



Minotaur Safety Relay (MSR) to Guardmaster Safety Relay (GSR) Conversion - Phase 4

Catalog Numbers 440R-S35001, 440R-S35003, 440R-S35002,
440R-W23219, 440R-W23220, 440R-W23218, 440R-W23217,
440R-23221, 440R-W23222, 440R-W23223, 440R-W23224,
440R-W23225, 440R-W23226



Allen-Bradley

by ROCKWELL AUTOMATION

Guardmaster®

Reference Manual

Original Instructions

Important User Information

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

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

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

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.



WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.



ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

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

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



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



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



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

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Notes:

A number of older Allen-Bradley Guardmaster® safety relays are discontinued and no longer available for sale. This publication suggests examples for how to convert these existing safety relay applications to safety relays with the latest technologies.

The products that are described in this publication can be used in various ways. Therefore, you must verify that each application and use of this control equipment meets all performance and safety requirements. Designers must consider applicable laws, regulations, codes, and standards.

The wiring diagrams in this publication are intended as examples. Because many variables and requirements are associated with any particular installation, Rockwell Automation does not assume responsibility or liability for actual use that is based on these examples.

The following MSR safety relays will continue to be offered for the foreseeable future (five or more years).

MSR Family	Cat. No.	MSR Family	Cat. No.	MSR Family	Cat. No.	MSR Family	Cat. No.
MSR125	440R-D23171	MSR127	440R-N23126	MSR132	440R-E23191	MSR138	440R-M23080
	440R-D23170		440R-N23129		440R-E23192		440R-M23143
	440R-D23169		440R-N23125		440R-E23193		440R-M23143S
	440R-D23168		440R-N23128		440R-E23194		440R-M23141
	440R-D23166		440R-N23124		440R-E23195		440R-M23140
	440R-D23164		440R-N23127		440R-E23097		440R-M23147
	440R-D23163		440R-N23132		440R-E23159		440R-M23147S
MSR126	440R-N23117		440R-N23135	MSR142	440R-E23160		440R-M23145
	440R-N23116		440R-N23132S		440R-E23098		440R-M23144
	440R-N23115		440R-N23135S		440R-E23161		440R-M23151
	440R-N23114		440R-N23131	MSR131	440R-E23162		440R-M23149
	440R-N23113		440R-N23134		440R-G23214		440R-M23148
	440R-N23112		440R-N23130		440R-G23215		440R-M23084
	440R-N23123		440R-N23133		440R-G23215		440R-M23082
	440R-N23122		440R-N23213		440R-C23139		440R-M23081
	440R-N23121	MSR5T	440R-B23020		440R-C23139S		440R-M23088
	440R-N23120	MSR117	440R-B23211		440R-C23137		440R-M23086
	440R-N23119	MSR124	440R-G23107		440R-C23136		440R-M23085
	440R-N23118		440R-G23108				440R-M23092
			440R-G23110				440R-M23090
							440R-M23089

Who Should Use this Manual?

This publication is intended for those machine safeguard system designers who have been adequately trained in the design and use of safeguard systems and risk assessments.

Use this manual to guide the conversion from the CU3 control unit to the MSR55P safety relay. This manual provides guidance on the differences between the control units' key features to help you select an appropriate solution for your application. You must perform a risk assessment of your converted design to confirm it meets your safeguarding requirements.

Additional Resources

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

Resource	Description
Guardmaster EtherNet/IP Network Interface User Manual, publication 440R-UM009	Provides detailed information to install, wire, configure, troubleshoot, and use the EtherNet/IP™ module.
Guardmaster Safety Relays User Manual, publication 440R-UM013	Provides detailed information to install, wire, configure, troubleshoot, and use Guardmaster safety relays.
Minotaur Safety Relay User Manual, publication 440R-UM014	Provides detailed information to install, wire, configure, troubleshoot, and use the Minotaur™ MSR55P safety relay.
Guardmaster Configurable Safety Relay, Publication 440C-UM001	Provides detailed information to install, wire, configure, troubleshoot, and use the Guardmaster configurable safety relay.
System Design for the Control of Electrical Noise Reference Manual, publication GMC-RM001	Provides a thorough review of the installation and grounding of noisy components and what can be done to minimize their potential to inject noise into the system.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation® industrial system.
Product Certifications website, rok.auto/certifications	Provides declarations of conformity, certificates, and other certification details.

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

Introduction

Product Overview

The next generation Guardmaster® safety relay (GSR) family is a high-quality replacement for most of the Minotaur™ safety relay (MSR) family.

The consistent 22.5 mm (0.9 in.) wide housing design and configurable functions for reset and logic of GSR modules let you consolidate various functions of MSR modules with fewer relays. These features help you reduce your stocking requirements.

The MSR family of safety relays typically offers one dedicated safety function for each safety circuit and actuator. MSR solutions have less connectivity to each other than GSR modules. If you add safety circuits, those circuits require additional safety relay modules and safety contacts for cascading to the maintain PLd or PLe safety ratings according to EN ISO 13849-1 or SIL 2 or SIL 3 according to IEC 62061.

The GSR family of safety relays offers configurable safety functions and consolidated safety circuits, which result in fewer units, less space, and less cost. Due to the unique capability to cascade single-wire safety (SWS), logic combinations and zones are constructed quickly.

A replacement with GSR modules is meant to be more than just a swap out.

New Machinery Directives have changed the designs of machines over the years. These changes have harmonized standards and demands of safety solutions that contribute to productivity and flexibility.

This publication offers detailed information to help with your conversion from the legacy MSR family to a smarter and cost-effective design of machine in compliance with the latest requirements of Machinery Directive and harmonized standards.

For further assistance in replacing those devices, contact Rockwell Automation support, your local Allen-Bradley distributor, or Rockwell Automation sales office.

GSR Benefits

The GSR family of safety relays provides the following benefits:

- One or two (dual-channel) inputs
- Single wire safety (SWS) expansion
- Narrow package (less panel space)
- Configurable operation
- Cat 4 PLe and SIL 3 rating on most models
- RoHS compliance

Conversion Concerns

Product obsolescence is a part of the industrial business cycle. This publication provides cost-effective recommendations for converting your MSR family of safety relays to the state-of-the-art GSR family, and considers the following major concerns.

Panel Space

Many control panel designers leave space in their panels for future expansion and improvements. Panel space can become tight as the extra space is used. With panel space in mind, the recommended conversion is intended to maintain, or even reduce, panel space.

Wiring Terminal Location

The need to move a wire from the top of the old device to the bottom of the new device in a control panel cannot be taken lightly. Each of the recommended conversions shows the terminal locations of the old and new devices, so you can plan the conversion appropriately.

Wiring Change

Example schematics are provided that compare the older device and the recommended newer device for each of the applications that the older device can provide.

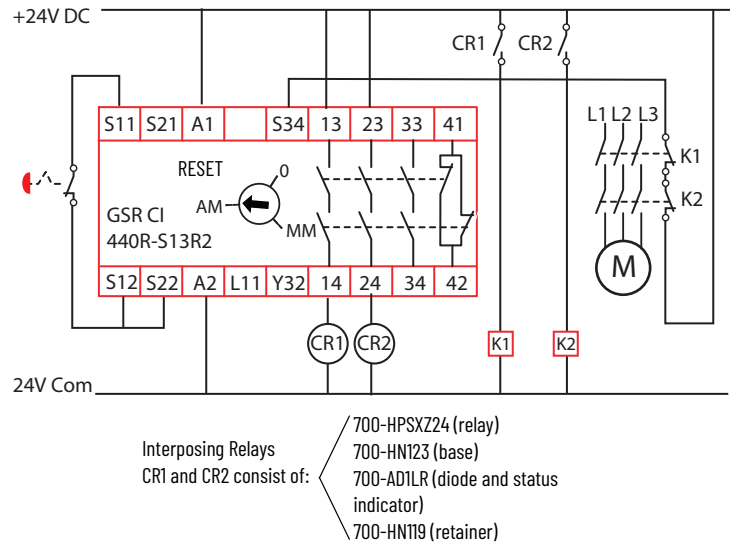
Response Time

Response time is the time that is required to perform the safety function. For each conversion, the comparable response time is provided. An increase in the response time requires you to adjust the safety distance. This increase is not as much of an issue when a safety gate must be opened manually. However, this additional response time is likely to be an issue when presence-sensing devices like light curtains and safety mats are used.

Output Load Capability

Every safety relay has limitations on the amount of current the relay can switch or carry. When the load exceeds the rating of the safety relay, you can use relays that interpose, as shown in [Figure 1](#).

Figure 1 - Output Load Capability Using Interposing Relays



Notes:

CU3 Control Unit



In late 2019, Rockwell Automation launched the MSR55P safety relay to provide additional features for monitoring the speed of a motor as the motor spins down to a stopped condition by sensing the back EMF of the motor. The MSR55P safety relay has been well accepted, and the CU3 control unit is now being obsolete.

Feature Comparison

[Table 1](#) compares the key feature differences between the CU3 control unit and the MSR55P safety relay. The MSR55P safety relay has several features that the CU3 control unit does not.

Table 1 - Key Feature Comparison

Feature	CU3	MSR55P
Panel space	45 mm (1.77 in.)	45 mm (1.77 in.)
Single-phase motor monitoring	Yes	Yes
Three-phase motor monitoring	No	Yes
Output monitoring	Yes	Yes
Fault output reporting	No	Yes
Monitors induction motors	Yes	Yes
Monitors servo motors	Not recommended	Yes
Adjustable threshold	Yes	Wider range
Delayed output capability	No	Yes
Safety rating	Cat 1	Cat4 PLe, SIL 3

Power Supply and Thresholds

The power supplies for the CU3 control unit and the MSR55P safety relay are similar, however, 24V AC cannot power the MSR55P safety relay. If the CU3 control unit is powered by 24V AC, you must provide an AC to DC converter to use the MSR55P safety relay.

[Table 2 on page 12](#) lists the CU3 control unit catalog numbers, threshold voltage range, and typical applications. [Table 3 on page 12](#) lists the MSR55P safety relay catalog numbers, threshold voltage range, and typical applications.

Table 2 - CU3 Catalog Options

Cat. No.	Supply Voltage	Standstill Monitoring Voltage Threshold	Typical Applications
440R-S35001	24V AC/DC	Up to 2.5V	Induction motors
440R-S35002	110V AC		
440R-S35002	230V AC		

Table 3 - MSR55P Catalog Options

Cat. No.	Supply Voltage	Standstill Monitoring Voltage Threshold	Typical Applications
440R-S35011	24V DC	20...400 mV	Induction motors
440R-S35012	115V AC		
440R-S35013	230V AC		
440R-S35014	24V DC	200 mV...4V	Servo (permanent magnet) motors
440R-S35015	115V AC		
440R-S35016	230V AC		

Threshold and Delay Settings

Both the CU3 control unit and the MSR55P safety relay have a potentiometer for adjusting the back EMF threshold setting. To access the threshold setting adjustment in the CU3 control unit, you must open the front cover. The MSR55P safety relay has the threshold setting adjustment on the front face.

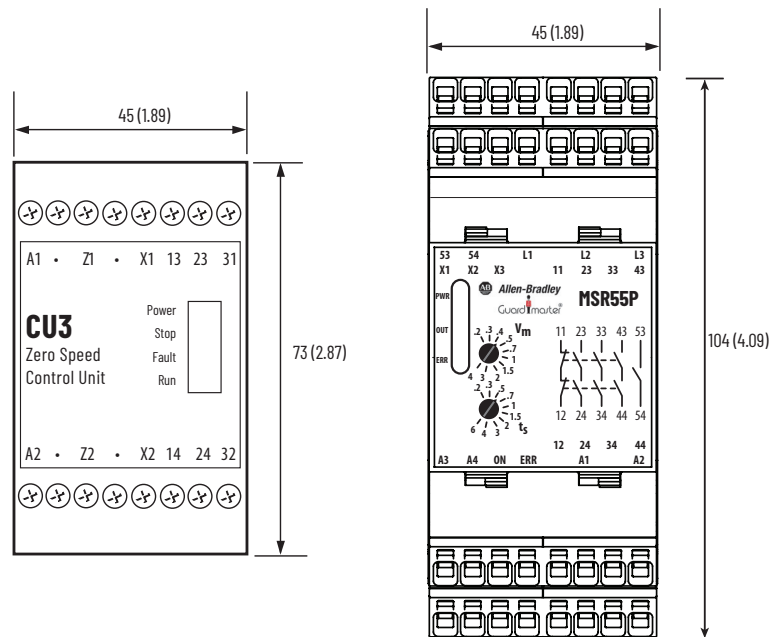
In addition, the MSR55P safety relay has a second potentiometer on the front face. This potentiometer is for adjusting a delay time from when standstill is detected to when the outputs are energized. This feature provides additional assurance that the motor has achieved a steady state speed that is considered safe.

Terminal Locations and Panel Space

[Figure 2 on page 13](#) shows the relay sizes and terminal locations. The CU3 control unit has one row of terminals at the top and bottom. The MSR55P safety relay has two rows of terminals at the top and bottom to accommodate the features that the CU3 control unit does not have.

Both control units are 45 mm (1.77 in.) wide. The MSR55P safety relay is taller. To achieve optimal heat dissipation, 50 mm (2 in.) of spacing is recommended above and below each control unit.

Figure 2 - Terminals and Panel Space [mm (in.)]



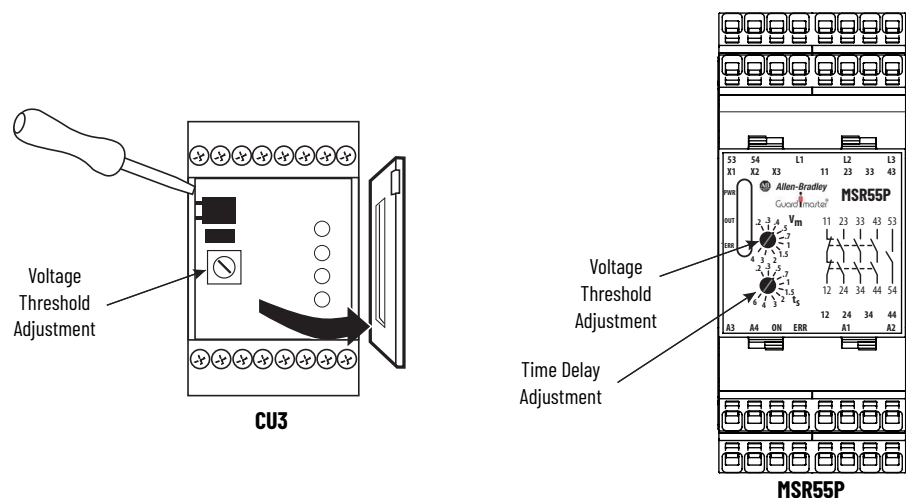
Threshold Settings

[Figure 3](#) shows the adjustment locations.

To access the voltage threshold adjustment on the CU3 control unit, use a screwdriver to pop open the cover. Use a screwdriver to rotate the potentiometer to the desired setting.

The MSR55P safety relay potentiometers are on the front face. Use a screwdriver to adjust both the voltage threshold and the desired time delay so the motor can achieve a safe standstill motion.

Figure 3 - Threshold and Delay Settings



Wiring Schematics

Figure 4 and Figure 5 show a direct comparison of schematics between the CU3 control unit and the MSR55P safety relay with Power to Release guard locking interlocks.

Figure 4 - TLS1-GD2 Guard Locking Example

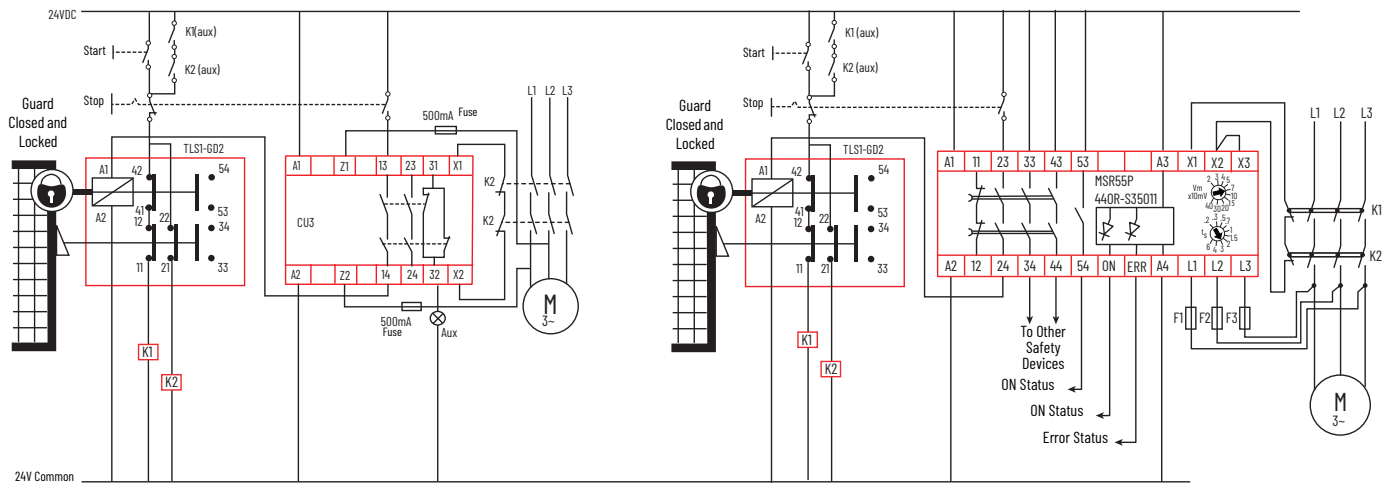
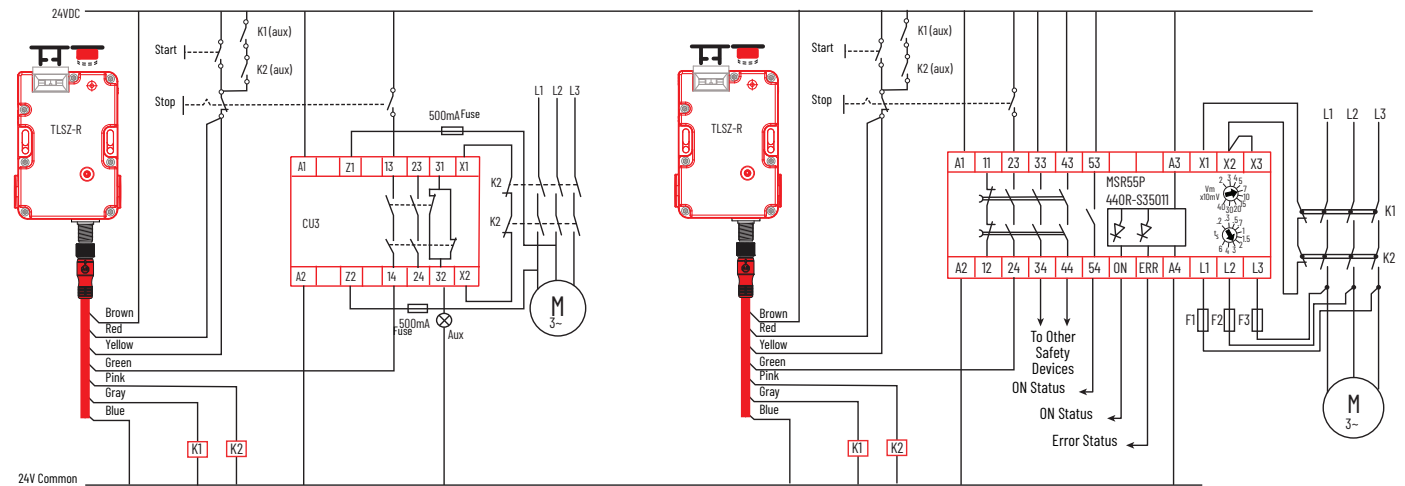


Figure 5 - TLSZ-R Guard Locking Example



Output Load Capability

The following table compares the output load capabilities of the CU3 control unit and MSR55P safety relay. The output switching capability of the two relays is similar. For AC loads, the MSR55P safety relay is derated when operating at higher ambient temperatures.

The MSR55P safety relay has a higher DC current rating than the CU3 control unit.

Load Description	CU3	MSR55P
AC-15 B300	5 A @ 250V AC 5 A @ 120V AC	5 A @ 250V AC @ 40 °C (104 °F) 2 A @ 250V AC @ 60 °C (140 °F)
DC	3 A @ 24V DC	4 A @ 24V DC

Feedback Monitoring

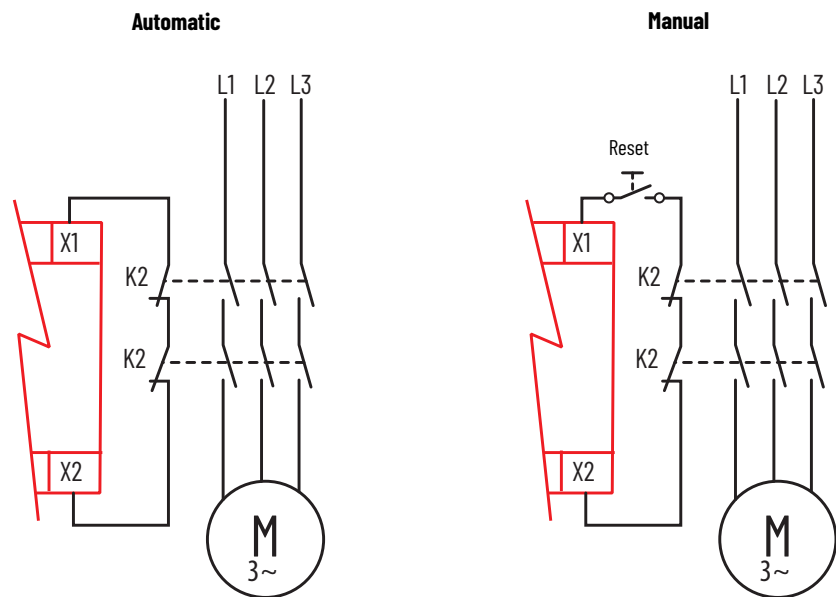
As shown in [Figure 6](#), both the CU3 control unit and the MSR55P safety relay are able to monitor their respective output devices with automatic/manual monitoring on terminals X1 and X2.

Automatic monitoring is accomplished by connecting the monitored contacts in series to X1 and X2. Manual reset is accomplished by adding a momentary normally open push button in series with the monitored contacts.



Upon manual reset, the MSR55P displays a fault code 4.

Figure 6 - Automatic and Manual Reset



Notes:

MSR300 Safety Relay



The best migration for the MSR300 safety relay is to the GSR relays. This migration can use many of the GSR relays due to the various relay configurations of the MSR300 safety relay.

Alternatively, you can migrate the MSR300 safety relay to the CR30 safety relay. The CR30 safety relay requires a computer that runs Connected Components Workbench™ software to accomplish the configuration. The Connected Components Workbench software is a free download from Rockwell Automation.

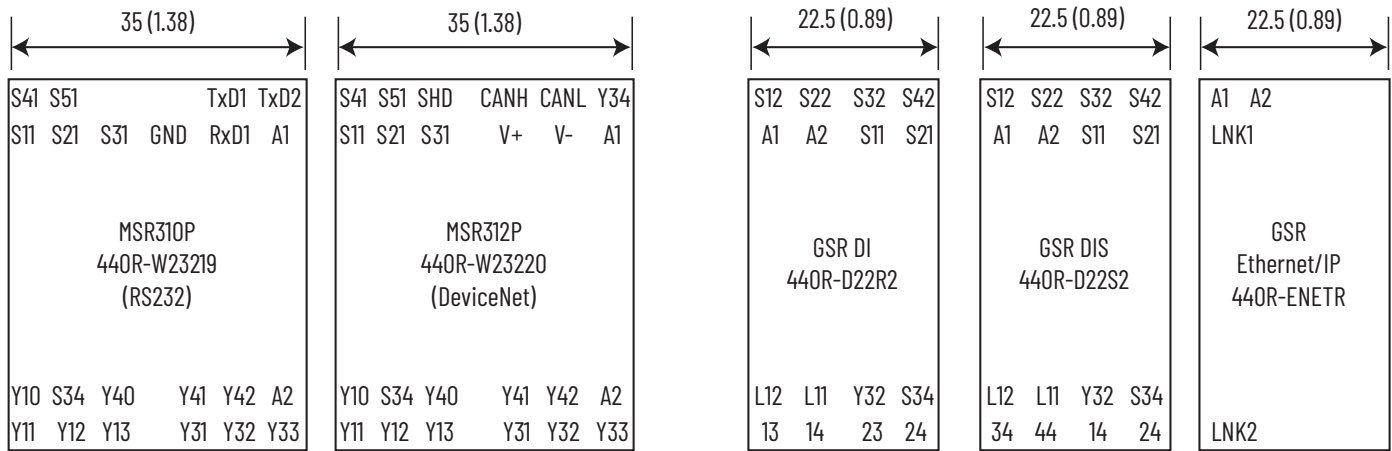
Terminal Locations and Panel Space

Host Module

The host module for the MSR300 safety relay is either an MSR310P or an MSR312P. You can replace both of these modules with either a DI or DIS safety relay. The MSR3xx has a 35 mm (1.38 in.) wide body as compared to the 22.5 mm (0.89 in.) for the GSR relays.

If communications are used in the application, you must convert from RS-232 or DeviceNet® to Ethernet/IP™ and add the GSR ENTER module.

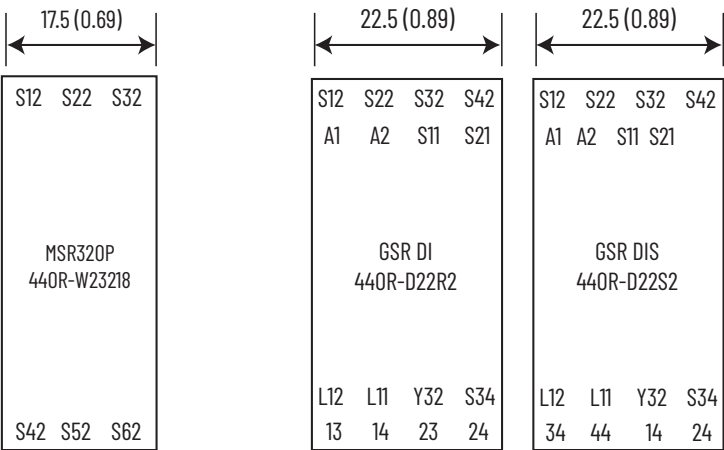
Figure 7 - Host Module Terminals and Panel Space [mm (in.)]



Input Module

Each MSR300 safety relay system must have at least one MSR320P safety relay input module and can have up to 10 input modules. An equivalent GSR module is the DI or DIS safety relay. The MSR320P safety relay occupies slightly less panel space at 17.5 mm (0.69 in.) compared to 22.5 mm (0.89 in.) for the GSR relays.

Figure 8 - Input Module Terminals and Panel Space [mm (in.)]

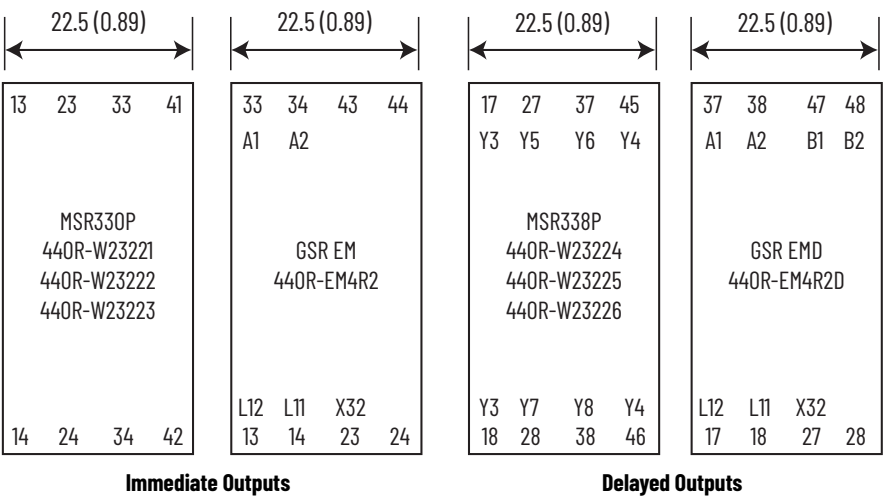


Output Module

Each MSR300 safety relay system must have at least one output module and can have up to six output modules. Equivalent modules in the GSR family are the EM safety relay for Immediate Outputs and the EDM safety relay for delayed outputs.

The significant difference is that the EM and EDM safety relays require power, ground and SWS connections, whereas the MSR330P and MSR338P safety relays get their power through the ribbon cable.

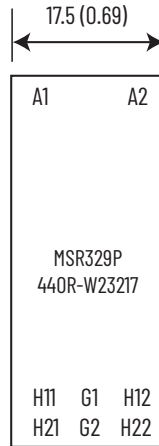
Figure 9 - Output Module Terminals and Panel Space [mm (in.)]



Muting Lamp Module

The MSR300 safety relay family has a separate muting lamp module: the MSR329. The GSR family has no equivalent; the machine control system can provide a muting lamp function.

Figure 10 - Muting Lamp Module Terminals and Panel Space [mm (in.)]

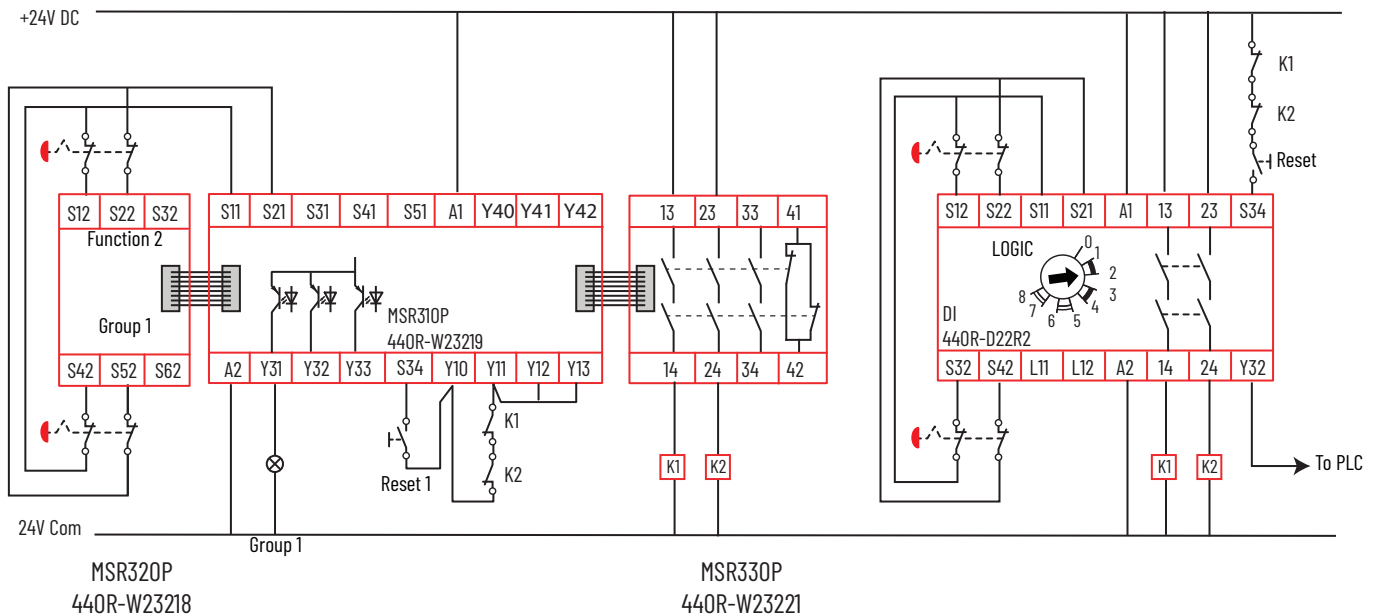


No Direct Replacement in GSR Family

Wiring Schematics

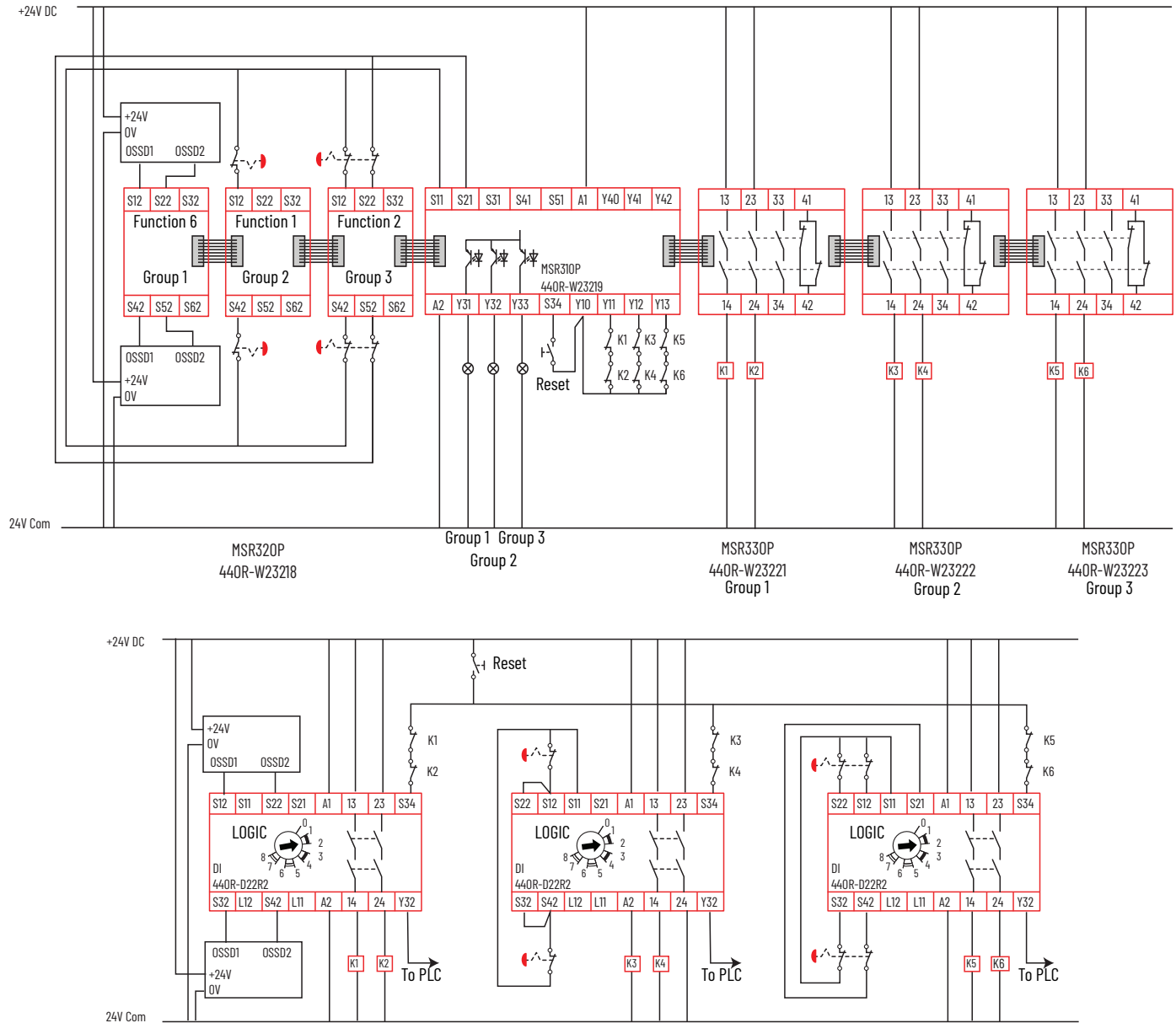
Single Input Module, Single Output Module

At the basic level, the MSR300 safety relay system has one input module and one output module. You can replace the MSR300 safety relay system with one DI safety relay.



Three Input Modules and Three Output Modules

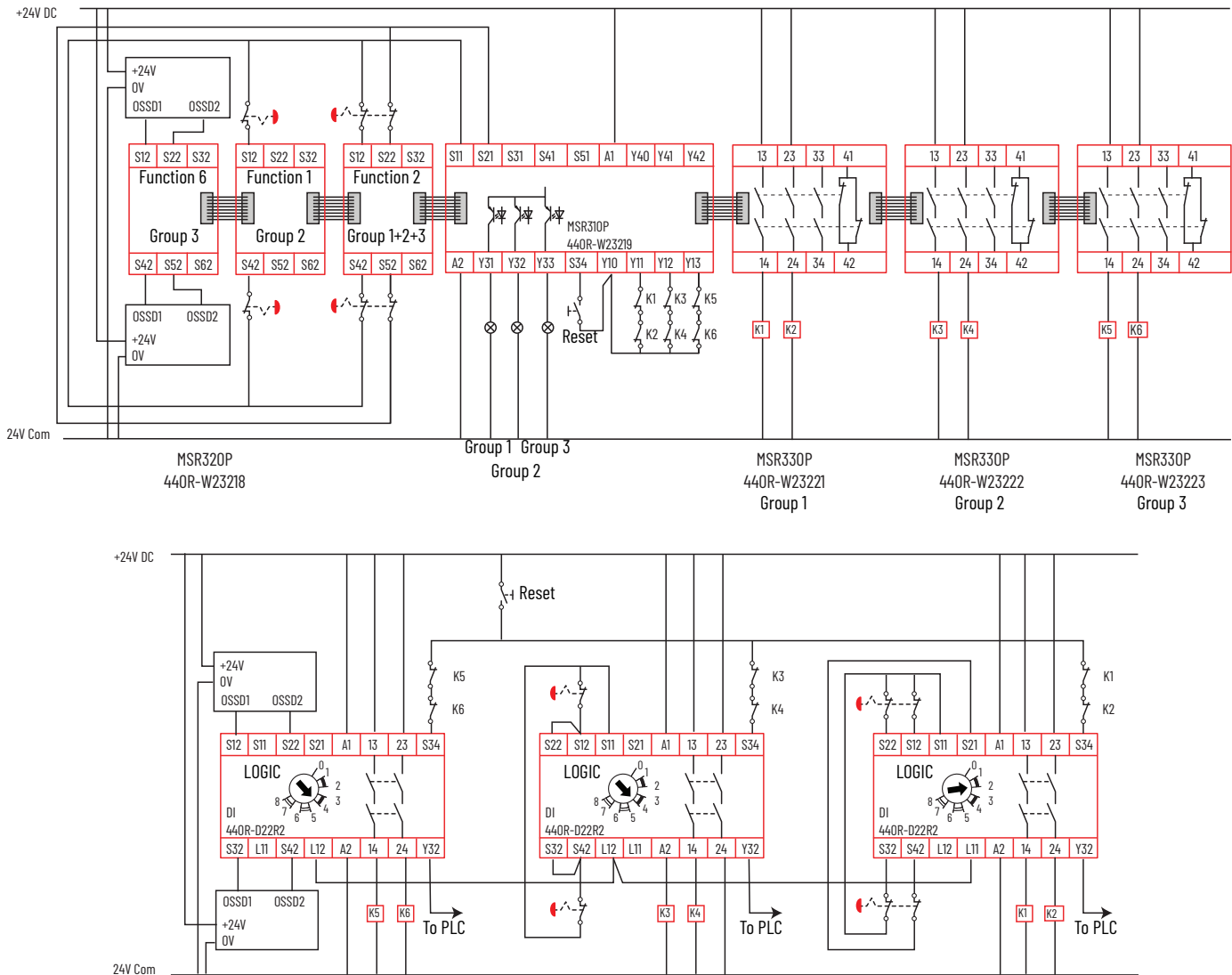
In the following example, the MSR300 safety relay has three input modules and three output modules. Each input module is set to another type of device (OSSD, single channel, and dual channel) and different output group (groups 1, 2, and 3). The equivalent GSR system is three DI safety relays. Both systems monitor the output contactors and one reset button resets the safety system.



Two Zones, Global E-stop

In the following example, the MSR300 safety relay has a global E-stop that turns off outputs groups 1, 2, and 3. Group 2 and 3 inputs control their respective outputs.

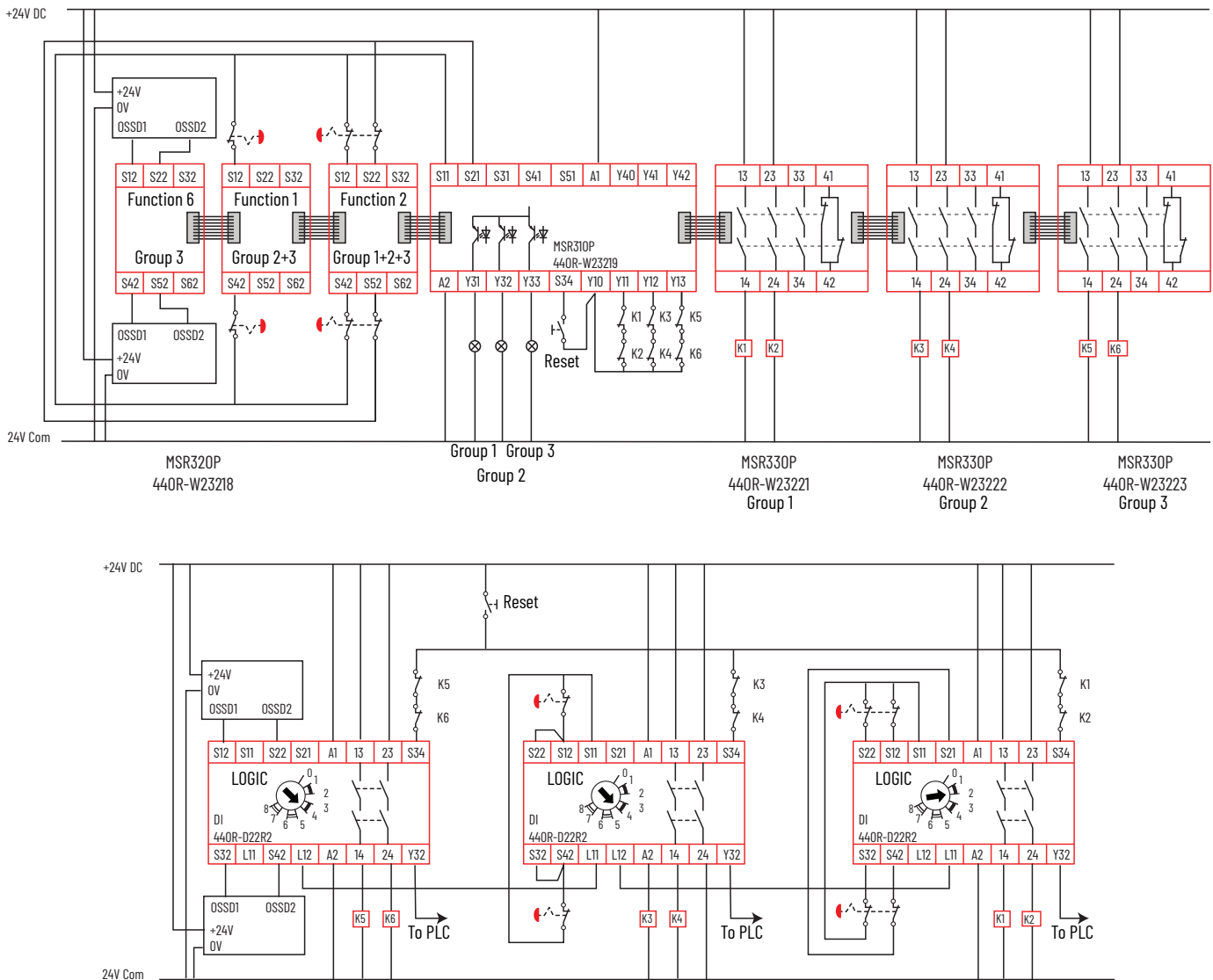
The GSR relays can use the Single Wire Safety signals on terminals L11 and L12 to perform the same global E-stop function. For the GSR system, the reset button must be pressed twice: the first press turns on the DI safety relay with dual-channel E-stop, the second press turns on the other two DI safety relays.



Global E-stop, Local E-stop

In the following example, the first MSR320P safety relay input module provides a global E-stop, which stops groups 1, 2 and 3. The middle MSR320P safety relay input modules stop groups 2 and 3. The third input module only stops the outputs in group 3. The GSR solution stops outputs with the Single Wire Safety connections on terminals L11 and L12.

For the GSR solution, you must press the reset button three times: the first press turns on the DI safety relay with the dual-channel E-stops, the second press turns on the DI safety relay with the single-channel E-stop, the third press turns on the DI safety relay with the OSSD devices.

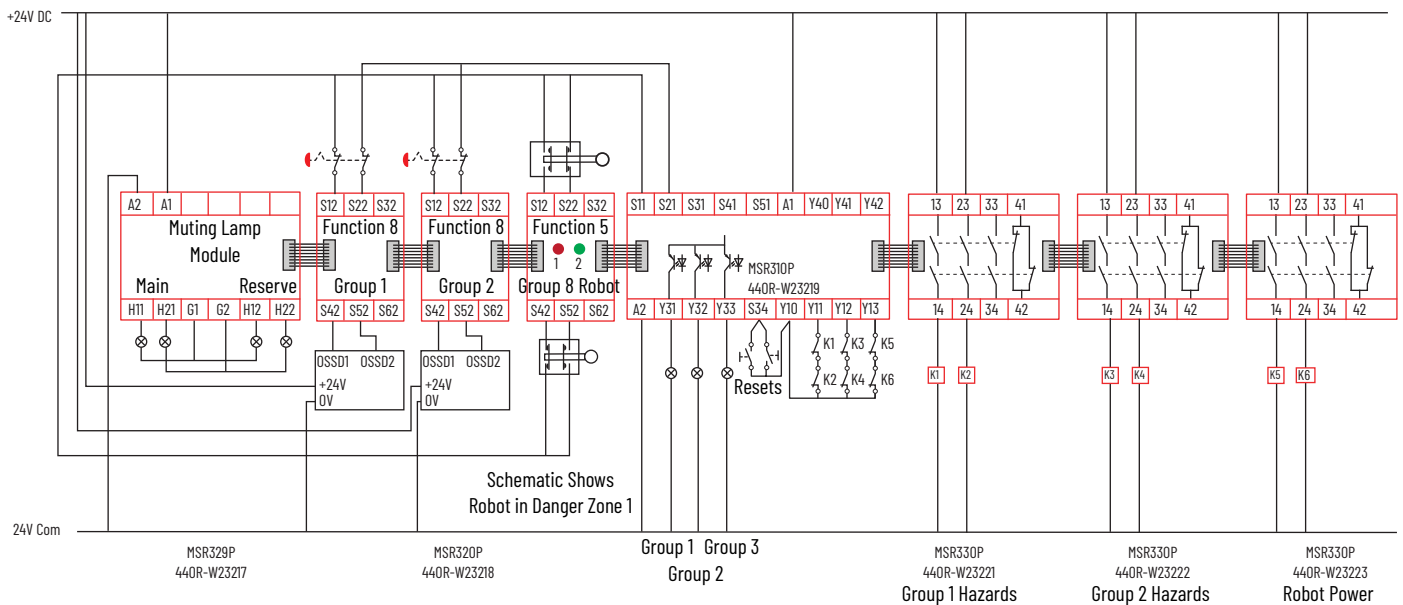
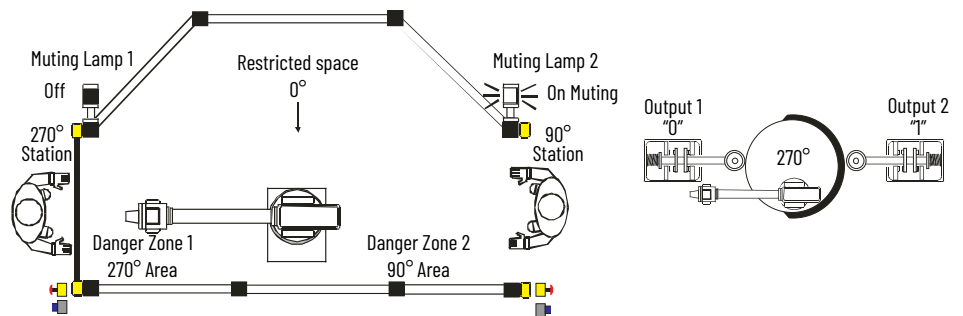


Robot Zone (Function 8)

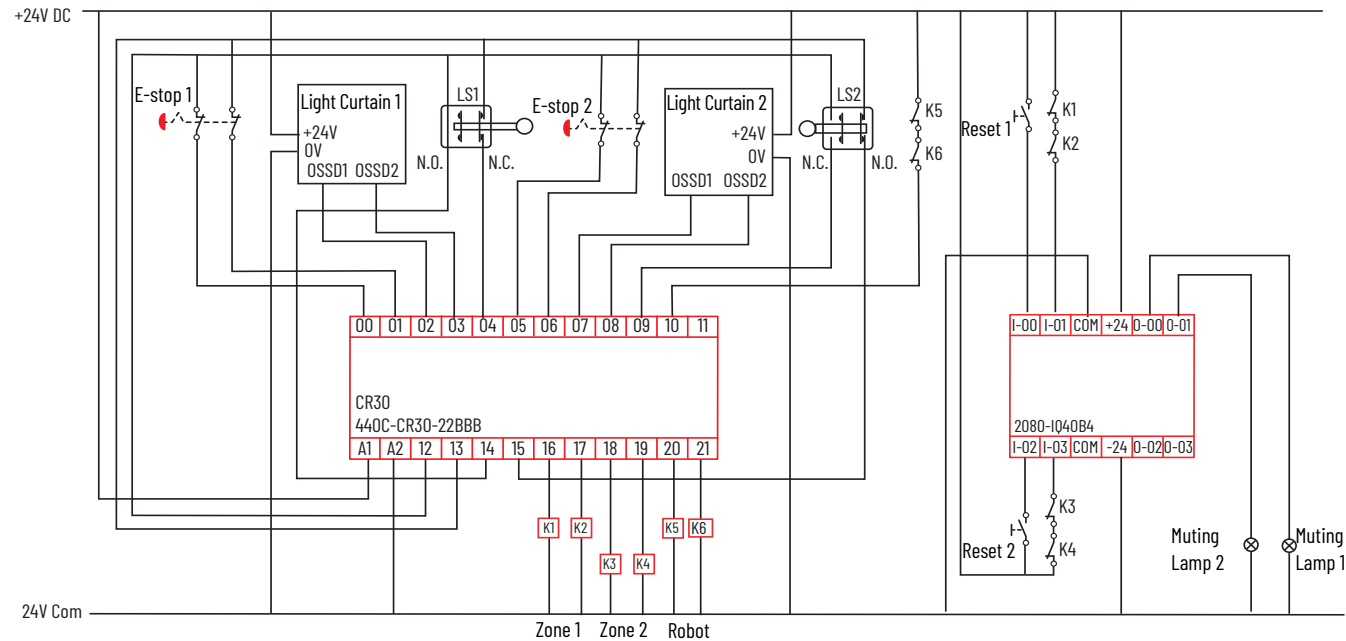
If one of the MSR300 safety relay input modules is set to '8', the MSR300 safety relay treats the safety system as a two-zone robot cell. While the robot is present in one danger zone, the safeguard devices in the other zone are muted.

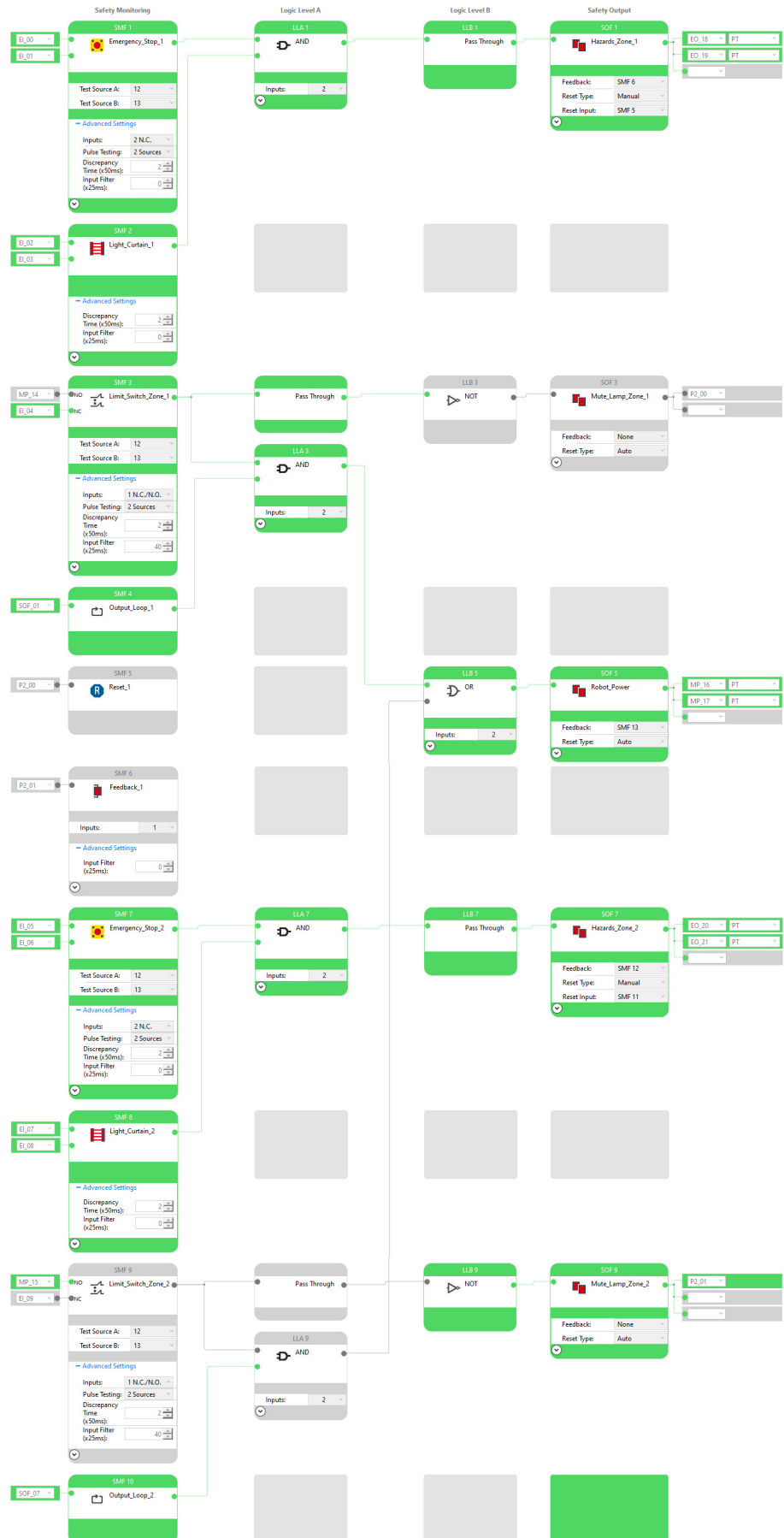
Safety rated limit switches with one N.O. and one N.C. contact detect the position of the robot. To convert the GSR solution, the limit switches must be changed to two N.C. plus one N.O. contacts.

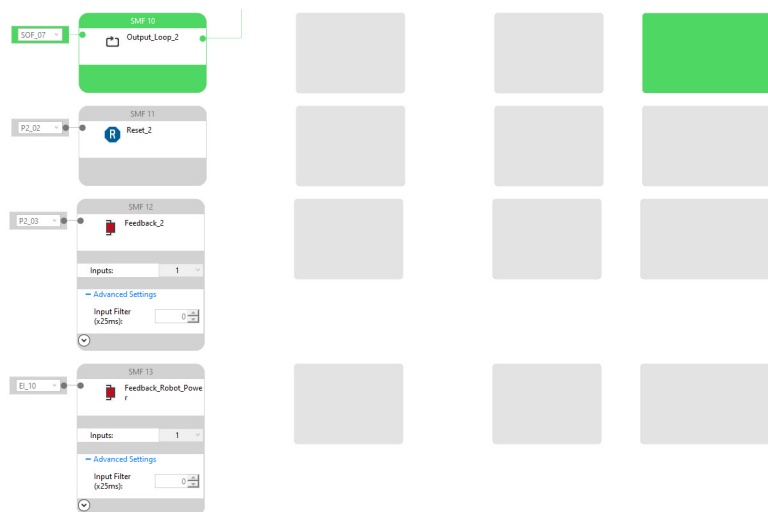
When the group 8 robot In1 LED is red, the robot is in danger zone 1. If the group 1 E-stop is pressed or the light curtain is blocked, both group 1 and robot power turn OFF (group 2 hazards remain energized). If the group 2 E-stop is pressed or the light curtain is blocked, only the group 2 outputs turn OFF. After the E-stop is released and the light curtain is cleared, the reset must be pressed to turn the group 2 hazards outputs back ON.



The CR30 safety relay with a 2080-IQ4OB4 plug-in module can replicate the robot zone function 8. The following schematic and logic diagram show the robot in zone 1.







The following schematic shows an equivalent circuit that uses the GSR relays. DIS safety relays are recommended as their solid-state outputs are pulse-tested. EM expansion relays provide voltage-free contacts to control the local hazards. The DI safety relay is suggested for robot power because it has electromechanical outputs.

Upon startup with the robot in zone 1, E-stops are released, and light curtains are clear; press reset once to energize the DIS safety relays 1, 3 and 4.

Press reset gain to energize the DIS safety relay 2.

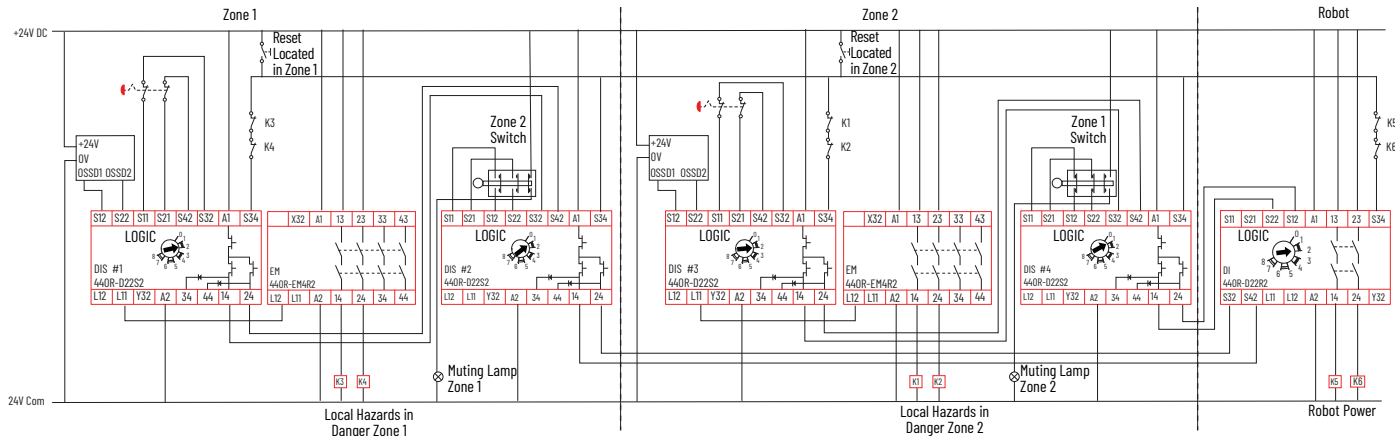
Press reset once more to energize the DI safety relay (robot power).

While the robot is in zone 1, if the E-stop is pressed or the light curtain is blocked in zone 1, the hazards in zone 1 and the robot power are de-energized. Zone 2 hazards remain energized.

After the E-stop is released and the light curtain is cleared, press the reset button three times to energize the hazards in zone 1 and robot power.

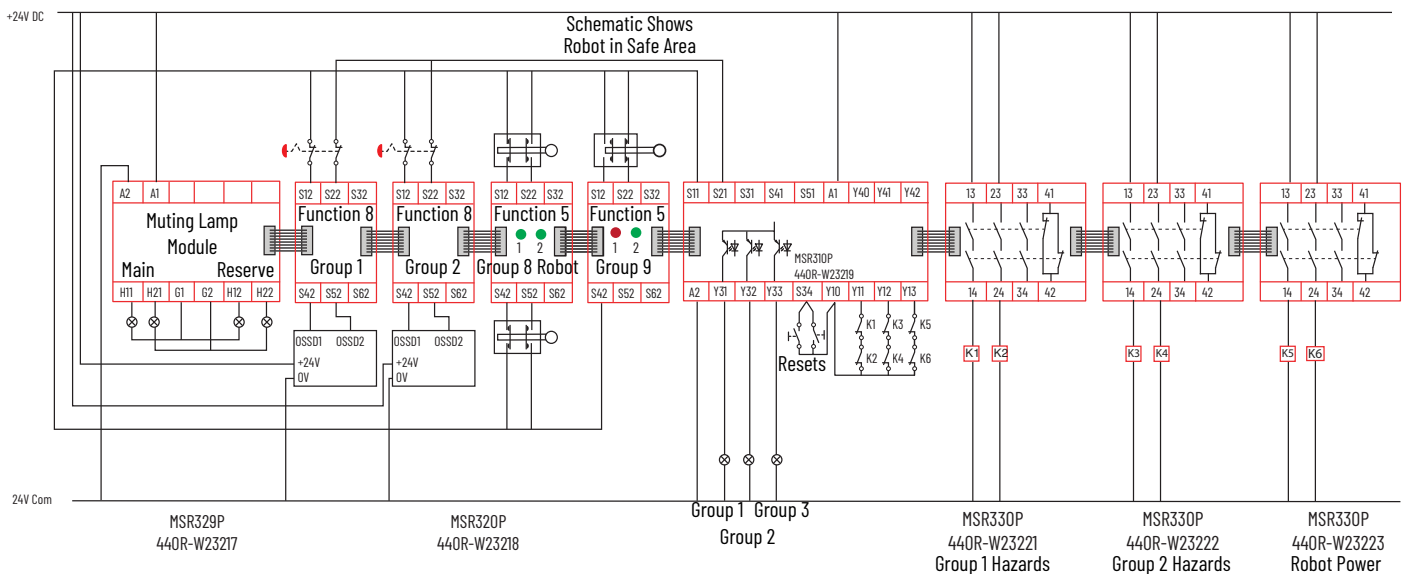
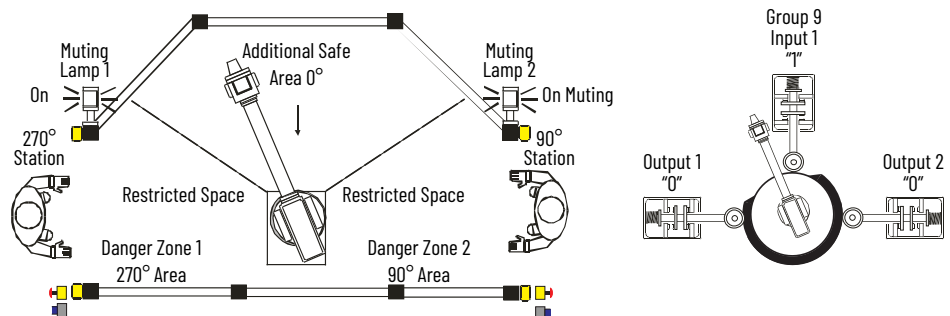
While the robot is in zone 1, if the E-stop is pressed or the light curtain is blocked in zone 2, the loads are de-energized in zone 2. The hazards in zone 1 and robot power remain energized. After the E-stop is released and the light curtain is cleared, press the reset button once to energize the hazards in zone 2.

The following schematic shows an equivalent circuit that uses the GSR relays. The DIS safety relays are recommended as their solid-state outputs are pulse-tested. The DI safety relay is suggested for robot power because it has electromechanical outputs.

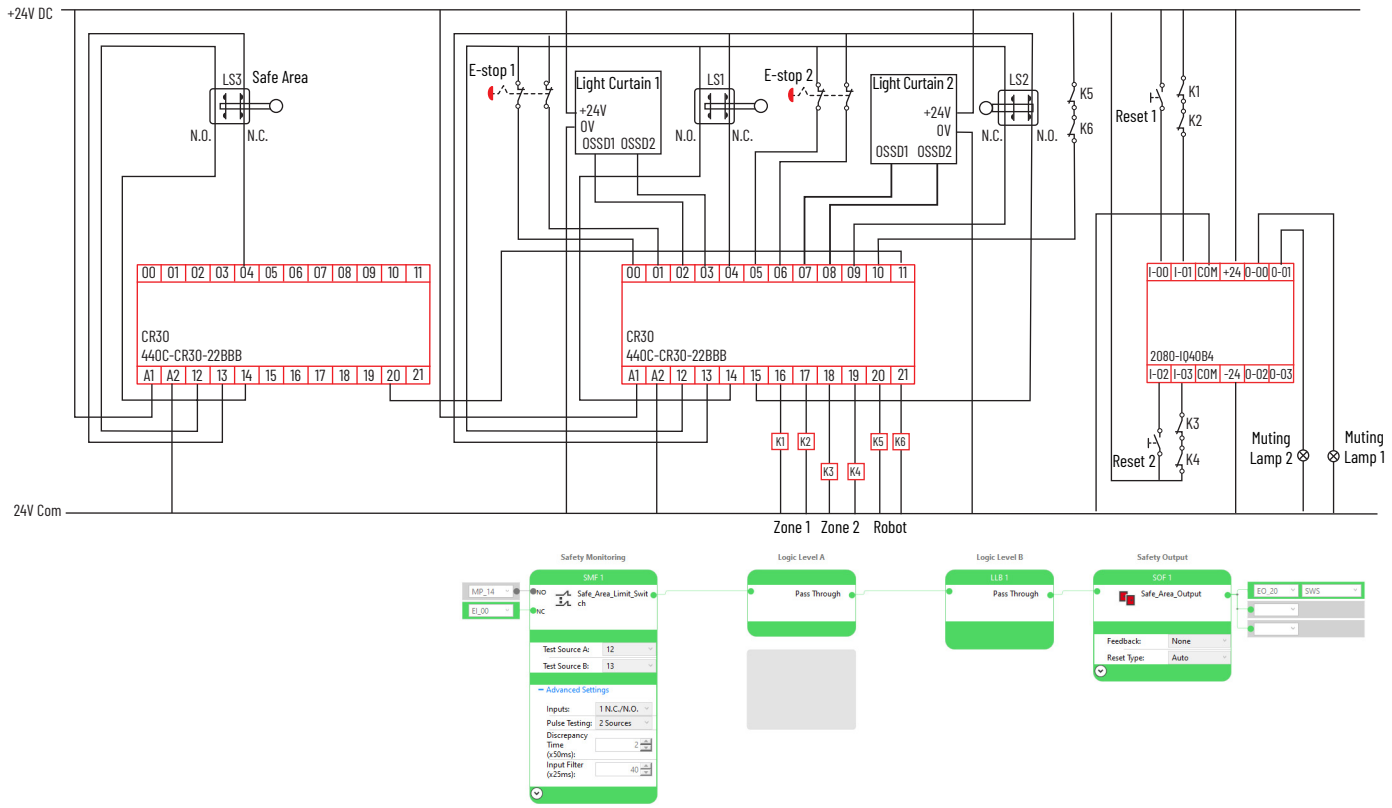


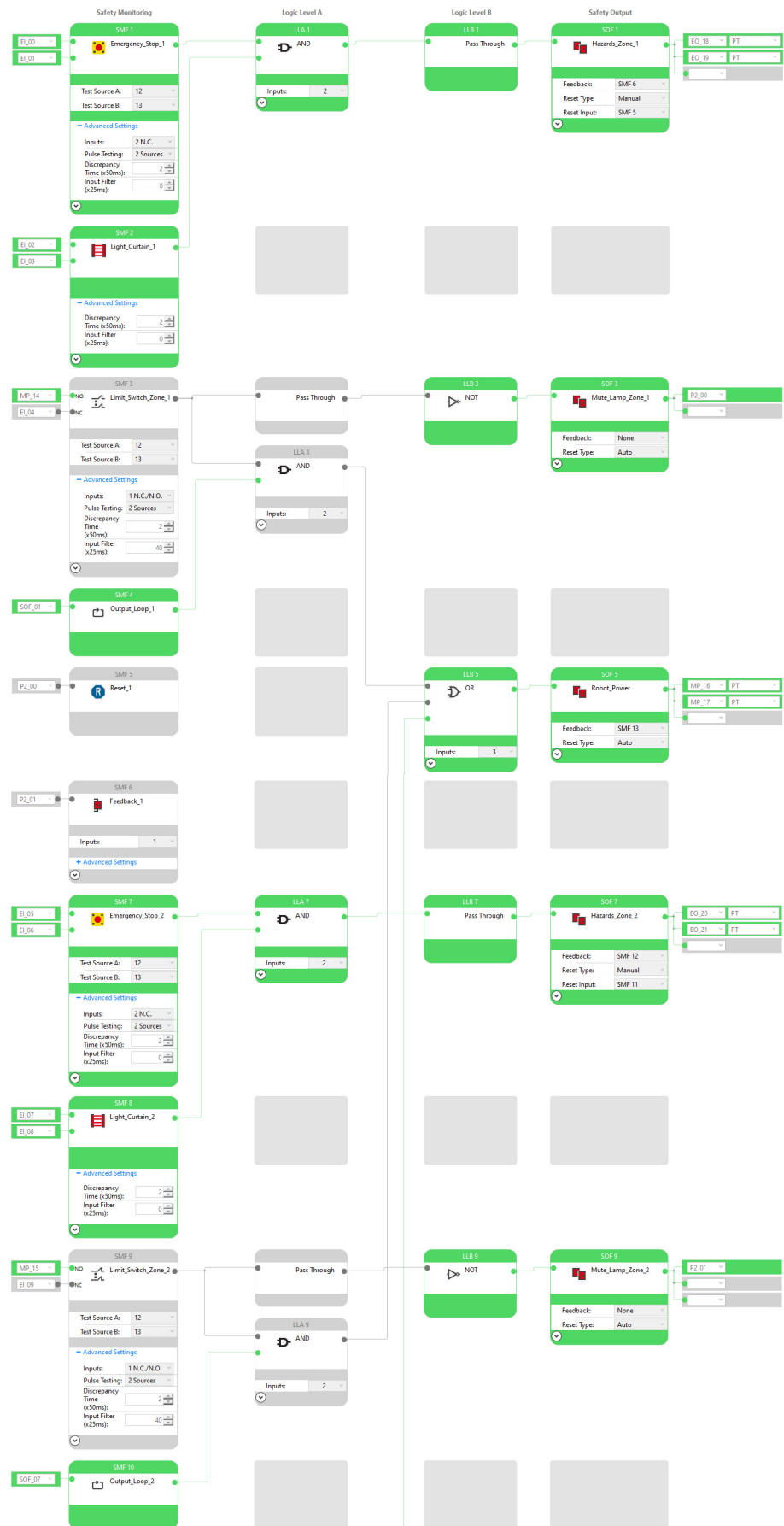
Robot Zone with Additional Safe Area (Function 9)

Function 9 of the MSR300 safety relay adds an additional safe area to the robot cell. When the robot is in the Additional Safe Area, both light curtains are muted.



Two CR30 safety relays, one with a 2080-IQ4OB4 plug-in module, can replicate the robot zone function 9. The following schematic and logic diagrams show the robot in the safe area.



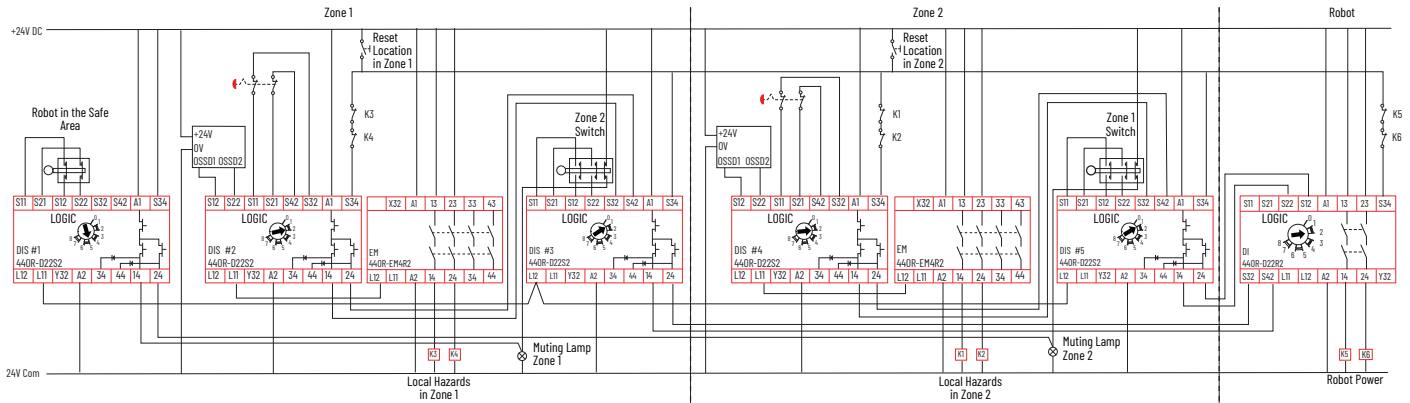




The following schematic shows an equivalent circuit that uses the GSR relays. DIS safety relays are recommended as their solid-state outputs are pulse-tested. EM expansion relays provide voltage-free contacts to control the local hazards. The DI safety relay is suggested for robot power because it has electromechanical outputs.

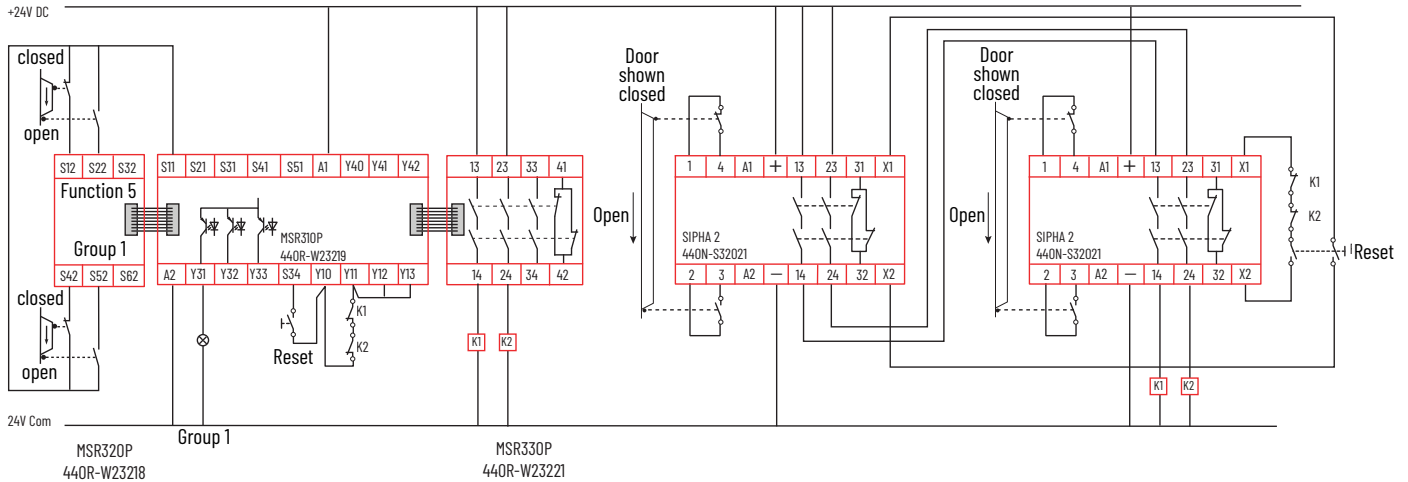
Upon power-up with the robot in the safe area, press the reset three times to energize the local hazards and robot power.

The E-stops and light curtains de-energize their respective local hazards, and the robot remains powered. Press the reset button once to re-energize the local hazards. The GSR solution cannot accommodate the muting lamps.



One N.C. and One N.O. Input

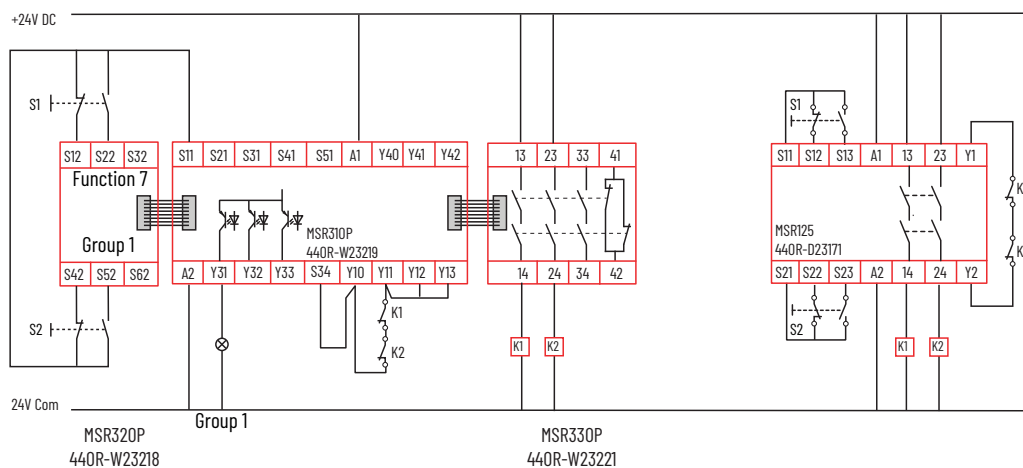
The dual-channel input has a definite simultaneity when the input for MSR300 safety relay is sourced from S11. When the dual-channel input is sourced from S21, the dual-channel inputs must change state within 3 seconds. The Sipha™ 2 controller supports the 3-second requirement.



Two-hand Control Input

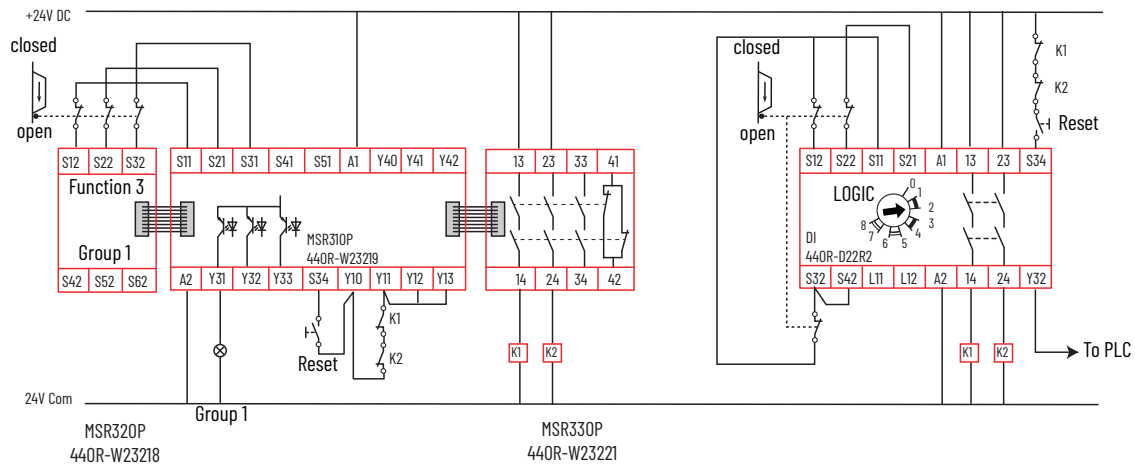
For simple applications, the MSR300 safety relay can be replaced with the MSR125 safety relay. A typical example is shown in the following schematic.

For more complex applications, the CR30 can couple two-hand control with other safety-related functions. See the Guardmaster® Configurable Safety Relay user manual, [440C-UM001](#), for more details.



Three-channel Input

The MSR300 safety relay example shows the input wiring where no simultaneity is required.



Connected Components Workbench Example - Muting with E-stop

Muting is accomplished with one safety monitor function. The muting function turns on the output with automatic reset and feedback monitoring. The E-stop turns OFF the outputs and requires a monitored manual reset. The E-stop turns OFF the outputs with the Output Loop block, which takes the E-stop output and logically ANDs it with the light curtain output.

Response Time

$MSR310P = 26 \text{ ms} + 6 \text{ ms per connected input}$

DIS = Inputs: 25 ms, Mat operation: 30 ms, SWS Fault: 45 ms

DI = Inputs: 35 ms, Mat operation: 40 ms, SWS Fault: 45 ms

EM = 35 ms, SWS output = 25 ms

EMD = 35 ms plus the timer selection, SWS output = 25 ms



ATTENTION: You must evaluate the response time of your existing system and compare it to the new system. Based on the difference, you must adjust the safety distance.

Output Load Capability

The MSR300 safety relay has a higher current capability than the EM and EDM safety relays as shown in the following table. See [Output Load Capability on page 15](#) for a wiring example of how to use relays that interpose for applications where the load exceeds the EM and the EDM safety relay capabilities.

Load Type	MSR330P	MSR338P	EM and EDM
AC Inductive	B300, AC-15 2x6 A or 3 x 5 A/250V AC	B300, AC-15 5 A/250V AC	B300, AC-15 1.5 A / 250V AC
DC	P300, DC-13 2x6 A or 3 x 5 A/24V DC	P300, DC-13 3A/30V DC	DC-13 2 A / 24V DC
Thermal (non-switching)	4 A	2 x 5 A, 3 x 4 A	6 A on 1 circuit

Notes:

Rockwell Automation Support

Use these resources to access support information.

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

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Waste Electrical and Electronic Equipment (WEEE)







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

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