEGORY REFERENCE

A2.1 SAFETY CIRCUIT INTEGRITY & ISO 13849-1 (EN954-1) SAFETY CIRCUIT PRINCIPLES

⚠ WARNINGS

SAFETY CATEGORIES

THE LEVEL OF SAFETY CIRCUIT INTEGRITY CAN BE GREATLY IMPACTED 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 SAFETY CIRCUIT INTEGRITY LEVEL OR SAFETY CATEGORY AS DESCRIBED BY ISO 13849-1 (EN 954-1) TO ENSURE THAT THE EXPECTED RISK REDUCTION IS ACHIEVED AND THAT ALL RELEVANT REGULATIONS ARE COMPLIED WITH.

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.

IT IS THE USER'S RESPONSIBILITY TO USE A DEVICE THAT CAN DETECT THESE SHORTS (E.G. THE BANNER EZ-SCREEN® LIGHT SCREEN CAN DETECT A SHORT BETWEEN ITS TWO SOLID STATE OUTPUTS OR FROM EACH OUTPUT TO +24 V).

CATEGORY 2 OR CATEGORY 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 (E.G. THE SAME TERMINAL FROM THE CONTROLLER IN A DUAL CHANNEL, 3 TERMINALS CONNECTION, 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.

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 performance (i.e., integrity) must be incorporated into its design. Standards for Europe that detail safety performance levels include ISO 13849-1 (EN954-1) Safety-Related Parts of a Control System.

A2.1.1 Safety Circuit Integrity Levels

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 (EN954-1), which establishes five levels: Categories B, 1, 2, 3, and the most stringent, *Category 4*.

The typical level of *Safety Circuit Integrity* is known as *Control Reliability*. *Control Reliability* typically incorporates *Redundant* control and self-checking circuitry and has been loosely equated to ISO 13849-1 Categories 3 and 4.

If the requirements described by ISO 13849-1 are to be implemented in Europe, a *Risk Assessment* must first be performed to determine the appropriate category, in order to ensure that the expected risk reduction is achieved. This *Risk Assessment* must also take into account national regulations such as European "C" level standards, to ensure that the minimum level of performance that has been mandated is complied with.

The following blocks (appendix A2.2 thru' to appendix A2.11) deal only with *Category 2*, *Category 3*, and *Category 4* applications, as described by ISO 13849-1 (2006). Table 24 on page 90 provides a breakdown of the possible *Safety Categories* that can be achieved for each device type, depending on the selected circuit option.

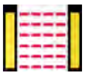
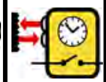
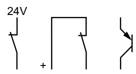
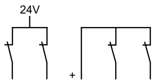
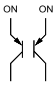
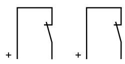
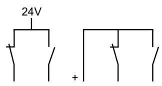
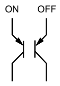
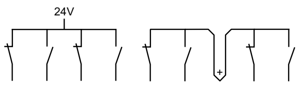
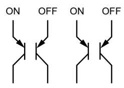
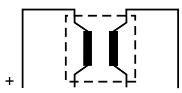
For further information refer to the remaining part of appendix A2 as well as the appropriate standards.

A2.1.2 Fault Exclusion

An important concept within the category requirements of ISO 13849-1 is the *Probability of the Occurrence of the Failure* which can be decreased using a technique termed *Fault Exclusion*. The rationale assumes that the possibility of certain well-defined failure(s) can be reduced to a point where the resulting fault(s) can be, for the most part, disregarded i.e., *excluded*.

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 intent requirements of *Category 2*, *Category 3* or *Category 4*. See ISO 13849-1/-2 for further information.

Table 24 Input Devices, Circuit Options, & their Potential Safety Categories

Circuit Symbol Examples	 *E-Stop*	 *Gate Switch*	 *Optical Sensor*	 *Two-Hand Control*	 *Rope Pull*	 *Protec-tive Stop*	 Safety Mat	 *Enabling Device*	 *Bypass Switch*	 *Mute Sensor*
	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. 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. 2 Cat. 3 Cat. 4	Cat. 2 Cat. 3
	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. 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. 4	—
	—	Cat. 3 Cat. 4	—	Type IIIc Cat. 4	—	—	—	Cat. 3 Cat. 4	Cat. 4	—
	—	—	—	—	—	—	Cat. 2 Cat. 3	—	—	—

☛ *Category B or Category 1 is assumed when not using safety-rated devices.*
All safety Input Device contacts are shown in the ON/active state (e.g. E-Stop in the armed state, safety gate in the closed state, light screen in the clear state, etc.)
Category B/Category 1, Category 2, Category 3 and Category 4 are as per ISO 13849-1 (EN 954-1), except for two-hand control.
Two-hand categories are as per ISO 13851.

A2.2 PROTECTIVE STOPS (SAFETY)

A *Protective Stop* (Safety) is designed for the connection of miscellaneous devices (not otherwise listed on the *Add Safety Input* screen) that could include *Safeguarding Devices* (protective) 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 either automatically or manually activated and *Reset* either manually or automatically.

A2.2.1 Requirements

The required *Safety Circuit Integrity* level is determined by a *Risk Assessment* and will indicate the level of control performance that is acceptable (e.g. *Category 4*, *Control Reliability)* (see appendix A2.1 on page 89 and appendix A2.1.1 on page 89). 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 is typically functional *Stop Category 0* or *Category 1* as described by IEC60204-1.

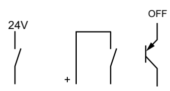
The user must follow the device manufacturer's installation, operation, and maintenance instructions and all relevant regulations. If there is any question about the device(s) that are to be connected to the *Safety Controller*, call Banner Corporate Office as listed on page 127 **for assistance.**

A2.2.2 Connection Options

☛ ***All figures show the Input Device in the OFF (Stop) state.***

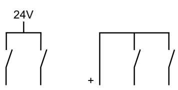
A2.2.2.1 Single channel, 1 terminal - Single channel, 2 terminal - Single channel, PNP switch

These circuits can typically meet ISO 13849-1 *Category 2* requirements, depending on the *Safety Rating* of the *Output Device(s)*. At a minimum, a safety-rated device must be used to achieve a *Category 2*. The *Single channel, 1 terminal* and the *Single channel, PNP switch* device circuits can not detect a short circuit to another source of power. *Single channel, 2 terminal* connection 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*.



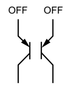
A2.2.2.2 Dual channel, 2 terminals - Dual channel, 3 terminals

This circuit typically can meet ISO 13849-1 *Category 2* or *Category 3* requirements, depending on the *Safety Rating* and installation of the *Output Device(s)*. *Dual channel, 3 terminals* connection uses pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connection can detect a short between channels when the contacts are open if the short is present longer than 2 seconds.



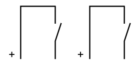
A2.2.2.3 Dual Channel, PNP

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating*, installation and the fault detection (e.g. short circuit) capabilities of the *Output Device*. The *Safety Controller* does not provide short circuit detection in this configuration.



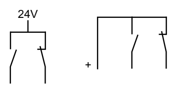
A2.2.2.4 Dual channel, 4 terminal

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements, depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels or to another source of power.



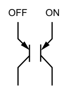
A2.2.2.5 Complementary, 2 terminals - Complementary, 3 terminals

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *Open* / S2 *Close*, see circuit below), a short across the closed contact can cause the response time to increase based on the debounce time. In this situation, the response time could be longer than specified, based on the (selected) debounce time (see block 4.6 on page 26).



A2.2.2.6 Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *OFF* /S2 *ON* below) a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.3 GATE SWITCHES (or INTERLOCKED GUARD)

The *Safety Controller Safety Inputs* may be used to monitor electrically interlocked guards or gates.

A2.3.1 Safety Circuit Integrity Levels

Requirements vary widely for the level of *Control Reliability* or *Safety Category* as per ISO 13849-1 (EN954-1) in the application of interlocked guards. While Banner always recommends the highest level of safety in any application, it is the responsibility of the user to safely install, operate and maintain each safety system and comply with all relevant laws and regulations.

The safety performance (integrity) must reduce the risk from identified hazards as determined by the machine's *Risk Assessment*. See appendix A2.1 for guidance if the requirements as described by ISO 13849-1 are to be implemented.

In addition to the requirements stated in this appendix A2.3.1, the design and installation of the interlocking device should comply with ISO 14119.

A2.3.2 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 be sure to comply 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 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 EN 294, ISO 14120 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 interlocking switches and actuators 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.

A2.3.2.1 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 be of *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 (see the *Banner Safety Catalogue* 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 NC contact when the guard *Opens*.

A2.3.2.2 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 (e.g. secondary magnetic fields). The circuitry or the *Safety Controller* that is monitoring the magnetic switch will detect and respond to a failure that results in the loss of the *Complementary* state (e.g. 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 (a ferrous metal, such as iron), the *Switching Distance* will be affected. This distance will be stated by the manufacturer.

A2.3.2.3 Monitoring Series-Connected Safety Interlocking Switches

When monitoring two individually mounted *Safety Interlocking Switches* (as shown in Figure 36 on page 87), a faulty switch will be detected if it fails to switch as the guard *Opens*. In this case, the *Controller* will de-energize its *Safety Outputs* (OSSDs on page 123) and disable its *Reset* function until the input requirements are met (i.e. the faulty switch is replaced). However, when multiple *Safety Interlocking Switches* are series-connected, the failure of one switch in the system may be masked or not be detected at all (refer to Figure 37 on page 87 and Figure 38 on page 88).

Series-connected *Safety Interlocking Switch* circuits may not meet ISO 13849 (EN954-1) *Safety Category 4* requirements because of the potential of an inappropriate *Reset* or a potential loss of the *Safety Stop Signal*. This is due to the typical inability to fault exclude the failure of the *Safety Interlocking 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 two scenarios assume two *Positive-Opening Safety Interlocking Switches* on each guard, both connected in series to *Safety Interlocking Switches* of a second guard:

Scenario 1 Masking of a Failure

If a guard is opened but a *Safety Interlocking Switch* fails to open, the *Redundant Safety Interlocking 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 *good* 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 (i.e. the accumulation of faults resulting in loss of the safety function).

Scenario 2 Non-Detection of a Failure

If a *good* guard is opened, the *Safety Controller* de-energizes its *Outputs* (a normal response) but if a faulty guard is then opened and closed before the *good* guard is re-closed, the faulty guard is not detected. This system also 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. In multiple-guard systems using series-connected safety switches, it is important to periodically check the functional integrity of each interlocked guard individually. 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.

Each safeguard should be *Opened* and *Closed* separately while verifying that the *Controller Outputs* operate correctly throughout the check procedure. Each safeguard closure should be followed 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 check-outs. If the application can not exclude these types of failures and such a failure could result in serious injury or death, then the series connection of safety switches must not be used.

A2.3.2.4 Series Connection & Safety Circuit Integrity Considerations

A2.3.2.5 Category 2

A *Single-Channel* interlocked guard application typically provides a *Category 2* level of circuit performance because a short circuit could cause 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 loss of the safety function. For circuit diagram refer to Figure 36 on page 87.

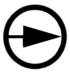
A2.3.2.6 Category 3

A *Dual-Channel* connection 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 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/common mode failures that could result in the loss of safety function. For circuit diagram refer to Figure 37 on page 87.

A2.3.2.7 Category 4

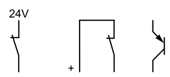
The self-monitoring *Safety Inputs* can be interfaced to achieve a *Category 4* level of safety. The principle of *Fault Exclusion* must be incorporated into the design and installation to either eliminate, or reduce to an acceptable (minimal) level of risk, the possibility of catastrophic/common mode failures that could result in loss of the safety function. For circuit diagram refer to Figure 38 on page 88.

A2.3.3 Gate Switch (or Interlocked Guard) Connection Options

☛ ***All layouts are shown with the Gate Switch (guard) in the Closed, or Run/ON state. The safety contact is considered to be the N.C. contact that is of a Positive-Opening design (unless otherwise noted), normally marked with the***  ***symbol.***

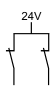
A2.3.3.1 Single channel, 1 terminal - Single channel, 2 terminal - Single channel, PNP switch

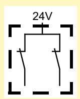
These circuits can typically meet ISO 13849-1 *Category 2* requirements, depending on the design and installation of the switch. At a minimum, the switch must be a safety-rated device to achieve a *Category 2* level. The *Single channel, 1 terminal* and the *Single channel, PNP switch* can not detect a short circuit to another source of power. *Single channel, 2 terminal* connection 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.



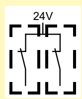
A2.3.3.2 Dual channel, 2 terminals - Dual channel, 3 terminals

This circuit typically can meet ISO 13849-1 *Category 2* or *Category 3* requirements, depending on the design and installation of the switch(es). *Dual channel, 3 terminals* connection uses pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connections can detect a short between channels if the contacts are open longer than 2 seconds.

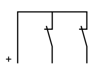


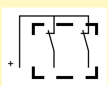


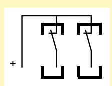
A single switch mounted on a single guard is typically a *Category 2* application.



Two switches individually mounted on a single guard is typically a *Category 3* application.

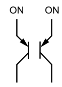






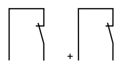
A2.3.3.3 Dual Channel, PNP

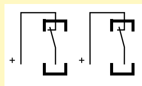
This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating*, installation, and the fault detection (e.g. short circuit) capabilities of the device(s). The *Safety Controller* does not provide short circuit detection in this configuration.



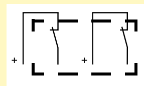
A2.3.3.4 Dual channel, 4 terminal

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements, depending on the design and installation of the switch(es). This circuit can detect a short circuit between channels or to another source of power.





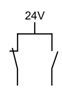
Two switches individually mounted on a single guard is typically a *Category 4* application. A series connection of switches on multiple guards is typically a *Category 3* application.

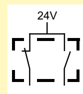


One switch mounted on a single guard is typically a *Category 2* application.

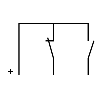
A2.3.3.5 Complementary, 2 terminals - Complementary, 3 terminals

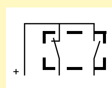
This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the design and installation of the switch(es). This circuit can detect a short circuit between channels. A coded magnetic switch would typically use this style. In the guard *Closed* condition (as shown) a short across the *Closed* contact can cause the *Response Time* to increase based on the *Debounce Time* (see block 4.6 on page 26).





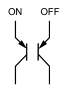
A single coded magnetic switch mounted on a single guard can meet *Category 3*, or *Category 4* depending on installation and the frequency of exercising the guard (*Closed-Open-Closed).*





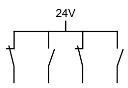
A2.3.3.6 Complementary, PNP switch

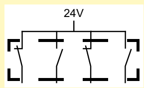
This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements, depending on the design and installation of the switch(es). This circuit can detect a short circuit between channels. In the guard *Closed* condition (as shown) a short across the *Closed* contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



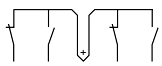
A2.3.3.7 2X Complementary, 4 terminals - 2X Complementary, 5 terminals

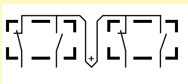
This circuit can meet ISO 13849-1 *Category 4* requirements, depending on the design and installation of the switches. A coded magnetic switch would typically use this style. In the guard *Closed* condition (as shown) a short across the *Closed* contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time*, (see block 4.6 on page 26).





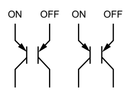
A two-coded magnetic switch mounted on a single guard can meet *Category 4*.

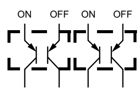




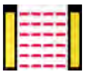
A2.3.3.8 2X Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 4* requirements depending on the design and installation of the device(s). This circuit can detect a short circuit between channels. In the guard *Closed* condition (as shown) a short across the *Closed* contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).





A2.4 OPTICAL SENSORS



The *Safety Controller Safety Inputs Optical Sensor* devices that use light as a means of detection.

A2.4.1 Safety Circuit Integrity Levels

Requirements vary widely for the level of *Control Reliability* or *Safety Category* as per ISO 13849-1 (EN954-1) in the application of *Optical Safeguarding*. While Banner Engineering always recommends the highest level of safety in any application, it is the responsibility of the user to safely install, operate and maintain each safety system and comply with all manufacturer instructions and 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 appendix A2.1 for guidance if the requirements as described by ISO 13849-1 (EN954-1) are to be implemented. In addition to the requirements stated in this appendix A2.4.1, the design and installation of the *Optical Safeguarding* device should comply with IEC 61496 (all parts).

A2.4.2 Requirements

⚠ WARNING

INCOMPLETE INFORMATION

MANY INSTALLATION CONSIDERATIONS NECESSARY TO PROPERLY APPLYING THESE DEVICES ARE NOT COVERED BY THIS DOCUMENT. REFER TO THE APPROPRIATE DEVICE INSTALLATION INSTRUCTIONS TO ENSURE THE SAFE APPLICATION OF THE DEVICE.

When used as *Safeguarding*, these devices are described by IEC 61496-1/-2/-3 as *Active Opto-Electronic Protective Device* (AOPD) and *Active Opto-Electronic Protective Device Responsive to Diffuse Reflection* (AOPDDR).

AOPDs include *Safety Light Screens* and *Safety Point & Grid Systems* (multiple-/single-beam devices). These devices are described as meeting *Type 2* or *Type 4* design requirements. A *Type 2* device is allowed to be used in a *Category 2* application as per ISO 13849-1 and a *Type 4* device can be used in a *Category 4* application. AOPDDRs can also be area or laser scanners. The primary designation for these devices is a *Type 3*, for use in up to *Category 3* applications.

Optical Safety Devices also must be placed at an appropriate *Minimum Safety Distance*, according to applicable standards.

The applicable standards should be referred to and also to Manufacturers documentation specific to the device for the appropriate calculations.

A2.4.3 Minimum Safety Distance

☛ ***The following information is only applicable to Œ certified installations.***

For the purpose of the *Minimum Safety Distance* calculation, the *Safety Controller* default *Response Time* is 0,010 seconds, plus any additional *Closed-open debounce time*. If the *Debounce Time* is adjusted, the time in excess of 6 ms (= default *Closed-open debounce time)* must be added to the stated response (refer to Specifications, block 3.2.1 on page 20). For quick access to a *Controller's* specific *Response Times* see also block 6.1.2.4 on page 54.

Calculation of *Minimum Safety Distance* takes into account several factors, including a calculated human speed, the total system stopping time (which itself has several components), and the additional distance based on the intrusion of the hand or object towards the danger zone prior to actuation of the safety device.

As an example, the *Minimum Safety Distance* for *Safety Light Screens* that are classified as *Type 2* or *Type 4 devices,* can be calculated using the general formula as specified in ISO 13855 (EN 999) and detailed as follows:

General Formula

S = **K x T + C** where:

S = *Minimum Safety Distance* in millimetres; from danger zone to centre line of detection zone (see Detection Zone on page 123). Minimum allowable safety distance is 100 mm (175 mm for non-industrial applications) regardless of calculated value.

K = Recommended hand-speed constant (in mm) derived from data on approach speeds of the body or parts of the body as stated in ISO 13855

T = Overall response time of machine; that is, time between physical initiation of safety device and machine coming to a stop or risk being removed. This can be broken down into two parts: $\mathbf{T_s}$ and $\mathbf{T_r}$ where $\mathbf{T = T_s + T_r}$

$\mathbf{T_s}$ = *Response Time* of machine measured between application of stop signal from *Safety Light Screen* and machine coming to a stop or risk being removed (including stop times of all relevant control elements measured at maximum machine velocity, e.g. *Interface Modules)*. $\mathbf{T_s}$ is usually measured by a stop-time measuring device

☛ *If the specified machine stop time is used, it is recommended that at least 20% be added as a safety factor to account for clutch/brake system deterioration.*

$\mathbf{T_r}$ = *Response Time* of *Safety Light Screen*

C = Additional distance in millimetres, based on intrusion of hand or object towards danger zone prior to actuation of safety device. **C** is calculated using the formula as follows: **C = 8 x(d-14)** where **d** is the resolution of the device

☛ *This measurement must take into account the slower of the two MPCE (see* MPCE on page 123*) channels, and response time of all devices or controls (such as interface modules) that react to stop machine. If all devices are not included, the calculated Minimum Safety Distance (S) will be too short and serious injury could result.*

User should consider all factors, including physical ability of operator, when determining value of K to be used.

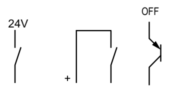
Access to danger zone by reaching over or round the Safety Light Screen(s) shall be prevented using values stated in ISO 13852.

A2.4.4 Generic Connection

☛ ***In** appendix A2.4.4 **the optical sensor is shown actuated in the N.O. or OFF state.***

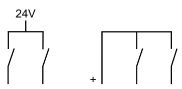
A2.4.4.1 Single channel, 1 terminal - Single channel, 2 terminal - Single channel, PNP switch

These circuits can typically meet ISO 13849-1 *Category 2* requirements, depending on the *Safety Rating* of the *Input Device(s)*. At a minimum, a safety-rated device must be used to achieve a *Category 2* level of safety. The *Single channel, 1 terminal* and the *Single channel, PNP switch* can not detect a short circuit to another source of power. *Single channel, 2 terminal* connection uses pulse monitoring and can detect a short circuit to another source of power. *Fault Exclusion* must be used to achieve higher level of *Safety Circuit Integrity*.



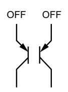
A2.4.4.2 Dual channel, 2 terminals - Dual channel, 3 terminals

This circuit typically can meet ISO 13849-1 *Category 2* or *Category 3* requirements, depending on the *Safety Rating* and installation of the *Input Device(s)*. *Dual channel, 3 terminals* connection uses pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connection can detect a short between channels when the contacts are open if the short is present longer than 2 seconds.



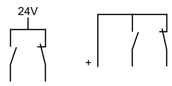
A2.4.4.3 Dual Channel, PNP

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements, depending on the *Safety Rating*, installation, and the fault detection (e.g. short circuit) capabilities of the *Input Device*. The *Safety Controller* does not provide short circuit detection in this configuration.



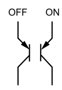
A2.4.4.4 Complementary, 2 terminals - Complementary, 3 terminals

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Input Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *Open* /S2 *Closed* below) a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer as specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.4.4.5 Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Input Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *OFF* / S2 *ON* below) a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer as specified based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.5 TWO-HAND CONTROL

WARNINGS

POINT-OF-OPERATION GUARDING

WHEN PROPERLY INSTALLED, THE 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 AND/OR FIXED GUARDS, TO PROTECT PERSONNEL FROM HAZARDOUS MACHINERY. FAILURE TO PROPERLY GUARD HAZARDOUS MACHINERY CAN RESULT IN A DANGEROUS CONDITION WHICH COULD LEAD TO SERIOUS INJURY OR DEATH.

HAND CONTROLS

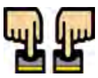
THE ENVIRONMENT IN WHICH HAND CONTROLS ARE INSTALLED MUST NOT ADVERSELY AFFECT THE MEANS OF ACTUATION. SEVERE CONTAMINATION OR OTHER ENVIRONMENTAL INFLUENCES MAY CAUSE SLOW RESPONSE OR FALSE ON CONDITIONS OF MECHANICAL OR ERGONOMIC BUTTONS. THIS MAY RESULT IN EXPOSURE TO A HAZARD.

INSTALL HAND CONTROLS TO PREVENT ACCIDENTAL ACTUATION

TOTAL PROTECTION FROM DEFEAT OF THE TWO-HAND CONTROL SYSTEM IS NOT POSSIBLE. HOWEVER, THE USER IS REQUIRED BY EUROPEAN REGULATIONS TO ARRANGE AND PROTECT HAND CONTROLS TO MINIMIZE POSSIBILITY OF DEFEAT OR ACCIDENTAL ACTUATION.

MACHINE CONTROL MUST PROVIDE ANTI-REPEAT CONTROL

APPROPRIATE ANTI-REPEAT CONTROL MUST BE PROVIDED BY THE MACHINE CONTROL AND IS REQUIRED BY INTERNATIONAL STANDARDS FOR SINGLE-STROKE OR SINGLE CYCLE MACHINES.



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* actuators must be located so that hazardous motion is completed or stopped before the Operator can release one or both of the buttons and reach the hazard (see appendix A2.5.1 *Minimum Safety Distance)*.

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 IEC60204-1 and ISO 13851 for two-hand control, which include:

- *Concurrent* actuation by both hands within a 500 ms time frame
- Where this time limit is exceeded, both hand controls must be released before operation is initiated
- Continuous actuation during hazardous condition
- Cessation of hazardous condition if either hand control was released
- Release and re-actuation of both hand controls to re-initiate the hazardous motion or condition (i.e. *Anti-Tie Down)*
- The appropriate performance level of the safety-related function (e.g. *Control Reliability*, *Category* or *SIL)* as determined by a *Risk Assessment*

The level of safety achieved (e.g. ISO 13849-1 *Category)* depend in part on the circuit type selected. See appendix A2.5.2.

The installation of the hand controls must consider:

- Failure modes that would result in a short circuit, a broken spring(s), mechanical seizure, etc. that would result in not detecting the release of a hand control
- Severe contamination or other environmental influences that may cause slow response when released or false ON condition of the hand control(s), e.g. sticking of a mechanical linkage
- Protection from accidental or unintended operation (e.g. mounting position, rings, guards or shields)
- Minimizing the possibility of defeat (e.g. 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 in a straight line, as per ISO 13851
- The functional reliability and installation of external logic devices
- Proper electrical installation as per IEC 60204

When used in 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* (see Caution)

A2.5.1 Minimum Safety Distance

> ⚠ **WARNING**
>
> **LOCATION OF TOUCH BUTTON CONTROLS**
>
> **HAND CONTROLS MUST BE MOUNTED A SAFE DISTANCE FROM MOVING MACHINE PARTS. IT MUST NOT BE POSSIBLE FOR THE OPERATOR OR OTHER NON-COMPETENT PERSONS TO RELOCATE THEM. FAILURE TO ESTABLISH AND MAINTAIN THE REQUIRED SAFETY DISTANCE COULD RESULT IN SERIOUS INJURY OR DEATH.**

☛ ***The following information is only applicable to Œ certified installations.***

ISO 13855 – Safety of Machinery – The positioning of protective equipment in respect of approach speeds of parts of the human body.

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. If no appropriate *Type C* standard exists then the *Minimum Safety Distance* shall be calculated using the general formula.

General Formula

S = K x T + C where:

S is the minimum safety distance in millimetres, from the danger zone to the detection point, line or plane;

K is a constant in millimetres per second, derived from data on approach speeds of the body or part of the body: **K = 1600 mm per second**;

T is the overall response time in seconds;

C is an additional distance in millimetres, based on intrusion towards the danger zone prior to actuation; **C = 250 mm**.

Where machine specific European standards specify a different distance than the safety distance calculated using this standard then the greater of the distances shall be used as the minimum safety distance.

☛ *Overall response time is the time between the physical initiation of the safety device and the machine coming to a stop or the risk being removed. The overall response time comprises a minimum of two phases:*

$T = T_1 + T_2$ where:

T_1 is the maximum response time of the safety device between the physical initiation of the sensing function and the output signal switching devices being in the *OFF* state.

The DUO-TOUCH with STB Buttons (AT-FM-10K Safety Module interfaced with STB Touch Buttons) has an output response time of 55 ms.

T_2 is the response time of the machine, that is the time required to stop the machine or remove the risk after receiving the output signal from the safety device.

☛ *If the risk from encroachment of the body or part of the body towards the danger zone is eliminated while the device is being actuated, e.g. by adequate shielding, then C may be zero, with a Minimum Safety Distance for S of 100 mm.*

See example of *Minimum Safety Distance* calculation opposite.

Example *Minimum Safety Distance* (S) Calculation

The following example illustrates the use of the formula to calculate the *Minimum Safety Distance:*

K = 1600 mm per second

T_1 = 0,055 seconds

T_2 = 0,50 seconds (measured by a stop-time measuring device)

C = 250 mm

S = K x T + C (where $T = T_1 + T_2$)

= 1600 x (0,055 + 0,50) + 250

= 1138 mm

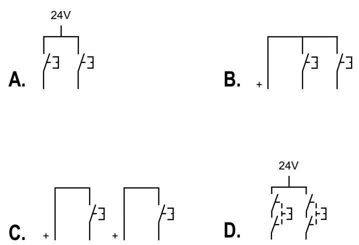
In this example, both hand controls must be located no closer than 1138 mm from the nearest hazard point.

A2.5.2 Connection Options

☛ ***The device is shown Not Actuated or in the OFF state. See ISO 13851 for a complete explanation of Type designations and ISO 13849-1 Category requirements.***

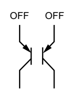
A2.5.2.1 Dual channel, 2 terminals - Dual channel, 3 terminals - Dual channel, 4 terminal

The circuit layouts below are of a *Type IIIa Two-Hand Control* circuit as described by ISO 13851, and typically can meet ISO 13849-1 EN 954-1) *Category 1* requirements. A *Type IIIb* and *Category 3* can be achieved if redundant contacts from each hand control are used in each channel, i.e. two each in series, as shown in Layout D below, or with a *Dual channel, 3 terminals* connection that uses pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connections can detect a short between channels when the contacts are open if the short is present longer than 2 seconds. The *Dual channel, 4 terminal* circuit can detect a short circuit between channels or to another source of power (Layout C).



A2.5.2.2 Dual Channel, PNP

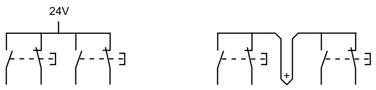
The layout below is a *Type IIIa Two-Hand Control* circuit as described by ISO 13851, and typically can meet ISO 13849-1 (EN 954-1) *Category 1* requirements. The *Safety Controller* does not provide short circuit detection between channels in this configuration.



A2.5.2.3 2X Complementary, 4 terminals - 2X Complementary, 5 terminals

The layout below is of a *Type IIIc Two-Hand Control* circuit as described by ISO 13851, and typically can meet ISO 13849-1 (EN 954-1) *Category 4* requirements. In the actuated condition (e.g. S1 *Open* / S2 *Closed* below) a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer as specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).

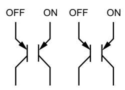
☛ *Select this option if using Banner Self-Checking Touch Button models STBVR81…*



A2.5.2.4 2X Complementary, PNP switch

The layout below is a *Type IIIc Two-Hand Control* circuit as described by ISO 13851 and typically can meet ISO 13849-1 (EN 954-1) *Category 4* requirements. In the actuated condition (e.g. S1 *Open* / S2 *Closed* below), a short across the closed contact can cause the *Response Time* to increase, based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).

☛ *Select this option if using Banner Self-Checking Touch Buttons models STBVP6…*



A2.6 SAFETY MATS (SAFETY EDGES)

> **⚠ WARNING**
>
> **APPLICATION OF SAFETY MATS**
>
> **Requirements vary widely for the level of control reliability or ISO 13849-1 (EN954-1) Category in the application of Safety Mats. It is the responsibility of the user to safely install, operate, and maintain each Safety Mat (or safety edge) system per the manufacturer's recommendations and comply with all relevant laws and regulations.**
>
> **Do not use a Safety Mat 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 (e.g. at a control station). This type of application uses reverse/negative logic and certain failures (e.g. loss of power to the Controller) can result in a 'false' enable signal.**

The *Safety Controller* may be used to monitor pressure-sensitive *Safety Mats* and *Safety Edges* (sensors).

The purpose of the *Safety Mat* input of the *Safety Controller* is to verify the proper operation of 4-wire *Presence-Sensing Safety Mats* (sensors). Multiple *Safety Mats* may be switched in series to one Controller (see appendix A2.6.2).

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

The function is to monitor the contacts *(Contact Plates)* and the wiring of one or more *Safety Mat(s)* for failures and prevent the machine from restarting if a failure is detected. A *Reset* routine after the operator steps off the *Safety Mat* can be provided by the *Safety Controller*, or, if the Controller is used in *Automatic Reset* mode, the *Reset/Restart* function must be provided by the machine control system. This prevents the controlled machinery from restarting automatically after the *Safety Mat* is cleared.

A2.6.1 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 information contained in ISO 13856-1. The user must review all relevant applicable regulations and standards and must ensure that the Controller and any associated sensors are in full compliance.

A2.6.1.1 Safety Mat System Design & 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 *Safety Mat's* sensing surface (less than 100 ms to 200 ms, depending on the relevant standard).

For a *Safety Mat* system, the minimum object sensitivity of the sensor must detect, at minimum, a 30 kg weight on an 80 mm diameter circular disk test piece, anywhere on the *Safety 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 permitted (ISO 13856-1). The sensor should be manufactured to prevent any reasonably foreseeable failures (e.g. 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 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; i.e. the effects on the sensor of liquids and other substance contamination which could be expected, must be taken into account (e.g. 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 of a lifetime non-slip design, or alternatively, the possibility of not meeting the expected operating conditions should be minimised.

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 (e.g. broken connections due to sharp pulls, steady pulls, or continuous flexing). If not, an alternate means must be employed to avoid such a failure, for example, a cable which disconnects without damage and results in a safe situation.

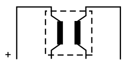
A2.6.2 Connection Options

Pressure-Sensitive Safety 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 (EN 954-1).

The *Safety Mat*, its Safety Controller and any output signal switching devices must meet the requirements of *Safety Category 1* as a minimum. To meet these requirements, the system must at minimum meet the requirements of ISO 13856-1 (EN 1760-1) and the relevant requirements of ISO 13849-1(EN 954-1).

The *Safety Controller* is designed to monitor 4-wire *Safety Mats* but is not compatible with two-wire devices (mats, sensing edges, etc., with two wires and a 'sensing' resistor).

This circuit typically can meet ISO 13849-1 *Category 2* or *Category 3* requirements depending on the *Safety Rating* and installation of the *Safety Mat(s)* or other sensor(s). This circuit can detect a short circuit between channels or to another source of power.



A2.6.3 Installation

The mounting surface quality and preparation for the sensor must meet the requirements stated by the sensor's manufacturer. Irregularities in the floor (or other mounting surfaces) may impair the function of the sensor and therefore should be reduced to an acceptable minimum.

The mounting surface should be level and clean. The collection of fluids under or around the sensor should be avoided. The risk of failure due to build-up of dirt, turning-chips, or other material under the sensor(s) or the associated hardware must be prevented. Special consideration should be given to joints between sensors to ensure that foreign material does not migrate under or into the sensor.

Any damage (e.g. cuts, tears, wear, or punctures) to the outer insulating jacket of the interconnect cable (in the presence of fluids) or to any part of the exterior of the sensor must be immediately repaired or replaced. Ingress of material (including dirt particles, insects, fluid, moisture or machine waste metal turnings) which may be present near the *Safety Mat* can cause the sensor to corrode or to lose its sensitivity.

Each sensor must be routinely inspected and tested per the manufacturer's recommendations. Care must be taken not to exceed operational specifications (e.g. the maximum number of switching operations).

Each sensor must be securely mounted 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 sensor 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 or more. Tripping hazards must be minimized at joints, junctions and edges, and when additional coverings are used. Methods include a ground-flush (recessed in floor so it is flush with surrounding floor area) installation of the sensor, or a ramp that does not exceed 20° from horizontal. Use contrasting colours or markings to identify ramps and edges.

The *Safety Mat* system must be sized and positioned so that persons cannot enter the hazardous area without being detected and can not 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. 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 mm to 1200 mm, 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.

A2.6.4 Minimum Safety Distance

☛ ***The following information is only applicable to Œ certified installations.***

As a stand-alone safeguard, the sensor must be installed at the *Minimum Safety Distance* so that the exterior edge of the sensing surface is at or beyond the safety distance, unless solely used to prevent start/restart or solely used for a clearance *Safeguarding Device*.

The *Minimum Safety Distance* required for an application depends upon 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*. The user must refer to the relevant standard to determine the appropriate distance or means to ensure that individuals can not be exposed to the hazard(s).

The *Minimum Safety Distance* calculated is the minimum horizontal distance from the outer edge of the *Safety Mat* sensor mat detection zone to the closest part of the hazard. The general formula for ground level mounted *Safety Mats* is as specified in ISO 13855 (EN 999).

General Formula

$$S = [1600 \times (t_1 + t_2)] + (1200 - 0{,}4H)$$

S is the ***Minimum Safety Distance*** in mm in a horizontal plane from the ***Danger Zone*** to the detecting edge of the device furthest from the ***Danger Zone***

1600 is a minimum speed constant based on the movement of the hand/arm only and the body being stationary
1600 mm/s

t_1 is the maximum time between the actuation of the sensing function and the output signal switching devices being in the ***OFF*** state

t_2 is the maximum ***Response Time*** of the machine, i.e. the time required to stop the machine or remove the risks after receiving the output signal from the protective equipment

1200 is the depth penetration factor which is the maximum travel towards the hazard within the ***Safety Mat*** area that may occur before a stop is signalled
1200 mm

H is the distance above the reference plane, e.g. floor, in millimetres

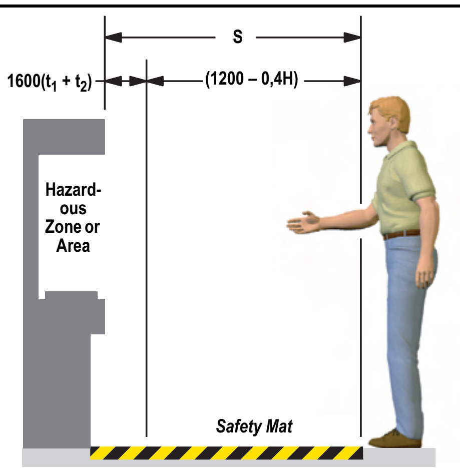


Figure 42 Determining Minimum Safety Distance (S) for the Safety Mat

If an individual can cross completely over the sensor and no longer be detected, supplementary *Safeguarding Devices* or other means should be used to prevent unexpected start-up and exposure to a hazard. At a minimum, the *Safety Mat* system (or the machine control) must be manually *Reset* and requires re-initiation of the normal actuating means prior to the start or re-start of the machine cycle.

A2.7 E-STOPS

WARNINGS

E-STOP FUNCTIONS

DO NOT MUTE OR BYPASS ANY E-STOP DEVICE. IEC 60204-1 REQUIRE THAT THE E-STOP FUNCTION REMAIN ACTIVE AT ALL TIMES. MUTING OR BYPASSING THE SAFETY OUTPUTS WILL RENDER THE EMERGENCY STOP FUNCTION INEFFECTIVE.

THE SAFETY CONTROLLER E-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.

RESET ROUTINE REQUIRED

INTERNATIONAL STANDARDS REQUIRE THAT A RESET ROUTINE BE PERFORMED AFTER RETURNING THE E-STOP SWITCH TO ITS CLOSED-CONTACT POSITION (WHEN ARMING THE E-STOP SWITCH). WHEN AUTOMATIC RESET IS USED, AN ALTERNATE MEANS MUST BE ESTABLISHED TO REQUIRE A RESET ROUTINE, AFTER THE E-STOP SWITCH IS ARMED. ALLOWING THE MACHINE TO RESTART AS SOON AS THE E-STOP SWITCH IS ARMED CREATES AN UNSAFE CONDITION WHICH COULD RESULT IN SERIOUS INJURY OR DEATH.

The *Safety Controller* safety *Inputs* may be used to monitor *E-Stop* push buttons.

A2.7.1 Safety Circuit Integrity Levels

Requirements vary widely for the level of *Control Reliability* or *Safety Category* as per ISO 13849-1 (EN954-1) in the application of *E-Stops*. While Banner Engineering always recommends the highest level of safety in any application, it is the responsibility of the user to safely install, operate and maintain each safety system and comply with all manufacturer instructions and 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 appendix A2.1 for guidance if the requirements as described by ISO 13849-1 (EN954-1) are to be implemented.

In addition to the requirements stated in this appendix A2.7.1, the design and installation of the *E-Stop* device should comply with ISO 13850.

A2.7.2 Requirements

The *E-Stop* switch must provide one or two contacts for safety which are closed when the switch is armed as shown in figure 39, figure 40 and figure 41. Once 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 open. This ensures that the switch contacts will open whenever the switch is activated.

Standards IEC 60204-1 and ISO 13850 specify additional *E-Stop* switch device requirements which include the following:

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

☛ *Some applications may have additional requirements. The user must comply with all relevant regulations.*

A2.7.2.1 Safety Circuit Integrity Levels & Multiple E-Stop Buttons

WARNING

MULTIPLE E-STOP SWITCHES

WHENEVER TWO OR MORE E-STOP SWITCHES ARE CONNECTED TO THE SAME CONTROLLER:

- CONTACTS OF THE CORRESPONDING POLE OF EACH SWITCH MUST BE CONNECTED TOGETHER IN SERIES. NEVER CONNECT THE CONTACTS OF MULTIPLE E-STOP SWITCHES IN PARALLEL TO ONE CONTROLLER. SUCH A PARALLEL CONNECTION DEFEATS THE SWITCH CONTACT MONITORING ABILITY OF THE CONTROLLER AND CREATES AN UNSAFE CONDITION WHICH COULD RESULT IN SERIOUS INJURY OR DEATH
- EACH SWITCH MUST BE INDIVIDUALLY ACTUATED (ENGAGED), THEN RE-ARMED AND THE CONTROLLER RESET. THIS ALLOWS THE CONTROLLER TO CHECK EACH SWITCH AND ITS WIRING TO DETECT FAULTS

FAILURE TO TEST EACH SWITCH INDIVIDUALLY IN THIS MANNER COULD RESULT IN UNDETECTED FAULTS AND CREATE AN UNSAFE CONDITION WHICH COULD RESULT IN SERIOUS INJURY OR DEATH. THIS CHECK MUST BE PERFORMED DURING PERIODIC CHECK-OUTS.

As part of the required *Risk Assessment* for the machine, IEC 60204-1 states that the safety performance (integrity) must reduce the risk from identified hazards as determined by the *Risk Assessment*. See appendix A2.1 on page 89 for guidance if the requirements as described by ISO 13849-1 (EN954-1) are to be implemented.

In addition to the requirements stated above, the design and the installation of the *E-Stop* device (e.g. 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 must be excluded (designed out). 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 per manufacturer's instructions are expected to open when the *E-Stop* device is actuated.

A2.7.2.2 Category 2

A *Single channel E-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 can result in the loss of the safety function. For circuit diagram refer to Figure 39 on page 88.

A2.7.2.3 Category 3

A *Dual channel* connection 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 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. It should be noted that an accumulation of faults may cause the loss of the safety function. For circuit diagram refer to Figure 40 on page 88.

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 could result in the loss of the safety function.

A2.7.2.4 Category 4

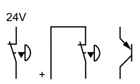
The self-monitoring *Safety Inputs* can be interfaced to achieve a *Category 4* application. The principle of *Fault Exclusion* must be incorporated into the design and installation to either eliminate, or reduce to an acceptable (minimal) level of risk, the possibility of catastrophic failures or faults that could result in the loss of the safety function. For circuit diagram refer to Figure 41 on page 88.

A2.7.3 Connection Options

☛ ***The device is shown in the Armed or Run state.***

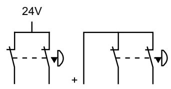
A2.7.3.1 Single channel, 1 terminal - Single channel, 2 terminal - Single channel, PNP switch

These circuits can typically meet ISO 13849-1 *Category 2* requirements, depending on the design and installation of the switch. At a minimum, the switch must be a safety-rated device in order to achieve *Category 2*. The *Single channel, 1 terminal* and the *Single channel, PNP switch* can not detect a short circuit to another source of power. *Single channel, 2 terminal* connection uses pulse monitoring and can detect a short circuit to another source of power. *Fault Exclusion* must be used to achieve higher level of *Safety Circuit Integrity*.



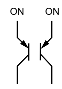
A2.7.3.2 Dual channel, 2 terminals - Dual channel, 3 terminals

This circuit typically can meets ISO 13849-1 *Category 3* requirements, depending on the design and installation of the switch. *Dual channel, 3 terminals* connection uses pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connection can detect a short between channels when the contacts are open if the short is present longer than 2 seconds.



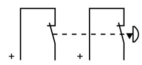
A2.7.3.3 Dual Channel, PNP

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements, depending on the *Safety Rating*, installation, and the fault detection (e.g. short circuit) capabilities of the switch. The *Safety Controller* does not provide short circuit detection in this configuration.



A2.7.3.4 Dual channel, 4 terminal

This circuit can meet ISO 13849-1 *Category 4* requirements, depending on the design and installation of the switch. This circuit can detect a short circuit between channels or to another source of power.



A2.8 ROPE PULLS (CABLE)

Rope Pull (Cable Pull) E-Stop switches use steel wire rope and provide emergency stop actuation continuously over a distance, such as along a conveyor.

Rope Pull E-Stop switches have many of the same requirements as *E-Stop* push buttons, such as *Positive-Opening* (or *Direct-Opening)* operation, as described by IEC 60947-5-1. See appendix A2.7 on page 104 on *E-Stop* push buttons for additional applicable information.

It is recommended to use *Rope Pull E-Stop* switches that have the capability not only to react to a pull in any direction, but also to 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 appendix A2.8.2 on page 106 for connection options.

Some *Rope Pull E-Stop* switches provide a latching function that requires a *Manual Reset* after actuation. If using a switch that does not provide a *Latch* function after the rope is released, a separate *Latch* circuit is required, which can be provided by the *Safety Controller*.

A2.8.1 Installation Guidelines

When installing *Rope Pull E-Stop* switches observe the following guidelines:

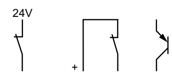
- The wire rope should be easily accessible and visible along its entire length. Markers or flags may be fixed on the rope to increase its visibility
- Mounting points, including support points, must be rigid
- The rope should be free of friction at all supports. Pulleys are recommended
- Use pulleys 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 E-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

A2.8.2 Connection Options

☛ ***The device is shown in the Armed or Run state.***

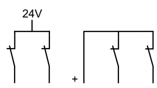
A2.8.2.1 Single channel, 1 terminal - Single channel, 2 terminal - Single channel, PNP switch

These circuits can typically meet ISO 13849-1 *Category 2* requirements, depending on the design and installation of the switch. At a minimum, to achieve a *Category 2*, the switch must be a safety-rated device. The *Single channel, 1 terminal* and the *Single channel, PNP switch* can not detect a short circuit to another source of power. *Single channel, 2 terminal* connection uses pulse monitoring and can detect a short circuit to another source of power. *Fault Exclusion* must be used to achieve higher level of *Safety Circuit Integrity*.



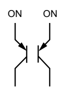
A2.8.2.2 Dual channel, 2 terminals - Dual channel, 3 terminals

This circuit typically can meet ISO 13849-1 *Category 3* requirements, depending on the *Safety Rating* and installation of the *Output Device(s)*. *Dual channel, 3 terminals* connection uses pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connection can detect a short between channels when the contacts are open if the short is present longer than 2 seconds.



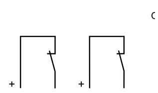
A2.8.2.3 Dual Channel, PNP

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements, depending on the *Safety Rating*, installation, and the fault detection (e.g. short circuit) capabilities of the *Output Device*. The *Safety Controller* does not provide short circuit detection in this configuration.



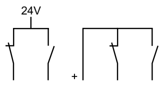
A2.8.2.4 Dual channel, 4 terminal

This circuit can meet ISO 13849-1 *Category 4* requirements, depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels or to another source of power.



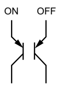
A2.8.2.5 Complementary, 2 terminals - Complementary, 3 terminals

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *Closed* /S2 *Open* below) a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.8.2.6 Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *ON* /S2 *OFF* below) a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.9 ENABLING DEVICE (PENDANTS)

An *Enabling Device* is a manually operated control that, 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

A2.9.1 Installation 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 machine motion must be prevented from other sources that would override the function of the *Enabling Device*. Simply actuating the *Enabling Device* should 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 be inhibited.

Since an individual's reaction to an emergency situation may be either to release or to tighten the grip, many standards require the use of three-position devices:

- **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)

Release of, or compression past, the midpoint-enabled position (position 2) of the *Enabling Device* must initiate an immediate stopping of hazardous motion or situations. It is required that the *Enabling Device* be released and re-actuated before machine motion can be re-initiated.

If allowed, for two-position types, the positions are as follows:

- **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*. The design and installation of the *Enabling Device* must consider the ergonomic issues (force, posture, etc.) of sustained activation. A visual means of indicating that the device is active may be required.

☛ *Only trained and qualified individuals* (see block 1.8.2 on page 4) *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 *Enabling Device*, the associated hazards, and the task requiring the use of the *Enabling Device*.

If more than one individual is to be safeguarded by the use of *Enabling Devices*, each individual must have their own device. Each *Enabling Device* must be concurrently operated before machine motion can be initiated.

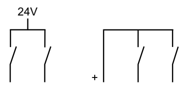
The means to return the machine to production mode must be located outside the hazardous area, where it can not be reached from within that area and is guarded against unintended operation. In addition, the *Reset* switch operator must have full view of the entire guarded area and verify that the area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

A2.9.2 Connection Options

☛ ***The device is shown in the Actuated Position or Stop state.***

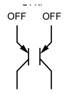
A2.9.2.1 Dual channel, 2 terminals - Dual channel, 3 terminals

This circuit typically can meet ISO 13849-1 *Category 2* or *Category 3* requirements depending on the *Safety Rating* and installation of the *Enabling Device(s)*. *Dual channel, 3 terminals* connection uses pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connection can detect a short between channels when the contacts are open if the short is present longer than 2 seconds.



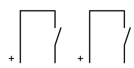
A2.9.2.2 Dual Channel, PNP

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating*, installation, and the fault detection (e.g. short circuit) capabilities of the *Enabling Device*. The *Safety Controller* does not provide short circuit detection in this configuration.



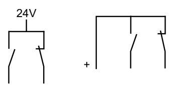
A2.9.2.3 Dual channel, 4 terminal

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements, depending on the *Safety Rating* and the installation of the enabling device. This circuit can detect a short circuit between channels or to another source of power.



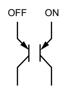
A2.9.2.4 Complementary, 2 terminals - Complementary, 3 terminals

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *Open* / S2 *Closed)* a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer as specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.9.2.5 Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *OFF* / S2 *ON)* a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer as specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).

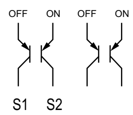


A2.9.2.6 2X Complementary, 4 terminals - 2X Complementary, 5 terminals

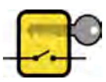
This circuit can meet ISO 13849-1 *Category 3* or *Category 4* requirements depending on the design and installation of the *Enabling Device*. This circuit can detect a short circuit between channels. In the guard closed condition (e.g. S1 *Open* / S2 *Closed)* a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).

A2.9.2.7 2X Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 3* or *Category 4* requirements depending on the design and installation of the *Enabling Device*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *OFF* / S2 *ON)* a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.10 BYPASS SWITCH (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.

A2.10.1 Requirements

Requirements to bypass a *Safeguarding Device* includes*:

- 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 (e.g., only used in inch, jog, or slow-speed modes). Bypass mode must not be used for production
- Supplementary *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 *E-Stops* must remain active
- The means of bypassing must be employed at the same level of reliability as the safeguard
- Visual indication that the *Safeguarding Device* has been bypassed must be provided and be readily observable from the location of the safeguard
- Personnel must be trained in the use of the safeguard and in the use of the bypass
- Risk assessment and risk reduction (per the relevant standard) must be accomplished
- The *Reset*, actuation, clearing, or enabling of the *Safeguarding Device* must not initiate hazardous motion or create a hazardous situation

* This summary was derived from the following and other sources: ISO 13849-1 (EN954-1) and IEC60204-1

Bypassing a *Safeguarding Device* should not be confused with *Muting* which is the 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 Safety Device* (e.g. disabling one or more beams of a *Safety Light Screen* so that a specific beam break is ignored).

A2.10.1.1 Safe Working Procedures and Training

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.

Safe work procedures provide a means for individuals to control exposure to hazards through the use of written procedures for specific tasks and the associated hazards. Such procedures also provide base documentation for a training program. Once again, personnel must be trained in the use of the safeguard and the use of the bypass.

A2.10.1.2 Lockout/Tagout

☛ *There is no specific European Standard covering Lockout/Tagout. This subject is covered in US standards OSHA 29CFR1910.147 "The control of hazardous energy (Lockout/Tagout)" or ANSI 2244.1 "Lockout/Tagout of Energy Sources"*

The intention is to prevent machine operation when the machine is temporarily down or being repaired. Inadvertent start-ups have caused injuries and deaths. This approach ensures that power is cut to a machine by physically locking the power switch in the *OFF* position. In addition, a tag is added to the switch that identifies the process underway and the personnel involved.

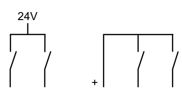
If *Lockout/Tagout* is to be implemented for machine maintenance and servicing situations in which the unexpected energisation, start up, or release of stored energy could cause injury, the above quoted standard(s) must be adhered to. The user must refer to these standard(s) to ensure that bypassing a *Safeguarding Device* does not conflict with the requirements that are contained within these standard(s).

A2.10.2 Connection Options

☛ ***The device(s) is shown not actuated or in the OFF state.***

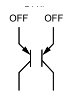
A2.10.2.1 Dual channel, 2 terminals - Dual channel, 3 terminals

This circuit typically can meet ISO 13849-1 *Category 2* or *Category 3* requirements depending on the *Safety Rating* and installation of the *Bypass Switch(es)*. *Dual channel, 3 terminals* connection uses pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connection can detect a short between channels when the contacts are open if the short is present longer than 2 seconds.



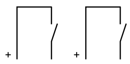
A2.10.2.2 Dual Channel, PNP

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating*, installation, and the fault detection (e.g. short circuit) capabilities of the *Bypass Switch(es)*. The *Safety Controller* does not provide short circuit detection in this configuration.



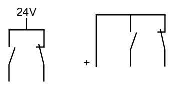
A2.10.2.3 Dual channel, 4 terminal

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Bypass Switch(es)*. This circuit can detect a short circuit between channels or to another source of power.



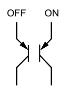
A2.10.2.4 Complementary, 2 terminals - Complementary, 3 terminals

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Bypass Switch(es)*. This circuit can detect a short circuit between channels. In the actuated condition (e.g., S1 *Open* /S2 *Closed*, as shown below) a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer as specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.10.2.5 Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Bypass Switch(es)*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *OFF* / S2 *ON)* a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer as specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).

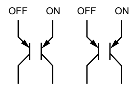


A2.10.2.6 2X Complementary, 4 terminals - 2X Complementary, 5 terminals

This circuit can meet ISO 13849-1 *Category 4* requirements depending on the design and installation of the *Bypass Switch(es)*. This circuit can detect a short circuit between channels. In the guard closed condition (e.g. S1 *Open* / S2 *Closed)* a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).

A2.10.2.7 2X Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 4* requirements depending on the design and installation of the *Bypass Switch(es)*. This circuit can detect a short circuit between channels. In the actuated condition (e.g. S1 *OFF* / S2 *ON)* a short across the closed contact can cause the *Response Time* to increase based on the *Debounce Time*. In this situation, the *Response Time* could be longer than specified, based on the (selected) *Debounce Time* (see block 4.6 on page 26).



A2.11 MUTE SENSOR (PAIR)

A2.11.1 Muting Function

WARNINGS

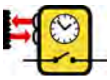
MUTING LIMITATIONS

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 as per ISO 13855.

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.



The user is required to arrange, install, and operate the safety system so as to protect personnel and minimize the possibility of defeating the safeguard.

To mute the primary safeguard appropriately, the design of a *Muting System* must:

- Identify the non-hazardous portion of the machine cycle
- Involve the selection of the proper *Mute Devices*
- 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* that the muting function has been assigned to; e.g. 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 may be triggered by a variety of external devices. This feature provides a variety of options (see appendix A2.11.2 on page 112) to tailor the System to the requirements of a specific application.

A pair of *Mute Devices* must be triggered simultaneously (within 3 seconds of one another). This reduces the chance of common mode failures or defeat.

A2.11.2 Requirements

The beginning and end of a *Mute Cycle* must be triggered by *Outputs* from either pair of *Mute Devices*, depending on the application. The *Mute Device* pairs both must have *N.O.* contacts, or have *PNP Outputs*, both of which fulfil the *Mute Device* requirements, described below. These contacts must *Close (Conduct)* when the switch is actuated to initiate the mute, and must *Open (Non-Conducting)* 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 can not occur.

Several types and combinations of *Mute Devices* can be used, including, but not limited to:

- *Limit Switches*
- *Photoelectric Sensors*
- *Positive-Opening Safety Switches*
- *Inductive Proximity Sensors*
- *Whisker Switches*

See appendix A2.11.2.1 on page 112 for further information.

A2.11.2.1 General

The *Mute Devices* (typically sensors or switches) must, at a minimum, comply with the following requirements:

- There must be a minimum of two independent hard-wired *Mute Devices*
- The *Mute Devices* must either both have *N.O.* contacts, *PNP Outputs* (both of which must fulfil the input requirements listed in the specifications (block 3.2.1 on page 20)) or *Complementary Switching* action. At least one of these contacts must *Close* when the switch is actuated, and must *Open* (or *Non-Conducting*) when the switch is not actuated or in a power *OFF* condition
- The activation of the *Inputs* to the muting function must be from separate sources. These sources must be mounted separately in order to prevent an unsafe muting condition resulting from misadjustment, misalignment, or a single common mode failure (e.g. physical damage to the mounting surface could cause both *Mute Devices* to be knocked out of alignment, resulting in false muting input signals). Only one of these sources may pass through, or be affected by, a programmable logic controller or similar device
- The *Mute Devices* must be installed so that they can not be easily defeated or bypassed
- The *Mute Devices* must be mounted so that their physical position and alignment can not be easily changed
- It must not be possible for environmental conditions to initiate a mute condition (e.g. extreme airborne contamination)
- The *Mute 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)

A2.11.2.2 Examples of Muting Sensors and Switches

> **WARNING**
>
> **AVOID HAZARDOUS INSTALLATIONS**
>
> **TWO OR FOUR INDEPENDENT POSITION SWITCHES (AT M1–M2 OR M3–M4) 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 IMPROPERLY ADJUSTED OR POSITIONED, INJURY OR DEATH COULD RESULT.**
>
> **THE USER HAS THE RESPONSIBILITY TO SATISFY ALL LOCAL, STATE, AND NATIONAL LAWS, RULES, CODES, AND REGULATIONS RELATING TO THE USE OF SAFETY EQUIPMENT IN ANY PARTICULAR APPLICATION. IT IS EXTREMELY IMPORTANT TO BE 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, which initiate the muted condition when the beam path is blocked, 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 Proxing* (activation due to shiny or reflective surfaces) is not possible. *Banner LP* 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 retro reflective target or tape is detected (e.g. *Home Position)*. Use a sensor configured for *Dark Operate (DO* or *N.C.*) when a blocked beam path initiates the muted condition (e.g. *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 could result in an unsafe situation.

Inductive Proximity Sensors

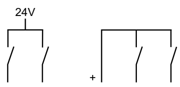
Typically, *Inductive Proximity Sensors* are used to initiate a *Mute Cycle* when a metal surface is detected. Due to excessive leakage current causing false *ON* conditions, two-wire sensors are not to be used. Only three- or four-wire sensors that have digital *PNP* or hard-contact *Outputs* that are separate from the input power should be used.

A2.11.3 Connection Options

The *Controller* provides configuration options for the *Mute Devices*. One or two pairs of *Mute 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*.

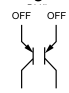
A2.11.3.1 Dual channel, 2 terminals - Dual channel, 3 terminals

This circuit typically can meet ISO 13849-1 *Category 2* or *Category 3* requirements depending on the installation of the *Mute Devices*. To meet *Category 4* requirements, user/installer must design out or otherwise eliminate the possibility of a short circuit between input channels (see section appendix A2.1.2 on page 89). *Dual channel, 3 terminals* connection use pulse monitoring and can detect a short circuit to another source of power. Both *Dual channel, 2 terminals* and *Dual channel, 3 terminals* connection can detect a short between channels when the contacts are *Open* if the short is present longer than 2 seconds.



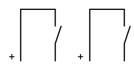
A2.11.3.2 Dual Channel, PNP

This circuit can meet ISO 13849-1 *Category 2* or *Category 3* requirements depending on the installation and the fault detection (e.g. short circuit) capabilities of the *Mute Device*. To meet *Category 4* requirements, user/installer must design out or otherwise eliminate the possibility of a short circuit between input channels (see section appendix A2.1.2 on page 89). The *Safety Controller* does not provide short circuit detection in this configuration.



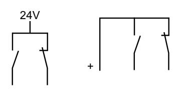
A2.11.3.3 Dual channel, 4 terminal

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the installation of the *Mute Device(s)*. This circuit can detect a short circuit between channels or to another source of power.



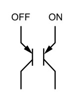
A2.11.3.4 Complementary, 2 terminals - Complementary, 3 terminals

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels. The *Complementary, 3 terminals* connection can detect a short circuit to another source of power, when the contact is closed.



A2.11.3.5 Complementary, PNP switch

This circuit can meet ISO 13849-1 *Category 2*, *Category 3* or *Category 4* requirements depending on the *Safety Rating* and the installation of the *Output Device*. This circuit can detect a short circuit between channels.



A2.11.4 Mute Enable (ME)

The *Mute Enable* input is a *non-safety-rated* input. When the input is *Closed*, the *Controller* will allow a mute condition to occur. Opening this input while the System is muted will have no effect.

Typical uses for *Mute Enable* include:

- To allow the machine control logic to create a "window" for *Muting* to begin;
  to inhibit *Muting* from occurring or
  to reduce the chance of unauthorized or unintended *Bypassing* or defeat of the safety system.

A2.11.4.1 Simultaneity Timer Reset Function

The *Mute Enable* input can also be used to *Reset* the *Simultaneity Timer* of the *Mute Inputs*. If one input is active for longer than three seconds before the second input becomes active, the *Simultaneity Timer* will prevent 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 Timer* 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 0,25 second, then open for longer than 0,25 second, but not longer than 2 seconds, and then must *Reclose* to *Reset* the *Simultaneity Timer*. The function can *Reset* the timer only once per *Mute Cycle* (i.e. all *Mute Inputs* M1–M4 must open before another *Reset* can occur).

A2.11.5 Mute Lamp Output (ML)

> **CAUTION**
>
> **MUTE STATUS MUST BE READILY OBSERVED**
>
> **Indication that the safety device is muted should 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 IEC 61496.**

Some applications require that a lamp (or other means) be used to indicate when the safety device (e.g. *Safety Light Screen)* is muted; the *Controller* provides for this through the *Status Outputs*. If a monitored output signal is required (see caution above), *Status Outputs* O9 and O10 can be configured for a *Monitored Output*. The *Monitored Output* will prevent the initiation of a mute after an indicator failure is detected. If the application requires compliance with IEC 61496, *Lamp Monitoring* must be selected and the lamp used must meet applicable requirements.

A2.11.6 Muting Time Limit (Backdoor Timer)

> **WARNING**
>
> **MUTING TIME LIMIT**
>
> **AN INFINITE TIME FOR THE BACKDOOR TIMER (I.E. 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. IT IS THE USER'S RESPONSIBILITY TO ENSURE THAT THIS DOES NOT CREATE A HAZARDOUS SITUATION.**

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 *Mute 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 *Mute Device* makes the *Simultaneity* requirement (within 3 seconds of the first device), and will allow a mute to continue for the predetermined time. After the timer expires, the mute ends – no matter what the signals from the *Mute Devices* indicate. If the input device being muted is in an *OFF* state, the mapped *OSSD Outputs* will turn *OFF* and must be manually reset (if the input device is configured for manual reset).

A2.11.7 Mute on Power-up

> **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 MUST NOT, IN ANY SITUATION, EXPOSE PERSONNEL TO ANY HAZARD**

If selected, the *Mute on Power-up* function will initiate a mute when power is applied, the *Mute Enable* input is *Closed* (if configured), the safety device *Inputs* are active *(Closed)*, and either M1-M2 or M3-M4 (but not all four) are *Closed*.

If *Automatic Reset* is configured, the *Controller* allows 2 seconds for the *Input Devices* to become active *(Closed)* to accommodate systems that may not be immediately active at power-up.

If *Manual Reset* is configured, the first valid *Reset* after the *Output Device* is active *(Closed)* will result in a *Mute Cycle* if all other conditions are satisfied.

A2.11.8 Corner Mirrors, Optical Safety Systems & Muting

Mirrors are typically used with *Safety Light Screens*, *Single Beam Safety Systems* and *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 supplementary *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.

A2.11.9 Multiple Presence Sensing Safety 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.**

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 appendix A2.11.8), 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*.

A2.11.10 Mute Timing Sequences

Figure 43, figure 44 and figure 45 detail typical *Mute Timing* sequences.

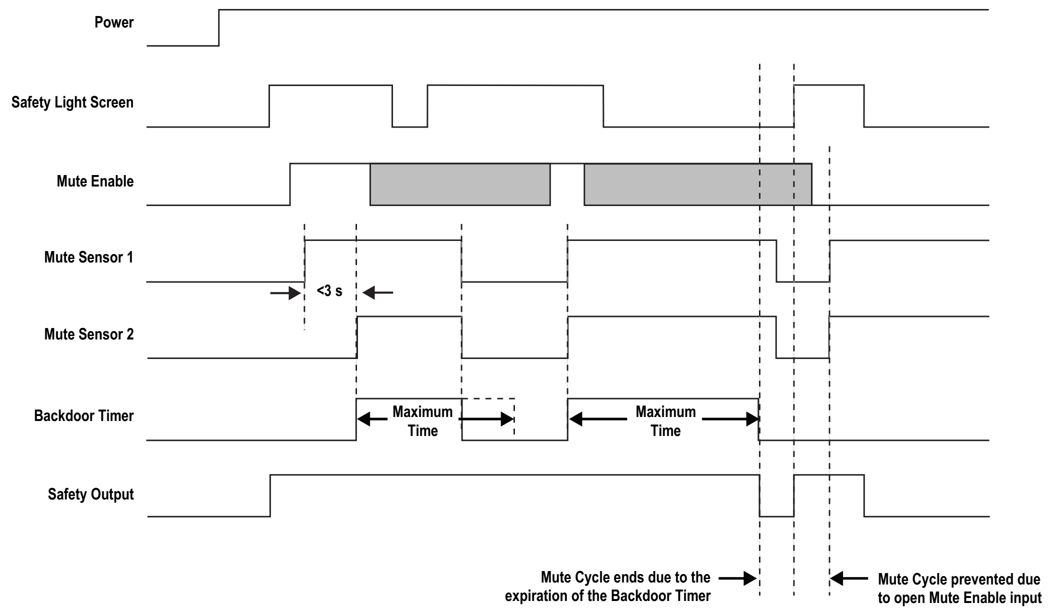


Figure 43 Mute Timing Diagram with Muting Sensor Pair, Mute Enable, Safety Light Screen and Limited Mute Time with Mutable Safety Device Configured for Automatic Reset

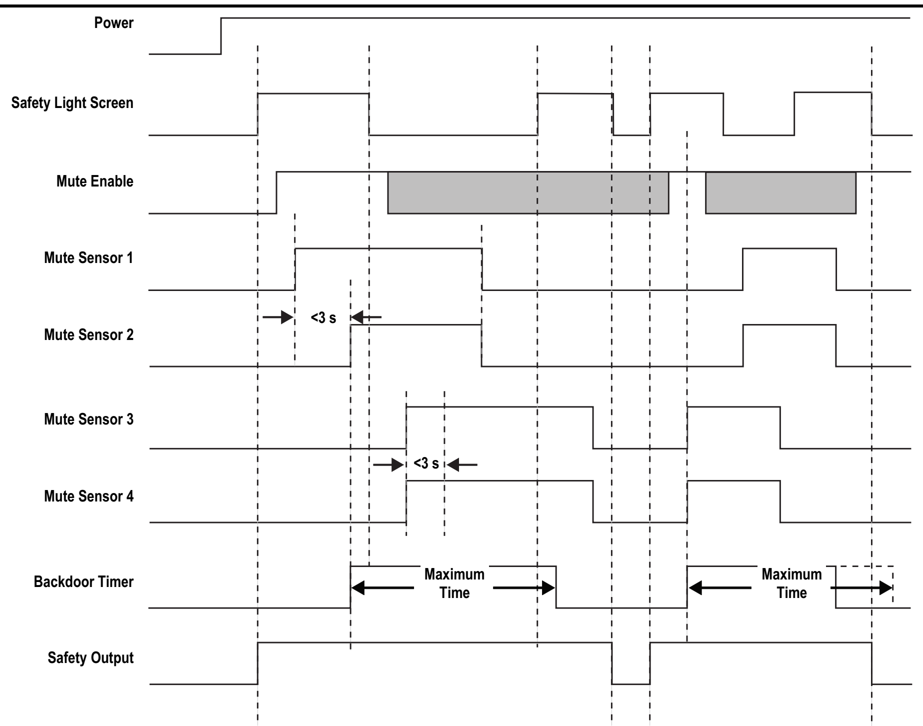


Figure 44 Mute Timing Diagram with four Mute Sensors, Mute Enable, Safety Light Screen & Limited Mute Time with Safety Light Screen Configured for Automatic Reset

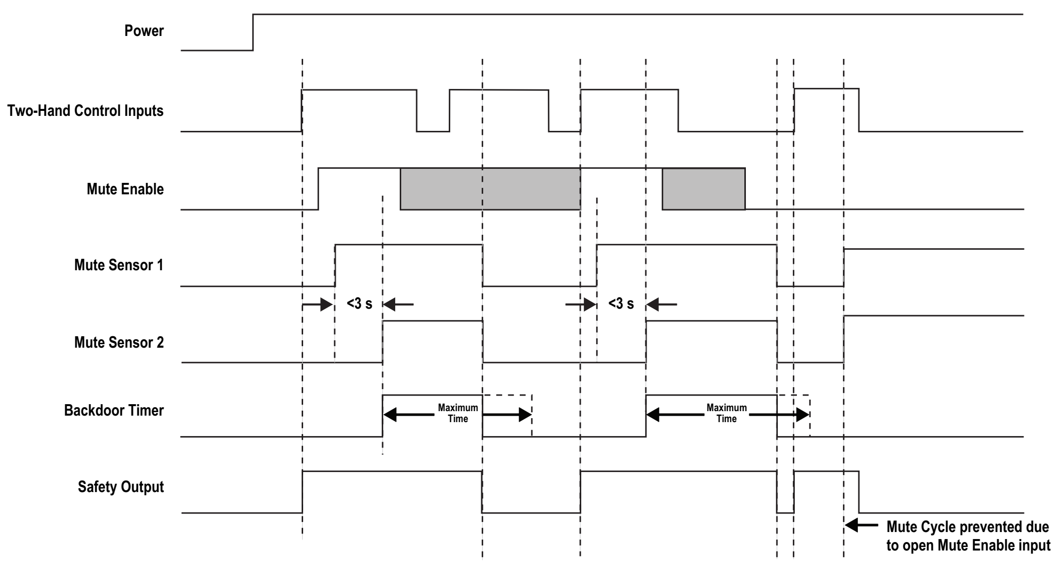


Figure 45 Mute Timing Diagram with Muting Sensor Pair, Mute Enable, Two-Hand Control & Limited Mute Time

A3 DECLARATION OF CONFORMITY

A3.1 DECLARATION OF CONFORMITY

Declaration of Conformity

Manufacturer: Address:	**Banner Engineering Corp.** **9714 10th Ave N.** **Minneapolis, MN 55441 USA**
Herewith declares that:	**SC22-3** **(Safety Controller)**
- is in conformity with the provisions of the Machinery Directive (Directive 98/37/EC), and all Essential Health and Safety Requirements have been met.	**(See attached schedule for list of models covered by this Declaration of Conformity)**
- is in conformity with the provisions of the following other EEC Directives:	**89/336/EEC, 73/23/EEC**
and that: - the following (parts/clauses of) harmonized standards, national technical standards and specifications have been used:	**IEC61508-Part 1-7:2000** **IEC 62061:2005** **IEC 61131-2:2003** **EN ISO 13849-1:2006** **EN 50178:1997** **EN 60204-1:2006** **EN 574:1996** **EN 61496-1:2004 Type 4** **IEC 61508/IEC62061 (SIL CL: 3)** **ISO 13849-1 (Cat. 4, PL e)** **EN 574 (Type III C)**
EU Notified Body:	**TUV Rheinland Product Safety GmbH** **Certificate: #968/EL 493.00/07**

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

R. Eagle / Engineering Manager — Date: 11 / 27 / 07

Declaration of Conformity

Attached Schedule

SAFETY CONTROLLER

Models covered by this Declaration of Conformity:	**SC22-3**

Figure 46 Declaration of Conformity

☛ ***CE pending for Safety Controller Model SC22-3E.***

Declaration of Conformity

Manufacturer:	**Banner Engineering Corp.**
Address:	**9714 10th Ave N. Minneapolis, MN 55441 USA**
Herewith declares that:	**SC22-3 (Safety Controller)**
- is in conformity with the provisions of the Machinery Directive (Directive 98/37/EEC), and all Essential Health and Safety Requirements have been met.	**(See attached schedule for list of models covered by this Declaration of Conformity)**
- is in conformity with the provisions of the following other EEC Directives:	**89/336/EEC, 73/23/EEC,**
and that: - the following (parts/clauses of) harmonized standards have been applied:	**IEC 61508-Part 1-7:2000 IEC 62061:2005 IEC 61131-2:2003 EN ISO 13849-1:2006 EN 50178:1997 EN 60204-1:2006 EN 574:1996 EN 61496-1:2004 Type 4 IEC 61508/IEC 62061 SIL 3 ISO 13849-1 (Cat. 4, PL e) EN 574 (Type III C)**
EU Notified Body:	**TUV Reinland Product Safety GmbH Certificate: #968/EL493.00/07**

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s)

R. Eagle / Engineering Manager

___ / ___ / ___
Date

Declaration of Conformity

Attached Schedule

Safety Controller

Models covered by this Declaration of Conformity:	**SC22-3**

Figure 47 Declaration of Conformity - Translation

☛ ***CE pending for Safety Controller Model SC22-3E.***

A4 ETHERNET REFERENCE

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

Overview: Description of supported Ethernet protocols (chapter 2)

Personal Computer Interface (PCI): Accessing Ethernet

functionality (block 4.8.2 on page 32)

Virtual Status Outputs: See Warning (block 2.6.3 on page 15)

Models: SC22-3E model options and accessory Ethernet cordsets (block 8.4.1 on page 83)

Specifications: Network Interface specifications (block 3.2.1 on page 20)

Virtual Status Outputs: Detailed description, including the Auto Configure function (block 4.10.3 on page 36)

Configuration Tools (block 5.1.3 on page 40), Descriptions of PCI icons and fields (Screen 5)

Starting PCI Program (block 5.1.2 on page 38), Examples of the Ethernet support documents (Screen 4)

A4.1 ETHERNET SETTING ACCESS

A4.1.1 PCI

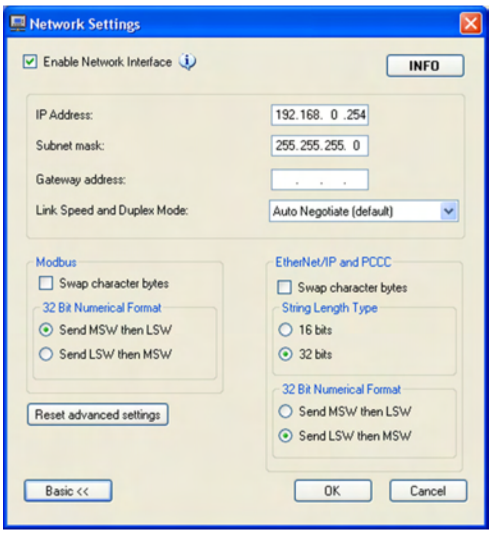
1) Click on button 

. The popup menu screen 173 is shown.

2) Click on 

to expand menu.

3) At screen 173 check *Enable Network Interface* and fill in remaining parameters for *Normal* and *Advanced Settings* as detailed below.



Screen 173

☛ *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 Gateway Address for the Safety Controller is disabled.

Link Speed & Duplex Mode

The following speed and duplex options are available for the Safety Controller. 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

To close advanced settings:

4) Click on 

to retract menu.

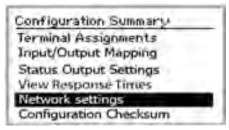
Menu reverts to normal settings.

5) On completion click **OK**.

A4.1.2 OBI

☛ *The Network settings feature is for viewing only.*

1) At screen 174, scroll down menu and choose *Network settings* then press ***OK***.



Screen 174

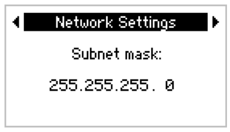
☛ *Procedure is similar to that detailed in block A4.1.1 on page 119.*

Sub-menu screens are shown as follows:

IP Address

Screen 175

Subnet Mask

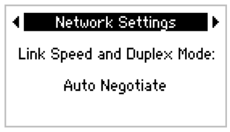


Screen 176

Gateway Address

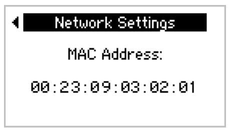
Screen 177

Link Speed & Duplex Mode



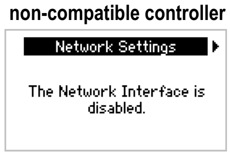
Screen 178

MAC Address



Screen 179

Displayed when trying to connect with a non-compatible controller



Screen 180

A4.2 ETHERNET/IP ASSEMBLY OBJECTS

Input (T->O) Assembly Objects

The following Instance IDs are supported:

- Instance ID 100 (0x64) with a data length of four 16-bit words
- Instance ID 101 (0x65) with a data length of forty-two 16-bit words
- Instance ID 102 (0x66) with a data length of one hundred forty 16-bit words

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.

A4.3 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 (e.g., "My Computer" or Windows Explorer).

Any references in this Appendix to files are referring to these support files. All of these files are also available on http://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.

A4.3.1 Retrieving Current Fault Information

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

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.

A4.3.2 Retrieving Fault Log Information

1) To retrieve information via network communications about faults contained in the fault log, the following procedure may be used:
2) 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.
3) Compute the real time that the Safety Controller powered up (e.g., hour, minute, second) by using the Seconds Since Power-up number with a real time reference.
4) 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.
5) 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.
6) 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.
7) 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.

A4.4 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 on the "Advanced" button 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 D-4.

Virtual Status Output

The reference designator associated with a particular Virtual Status Output (e.g. VO10 is Virtual Status Output ten).

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.

Intentionally left blank

A5 GLOSSARY & ABBREVIATIONS

A5.1 LIST OF ABBREVIATIONS

AOPD	Active Opto-Electronic Protective Device
AOPDDR	Active Opto-Electronic Protective Device Responsive to Diffuse Reflection
COS	Change of State
EDM	External Device Monitoring
EN	Engineering Norm
ESPE	Electro-sensitive Protective Equipment
FMEA	Failure Mode & Effects Analysis
FSD	Final Switching Device
HMI	Human Machine Interface
IEC	International Electro-technical Commission
IP...	Ingress Protection (Class)
ISO	International Organisation for Standardisation
LCD	Liquid Crystal Display
LED	Light Emitting Diode
ME	Mute Enable
ML	Mute Lamp
MSSI	Mutable Safety Stop Interfaces
MPCE	Machine Primary Control Element
N.O.	Normally Open
N.C.	Normally Closed
OBI	On Board Interface
OSSD	Output Signal Switching Device
PCI	PC Interface
PL	Performance Level
PLC	Programmable Logic Controller
prEN	preliminary European Norm
PSSD	Presence Sensing
PSDI	Presence Sensing Device Initiation
QD	Quick Disconnect
SIL	Safety Integrity Level
SSI	Safety Stop Interface
USB	Universal Serial Bus
VAC	Voltage Alternating Current
V dc	Voltage Direct Current

A5.2 GLOSSARY OF TERMS

The following terms are used often in this manual. Where possible, this manual uses definitions from the U.S. and international product performance standards that govern the design of the Safety Controller. Additional definitions are available on http://www.bannerengineering.com/iknow.

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. No *Manual Reset* operation is required for the *Safety Output* to turn on when controlled only by *Safety Input* devices configured for *Automatic Reset*.

☛ *When Automatic Reset is selected, the Input Device may be said to be configured to run in Trip mode.*

Change-of-state: The change of an input signal when it switches from *Run*-to-*Stop* or *Stop*-to-*Run* state. *Dual channel* input signals, have two possible configurable COS settings describing the signal disparity limits that can exist between channels before a fault condition is registered; Simultaneity and Concurrent.

☛ *Simultaneity vs. Concurrency. If Simultaneity is a requirement or a concern for the application, the user has to ensure that the correct selection was made during the configuration.*

Closed-open debounce time: The time required 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. Default is 50 ms for mute sensors, 6 ms for other devices.

☛ *A longer Closed-open debounce time will also affect and increase the Response Time of the system and/or the Machine response time (see page 124).*

Code validation: The configuration code file inspection process automatically performed by the *Controller* to verify that the configuration code has not been corrupted or altered in any way.

Concurrent: The setting that permits an indefinite signal disparity between channels, without going into a fault condition. A fault condition is created if the *Stop* signal changes back to a Run signal before its allied signal changes to the *Stop* state. Both signals must change from the *Stop* state to the *Run* state before the *Dual channel* device is considered to be in the *Run* state.

Control Reliability: A method of ensuring the performance integrity of a control system. Control circuits are designed and constructed so that a single failure or fault within the system does not prevent the normal stopping action from being applied to the machine when required, or does not create unintended machine action, but does prevent initiation of successive machine action until the failure is corrected.

Designated Person: An individual identified and designated in writing, by the employer, as being appropriately trained to perform a specified checkout procedure. See designated person as specified in block 1.8.1 (see also qualified person on page 125).

Detection Zone: The light curtain generated by the System. When the detection Zone is interrupted by an opaque object of a specified cross section or larger, a trip condition (or latch condition, depending on the Controller) results.

Emitter: The light-emitting component of a safety light screen system, consisting of a row of synchronized modulated LEDs. The emitter, together with the receiver (placed opposite), creates a "screen of light" called the defined area.

E-Stop: Special switch push button positioned in strategic locations and used for shutting off electrical power and motion in an emergency to the machine.

External Device Monitoring (EDM): A means by which a safety device (such as a safety light screen) actively monitors the state (or status) of external devices that may be controlled by the safety device. A lockout of the safety device results if an unsafe state is detected in the external device. External device(s) may include, but are not limited to: MPCEs, mechanically linked relays/contactors, and safety modules.

Failure to Danger: A failure which delays or prevents a machine safety system from arresting dangerous machine motion.

False Proxing: Sensor activation due to shiny or reflective surfaces.

Final Switching Device (FSD): The component of the machine's safety-related control system that interrupts the circuit to the machine primary control element (MPCE) when the output signal switching device *(OSSD)* goes to the *OFF* state.

Fixed or Hard Guarding: Screens, bars, or other mechanical barriers affixed to the frame of the machine intended to prevent entry by personnel into the hazardous area(s) of a machine, while allowing the *Point-of-Operation* to be viewed. The maximum size of openings is determined by the applicable standard.

FMEA (Failure Mode and Effect Analysis): A testing procedure by which potential failure modes in a system are analysed to determine their results or effects on the system. Component failure modes that produce either no effect or a Lockout condition are permitted; failures which cause an unsafe condition (a failure to danger) are not. *Banner* safety products are extensively FMEA tested.

Forced-Guided Contacts: Relay contacts that are mechanically linked, so that when the relay coil is energized or de-energized, all of the linked contacts move together. If one set of contacts in the relay becomes immobilized, no other contact of the same relay is able to move. The function of forced-guided contacts is to enable the safety circuit to check the status of the relay. Forced-guided contacts are also known as "positive-guided contacts," "captive contacts," "locked contacts," or "safety relays."

Hazardous Area: An area that poses an immediate or impending physical hazard.

Hazard Point: The closest reachable point of the hazardous area.

Key System Reset (Manual Reset): A key-operated switch used to *Reset* a *Safety Light Screen* for example, to the *ON* state following a *Lockout* condition. Also refers to the act of using the switch to *System Reset* a safety system from a *Latch* condition.

Latch Condition: The response of the *Safety Output* (e.g. *OSSDs*) of a safety light screen system when an object equal to or greater than the diameter of the specified test piece enters the defined area. In a *Latch* condition, *Safety Output* simultaneously de-energize and open their contacts. The contacts are held (latched) open until the object is removed from the defined area and a *Manual Reset* is performed. A latching output is used most often in perimeter guarding applications (see trip condition on page 125).

Lockout Condition: A *Safety Light Screen* system condition that is automatically attained in response to certain failure signals (an internal *Lockout)*. When a *Lockout* condition occurs, the *Safety Light Screen* system's *Safety Output* turns *OFF*, and a *Manual Reset* is required to return the system to *Run* mode. Requires the attention of a qualified person as specified in block 1.8.2 on page 4.

Machine Operator: An individual who performs production work and who controls operation of the machine.

Machine Primary Control Element (MPCE): An electrically-powered element, external to the safety system, which directly controls the machine's normal operating motion in such a way that the element is last (in time) to operate when machine motion is either initiated or arrested.

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.

☛ *When Manual Reset is selected, the Input Device may be said to be configured to run in Latch mode; meaning that the controlled output has latched to the OFF state and requires a Manual Reset to turn back ON. This Reset is sometimes called a Manual Latch Reset.*

Mapped to: 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.

Minimum Safety Distance: That distance, along the direction of approach, between the outermost position at which the appropriate test piece is just detected and the nearest dangerous machine part(s).

Muting: The *Automatic* suspension of the *Safeguarding* function of a safety device during a non-hazardous portion of the machine cycle.

OFF State: 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 0V dc nominally.

ON State: 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 24V dc nominally.

Open-closed debounce time: The required time to bridge a jittery input signal or bouncing of input contacts to prevent unwanted start of the machine. Adjustable from 10ms to 500ms. Default is 50ms.

☛ *A longer Open-closed debounce time will also affect the reaction time of the Controller.*

Output Signal Switching Device (OSSD): The *Safety Output* that is used to initiate a *Stop* signal.

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.”

Point-of-Operation: the location of a machine where material or a workpiece is positioned and a machine function is performed upon it.

Positive-Opening Safety Switches: Term used with reference to *E-Stops*. A mechanical force applied to such a button (or switch) is transmitted directly to the contacts, forcing them open without the use of springs. This ensures that the switch contacts open whenever the switch is activated even if a contact has welded closed.

Presence-Sensing-Device Initiation (PSDI): An application in which a presence-sensing device is used to actually start the cycle of a machine. In a typical situation, an operator manually positions a part in the machine for the operation. When the operator moves out of the hazardous area, the presence-sensing device starts the machine (no start switch is used). The machine cycle runs to completion, and the operator can then insert a new part and start another cycle. The presence-sensing device continually safeguards the machine. Single break mode is used when the part is automatically ejected after the machine operation. Double break mode is used when the part is both inserted (to begin the operation) and removed (after the operation) by the operator.

Qualified Person: An individual who, by possession of a recognized degree or certificate of professional training, or by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve problems relating to the subject matter and work. See qualified person as specified in block 1.8.2 on page 4 (see also designated person on page 123).

Receiver: the light-receiving component of a *Safety Light Screen* system, consisting of a row of synchronized photo transistors. The *Receiver*, together with the *Emitter* (placed opposite), creates a “screen of light” called the defined area.

Reset: The use of a manually operated switch to restore the *Safety Output* to the *ON* state from a lockout or a *Latch* condition.

Response Time: The time between the physical initiation of the safety device and the machine coming to a stop or the risk being removed.

Run State: 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.

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.”

Simultaneity: The setting that permits a signal disparity between channels within the *Input Device* for a limited time, without going into a fault condition. If a signal disparity exists for more than 3 seconds, then a fault condition occurs.

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 *Gate Switches*, 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 it is clear at power up, it would be necessary to cycle the *Safety Light Screen* one time (from *ON* to *OFF* and back to *ON)*, even if the *Controller* has been configured for auto power up.

Stop State: 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.

Supplementary Guarding: Additional or fixed guarding, used to prevent a person from reaching over, under, through or around the primary safeguard or otherwise accessing the guarded hazard.

System Reset: The term used to describe a *Manual 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.

Trip Condition: the response of the *Safety Output* (e.g. *OSSDs)* of a safety light screen system when an object equal to or greater than the diameter of the specified test piece enters the defined area. In a *Trip* condition, the *OSSDs* simultaneously de-energize. A *Trip* condition clears *(Resets*) automatically when the object is removed from the defined area (see also Latch Condition on page 124).

TUV (Technischer Überwachungsverein): independent testing and certification organization providing EMC (electromagnetic compatibility) and product safety testing, certification, and quality management systems registration.

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