Instruction Manual

MSR300 Modular Safety Control System

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1 User Information

The meanings of the following words used in this document should be understood:

"Standard" can mean a named / numbered industry standard, EU / IEC directive, technical statute or regulation.

"Product" can refer to an MSR300 System consisting of a combination of MSR300 Series Modules or any one of these modules.

1.1 Intended Product Applications

The MSR300 Safety System is a modular, intelligent safety control system for monitoring of

- 1, 2, or 3 - channel emergency stops
- Safety gates
- Light curtains
- Safety mats
- Two-hand controls

The MSR300 is particularly suitable where multiple safety loops and hazardous areas are to be monitored, or where users require flexibility and possible future expansion and reconfiguration of the safety monitoring and control system.

The MSR300 Safety System is intended for applications requiring safety monitoring of machinery in accordance with the following standards:

- EN954-1: Safety-Related Parts Of Control Systems; up to Category 4.
- IEC 61508: Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems, Parts 1-7, 1998; level SIL 3.

This equipment must not be used for unintended applications, or in ways that do not conform to applicable safety standards. The safety functions may not operate properly (or at all) if this equipment is not used for the intended purposes.

1.2 Authorized Personnel

This equipment is to be installed, started up, and operated **only** by technical personnel who have been trained and made familiar with:

- The product/s for which this document exists
- Directives, regulations and practices relating to machine safety
- Instrumentation and automation components, equipment and systems
- Industrial electrical practices

1.3 General Safety Precautions

This product, the equipment on which it installed, persons handling the product and equipment, and/or the immediate environment can be harmed if this equipment is operated outside the specified limits of any of its technical parameters.

Observe all electrical safety regulations stipulated by the appropriate technical authorities.

The latest version of user documentation that includes instructions for installation, operation and maintenance of this product must be readily available with personnel involved in any of these tasks.

Machine safety applications make it necessary for hazardous areas and dangerous operating modes to be carefully identified, and adequate measures taken to ensure that failure or tampering does not allow automated equipment to be of risk to personnel.

It must be understood that the use of safety monitoring and control devices such as this product is not sufficient to ensure that the equipment on which it is installed will meet the relevant stipulated regulations and directives. The design and reliability of the machinery on which this product is used, the proper selection and co-ordination of the safety controls with the machinery, the safety system design, and proper installation practices are all necessary to meet the objectives of overall safety.

Careful attention must be paid to safety instructions in other parts of this document, particularly regarding installation, start-up and operation.

1.4 Product Warranty and Disclaimer

A partial statement of the product warranty and disclaimer is annexed at the end of this manual, and is subject to the warranty terms and disclaimer included in the detailed standard terms of sale/contract of the Seller.

1.5 Technical Support

Technical information related to this product and its application is available in product literature, manuals, and other documentation available from the following sources:

- Rockwell Automation / Allen Bradley web sites:
  http://shop.rockwellautomation.com/
  http://www.ab.com/
  > Literature library > Safety > Safety control relays
- The Rockwell Automation / Allen Bradley reseller from whom the product was purchased or the distributor nearest to you. This information is available at:
  http://www.rockwellautomation.com/distributor/index.html
  [Presently only for USA and Canada. Information for other zones expected here in the near future]
- The Rockwell Automation / Allen Bradley sales / customer support office nearest to you. This information is available at:
  http://www.rockwellautomation.com/locations/

2 About This Manual

This manual contains detailed information about the product, and instructions for its installation, operation and maintenance.

Operators and other technical personnel responsible for the equipment must read this manual thoroughly before attempting to install or operate this equipment.

The latest version of this manual must be readily available with personnel involved installation, operation or replacement of this product.

Product documentation that accompanies the product in its packing must be considered to have precedence over corresponding contents of this manual

Note: The meanings of the following words used in this document should be understood:
"Standard" can mean a named / numbered industry standard, EU / IEC directive, technical statute or regulation.
"Product" can refer to an MSR300 System consisting of a combination of MSR300 Series Modules, or to any one of these modules.

2.1 Content Guidance

Chapter 1 contains preliminary user information: this must be read and understood before proceeding to Chapters 3 onward.

Chapter 2 (this chapter) has information about this manual. Sections 2.1 (this section) and 2.2 must be read before proceeding to remaining chapters. Sections 2.3 and 2.4 are for incidental reference.

Chapter 3 provides information about the relevant safety directives and standards applicable to the safety of automatic machinery, the safety functions that can be implemented by the use of MSR300 Systems, an overview of the MSR300 System, a summary of the individual modules, and their technical specifications.

Chapter 4 has detailed information about each of the MSR300 Series Modules and how they are used for specific applications.

Chapter 5 describes the special applications of safety control of industrial robots and related automatic machines. This chapter also includes information about the special logic functions available in the MSR300 System.

Chapter 6 describes possible faults and error conditions, and how the MSR300 System handles these.

Chapter 7 contains instructions about installation, start-up, operation and maintenance.

Application examples are described in Chapter 8.

Chapter 9 has detailed information about the serial data communication protocols.

2.2 Annotation Symbols

The following symbols have prominently inserted at appropriate places in this document to draw the reader's attention to important points:

Symbol	Meaning
	This symbol is intended to draw the reader's attention to important safety points that help in one or more of these ways: • Identify a hazard • Avoid a hazard • Recognize the consequence
	Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.
	Identifies information that is critical for successful application and understanding of the product.
	Identifies information that could help in completing a task or achieving a result more efficiently or quickly.

2.3 Document Disclaimer

The contents of this manual have been compiled with the utmost care, and diligence has been used to present all the information clearly and accurately. However, the manufacturer cannot accept any liability for any residual errors or omissions that may be found in this document. If users find any errors, omissions or other deficiencies, please inform the manufacturer immediately. Corrections will be made in the next edition of this document.

Nothing in this document can be interpreted to create new conditions or modify existing conditions of the product warranty.

3 MSR300 System: Product and Applications Overview

3.1 Safety Standards and Safety Relay Functions

Note: In this document, the word "standard" can mean a defined industry standard, EU directive, technical statute or regulation.

The safety standards relevant to this product and its application are outlined in brief in Section 3.1.2 below.

General

The MSR300 Safety System is intended for applications requiring safety monitoring of machinery in accordance with the following directives / standards:

- EN954-1: Safety-Related Parts Of Control Systems; up to Category 4.
- IEC 61508: Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems, Parts 1-7, 1998; level SIL 3.

An MSR300 System will conform to these standards provided external devices connected to it, overall system and safety design, and installation practices conform to appropriate standards.

WARNING

This equipment must not be used for unintended applications, nor in ways that do not conform to appropriate safety standards and good practices. The safety functions may not operate properly (or at all) if this equipment is not used for the intended purposes.

This product, the equipment on which it is installed, persons handling the product and equipment, and/or the immediate environment can be harmed if this equipment is operated outside the specified limits of any of its technical parameters.

Electrical safety regulations stipulated by the appropriate technical authorities must be observed.

Machine safety applications make it necessary for hazardous areas and dangerous operating modes to be carefully identified, and adequate measures taken to ensure that failure or tampering does not allow automated equipment to be of risk to personnel.

It must be understood that use of safety monitoring and control devices such as this product is not sufficient to ensure that the equipment on which it is installed will meet the relevant stipulated regulations and directives. The design and reliability of the machinery on which this product is used, the proper selection and co-ordination of the safety controls with the machinery, the safety system design, and proper installation practices are all necessary to meet the objectives of overall safety.

3.1.1 Safety Standards

MSR300 Series Modules conform to the Essential Health & Safety Requirements (EHSR's) of the European Machinery Directive (98/37/EC), the relevant requirements of the Low Voltage Directive (73/23/EEC as amended by 93/68 EEC) and the essential protection requirements of the EMC Directive (89/336/EEC as amended by 92/31 EEC). The MSR310P also conforms to EN 292, EN 60204-1, EN61508, EN 954-1, and UL 508.

3.1.1.1 EN 954-1

This product conforms to Category 4 of EN954-1: Safety-Related Parts Of Control Systems.

The main stipulations of this standard are:

Safety-related parts of control systems conforming to Category 4 shall be designed so that:

- A single fault in any of these safety-related parts does not lead to a loss of the safety function.
- The single fault is detected at or before the next demand upon the safety functions, e.g. immediately at switch on, at end of a machine operating cycle. If this detection is not possible, then an accumulation of faults shall not lead to a loss of the safety function.

If the detection of certain faults is not possible, at least during the next check-up after the occurrence of the fault, for reasons of technology or circuit engineering, the occurrence of further faults shall be assumed. In this situation the accumulation of faults shall not lead to the loss of the safety function.

Fault review may be stopped when the probability of occurrence of further faults is considered to be sufficiently low. In this case the number of faults in combination, which need to be taken into consideration, will depend upon the technology, structure and application but shall be sufficient to meet the detection criteria.

3.1.1.2 IEC/EN 61508

This product has been designed to conform to SIL 3 of IEC/EN 61508: Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems, Parts 1-7, 1998.

IEC/EN 61508 relates to the functional safety of electrical, electronic, and programmable electronic safety-related systems. These are referred to as Safety Instrumented Systems (SIS). IEC/EN 61508 is an umbrella standard applicable to all industries. Safety Integrity Level (SIL) is a statistical representation of the reliability of the SIS. Four SIL levels are defined: SIL 1 through SIL 4. The higher the SIL number, the more reliable or effective

the system is. SILs are correlated to the probability of failure of demand (PFD), which is equivalent to the unavailability of a system at the time of a process demand.

IEC/EN 61508 is approximately equivalent to ANSI/ISA-S84.0: Application of Safety Instrumented Systems for the Process Industries," Instrument Society of America Standards and Practices, 1996.

IEC/EN 61508 SIL 3 summary for the MSR300 System:

Safety Integrity Level:	SIL 3 $10^{-4} \leq PFD \leq 10^{-3}$ (whole safety function) $10^{-8}\ h^{-1} \leq PFH \leq 10^{-7}\ h^{-1}$
SIL – part of logic unit:	15% $PFD \leq 0{,}15 \times 10^{-3}$ $PFH \leq 0{,}15 \times 10^{-7}$
Mode of operation:	low demand mode (※ PFD) High demand mode (※ PFH)
Safety related subsystems:	Type B (use of programmable / complex Components)
Hardware Fault Tolerance:	HFT = 1 (two channel system)
Safe Failure Fraction:	SFF = 90% to 99% (61508-2, table3)

Calculations for MSR300:

MSR310 Base Module		
$PFD_{av}(T_1) \approx$	5,9E-10	*t
$PFH(T_1) \approx$	1,2E-09	[1/h]

MSR329 Muting Lamp Module		
$PFD_{av}(T_1) \approx$	6,92E-11	*t
$PFH(T_1) \approx$	1,38E-10	[1/h]

MSR320 Input Module		
1-Channel Wiring		
$PFD_{av}(T_1) \approx$	3,19E-11	*t
$PFH(T_1) \approx$	6,39E-11	[1/h]
2-Channel Wiring		
$PFD_{av}(T_1) \approx$	1,19E-11	*t
$PFH(T_1) \approx$	2,39E-11	[1/h]
3-Channel Wiring		
$PFD_{av}(T_1) \approx$	1,43E-11	*t
$PFH(T_1) \approx$	2,86E-11	[1/h]

MSR330 Output Module			
$PFD_{av}(T_1) \approx$	2,50E-09	*t	
$PFH(T_1) \approx$	5,00E-09	[1/h]	1 contact
$PFD_{av}(T_1) \approx$	5,00E-09	*t	
$PFH(T_1) \approx$	1,00E-08	[1/h]	2 contacts
$PFD_{av}(T_1) \approx$	7,50E-09	*t	
$PFH(T_1) \approx$	1,50E-08	[1/h]	3 contacts

Standard configuration:
MSR300 System consisting of: 1 MSR310, 4 MSR320, 1 MSR330, 1 MSR329
(Each MSR320 configured for two single channel inputs)

$PFD_{avSystem}(T_1)$= 8,17E-09 *t T_1(15% PFD_{zul}) **Test interval: 2,1 Years**
$PFH(T_1)$= 1,63E-08 [1/h]

3.1.2 MSR300 Safety Relay Functions

MSR300 Systems can be used for various safety relay functions outlined below, when appropriately configured for the respective function.
Simultaneity monitoring (sometimes referred to as synchronization monitoring or coincidence gating) is often necessary for many of these safety applications. This means that 2 (sometimes even 3) input contacts must be closed (or reset) simultaneously to clear this set of inputs (simultaneity between all channels of **one** input). For these applications, the allowable time window is 3 seconds. Another common application that involves simultaneity monitoring (0.5 seconds window) is two-hand safety control. (simultaneity activation of **both** inputs of one module).

3.1.2.1 One-Channel Emergency Stop

- Safety output contacts are opened if the input loop is open.
- Stop category: 0.
- Short-circuiting of the input loop to electrical ground or 24V will be detected.

3.1.2.2 Two-Channel Emergency Stop

- Safety output contacts are opened if at least one input loop is open.
- Stop category: 0.
- Short-circuiting of the input loop to electrical ground or 24V will be detected.
- Cross loops will be detected.
- Suitable for use with safety mats.
- Can be configured for simultaneity detection: 3 seconds limit.

3.1.2.3 Three-Channel Emergency Stop

- Safety output contacts are opened if at least one input loop is open.
- Stop category: 0.
- Short-circuiting of the input loop to electrical ground or 24V will be detected.
- Cross loops will be detected.
- Can be configured for simultaneity detection: 3 seconds limit.

3.1.2.4 Two-Channel Safety Gates

- Safety output contacts are opened if the N/O input is closed or the N/C input is open
- Stop category: 0.
- Short-circuiting of the input loop to electrical ground or 24V will be detected.
- Cross loops will be detected.
- Can be configured for simultaneity detection: 3 seconds limit.
- Can be configured to execute a start-up test of the input loops.

3.1.2.5 Two-Channel Light Curtain

- Safety output contacts are opened if one or more inputs have has no signal.
- Stop category: 0.

3.1.2.6 Two-Hand Control

- Two-hand control type IIIC (EN 574)
- Simultaneity detection: 0.5 seconds limit.

The two-hand control function ensures that operators keep their hands clear of a hazardous area of a machine. It is meant for use with machines such as mechanical and hydraulic presses. A machine cycle can only be initiated by pressing two momentary pushbutton switches simultaneously. Switches must fulfill the requirements of EN574 type IIIC. Releasing one or both pushbutton switches open the output contacts to interrupt the cycle and stop the machine. The output contacts can be closed again only after the inputs have released and the pushbutton switches actuated again.

If a machine is operated by more than one person simultaneously, separate two-hand controls are required for each operator station.

The two-hand operator station should be located far enough from the hazardous area so that the latter cannot be reached by the operator before the machine stops (after a stop command is given).

Typical applications of two-hand safety controls are: presses, shears, plastic-molding machines, etc.

3.1.2.7 Reset Action

The reset logic of the three Output Groups of the system can be configured for one of the following modes:

- Automatic reset: The Output Group is active as soon as all input circuits and feedback loop are closed.
- Manual monitored reset: The Output Group is not active until the reset button has been operated and then released (and feedback loop closed). This eliminates the possibility of triggering automatic activation if the reset switch is overridden.
- Manual (non-monitored) reset: The Output Group can be set up for automatic reset and yet have a reset contact connected in series with the feedback loop. In this case manual reset is not monitored.

3.1.2.8 Muting (for Robot cell applications)

Muting is the safe, automatic and temporary suspension of an electrosensitive protective device, in accordance with EN 61496-1 A.7. Muting is typically applied to allow material in process to be moved into and out of a hazardous area. The presence / movement of such material can be detected by muting sensors. Typically, muting causes the signal inputs from safety barriers such as opto-switches or light curtains to be temporarily ignored, - only as long as the muting sensors detect material in process approaching entry to, or exit from a machine. MSR300 muting does not monitor material flow but is especially designed and limited to applications as explained in the Robot cell examples later in this document (safe position monitoring of the Robot arm).

Muting lamps are deployed to indicate that muting is existent. Special safety controls are necessary to ensure that muting lamps operate correctly and safely. The MSR329 Muting Lamp Controller is expressly designed for this purpose. Details of this module are given later in this document.

3.2 MSR300 System: Overview

The MSR300 System is a modular safety control system with extended functions, and is intended for monitoring and safety control of:

- 1-, 2-, or 3-channel emergency stops
- Safety gates and doors
- Light curtains
- Safety mats
- Two-hand control

An MSR300 System is made up of a combination of the following MSR300 Series Modules:

- MSR310 Base Module
- MSR320 Input Module
- MSR330 Output Module
- MSR329 Muting Lamp Module:

An MSR300 System is constituted as follows:

- One MSR310 Base Module
- At least one MSR320 Input Module
- At least one MSR330 Output Module
- One MSR329 Muting Modules may be optionally included if needed (provided one MSR320 Input Module is configured for the robot function).

MSR320 and MSR329 Modules are daisy-chain connected to the left bus interface connector of the MSR310 Base Module. Up to ten MSR 320 Input Modules can be included in an MSR300 System, for a maximum of 20 input circuits.

MSR330 Output Modules are daisy-chain connected to the right bus interface connector of the MSR310 Base Module. Up to six MSR330 Output Modules can be included in an MSR300 System, for a maximum of 18 N/O safety outputs plus 6 N/C auxiliary outputs.

The integrity of all safety inputs are constantly checked by means of feedback of the safety loops. Dynamic (pulse frequency) excitation signals are generated by the MSR310 Base Module. These signals are fed (as a star-connected bus) to monitor the contact(s) of every safety sensing device connected to the MSR 300 System. The signals are then feed back to the Input Module to which each corresponding safety contact input is connected. If a safety-sensing device is defective the system will detect non-valid signals or signal sequences on the Inputs. This causes a fail-safe fault response by the MSR300 System.

Every input can be connected to a separate input switching circuit.

Input modules can be freely assigned to any output group module.

Unintended modifications to MSR300 Systems are prevented by design. The system configuration is automatically checked when it is first started up, and this information is stored in non-volatile memory (EEPROM) in the Base Module. Whenever the system is started up (or restarted) thereafter, the current system configuration is checked against the stored configuration. If a discrepancy is detected, a fault response is immediately generated, with appropriate diagnostic indication and output (see setup details in Chapter 7.3).
The MSR300 System is suitable for safety monitoring and control of robot cells, with or without additional safe areas. The special MSR329 Muting Lamp Module is available for this.
Special logic functions can be implemented in MSR300 Systems (see Section 5.2 and Chapter 8).

3.3 MSR300 Modules: Summary

Brief descriptions of the MSR300 Series Modules are given in this section, followed by the specifications of the modules in tabular format in the next section. Details of the Modules are given in Chapter 4.

MSR310 Base Module:

Functions:
System control, safety and auxiliary output contacts, supervision of bus-connected input and output modules, monitoring of reset and feedback loops
Auxiliary outputs:
3 solid-state switch outputs for signaling the states of output groups
Serial data interfaces:
Two RS232 ports (bi-directional and uni-directional)

The MSR310 Base Module has two microprocessors for redundancy and supervision of I/O modules and one for interface and diagnostic operations. Comprehensive diagnostic information is available through LED indicators, auxiliary solid-state switch outputs and a serial data interface.

MSR320 Input Module:

Functions:
Processing inputs from various safety sensing devices, assignment of sensing inputs to output switching groups by means of rotary coded switches.
Inputs:
2 safety inputs (each module)
2 auxiliary outputs (if third channel is not used)

Rotary switches on the side of the MSR320 Input Module are used to set the assignment of inputs to specific output switching groups: each group has a designated Output Module (Output Groups 1, 2 and 3).

MSR330 Output Module:

Functions:
Safety contact outputs.
Outputs:
Each module: 3 x N/C outputs plus 1 x N/O safety contact outputs.
System maximum:
3 x 6 = 18 N/C plus 1 x 6 = 6 N/O auxiliary contacts.

A minimum of one and a maximum of six Output Modules can be included in a single MSR300 System.

MSR330 Output Modules are available in three versions, each specific for one of three output groups: i.e., Group 1, Group 2, Group 3, respectively. The group number must be specified when ordering these modules.

MSR329 Muting Lamp Module:

Functions:
Connection and control of muting lamps.
Capacity:
2 x main muting lamps plus 2 x reserve muting lamps

One Muting Lamp Module can be optionally included in an MSR300 System in lieu of one MSR320 Input.

3.4 MSR300 Modules: Specifications

3.4.1 MSR310 Specifications

Standards	IEC/EN60204-1, ISOTR12100, ISO13849-1
Approvals	CE marked for all applicable directives
Power supply	Nominal: 24 VDC. Range: 0.8 to 1.1 x rated voltage
Power consumption	5W
Reset	Monitored manual and / or automatic
System inputs capacity	1 to 10 Input Modules, each with 2 inputs
System outputs capacity	1 to 6 Output Modules, each with 3 N/C and 1 N/O safety contacts, 3 Group indicating auxiliary solid-state outputs plus 2 optional aux. Outputs on each connected Input Module
Solid-state output rating	24 VDC (nominal); 50 mA; short-circuit protected
Serial data interface	RS232. Unidirectional: 4800 baud. Birectional: 2400, 4800, 9600, or 19200 baud.
Bus connectors	Flat cable type, with gold plated pins/sockets
Power on delay	3 sec.
Response time	26ms + (6ms x number of input extension modules)
Recovery time	26ms + (6ms x number of input extension modules)
Pollution degree	2
Operating temperature	-5°C to +55°C (+23°F to 131°F)
Relative humidity (RH)	90%
Enclosure protection	IP40
Terminals protection	IP20
Short circuit protected output terminals	S11, S21, S31, S41, S51, Y40, Y10, Y31, Y32, Y33
Connecting wire	Copper conductor. Temperature rating: 60/75 °C
Conductor size	0.2 to 2.5 mm² (24-12 AWG)
Terminal screw torque	0.6 to 0.8 Nm (5 to 7 lb-in)
Housing material	Polyamide PA 6.6
Mounting	35mm DIN rail
Weight	210g (0.46 lbs)
Vibration	10 – 55 Hz, 0.35 mm
Mechanical shock	10g, 16 msec, 100 shocks

3.4.2 MSR320 Specifications

Standards	IEC/EN60204-1, ISOTR12100, ISO13849-1
Approvals	CE marked for all applicable directives
Power supply	Nominal: 24 VDC. Range: 0.8 to 1.1 x rated voltage
Power consumption	approx. 3W
Safety inputs	1 N/C, 2 N/C, 3 N/C, safety mat, light curtain, N/C-N/O, two-hand control
Solid-state switch output rating	24 VDC (nominal); 20 mA; short-circuit protected
Input simultaneity detection	3 secs. or disabled (infinite time limit) Two Hand Operation Mode: 0.5s between both Inputs
LED indicators	Input status (2): Green = input closed. Red = input open Output switch group assignment (3)
Input load impedance	900 ohms (max.)
Bus connectors	Flat cable type, with gold plated pins/sockets
Pollution degree	2
Operating temperature	-5°C to +55°C (+23°F to 131°F)
Relative humidity (RH)	90%
Enclosure protection	IP40
Terminals protection	IP20
Conductor size	0.2 to 2.5 mm² (24-12 AWG)
Terminal screw torque	0.6 to 0.8 Nm (5 to 7 lb-in)
Housing material	Polyamide PA 6.6
Mounting	35mm DIN rail
Weight	110g (0.24 lbs)
Vibration	10 – 55 Hz, 0.35 mm
Mechanical shock	10g, 16 msec, 100 shocks

3.4.3 MSR330 Specifications

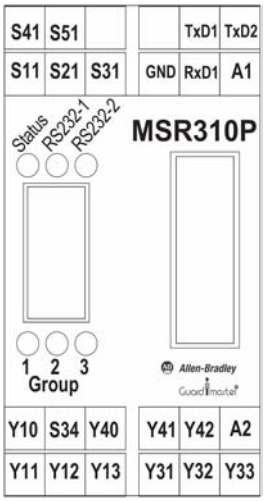
Standards	IEC/EN60204-1, ISOTR12100, ISO13849-1
Approvals	CE marked for all applicable directives
Power supply	24 VDC from the MSR310 Base Module
Power consumption	1.5 W
Output fuses (external)	6 A slow blow, or 10 A quick blow.
Safety outputs	3 x N/O plus 1 x N/O (safety contacts)
Safety contact rating	B300, AC-15, 6A / 250 VAC DC-13, 3A / 24 VDC
Thermal Current rating	2x6A or 3x5A
Min. switched current / voltage	10 mA / 10 V
Contacts material	$AgSnO_2$; 2 micron gold plated
Relay contacts life expectancy	Electrical: 220VAC, 4A, 880VA, cos φ = 0.35: 100,000 operations 220VAC, 1.7A, 375VA, cos φ = 0.6: 500,000 operations 30VDC, 2A, 60W: 1,000,000 operations 10VDC, 0.01A, 0.1W: 2,000,000 operations Mechanical: 2,000,000 operations
Impulse withstand voltage	2500 V
LED indicators	Relays state indication
Bus connectors	Flat cable type, with gold plated pins/sockets
Pollution degree	2
Operating temperature	-5°C to +55°C (+23°F to 131°F)
Relative humidity (RH)	90%
Enclosure protection	IP40
Terminals protection	IP20
Conductor size	0.2 to 2.5 mm² (24-12 AWG)
Connecting wire	Copper conductor. Temperature rating: 60 / 75°C
Terminal screw torque	0.6 to 0.8 Nm (5 to 7 lb-in)
Housing material	Polyamide PA 6.6
Mounting	35mm DIN rail
Weight	190g (0.42 lbs)
Vibration	10 – 55 Hz, 0.35 mm
Mechanical shock	10g, 16 msec, 100 shocks

3.4.4 MSR329 Specifications

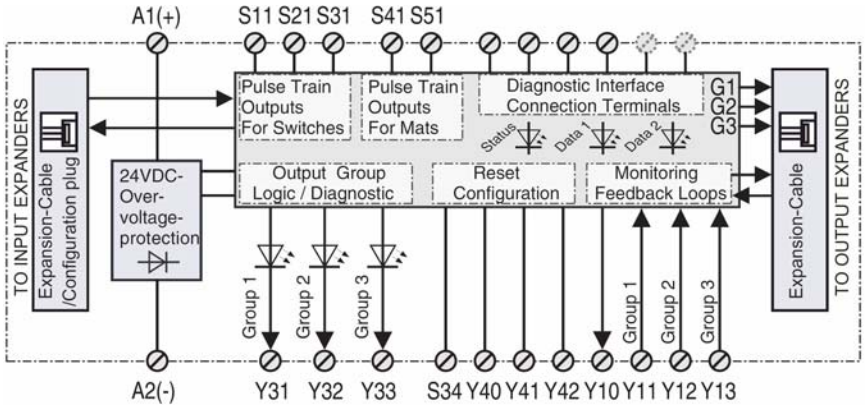
Standards	IEC/EN60204-1, ISOTR12100, ISO13849-1
Approvals	CE marked for all applicable directives
Power supply	Nominal: 24 VDC. Range: 0.8 to 1.1 x rated voltage
Power consumption	1 W
Inputs	Monitoring of 2 muting lamps, 30 mA - 200 mA each
Outputs	2 x muting lamps, plus 2 x reserve muting lamps
LED indicators	State of muting lamps
Bus connectors	Flat cable type, with gold plated pins/sockets
Pollution degree	2
Operating temperature	-5°C to +55°C (+23°F to 131°F)
Relative humidity (RH)	90%
Enclosure protection	IP40
Terminal protection	IP20
Conductor size	0.2 to 2.5mm² (24-12 AWG)
Terminal screw torque	0.6 to 0.8 Nm (5 to 7 lb-in)
Housing material	Polyamide PA 6.6
Mounting	35mm DIN rail
Weight	190g (0.42 lbs)
Vibration	10 – 55 Hz, 0.35 mm
Mechanical shock	10g, 16 msec, 100 shocks

4 MSR300 Modules: Details

4.1 MSR310 Base Module



MSR310 Front View



MSR310 Internal Block Schematic Diagram

Functions: System control, safety and auxiliary output contacts, supervision of bus-connected input and output modules.
Auxiliary outputs: 3 solid-state switch outputs for signaling the states of output groups.
Serial data interface: two RS232 ports (bi-directional and uni-directional).
Selectable start mode: Monitored (manual) or automatic.

The MSR310 has independent feedback loops for each output group.
There are no safety inputs or outputs on this module.

The MSR310 Base Module has three microprocessors: for redundancy and supervision of I/O modules. Comprehensive diagnostic information is available via two-color LED indicators, auxiliary solid-state switch outputs and the serial data interface.

4.1.1 Terminals

Name	Function
A1	Supply +24 VDC
A2	Supply 0 V ; ground for solid-state switch outputs
GND, TxD1, RxD1	Bi-directional RS232
GND, TxD2	Uni-directional RS232
S11 – S51	Pulse train outputs (bus) to input devices

Y40, Y41, Y42	Reset configuration
S34	Start button
Y31 – Y33	Solid-state auxiliary outputs for groups 1, 2 and 3
Y10	+24V for reset circuit and feedback loops
Y11 – Y13	Feedback loop inputs for Groups 1, 2 and 3

4.1.2 LED Indicators

Function	Status LED	Group 1-2-3 LEDs
Power up / normal operation	Continuous on: green	---
Internal fault	Continuous on: red	---
Entering configuration mode	1 flash: red	---
Input switch fault or reset switch closed during power up	2 flashes; red	---
Configuration change during operation	3 flashes; red	---
Current configuration not as stored on EEPROM	4 flashes; red	---
At least one muting lamp and one reserve lamp defective	5 flashes; red	---
Invalid switch settings of input modules	6 flashes; red	---
Invalid reset configuration (Y41, Y42, S34 terminal jumpers)	7 flashes; red	---
Input terminal block not (or improperly) plugged in	8 flashes; red	---
Group output active	---	Continuous on: green
Group ready	---	Blinking: green
At least one input corresponding to the output group is faulty	---	Continuous on: red
A feedback (EDM) loop of the output group is open, or no input is assigned to the group	---	Off

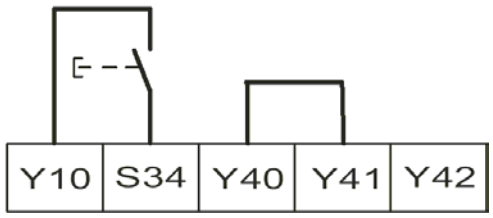
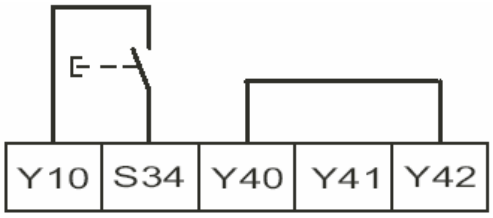
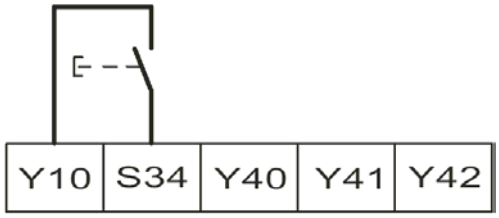
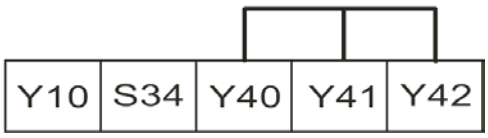
LEDs "TxD1" and "TxD2" indicate RS232 data communication activity when flashing.

4.1.3 Settings, Connections, Start-Up

Reset mode selection (reset switch connection and jumper settings):

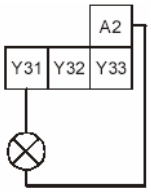
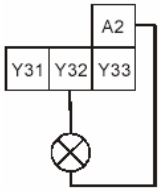
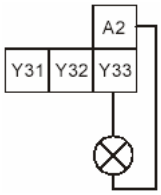
ATTENTION

Reset button has to be installed at a place where the dangerous area can be visual monitored. Automatic reset is only allowed if the start of the machine cannot lead to a hazard or a restart interlock must be accomplished by other means of control (per EN 60204-1)

Reset behavior	Circuit
Group1 and 2: manual, monitored reset Group3: automatic reset	
Group 1 and 2: automatic reset Group 3: manual, monitored reset	
Groups1, 2 and 3: manual, monitored reset	
Groups 1, 2 and 3: automatic reset	

4.1.4 Auxiliary Outputs (Solid-State Switches)

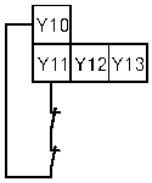
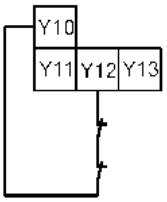
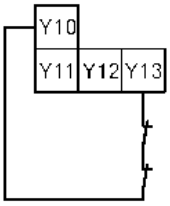
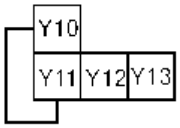
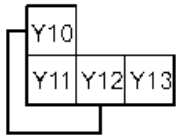
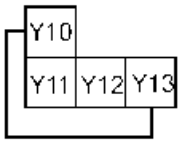
The MSR310 Base Module has three LEDs and three auxiliary (solid-state switch) outputs that indicate the states of the three Output Groups, respectively.

Condition	Y31	Y32	Y33
Group 1 active	24V	---	---
Group 1 inactive	0V	---	---
Group 2 active	---	24V	---
Group 2 inactive	---	0V	---
Group 3 active	---	---	24V
Group 3 inactive	---	---	0V
Wiring			

These outputs are short-circuit protected. Current limit: 50 mA.

4.1.5 Output Groups Feedback

Every output group has its own feedback loop. This loop has to be closed for each group before the respective group can be activated.

Function	Wiring
External device for Group 1	
External device for Group 2	
External device for Group 3	
No external device connected for Group 1	
No external device connected for Group 2	
No external device connected for Group 3	

4.1.6 Input Fault Logging

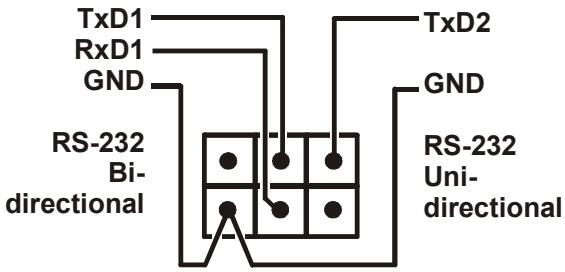
If inputs are wired for simultaneity monitoring, the following events are registered as faults and stored in EEPROM:

- Simultaneity time limit is exceeded.
- Not all channels change state as required if input is cycled
- The reset switch is closed while not all channels of at least one input are in the correct state for either “on” or “off”.

The faults can be cleared by opening and closing the circuits of all channels of one input simultaneously. If the faults are not cleared, the MSR310 indicates this on the next power up. The faults can even then be cleared by opening and closing the circuits of all channels of the faulty input simultaneously.

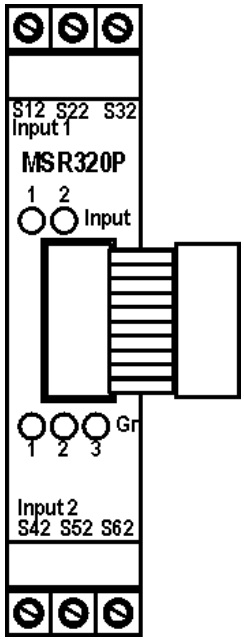
4.1.7 Serial Communication Interface Connections

The MSR310 is equipped with two RS232 serial data interfaces: one for bi-directional and one for uni-directional communication mode. The interface connections are illustrated below.

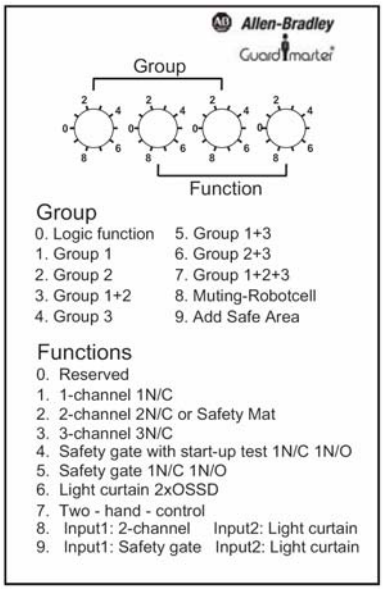


Serial data communication protocol details (uni-directional and bi-directional) are given in Chapter 9, at the end of this document.

4.2 MSR320 Input Module



MSR320
Front View



MSR320 Rotary Switches & Settings
(Located on right side of the module)

Functions: Processing inputs from various safety sensing devices. Assignment of sensing inputs to output switching groups by means of redundant rotary coded switches: one set selects the input function, the other set selects the output group.

Inputs: 2 inputs for single-, dual- or three-channel activation. A solid-state switch on-off signal input from a light curtain and an on-off signal input from safety contacts (switch or electromechanical relay) input can be given as inputs to the same Input Module.

Rotary switches on the right side of the MSR320 Input Module. One rotary switch selects the function of the Input Module (see functions list below), the other assigns an Output Group (Module) assigned to this Input Module.

IMPORTANT

Two switches per selection have been provided for redundancy. **Both sets of rotary switches of one input module must be set identically.**

An MSR320 Input Module can be set up for any one of the following safety functions:

- Logic function (Group3 = Input1 OR Input2 OR Group1)
- 1-channel emergency stop
- 2- channel emergency stop or 4-wire safety mat
- 3- channel emergency stop
- Safety gate (N/O, N/C) with start-up test
- Safety gate (N/O, N/C) without start-up test
- Light curtains: both inputs
- Two-hand operation
- Input 1 = 2-channel emergency stop; Input 2 = Light curtain
- Input 1 = Safety gate without start up test; Input 2 = Light curtain

The terminal of third channel of an Input Module acts as an auxiliary output (+24 VDCsignal if input active) when the Input Module is configured for 1- or 2-channel monitoring. The same terminal acts as the third input when an Input Module is configured for 3-channel monitoring.

4.2.1 Terminals

Name	Function
S12	Input channel for Input 1
S22	Input channel for Input 1
S32	Input channel for Input 1 if 3-channel e-stop is selected Otherwise: solid-state auxiliary output for Input 1
S42	Input channel for input 2
S52	Input channel for input 2
S62	Input channel for Input 2 if 3-channel e-stop is selected Otherwise: solid-state auxiliary output for Input 2

4.2.2 Settings, Connections and LED Indicators

Selecting input functions (sensors):

Switch position	Function
0	Logic function
1	1- channel emergency stop
2	2- channel emergency stop
3	3- channel emergency stop
4	Safety gate with start-up test
5	Safety gate without start-up test
6	Light curtain
7	Two-hand operation
8	Input 1: 2- channel emergency stop. Input 2: light curtain
9	Input 1: Safety gate without start-up test. Input 2: Light curtain

Selecting output groups:

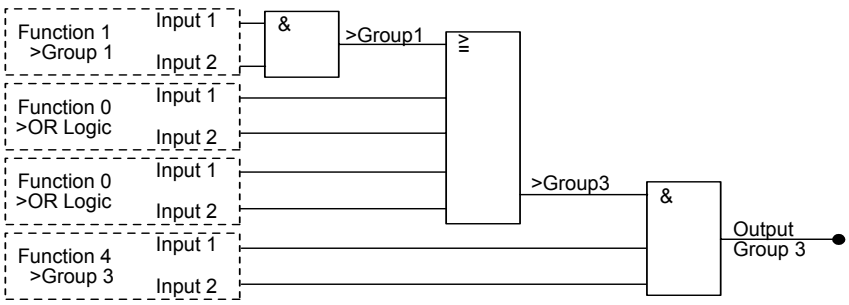
Switch settings	Function	LED Gr 1	LED Gr 2	LED Gr 3
0	OR logic function (*[1]) (Group 3 = Input 1 OR Input 2 OR Group 1)	On	Off	Flashes
1	Group 1 (*²)	On	Off	Off
2	Group 2	Off	On	Off
3	Group 1 + 2	On	On	Off
4	Group 3	Off	Off	On
5	Group 1 + 3	On	Off	On
6	Group 2 + 3	Off	On	On
7	Group 1 + 2 + 3	On	On	On
8	Robot function (incl. muting) (see chapter 5)	On	On	Flashes
9	Additional Safe Area (3 zone robot function see chapter 5)	Off	Off	Flashes

(*) Explanations:

(*[1]): Switch setting 0:
This Input Module will generate a Group 3 command if at least one of the conditions occur:
Input 1 of this Input Module is active
OR
Input 2 of this Input Module is active
OR
Group 1 output is active

(*²): Switch setting 1:
Group 1 Output Module is active if all inputs circuits to the assigned Input Module/s are closed.

If several Input Modules are set up for logic function ("Function" switch setting = 0), then the output of the Group 3 Output will be active only if at least one input of all these Input Modules is active.
This OR function can be AND-logic combined with other inputs assigned to Output Group 3 (switch setting = 4,....., 7: see example below and in section 5.2).



LED indication of Output Group assignment:

The Input Module has three LEDs for indicating its assigned Output Group Module.

The Input Module has two additional LEDs that give diagnostic information as follows:

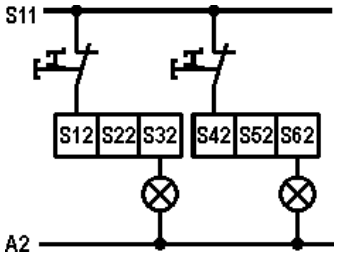
States	Function	LED Input 1	LED Input 2
1	Input 1 valid	Continuous green	---
2	Input 1 invalid	Continuous red	---
3	Input 1 switch faulty	Flashes red	---
4	Input 2 valid	---	Continuous green
5	Input 2 invalid	---	Continuous red
6	Input 2 switch faulty	---	Flashes red
7	Detected configuration does not match that stored in the EEPROM	Input 1 LED flashes red alternately with Input 2 LED	Input 2 LED flashes red alternately with Input 1 LED
8	Redundant rotary switches are not set identically.	Input 1 LED flashes red alternate with Input 2 LED	Input 2 LED flashes red alternate with Input 1 LED

4.2.3 Connections For Input Functions

4.2.3.1 1-Channel Emergency Stop

Switch setting: 1

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S12: N/C	S11-S42: N/C	S32	S62



IMPORTANT Switches with forced driven contacts and additional failure exclusions related e.g. to wiring and crossfaults required to achieve safety cat 4 in this application (e.g. installation and wiring in IP54 cabinet)

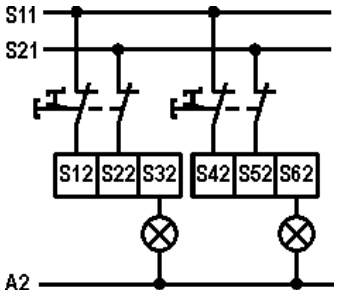
IMPORTANT For following 2- and 3 channel E-stop examples fault exclusion between wiring both e-stop circuits (Input1 and Input2).

4.2.3.2 2-Channel Emergency Stop

Switch setting: 2

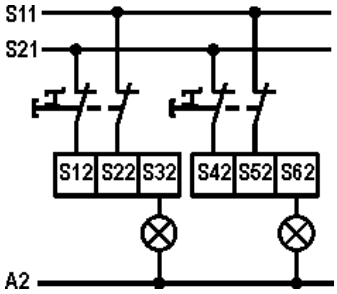
Without simultaneity monitoring

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S12: N/C S21-S22: N/C	S11-S42: N/C S21-S52: N/C	S32	S62



With simultaneity monitoring (3 second time limit to close channels per input)

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S22: N/C S21-S12: N/C	S11-S52: N/C S21-S42: N/C	S32	S62

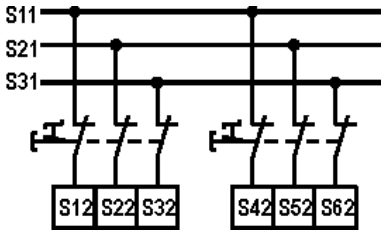


4.2.3.3 3-Channel Emergency Stop

Switch setting: 3

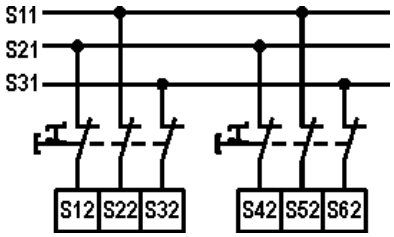
Without simultaneity monitoring.

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S12: N/C S21-S22: N/C S31-S32: N/C	S11-S42: N/C S21-S52: N/C S31-S62: N/C	Not available	Not available



With simultaneity monitoring (3 second limit).

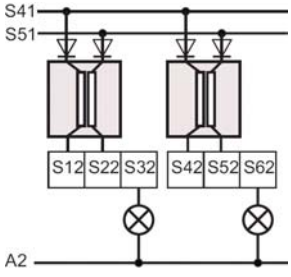
Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S22: N/C S21-S12: N/C S31-S32: N/C	S11-S52: N/C S21-S42: N/C S31-S62: N/C	Not available	Not available



4.2.3.4 Safety Mats

Switch setting: 2
Without simultaneity monitoring.

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S41-S12: N/C S51-S22: N/C	S41-S42: N/C S51-S52: N/C	S32	S62



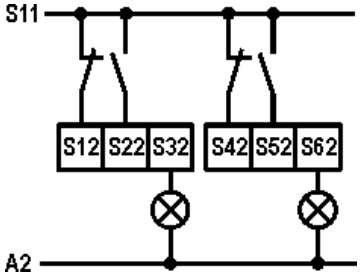
Note: if more than a single input is connected to Safety Mats it is recommended to install two diodes in series to the input wires of each mat.
This avoids crossfault-feedback to S41 and S51 and is required to achieve individual annunciation on each input.

4.2.3.5 Safety Gate

Switch setting: 4 or 5

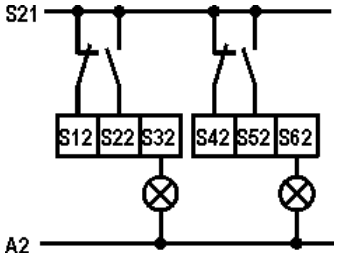
Without simultaneity monitoring.

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S12: N/C S11-S22: N/O	S11-S42: N/C S11-S52: N/O	S32	S62



With simultaneity monitoring (3 second limit).

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S21-S12: N/C S21-S22: N/O	S21-S42: N/C S21-S52: N/O	S32	S62

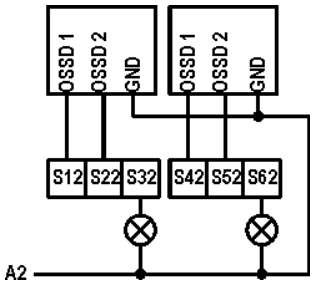


4.2.3.6 Light Curtain

Switch setting: 6

Without simultaneity monitoring.

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
OSSD1-S12 OSSD2-S22	OSSD1-S42 OSSD2-S52	S32	S62

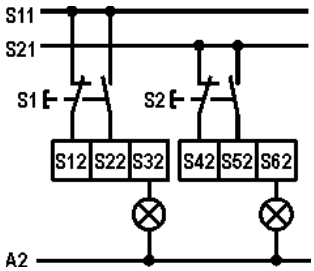


4.2.3.7 Two-hand Control

Switch setting: 7

With simultaneity monitoring (0.5 second limit).

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S12: N/C S11-S22: N/O	S21-S42: N/C S21-S52: N/O	S32	S62

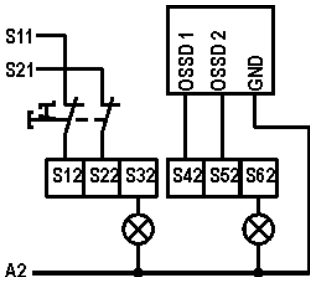


4.2.3.8 2-Channel Emergency Stop and Light Curtain

Switch setting: 8

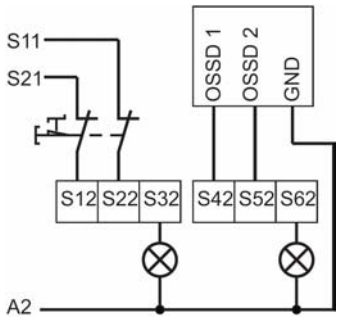
Without simultaneity monitoring of Input 1 and Input 2.

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S12: N/C S21-S22: N/C	OSSD1-S42 OSSD2-S52	S32	S62



With simultaneity monitoring (3 second limit) of Input 1

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S12: N/C S21-S22: N/C	OSSD1-S42 OSSD2-S52	S32	S62

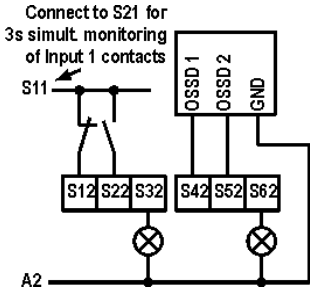


4.2.3.9 Safety Gate and Light Curtain

Switch setting: 9

Without simultaneity monitoring of Input 1 and Input 2.

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S11-S12: N/C S11-S22: N/O	OSSD1-S42 OSSD2-S52	S32	S62

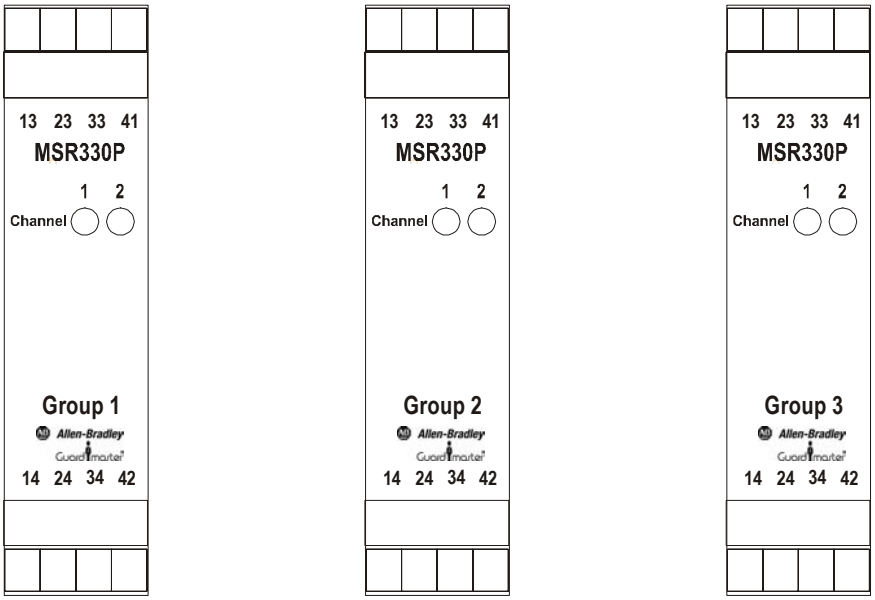


With simultaneity monitoring (3 second limit) of Input 1 and without simultaneity monitoring of Input 2.

Input 1	Input 2	Solid-state auxiliary output: Input 1	Solid-state auxiliary output: Input 2
S21-S12: N/C S21-S22: N/O	OSSD1-S42 OSSD2-S52	S32	S62

See respective wiring diagrams for safety door and light curtain (above).

4.3 MSR330 Output Module



MSR330 Modules: Group 1, Group 2, Group 3

Functions: Safety contact outputs.
Outputs: Each module: 3 x N/C outputs plus 1 x N/O safety contact outputs.
System maximum: 3 x 6 = 18 N/C plus 1 x 6 = 6 N/O auxiliary contacts.

A minimum of one up to a maximum of six Output Modules can be included in a single MSR300 System.

MSR330 Output Modules are available in three distinct versions, each specific for one of three output groups: i.e., Group 1, Group 2, Group 3 respectively. The group number must be specified when ordering these modules, and Output Group versions must correspond with the assignment settings of the Input Modules.

The MSR330 is housed in a 22.5 mm wide DIN rail mounting enclosure with plug-in screw terminal blocks.

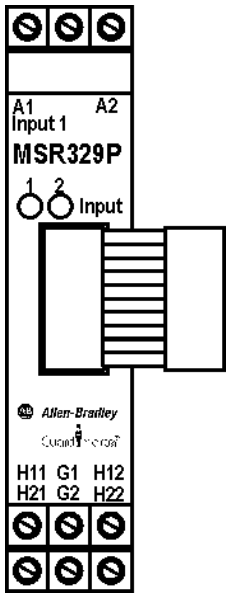
4.3.1 Terminals

Name	Function
13-14	Safety output 1: N/O
23-24	Safety output 2: N/O
33-34	Safety output 3: N/O
41-42	Auxiliary output 4: N/C

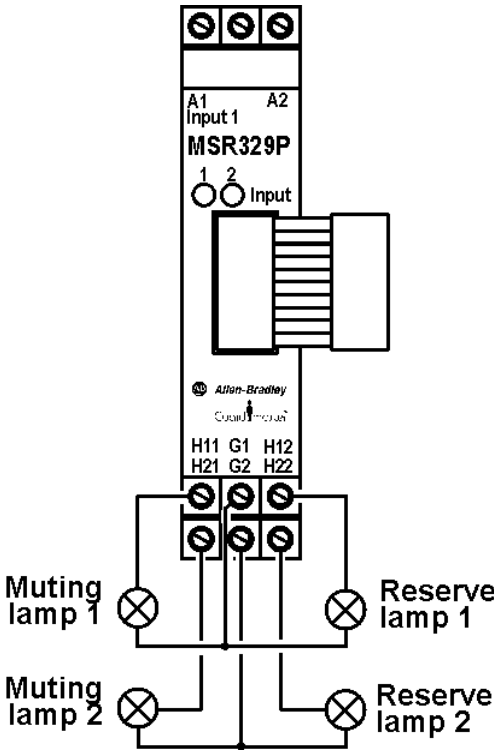
4.3.2 LED Indicators

Function / Diagnostics	Ch 1	Ch 2
Relay 1 on	Green	-
Relay 1 off	Off	-
Relay 2 on	-	Green
Relay 2 off	-	Off

4.4 MSR329 Muting Lamp Module



MSR329 Front View



MSR329 Connections

Functions: Connection and control of muting lamps.
Capacity: Two main muting lamps plus two reserve muting lamps

Muting is the safe, automatic and temporary suspension of an electrosensitive protective device, in accordance with EN 61496-1 A.7. Muting is typically applied to allow material in process to be moved into and out of a hazardous area. Typically, muting causes the signal inputs from safety barriers such as opto-switches or light curtains to be temporarily

ignored, -A kind of muting control is implemented in an MSR300 System as part of the robot safety control function. In this special application safety cam-switches or sensors at the robot shaft initiate the muting process. These provide area position feedback to the MSR300 system in order to ignore e.g. safety light curtains as long as the robot arm is not working in the near of the light curtain protected area.

Muting lamps are deployed to indicate the occurrence of muting. Special safety controls are necessary to ensure that muting lamps operate correctly and safely. The MSR329 Muting Lamp Controller is expressly designed for this purpose.

An MSR329 Muting Module may be included in an MSR300 System only if at least one Input Module in the system is programmed for robot safety control. If an MSR329 is included in a system, but no Input Module has been set up for robot safety control, the Base Module will announce an invalid configuration.

Two muting lamps and two spare lamps can be connected to an MSR329 Module. The valid load current range for each lamp is 30 mA to 200 mA. If the current load of a muting lamp is outside this range, the spare lamp is switched on automatically. If the defective lamp is replaced, the normal muting lamp will light up when the next muting condition occurs, and the spare lamp will remain off. If a muting lamp and its spare lamp are both defective (detected by out-of-range current), the corresponding input cannot longer be muted (which means Light curtain always monitored). Restore the muting operation requires that at least one of these two defective lamps will be replaced.

If an MSR329 Muting Lamp Module fails when installed in an MSR300 System, this will result in the muting function being disabled: i.e., the corresponding light curtain will no longer be muted.

The use of the MSR29 Muting Module is subject to the following system configuration rules:

- A Muting Module can be installed only in an MSR300 System that has a Robot Module (Input Module set up for robot function).
- An MSR300 System can have only one Muting Module, bus-connected instead of a normal Input Module (which leaves a maximum number of 9 Input modules to be connected when an MSR329 is used).
- An MSR300 System cannot have a Muting Module and a Logic Module (Input Module set up for logic function): i.e., the system can have either one or the other type of module, not both.

4.4.1 Terminals

Name	Function
A1	Supply +24 VDC
A2	GND, Supply 0 V
H11	Muting lamp 1: positive (+)
H12	Reserve lamp 1: positive (+)
G1	Muting lamp 1 and reserve lamp 1: negative (-)
H21	Muting lamp 2: positive (+)
H22	Reserve lamp 2: positive (+)
G2	Muting lamp 2 and reserve lamp 2: negative (-)

4.4.2 LED Indicators

Function / Diagnostics	H1	H2
Muting lamp 1 off	Off	---
Muting lamp 1 on	Green	---
Muting lamp 1 faulty, but reserve lamp 1 OK	Red	---
Muting lamp 1 and reserve lamp 1 faulty	Flashes red	---
Muting lamp 2 off	---	Off
Muting lamp	---	Green
Muting lamp 2 faulty, but reserve lamp 2 OK	---	Red
Muting lamp 2 and reserve lamp 2 faulty	---	Flashes red

5 Special Functions: Robot Safety and Combination Logic

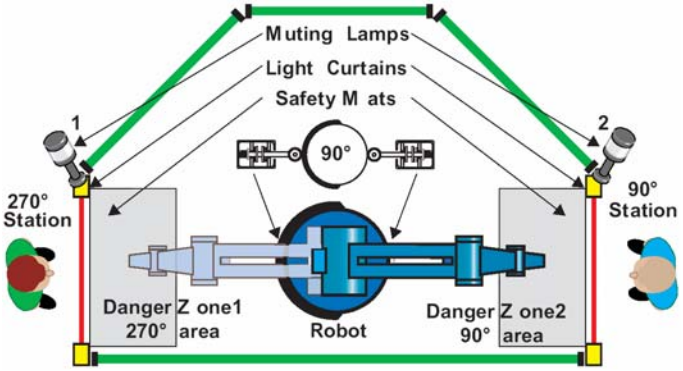
5.1 Robot Safety Control

5.1.1 General

Robot safety control is a special function for which an MSR300 System can be set up. This function makes it possible to continuously verify that a robot arm is always within its specified safe operating zone, typically demarcated by light curtain type safety sensors in combination with special cam-switches fitted on robot rotating turrets or arms.
The safety light curtain on the opposite side of the robot-working zone is disabled (muted) and allows limited access to the cell. This must be a fixed installation and is limited to applications as detailed later in the document. The safety related parts of the installation must be failsafe and protected against override (e.g. cam switches with forced driven contact activation). The robot application itself must fulfill the requirements as specified in the applicable standards, e.g. RIA15.06. The operator access to the area between the light curtain and hazardous machine parts must be prevented or monitored via safety mats.
For implementing this function, one Input Module has to be set up for robot safety control function by setting its rotary switch to 8.

5.1.2 Robot Cell with Two Areas

One MSR300 System can have only one robot control module (i.e., one Input Module with switch set for Robot function).



The robot safety control connections are based on the following logic:

- The robot motor is controlled by output/s of Group 3
- Input sensors like light curtains and safety mats or emergency stop switches demarcating the stations are connected to Input Group 1 for Danger Zone 1 (270°) and Group 2 for Danger Zone 2 (90°)
- For an Input Module whose rotary switch has been set to position 8, the robot cam switch for Danger Zone 1 is connected to Input 1 and the robot cam switch for Danger Zone 2 is connected to Input 2 to monitor the safe positioning of the robot arm.

Input1 Danger zone 1 270° area	Input Status Group 1 270° station	Input2 Danger zone 2 90° area	Input Status Group 2 90° station	Output Group 3 >Robot	Muting Lamp 1 270° station	Muting Lamp 2 90° station
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	1	0	0	0	0	0
0	1	0	1	1	0	0
0	0	1	0	0	0	1
0	0	1	1	0	0	1
0	1	1	0	1	0	1
0	1	1	1	1	0	1
1	0	0	0	0	1	0
1	0	0	1	1	1	0
1	1	0	0	0	1	0
1	1	0	1	1	1	0
1	0	1	0	0	0	0
1	0	1	1	0	0	0
1	1	1	0	0	0	0
1	1	1	1	1	0	0

Definitions:

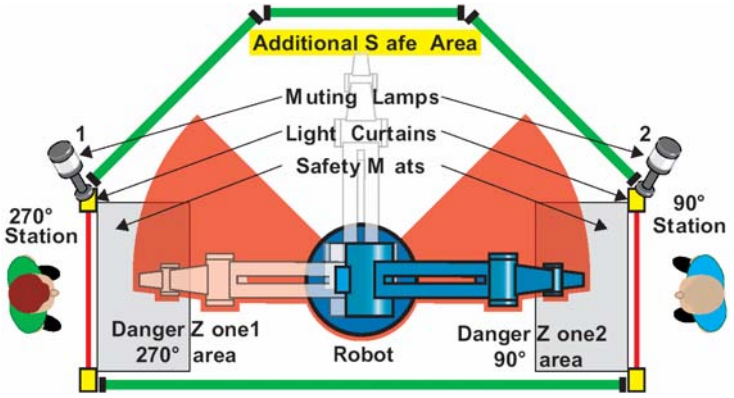
Input danger zone: 0: robot is in danger zone
1: robot is not in danger zone
Input status of groups: 0: output inactive
1: output active
Muting lamp: 0: lamp off
1: lamp on

Implementation of an MSR300 System for robot safety control is subject to the following system configuration rules:

- One MSR300 System cannot have more than one Robot Module (Input Module set up for robot function).
- The MSR310 Input Module configured for robot safety control must have a Group 1 or Group 2 Output assigned to it. (Note: Output Module Group 1 and 2 not physically necessary)
- An MSR300 System cannot have a Robot Module (Input Module set up for robot function) and a Logic Module (Input Module set up for logic function): i.e., the system can have either one or the other type of module, not both.

5.1.3 Robot Safety Control With Additional Safe Area

A robot cell can be safety-controlled for an additional safe area by a combination of two Input Modules in an MSR300 System. **One Input Module is set up for robot safety control (function switch setting: 8), and a second one is set up for the additional safe area function (function switch setting: 9).**



One MSR300 System cannot have more than one Additional Safe Area Module: i.e., an MSR300 System can be configured for robot safety control with not more than one additional safe area.

The functional logic for additional safe area control is as follows:

- The robot is controlled by the output/s of Group 3.
- Inputs assigned to Group 1 monitor dangerous zone 1 (270°)(e.g. light curtains).
- Inputs assigned to Group 2 monitor dangerous zone 2 (90°) (e.g. light curtains).
- One input module is set up for monitoring the safe positioning of the robot arm. (Input 1: Danger Zone 1. Input 2: Danger Zone 2).
- The other input module is set up for monitoring additional safe area of the robot cell.

Implementation of an MSR300 System for robot safety control with additional safe area control is subject to the following system configuration rules:

- One MSR300 System cannot have more than one Additional Safe Area Module (Input Module set up for additional safe area function).
- An MSR300 System cannot have an Additional Safe Area Module (Input Module set up for additional safe are function) and a Logic Module (Input Module set up for logic function): i.e., the system can have either one or the other type of module, not both.

Input1 Danger Zone1 270°area	Input Status Group 1 270° station	Input 2 Danger Zone2 90°area	Input Status Group 2 90° station	Add Safe Area	Output Group 3	Muting Lamp 1 270°area	Muting Lamp 2 90°area
0	0	1	0	0	0	0	1
0	0	1	0	1	0	0	1
0	0	1	1	0	0	0	1
0	0	1	1	1	0	0	1
0	1	1	0	0	1	0	1
0	1	1	0	1	1	0	1
0	1	1	1	0	1	0	1
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1	1	0	0	1	0	1	0
1	1	0	1	0	1	1	0
1	1	0	1	1	1	1	0
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1	0	1	1	0	0	0	0
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1	1	1	0	0	0	0	0
1	1	1	0	1	1	1	1
1	1	1	1	0	1	0	0
0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0
0	0	0	1	0	0	0	0
0	0	0	1	1	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	1	0	0	0
0	1	0	1	0	1	0	0
0	1	0	1	1	1	0	0

Grey marked Section at bottom: Undefined status of at least one Input, which results either in disabling the Robot operation or disabling the Muting function. As soon as Inputs are back in defined status the MSR300 automatically returns to normal operation mode.

Definitions:

Input danger zone: 0: robot is in danger zone
1: robot is not in danger zone
Add Safe Area: 1: robot is in Add Safe Area
0: robot is not in Add Safe Area
Input status of groups: 0: output inactive
1: output active
Muting lamp: 0: lamp off, 1: lamp on

5.2 Special Logic Functions

An MSR300 System can be configured for applying OR logic to a combination of inputs of one or more Input Modules. This allows e.g. limited access to dangerous areas by use of 3-position enabling switches or enabling pendants (see application examples below).

Switch setting for logic function: 0
Group 3 = Input 1 OR Input 2 OR Group 1

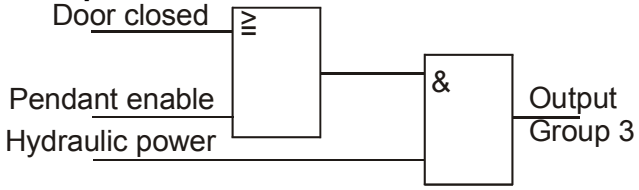
When an MSR300 System includes more than one Input Module set for OR logic, the logic function is:
Group 3 = Input $1_{Module1}$ OR Input $2_{Module1}$ OR Input $1_{ModuleX}$OR Group 1
["X" is the input module number of the second or other Input Module]

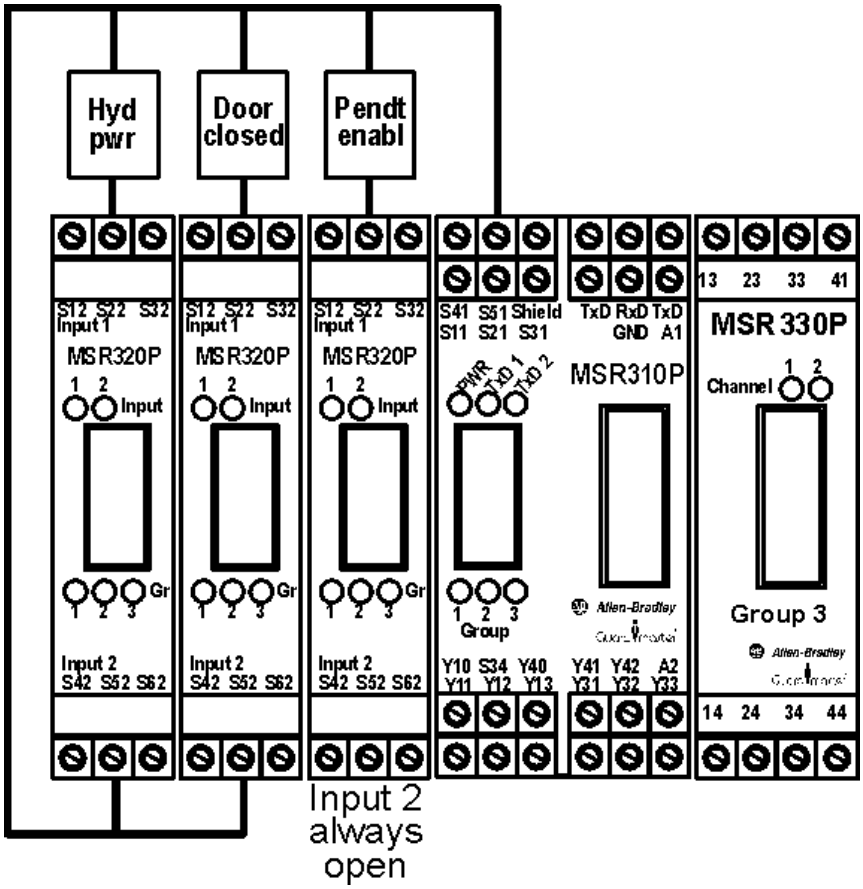
The logic function cannot be implemented in an MSR300 System that is configured for robot safety control, for additional safe area monitoring or for muting.

Implementation of the logic function in an MSR300 System is subject to the following system configuration rules:

- An MSR300 System cannot have a Muting Module and a Logic Module (Input Module set up for logic function): i.e., the system can have either one or the other type of module, not both.
- An MSR300 System cannot have a Robot Module (Input Module set up for robot function) and a Logic Module (Input Module set up for logic function): i.e., the system can have either one or the other type of module, not both.
- An MSR300 System cannot have an Additional Safe Area Module (Input Module set up for additional safe are function) and a Logic Module (Input Module set up for logic function): i.e., the system can have either one or the other type of module, not both.
- A Group 3 Output Module must be included in an MSR300 System in which logic control is implemented.
- Additionally one of the Input Modules must have its output group assignment (by rotary switch) set to Group 1. This is to be done only to implement the logic function: physical connection of a group 1 output module is not necessary for this purpose, but may be used if the safety system design requires this.

Example 1

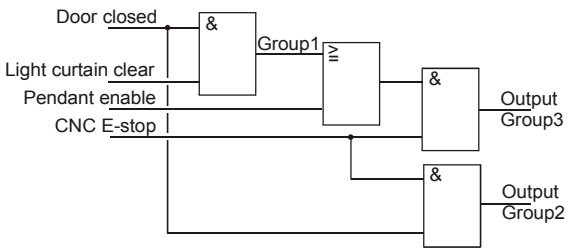


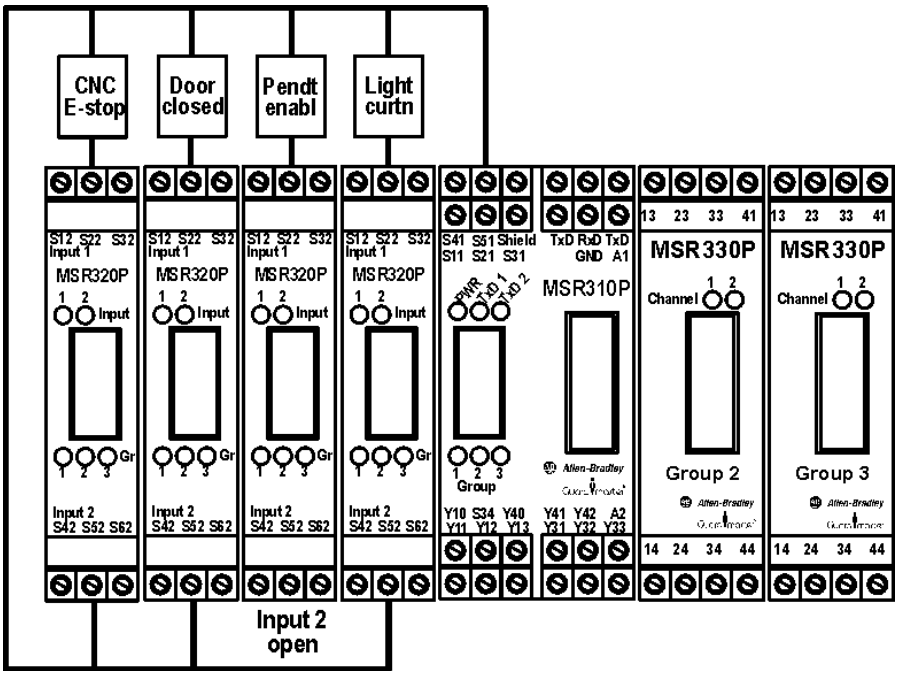


Hydraulic power Group 3 2-channel	Door closed Group 1 Safety gate	Pendant enable Logic function 2-channel

Logic function:	Switch setting: 0
Group 1:	Switch setting: 3
Group 3:	Switch setting: 4

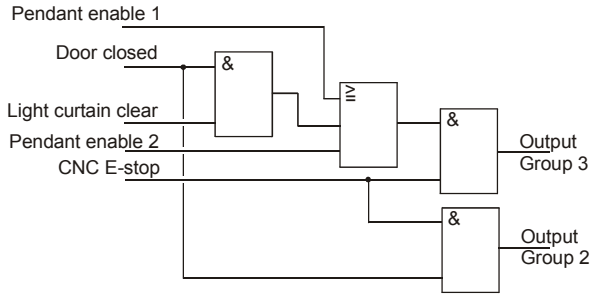
Example 2

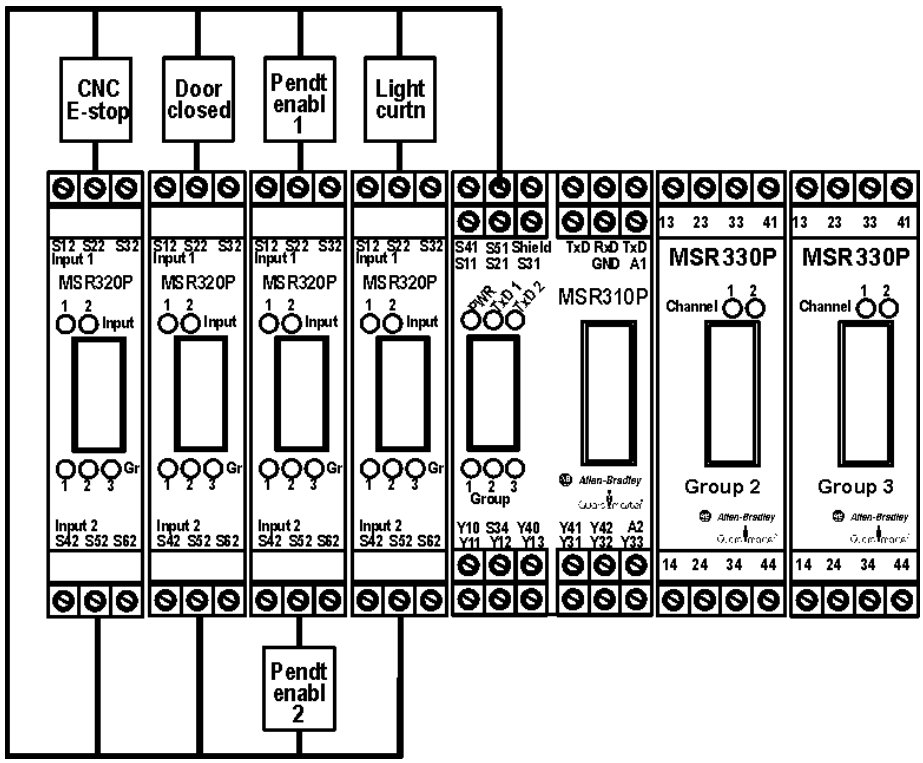




CNC E-stop Group2 + 3 2-channel	Door closed Group 1 + 2 Safety gate	Pendant enable Logic function 2-channel	Light curtain Group 1 2-channel

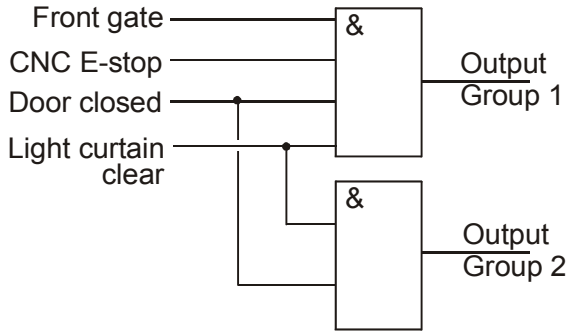
Example 3

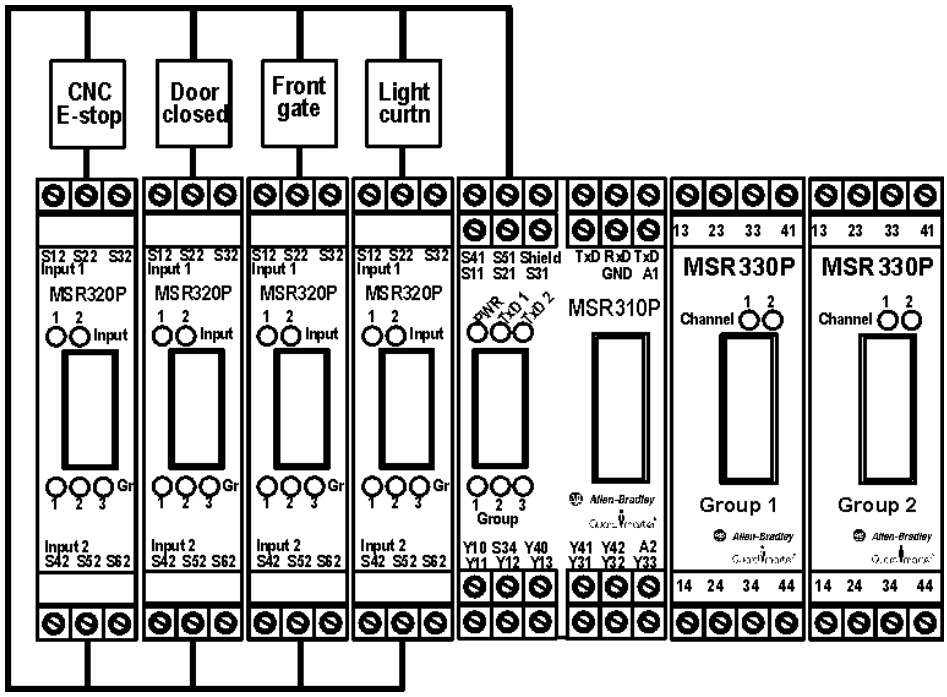




CNC E-stop Group2 + 3 2-channel	Door closed Group 1 + 2 Safety gate	Pendant enable Logic function 2-channel	Light curtain Group 1 2-channel

Example 4
(Zoning application without OR-logic function)





CNC E-stop Group 1 + 2 2-channel	Door closed Group 1 + 2 Safety gate	Front gate Group 1 Safety gate	Light curtain Group 1 2-channel

6 Faults Detection and Response

[Note: In the following part of this document, "fault" can mean the occurrence of an internal failure or defect, an external wiring or signal error, or a system configuration error].

The MSR300 System has extensive error detection capabilities. Faults, symptoms and corrective action are categorized and described below.

6.1 Major Faults

Major faults are indicated by the "Status" LED lighting up red continuously. These faults include:

- The two redundant microprocessors of the MSR310 Base Module perceive different operating states of the system as a whole.
- Tripping due to:
  - Difference in the settings of the two redundant sets of rotary switches of any Input Module
  - Detection of high level of electromagnetic radiation
  - Internal fault/s

6.2 Recoverable Faults During Start-Up or Operation

Recoverable faults are also indicated by the "Status" LED, but by different flashing patterns.

The various recoverable faults and their corresponding LED flashing patterns are described below.
Note: Shut down power before corrective action (except Input switch fault). After modification of configuration the set-up procedure as described in the next chapter is required.

[In the LED Indication column, a number followed by "x" means that the LED flashes (blinks) that many times, followed by a pause. The cycle repeats while the fault condition exists.]

Fault	Indication	Corrective Action
Input switch fault (if switch monitoring is enabled).	"Status" LED flashes 2 x. LED of the faulty input flashes, red.	Unlock the faulty input.
The reset pushbutton (momentary switch) is pressed while the system is being powered up.	"Status" LED flashes 2 x.	Replace the reset switch.
Configuration changes during operation. (Terminals Y40, Y41, Y42, S34).	"Status" LED flashes 3 x.	Check the jumpers at terminals Y40, Y41, Y42, S34.
The actual configuration does not match what has been previously stored in EEPROM.	"Status" LED flashes 4 x.	Check the system configuration. Reconfigure as necessary, or have the system read and store the current configuration.
At least one muting lamp and reserve lamp are defective.	"Status" LED flashes 5 x.	Check and replace both defective lamps.
Bus terminator plug of last Input Module not (or improperly) plugged in.	"Status" LED flashes 8 x.	Insert the bus terminator plug.

6.3 Recoverable Configuration Faults During Start-Up or Operation

Recoverable configuration faults are also indicated by the "Status" LED, but by different flashing patterns.

The various configuration faults and their corresponding LED flashing patterns are described below.
Note: Shut down power before corrective action. After modification of configuration the set-up procedure as described in the next chapter is required.

[In the table below, Logic Module, Robot Module, and Additional Safe Area Module are Input Modules whose rotary switches are set for the corresponding function.]

Fault	Indication	Corrective Action
Logic Module and Muting Module installed in system	"Status" LED flashes 6 x	Modify modules configuration
Logic Module and Robot Module installed in system	"Status" LED flashes 6 x	Modify modules configuration
Logic Module and Additional Safe Area Module installed in system	"Status" LED flashes 6 x	Modify modules configuration
More than one Robot Module installed in system	"Status" LED flashes 6 x	Modify modules configuration
More than one Additional Safe Area Module installed in system	"Status" LED flashes 6 x	Modify modules configuration
More than one Muting Module installed in system	"Status" LED flashes 6 x	Modify modules configuration
Additional Safe Area Module installed without Robot Module	"Status" LED flashes 6 x	Modify modules configuration
Muting Module installed without Robot Module	"Status" LED flashes 6 x	Modify modules configuration
Robot Module installed without Group 1 or 2 Output Module	"Status" LED flashes 6 x	Modify modules configuration
Logic Module installed without Group 1 Output Module	"Status" LED flashes 6 x	Modify modules configuration
Terminals Y40, Y41, Y42, S34 wrongly connected.	"Status" LED flashes 7 x	Connect these terminals only as follows: Jumper: Y40 - Y41 Jumper: Y40 - Y42 Jumper: Y40 - S34
At least one Input Module has difference in redundant rotary switches settings.	"Status" LED continuously lighted, red. All input LEDs of the offending Input Module flash, red	Adjust rotary switch settings: both sets must match

7 Installation, Start-Up, Operation, Maintenance

7.1 Safety Precautions and Practices

Use this product only for intended applications:
The MSR300 Safety System is intended for applications requiring safety monitoring of machinery in accordance with the following directives / standards:

- EN954-1: Safety-Related Parts Of Control Systems.
- IEC 61508: Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems, Parts 1-7, 1998.

This equipment must not be used for unintended applications, nor in ways that do not conform to appropriate safety standards and good practices. The safety functions may not operate properly (or at all) if this equipment is not used for the intended purposes.

Installation and operation to be done only by qualified technical personnel:

WARNING

This equipment is to be installed, started up, and operated only by technical personnel who have been trained and made familiar with:

- The product/s for which this document exists
- Directives, regulations and practices relating to machine safety
- Instrumentation and automation components, equipment and systems
- Industrial electrical practices

Uptodate user documentation must readily accessible by technical personnel:
The latest version of user documentation that includes instructions for installation, operation and maintenance of this product must be readily available near at hand to personnel involved in any of these tasks.

Identify hazardous areas and dangerous operating modes before using:
Machine safety applications make it necessary for hazardous areas and dangerous operating modes to be carefully identified, and adequate measures taken to ensure that failure or tampering does not allow automated equipment to be of risk to personnel.

Use within specified operating limits:
This product, the equipment on which it installed, persons handling the product and equipment, and/or the immediate environment can be harmed if this equipment is operated outside the specified limits of any of its technical parameters.

WARNING

Observe electrical safety regulations and good practices:
Electrical safety regulations stipulated by the appropriate technical authorities must be observed.

Do not use if the product is damaged or diminished in any way:
Carefully inspect each module before it is installed (or re-installed). If at any time it is observed that the condition of equipment is diminished in any way so that there is even the slightest possibility of incorrect functioning, it should be assumed that safe operation is no longer possible, and the equipment should be removed immediately so that even unintentional operation is made impossible. Examples of such conditions are:

- Visible damage to the equipment
- Loss of electrical function/s
- Exposure to temperatures higher the specified operating limit
- Visible indication of burning
- Visible physical damage due to impact or excessive mechanical shock

Do not attempt to open the housing or repair any of the modules:
It is forbidden for safety control products such as this to be repaired or modified in any way: this can diminish or render inoperative its critical safety functions. A malfunctioning or damaged module must be immediately removed, so that even inadvertent operation of the system becomes impossible in such circumstances. An identical module should be installed in its place, after the new module has been tested to confirm that it is in proper working condition.

Opening the enclosure of a module will immediately void its warranty.

7.2 Installation

7.2.1 Environmental Considerations

IMPORTANT

MSR300 Series Modules must be installed inside protected control panels / cabinets appropriate for the environmental conditions of the industrial location. The protection class of the panel / cabinet should preferably be IP 54 or higher.

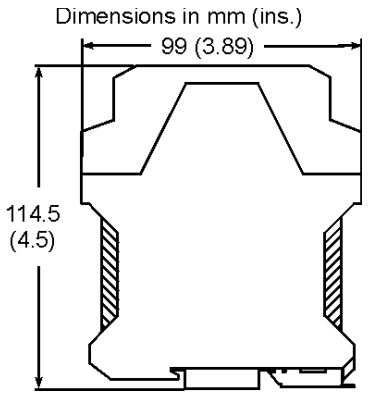
The environmental protection ratings of the modules in accordance with IEC/EN 60529 are:
Housing: IP 40
Terminals: IP 20

Operating ambient condition limits are:
Operating temperature: -5°C to +55°C (+23°F to 131°F)
Relative humidity (RH): 90% (max.)

7.2.2 Mechanical

Dimensions:

Side view and dimensions: all MSR300 Modules



Modules widths:

MSR310 = 35 mm / 1.78 in.
MSR320 = 17.5 mm / 0.69 in.
MSR329 = 17.5 mm / 0.69 in.
MSR330 = 22.5 mm / 0.89 in.

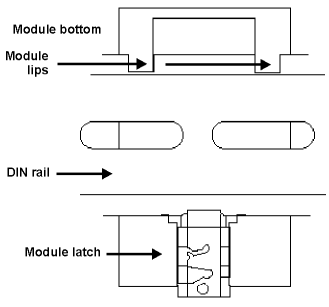
Spacing:

Adequate air space must be provided around the system (modules cluster). Minimum recommended clearances:

Above:	15 mm
Below:	15 mm
Between modules:	2 - 3 mm recommended at ambient temperatures higher than +40°C / +104°F

Mounting and removal:

The modules are mounted on standard DIN 35 mm rails.



To mount the module, first engage its bottom lips with the upper flange of the DIN rail, then rotate and press the module down until the latch snaps onto the lower flange of the DIN rail.

To dismount the module, first disengage the latch from the lower flange of the DIN rail, turn the module upward slightly, then lift the module up to disengage its bottom lips from the upper flange of the DIN rail.

Vibration and mechanical shock:
The MSR300 modules must not be subjected to vibration or mechanical in excess of the specified limits (in accordance with IEC 68 part: 2-6/7):
Vibration: 10 – 55 Hz, 0.35 mm
Mechanical shock: 10g, 16 msec, 100 shocks

7.2.3 Electrical

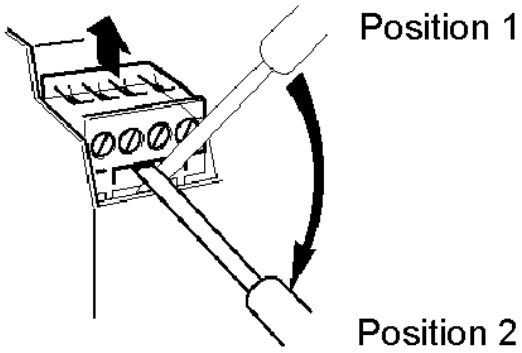
IMPORTANT

The external power supply unit for the MSR300 System must conform to the Directive 73/23/EEC Low Voltage, by applying the requirements of EN 61131-2 Programmable Controllers, Part 2 - Equipment Requirements and Tests, and one of the following:

- EN 60950 - SELV (Safety Extra Low Voltage)
- EN 60204 - PELV (Protective Extra Low Voltage)
- IEC 60536 Safety Class III (SELV or PELV)

For planning information, refer to the guidelines in the document "Industrial Automation Wiring and Grounding Guidelines" (Allen Bradley Publication 1770-4.1).

Removing the terminal blocks:



- To remove the terminal block, insert the screw driver in position 1and then move it slowly to position 2. For the lower terminal blocks, the action will be in the reverse direction

Make sure that electrical power supply to MSR300 System is switched off before making or removing any electrical connections,

Connecting wires should be installed so that no mechanical forces (e.g., mechanical tension) are transmitted through them to the modules, particularly the terminals.

Tighten all terminal screws firmly (*) and re-check all after connections have been made. (* Recommended screw-tightening torque: 0.6 to 0.8 Nm or 5 to 7 lb-in).

Suitable arc and spike suppression components must be connected across load devices of switching outputs (electromechanical contacts or solid-state switch) where the load devices are inductive or capacitive.

7.3 Set-Up

After the MSR300 System has been assembled, it must be programmed with information about the system modules configuration. This data is stored in non-volatile memory and compared with the configuration detected each time the system is switched on. Any difference between the freshly detected configuration and the programmed configuration is interpreted as an error condition. This prevents unintentional modifications in the system configuration.

Configuration detection and saving:

Unintended modifications to MSR300 Systems are prevented by design. The system configuration is automatically checked when it is first started up, and this information is stored in non-volatile memory (EEPROM) in the Base Module. Whenever the system is started up (or restarted) thereafter, the current system configuration is checked against the stored configuration. If a discrepancy is detected, a fault response is immediately generated, with appropriate diagnostic indication and output.
The Base Module is set up in auto-detection mode as default. If it is powered up the first time it will automatically read in the configuration of the connected modules.
Follow the procedure below for changes or modifications of the configuration.

TIP

Procedure for auto detecting and storing a new system configuration:

1. Disconnect Expansion Modules from the Base Module.
2. Insert the bus terminator plug into the left bus connector.
3. Power up the Base Module:

a) The "Status" LED blinks to indicate that the Base Module is in configuration detection mode. LED indication:

b) The previous configuration is erased.

4. Disconnect the power after at least one blink of the LED.
5. Remove the bus terminator plug from the Base Module, and then connect the required Expansion Modules to the Base Module.
6. Insert the bus terminator plug into the free bus connector of the last Expansion Module.
7. Power up the system. After powering up, the current configuration is detected and stored by the Base Module in internal EEPROM.
8. The MSR300 System then automatically steps into normal operating mode.

7.4 Operation

Once an MSR300 System is correctly set up, it starts and operates automatically in accordance with the settings done: it needs no operator attention or action during its normal operation

7.5 Maintenance

An MSR300 System that is correctly configured, set up and installed is inherently maintenance-free.

WARNING

Do not attempt to open the housing or repair any of the modules:

- It is forbidden for safety control products such as this to be repaired or modified in any way: this can diminish or render inoperative its critical safety functions.
- Opening the enclosure of a module will immediately void its warranty.

Defective or damaged modules must be immediately removed to prevent unintentional usage, and replaced before attempting to operate the machinery under the control of this safety system.

IMPORTANT

It is recommended that the integrity of all electrical connections (tightness of terminal screws, firm seating of the plug-in terminal blocks) be inspected at planned intervals.

IMPORTANT

System checking:

Input devices (safety sensors) and output devices (e.g. contactors) should be inspected and tested at planned intervals to confirm they are in good operating condition.

The complete safety system should be inspected and tested at planned intervals, to confirm that all safety functions are operating correctly, e.g., by activating the safety sensors under safe conditions.

Inspection and test schedules depend on operating and site conditions, and on the user's operations and maintenance policies.

Test intervals for SIL3 applications depend on system and input configuration: e.g. worst case scenario: full configuration with 20 single channel inputs and 6 output modules should be tested at approx. 4.38 month

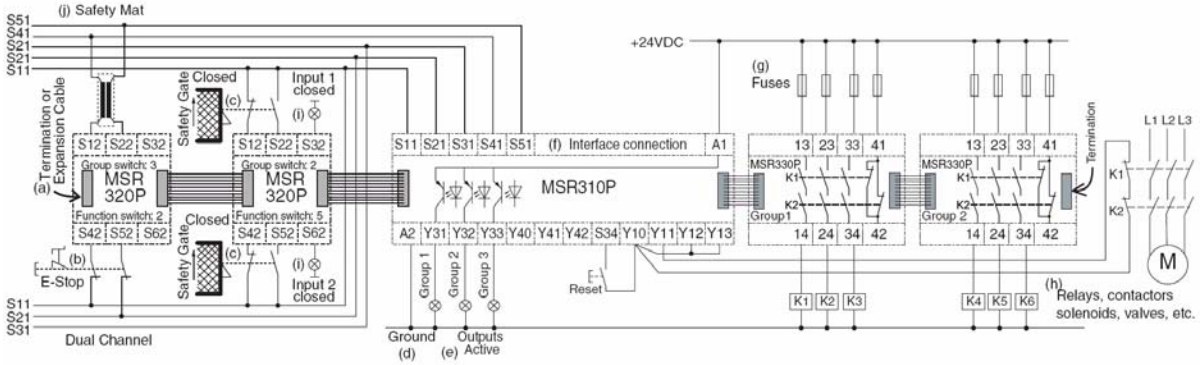
8 Application Examples

Some application examples are presented in this chapter to assist the understanding and usage of this product.

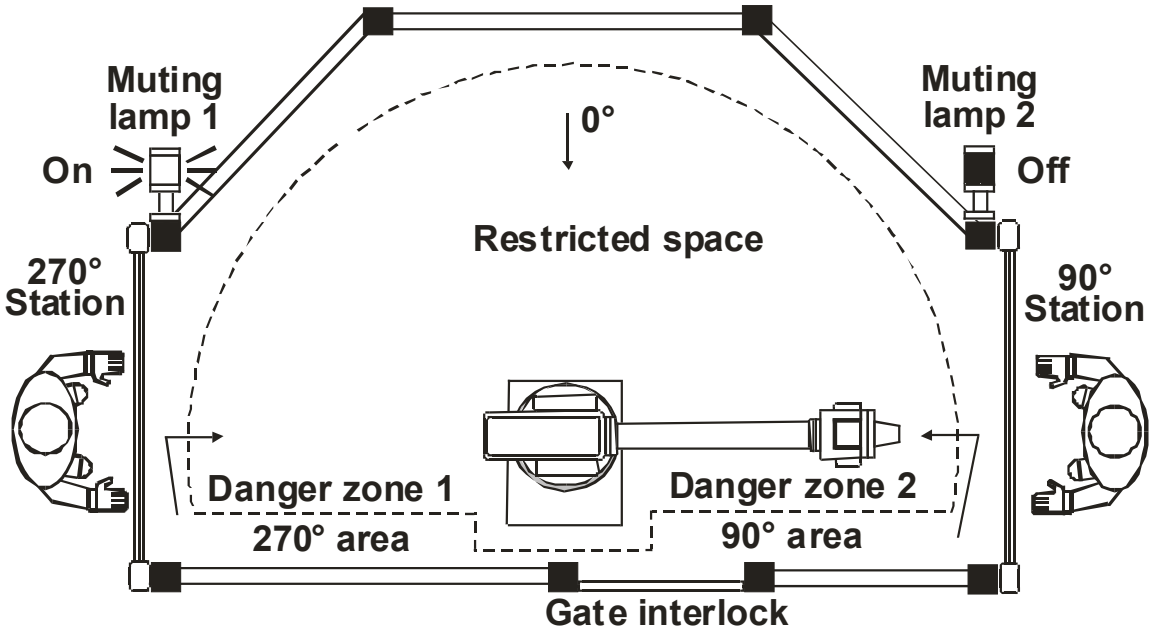
The over-all safety system, external devices, and external electrical circuits will have to designed / selected / configured depending on the unique requirements of each application.

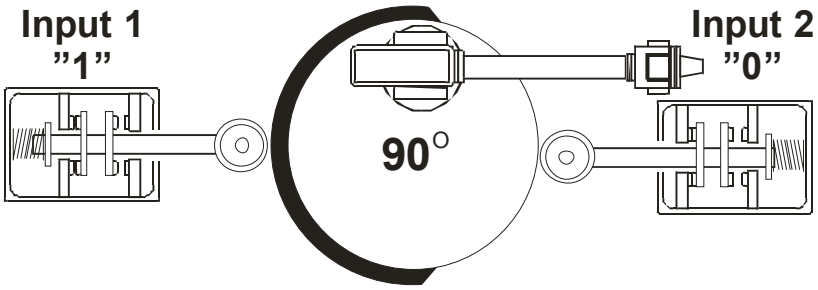
Application Example 1

MSR 300 system with various Inputs, two output groups with common monitored reset, Group 1 with monitored contactors. Safety mat or emergency-stop activation results in a shutdown response by both output modules. Safety gates activation results in a shutdown response by the Group 2 Output Module.



Robot Cell, 2 areas
(Input 1 OR Group 1) AND (Input 2 OR Group 2) = Group 3 (muting with cross control)

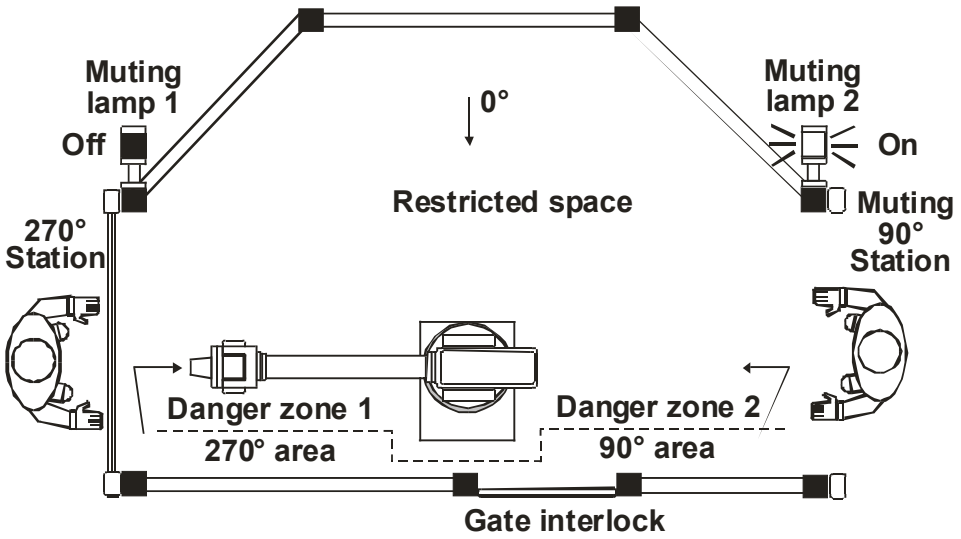


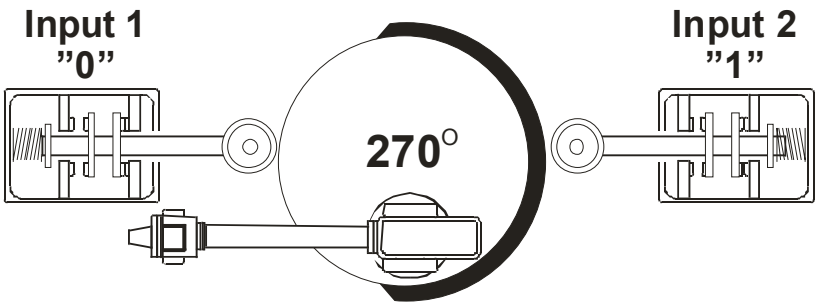


Input 1 Danger zone 1 270° area	Input Status Group 1 270° station	Input 2 Danger zone 2 90° area	Input Status Group 2 90° station	Output Group 3 >Robot	Muting Lamp 1 270° station	Muting Lamp 2 90° station
1	1	0	1	1	1	0

- Base Cam switch pressed on Input 1
- Input Status on both stations "1": No Light curtain interruption
- Robot operation is enabled
- Muting Lamp on 270° station is lightning > Light curtain interruption at 270° station would not stop Robot function

Robot Cell, 2 areas
(Input 1 OR Group 1) AND (Input 2 OR Group 2) = Group 3 (muting with cross control)

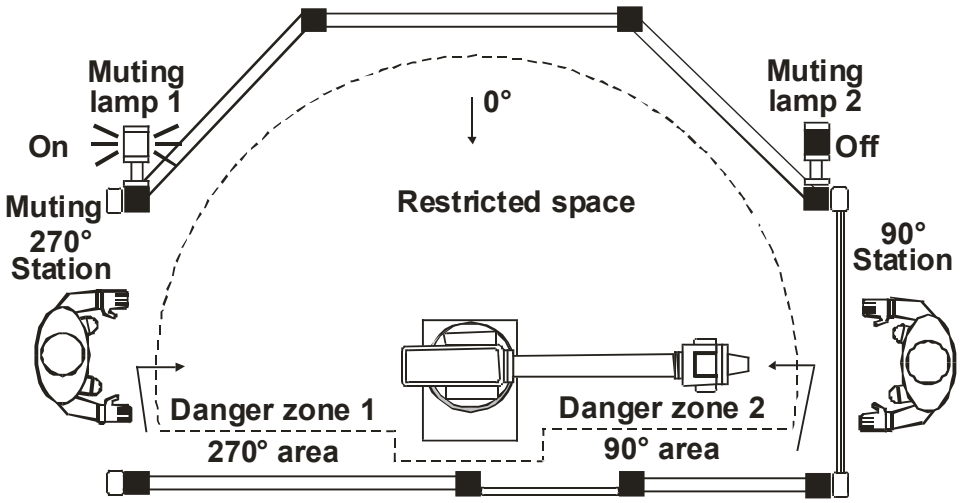


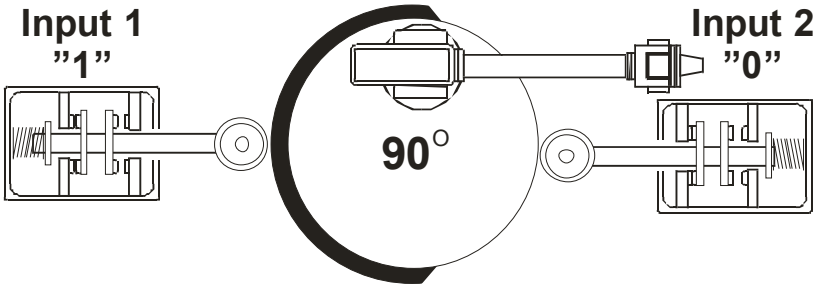


Input 1 Danger zone 1 270° area	Input Status Group 1 270° station	Input 2 Danger zone 2 90° area	Input Status Group 2 90° station	Output Group 3 >Robot	Muting Lamp 1 270° station	Muting Lamp 2 90° station
0	1	1	0	1	0	1

- Base Cam switch pressed on Input 2
- Input Status on 90° station "0": Light curtain interrupted
- Robot operation is enabled
- Muting Lamp on 90° station is lightning > Light curtain interruption at 90° station does not stop Robot function

Robot Cell, 2 areas
(Input 1 OR Group 1) AND (Input 2 OR Group 2) = Group 3 (muting with cross control)

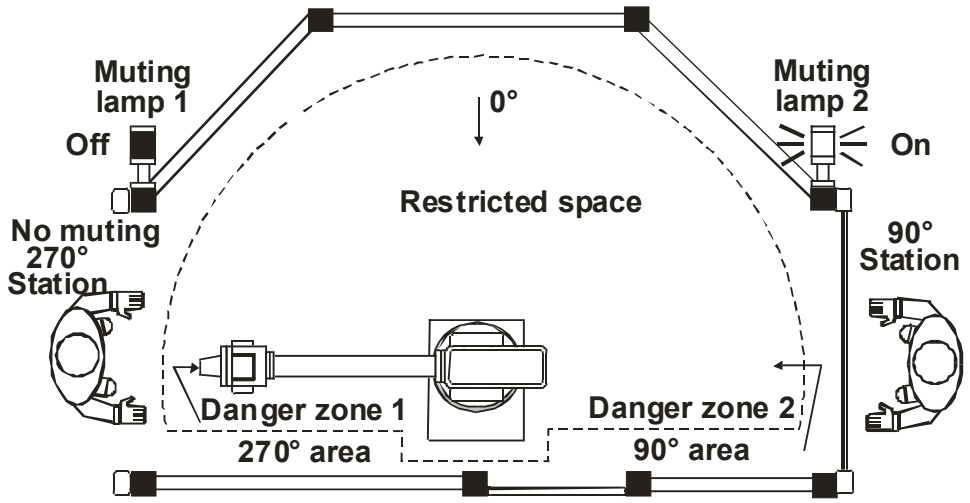


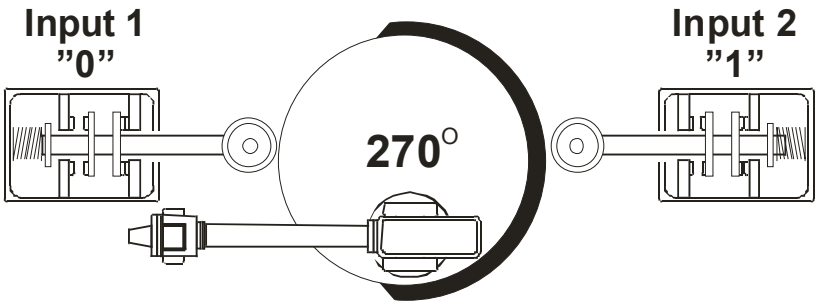


Input 1 Danger zone 1 270° area	Input Status Group 1 270° station	Input 2 Danger zone 2 90° area	Input Status Group 2 90° station	Output Group 3 >Robot	Muting Lamp 1 270° station	Muting Lamp 2 90° station
1	0	0	1	1	1	0

- Base Cam switch pressed on Input 1
- Input Status on 270° station "0": Light curtain interrupted
- Robot operation is enabled
- Muting Lamp on 270° station is lightning > Light curtain interruption at 270° station does not stop Robot function

Robot Cell, 2 areas
(Input 1 OR Group 1) AND (Input 2 OR Group 2) = Group 3 (muting with cross control)

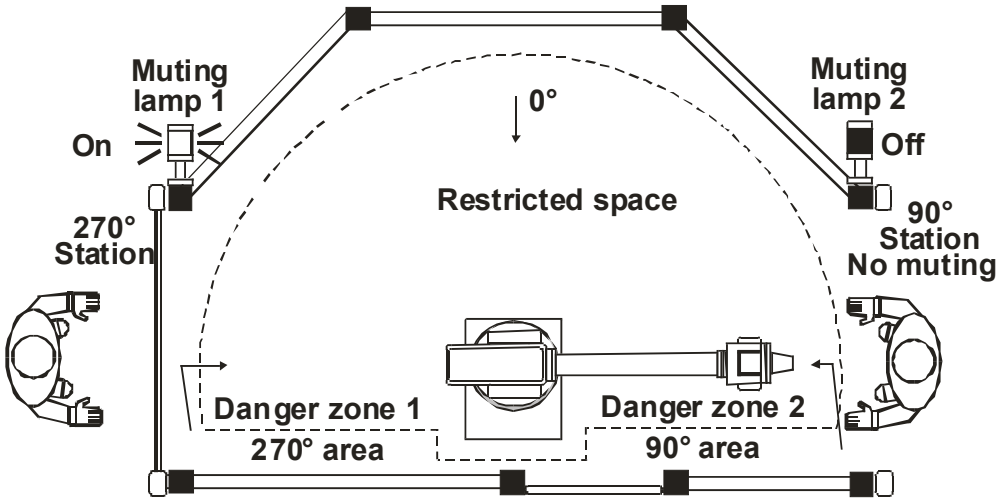


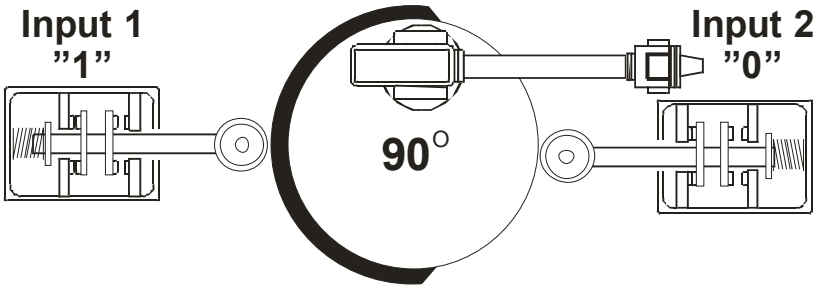


Input 1 Danger zone 1 270° area	Input Status Group 1 270° station	Input 2 Danger zone 2 90° area	Input Status Group 2 90° station	Output Group 3 >Robot	Muting Lamp 1 270° station	Muting Lamp 2 90° station
0	0	1	1	0	0	1

- Base Cam switch pressed on Input 2
- Input Status on 270° station "0": Light curtain interrupted
- Robot operation disabled (stopped) because operator enters danger zone 1 while Robot arm is present
- No Muting Lamp indication for 270° station
- Muting Lamp on 90° station is lightning > Light curtain interruption at 90° station would not stop Robot function

Robot Cell, 2 areas
(Input 1 OR Group 1) AND (Input 2 OR Group 2) = Group 3 (muting with cross control)



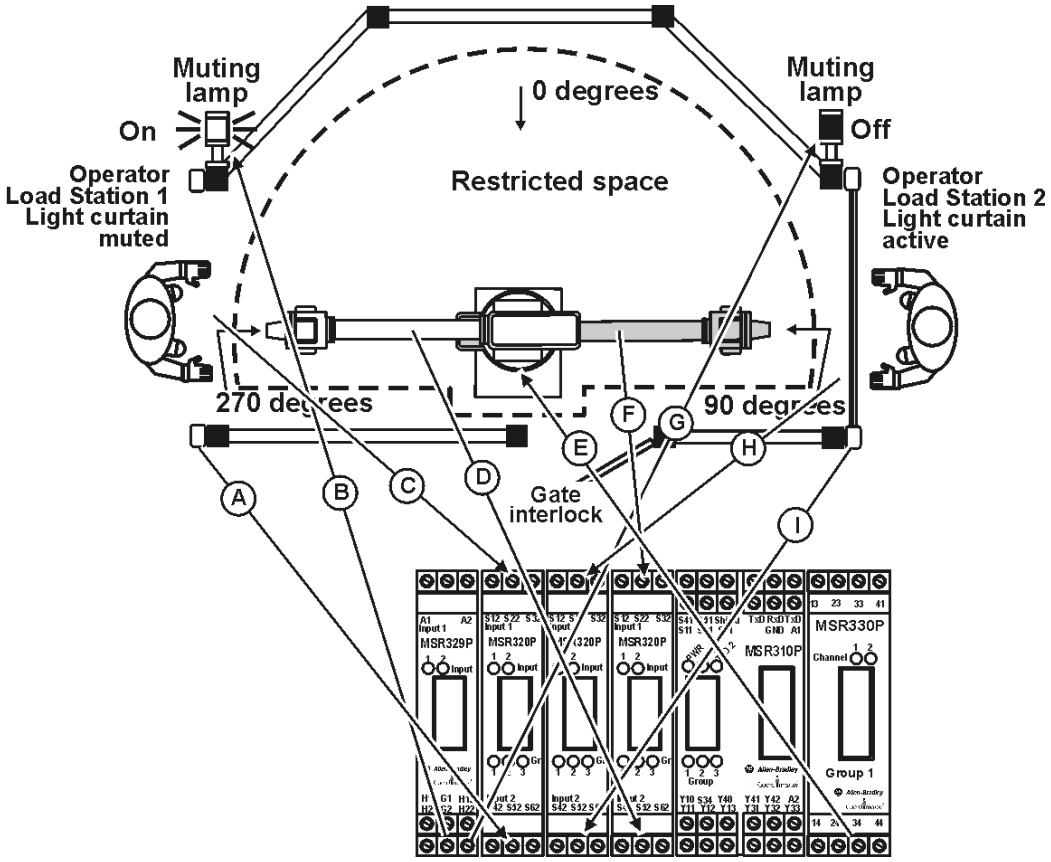


Input 1 Danger zone 1 270° area	Input Status Group 1 270° station	Input 2 Danger zone 2 90° area	Input Status Group 2 90° station	Output Group 3 >Robot	Muting Lamp 1 270° station	Muting Lamp 2 90° station
1	1	0	0	0	1	0

- Base Cam switch pressed on Input 1
- Input Status on 90° station "0": Light curtain interrupted
- Robot operation disabled (stopped) because operator enters danger zone 2 while Robot arm is present
- No Muting Lamp indication for 90° station
- Muting Lamp on 270° station is lightning > Light curtain interruption at 90° station would not stop Robot function

Robot cell, 2 areas

Modules and I/O configuration

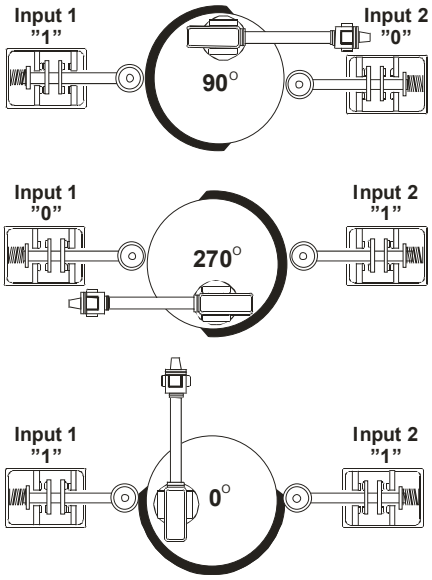


MSR300 System configuration:

MSR310 Base Module – 1
MSR320 Input Modules – 3
MSR330 Output Module – 1
MSR329 Muting Lamp Module – 1

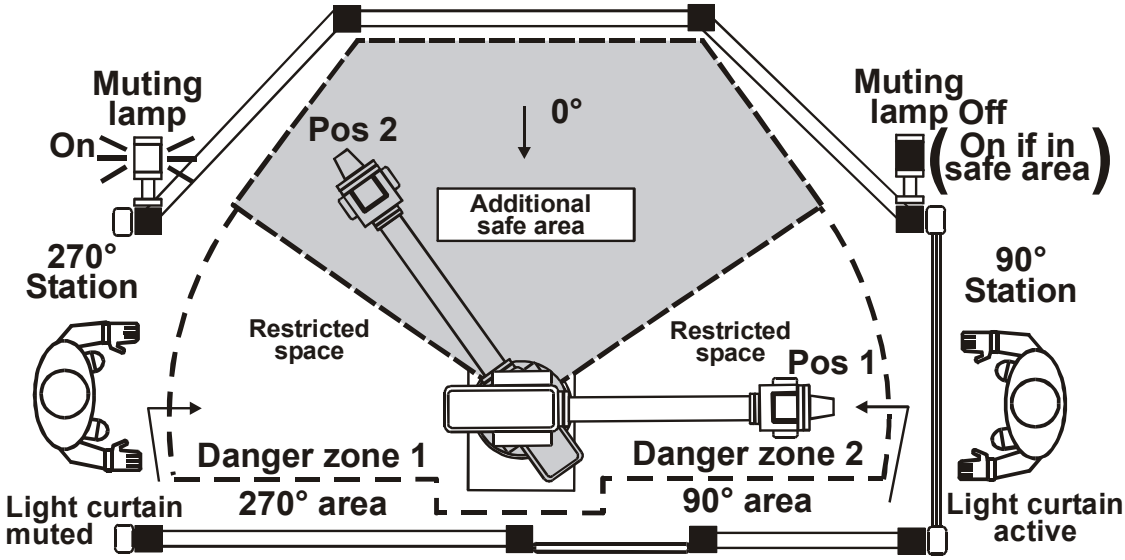
I/O:

A, I = Light curtain inputs
C, H = Safety mat inputs
D, F = Robot cam switch inputs
B, G = Muting lamp control
E = Robot run/stop output



Base Cam Switches in various Robot Arm Positions

Robot Cell 3 Areas

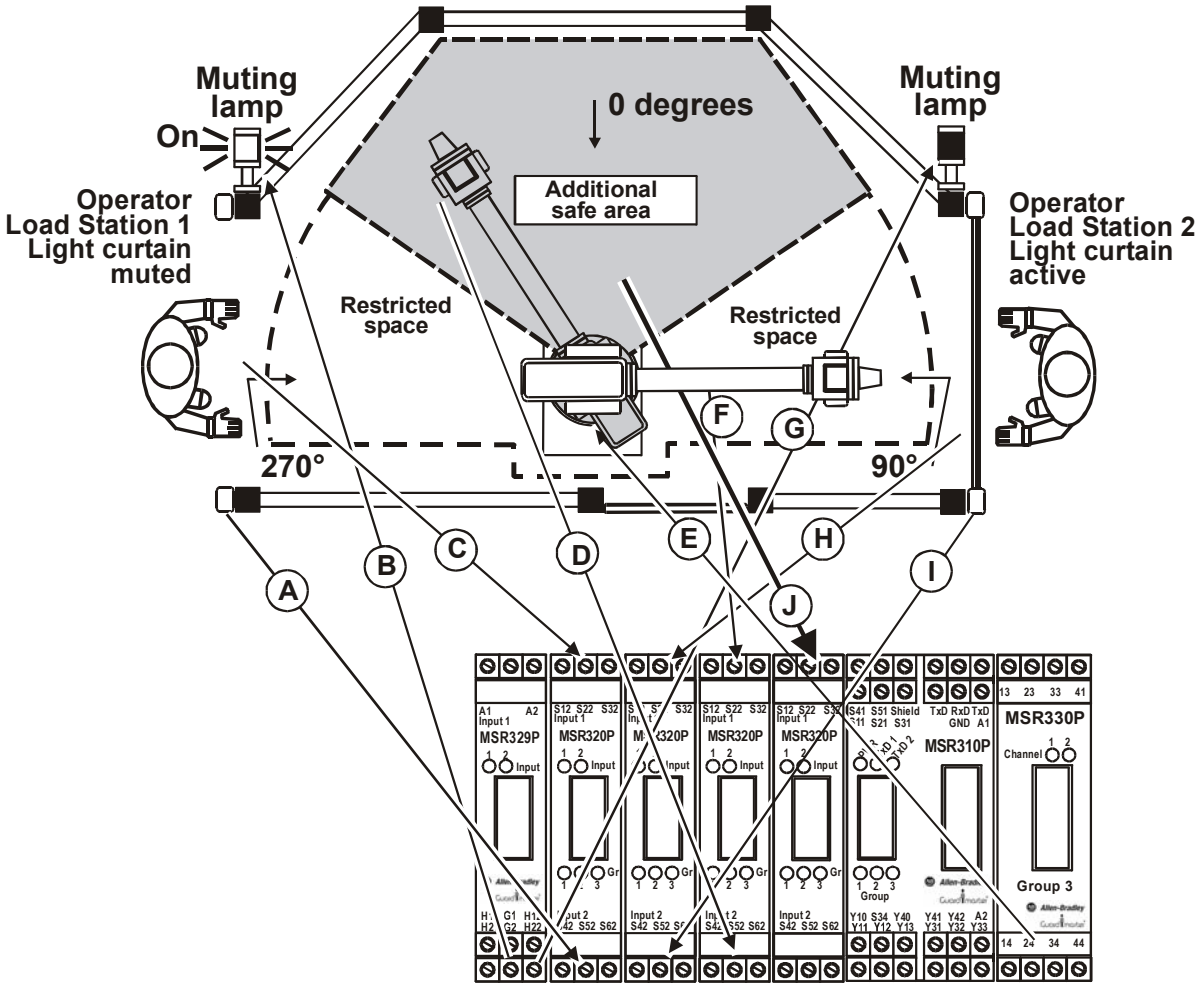


	Input1 Danger Zone 1 270°area	Input Status Group 1 270° station	Input 2 Danger Zone 2 90°area	Input Status Group 2 90° station	Add Safe Area	Output Group 3 >Robot	Muting Lamp1 270° station	Muting Lamp2 90° station
Pos 1	1	0	0	1	0	1	1	0
Pos 2	1	0	1	1	1	1	1	1

Input 1 270°area	=	Light curtain (and Safety Mat) at 270 Station
Status Group 1	=	Robot arm in 270° area (Cam limit switches)
Inpur 2 90° area	=	Light curtain (and Safety Mat) at 90° Station
Status Group 2	=	Robot arm in 90° area (Cam limit switches)
Add. Safe Area	=	Robot arm in safe distance from both: 270° area and 90° area
Output	=	Robot operation > 1: enable, 0: disable

Robot cell 3 areas

Modules and I/O configuration



MSR300 System configuration:

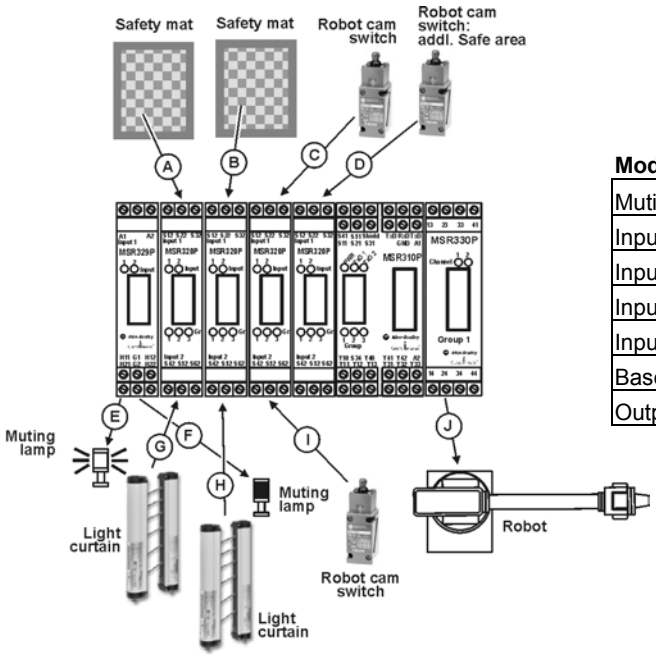
MSR310 Base Module – 1
MSR320 Input Modules – 4
MSR330 Output Module – 1
MSR329 Muting Lamp Module – 1

I/O:

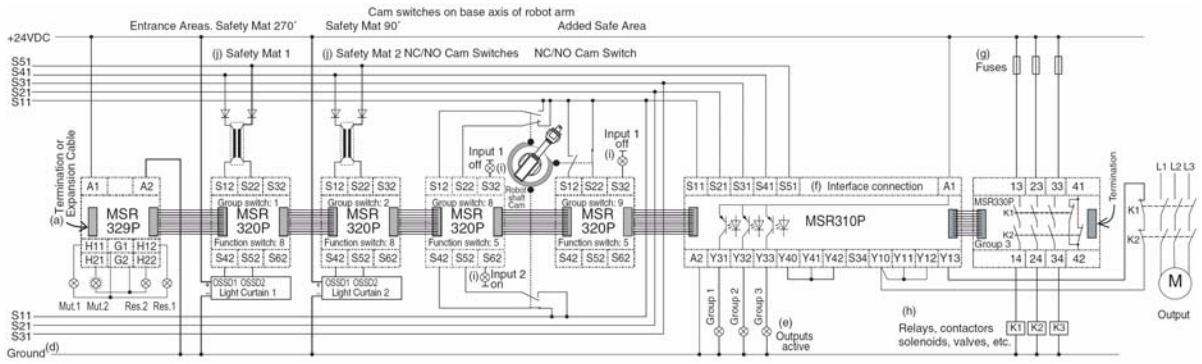
A, I = Light curtain inputs
C, H = Safety mat inputs
D, F = Robot cam switch inputs
B, G = Muting lamp control
E = Robot run/stop output
J = "Addl. Safe Area" cam switch

Robot cell, 3 areas

Modules and I/O configuration: external device linkages



Module		Configuration
Muting Lamp Control	=	2 Lamps + 2 Reserve Lamps
Input Module 1	=	Group selection 1, Function 8
Input Module 2	=	Group selection 2, Function 8
Input Module 3	=	Group selection 8, Function 5
Input Module 4	=	Group selection 9, Function 5
Base Module	=	Y40-S34 linked: Auto reset
Output Module	=	Group 3 Type



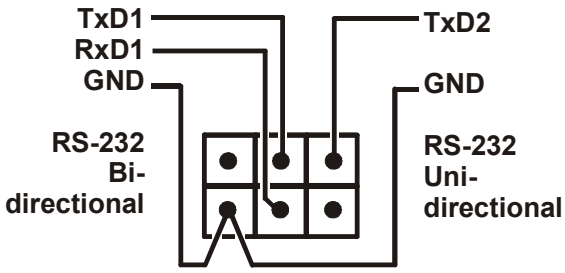
MSR 300 three-zone Robot Cell application allowing safe material flow in and out of the cell without process interruption as long as the robot arm is working in monitored safe zones

9 Serial Data Communication: Details

The MSR310 is equipped with two RS232 serial data interfaces: one can be used in bi-directional, the other in uni-directional mode.

9.1 Serial Data Interface Connections

The serial interface connections are illustrated below.



9.2 RS232 Bi-directional

Bi-directional RS232 features automatic baud rate detection, and can handle baud rates of 2400, 4800, 9600, or 19200 baud.

9.2.1 Protocol:

Supported exception codes:

Code	Name	Meaning
0x01	Illegal function	The function code is not supported by the MSR310
0x02	Illegal data address	The data address in the query is not allowed for the MSR310
0x03	Illegal Data Value	The data value in the query is not valid

Supported functions:

Code	Name	Meaning
0x03	Read Multiple Registers	Reads the contents of a sequence of registers
0x06	Write Single Register	Writes a value to a single register.

Read Multiple Registers (0x03)

Query:

Fieldname	Example
Slave Address	0x01
Function Code	0x03
Start Address (High byte)	0x00
Start Address (Low byte)	0x02
Number of registers (High byte)	0x00
Number of registers (Low byte)	0x02
CRC (High byte)	0x65
CRC (Low byte)	0xCB

Response:

Fieldname	Example
Slave Address	0x01
Function Code	0x03
Byte Count	0x04
Data (High byte)	0x1F
Data (Low byte)	0x70
Data (High Byte)	0xC0
Data (Low Byte)	0x04
CRC (High byte)	0xAD
CRC (Low byte)	0xFF

Error Response:

Fieldname	
Slave Address	0x01
Function Code	0x83
Exception Code	(See supported exception codes)
CRC (High byte)	0x..
CRC (Low byte)	0x..

Write Single Registers (0x06)

Query:

Fieldname	Example
Slave Address	0x01
Function Code	0x06
Start Address (High byte)	0x00
Start Address (Low byte)	0x03
Data (High byte)	0x00
Data (Low byte)	0x02
CRC (High byte)	0xF8
CRC (Low byte)	0x0B

Response:

Fieldname	Example
Slave Address	0x01
Function Code	0x03
Start Address (High byte)	0x00
Start Address (Low byte)	0x03
Data (High Byte)	0x00
Data (Low Byte)	0x02
CRC (High byte)	0x34
CRC (Low byte)	0x0B

Error Response:

Fieldname	
Slave Address	0x01
Function Code	0x86
Exception Code	(See supported exception codes)
CRC (High byte)	0x..
CRC (Low byte)	0x..

9.2.2 MSR310 Parameters

Para-meter	R/W	Name	Size	Value	Address
1	R	Device status	2 bytes	0x0000 – 0xFFFF	0x0000
2	R	Input status 1	2 bytes	0x0000 – 0xFFFF	0x0001
3	R	Input status 2	2 bytes	0x0000 – 0xFFFF	0x0002
4	R	Configuration status EM 1	2 bytes	0x0000 – 0xFFFF	0x0003
5	R	Configuration status EM 2	2 bytes	0x0000 – 0xFFFF	0x0004
6	R	Configuration status EM 3	2 bytes	0x0000 – 0xFFFF	0x0005
7	R	Configuration status EM 4	2 bytes	0x0000 – 0xFFFF	0x0006
8	R	Configuration status EM 5	2 bytes	0x0000 – 0xFFFF	0x0007
9	R	Configuration status EM 6	2 bytes	0x0000 – 0xFFFF	0x0008
10	R	Configuration status EM 7	2 bytes	0x0000 – 0xFFFF	0x0009
11	R	Configuration status EM 8	2 bytes	0x0000 – 0xFFFF	0x000A
12	R	Configuration status EM 9	2 bytes	0x0000 – 0xFFFF	0x000B
13	R	Configuration status EM 10	2 bytes	0x0000 – 0xFFFF	0x000C
14	R	Input with error monitoring: extension modules 1 to 8	2 bytes	0x0000 – 0xFFFF	0x000D
15	R	Input with error monitoring: extension modules 9 to 10	2 bytes	0x0000 – 0xFFFF	0x000E
16	R	Input switch error status	2 bytes	0x0000 – 0xFFFF	0x000F
17	R	Input switch error status, other faults, version number, number of input modules	2 bytes	0x0000 – 0xFFFF	0x0010
18	R/W	Bus status (Baud rate)	2 bytes	0x0000 – 0x0300	0x0011

Status of device (Parameter 1: configuration and status of device)

High Byte:

Bit	Function
7 + 6	00: Jumper Y40 – Y41–Y42 01: Jumper Y40 – Y41 10: Jumper Y40 – Y42 11: Y41 and Y42 open
5	Group 3 active
4	Group 2 active
3	Group 1 active
2	Group 3 ready
1	Group 2 ready
0	Group 1 ready

Low Byte:

Bit	Function
7	Fault
6	Cross loop
5	Group 3 interrupted
4	Group 2 interrupted
3	Group 1 interrupted
2	Group 3 EDM Loop closed
1	Group 2 EDM Loop closed
0	Group 1 EDM Loop closed

Input status 1 (Parameter 2: states of safety inputs)

High Byte:

Bit	Function
7	Extension module 8 Input 2 interrupted
6	Extension module 8 Input 1 interrupted
5	Extension module 7 Input 2 interrupted
4	Extension module 7 Input 1 interrupted
3	Extension module 6 Input 2 interrupted
2	Extension module 6 Input 1 interrupted
1	Extension module 5 Input 2 interrupted
0	Extension module 5 Input 1 interrupted

Low Byte:

Bit	Function
7	Extension module 4 Input 2 interrupted
6	Extension module 4 Input 1 interrupted
5	Extension module 3 Input 2 interrupted
4	Extension module 3 Input 1 interrupted
3	Extension module 2 Input 2 interrupted
2	Extension module 2 Input 1 interrupted
1	Extension module 1 Input 2 interrupted
0	Extension module 1 Input 1 interrupted

Input status 2 (Parameter 3: states of safety inputs, muting lamp)

High Byte:

Bit	Function
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Extension module 10 Input 2 interrupted
2	Extension module 10 Input 1 interrupted
1	Extension module 9 Input 2 interrupted
0	Extension module 9 Input 1 interrupted

Low Byte:

Bit	Function
7	Reserved
6	Fault: Different switch settings of input modules between the two channels
5	Fault: Invalid configuration of extension modules
4	Fault: Reserve Muting lamp 2
3	Fault: Muting lamp 2
2	Fault: Reserve Muting lamp 1
1	Fault: Muting lamp 1
0	Fault: at least one Input (lock-out-release, no synchrony activity)

Configuration status (Parameters 4 ... 13: current configuration of Extension modules 1...10)
High Byte:

Bit	Function
7	Switch settings of function bit 3
6	Switch settings of function bit 2
5	Switch settings of function bit 1
4	Switch settings of function bit 0
3	Switch settings of group bit 3
2	Switch settings of group bit 2
1	Switch settings of group bit 1
0	Switch settings of group bit 0

Low Byte:

Bit	Function
7	Stored EEPROM settings of function bit 3
6	Stored EEPROM settings of function bit 2
5	Stored EEPROM settings of function bit 1
4	Stored EEPROM settings of function bit 0
3	Stored EEPROM settings of group bit 3
2	Stored EEPROM settings of group bit 2
1	Stored EEPROM settings of group bit 1
0	Stored EEPROM settings of group bit 0

Configuration status (Parameter 14: input with error monitoring)

High Byte:

Bit	Function
7	Input error monitoring, extension module 8, input 2
6	Input error monitoring, extension module 8, input 1
5	Input error monitoring, extension module 7, input 2
4	Input error monitoring, extension module 7, input 1
3	Input error monitoring, extension module 6, input 2
2	Input error monitoring, extension module 6, input 1
1	Input error monitoring, extension module 5, input 2
0	Input error monitoring, extension module 5, input 1

Low Byte:

Bit	Function
7	Input error monitoring, extension module 4, input 2
6	Input error monitoring, extension module 4, input 1
5	Input error monitoring, extension module 3, input 2
4	Input error monitoring, extension module 3, input 1
3	Input error monitoring, extension module 2, input 2
2	Input error monitoring, extension module 2, input 1
1	Input error monitoring, extension module 1, input 2
0	Input error monitoring, extension module 1, input 1

Configuration status (Parameter 15: input with error monitoring)

High Byte:

Bit	Function
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	Reserved
1	Reserved
0	Reserved

Low Byte:

Bit	Function
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Input error monitoring, extension module 10, input 2
2	Input error monitoring, extension module 10, input 1
1	Input error monitoring, extension module 9, input 2
0	Input error monitoring, extension module 9, input 1

Error status 1 (Parameter 16: input switch faults)

High Byte:

Bit	Function
7	Faulty input switch, extension module 8, input 2
6	Faulty input switch, extension module 8, input 1
5	Faulty input switch, extension module 7, input 2
4	Faulty input switch, extension module 7, input 1
3	Faulty input switch, extension module 6, input 2
2	Faulty input switch, extension module 6, input 1
1	Faulty input switch, extension module 5, input 2
0	Faulty input switch, extension module 5, input 1

Low Byte

Bit	Function
7	Faulty input switch, extension module 4, input 2
6	Faulty input switch, extension module 4, input 1
5	Faulty input switch, extension module 3, input 2
4	Faulty input switch, extension module 3, input 1
3	Faulty input switch, extension module 2, input 2
2	Faulty input switch, extension module 2, input 1
1	Faulty input switch, extension module 1, input 2
0	Faulty input switch, extension module 1, input 1

Error status 2 (Parameter 17: input switch faults, other faults, number of extension modules, version number)

High Byte:

Bit	Function
7	Faulty input switch, extension module 10, input 2
6	Faulty input switch, extension module 10, input 1
5	Faulty input switch, extension module 9, input 2
4	Faulty input switch, extension module 9, input 1
3	Internal fault
2	Adjusted configuration is not equal like the stored one
1	The configuration changed during operation
0	Terminal connector is missing

Low Byte:

Bit	Function
7	Version number of Base Module firmware bit 3
6	Version number of Base Module firmware bit 2
5	Version number of Base Module firmware bit 1
4	Version number of Base Module firmware bit 0
3	Number of extension modules bit 3
2	Number of extension modules bit 2
1	Number of extension modules bit 1
0	Number of extension modules bit 0

Bus status (Parameter 18: Baud rate)

Bus status	High Byte	Low Byte
Function	Reserved	Baud rate
Range		0: 2400 Baud 1: 4800 Baud 2: 9600 Baud 3: 19200 Baud

9.2 RS232 Unidirectional

Baud rate: 4800
Circle time: 1s
Data transmission without query

Byte No.	Name	Function	Value
1	Start byte	---	0x02
2	Device status	Bit 7 + Bit 6: 00 = Jumper Y40 – Y41–Y42 01 = Jumper Y40 - Y41 10 = Jumper Y40 - Y42 11 = Y41 und Y42 open Bit 5: Group 3 active Bit 4: Group 2 active Bit 3: Group 1 active Bit 2: Group 3 ready Bit 1: Group 2 ready Bit 0: Group 1 ready	0x00 … 0xFF
3	Device status 2	Bit 7: Internal fault Bit 6: Cross loop Bit 5: Group 3 interrupted Bit 4: Group 2 interrupted Bit 3: Group 1 interrupted Bit 2: Group 3 EDM loop closed Bit 1: Group 2 EDM loop closed Bit 0: Group 1 EDM loop closed	0x00 … 0xFF
4	Input status 1	Bit 7: Extension module 4 Input 2 interrupted Bit 6: Extension module 4 Input 1 interrupted Bit 5: Extension module 3 Input 2 interrupted Bit 4: Extension module 3 Input 1 interrupted Bit 3: Extension module 2 Input 2 interrupted Bit 2: Extension module 2 Input 1 interrupted Bit 1: Extension module 1 Input 2 interrupted Bit 0: Extension module 1 Input 1 interrupted	0x00 … 0xFF
5	Input status 2	Bit 7: Extension module 8 Input 2 interrupted Bit 6: Extension module 8 Input 1 interrupted Bit 5: Extension module 7 Input 2 interrupted Bit 4: Extension module 7 Input 1 interrupted Bit 3: Extension module 6 Input 2 interrupted Bit 2: Extension module 6 Input 1 interrupted Bit 1: Extension module 5 Input 2 interrupted Bit 0: Extension module 5 Input 1 interrupted	0x00 … 0xFF

6	Input status 3	Bit 7: reserved Bit 6: reserved Bit 5: reserved Bit 4: reserved Bit 3: Extension module 10 Input 2 interrupted Bit 2: Extension module 10 Input 1 interrupted Bit 1: Extension module 9 Input 2 interrupted Bit 0: Extension module 9 Input 1 interrupted	0x00 … 0x0F
7	Muting lamp status	Bit 7: reserved Bit 6: reserved Bit 5: reserved Bit 4: Fault: Reserve Muting lamp 1 Bit 3: Fault: Muting lamp 2 Bit 2: Fault: Reserve Muting lamp 1 Bit 1: Fault: Muting lamp 1 Bit 0: Fault: at least one Input (lockout-release, no simultaneity monitoring)	0x00 … 0x1F
8	Number of split bytes		0x01 … 0x1B
9	Split byte	See table below	
10	CRC (high bytes)	CRC high byte number 1 to byte number 7	0x00 … 0xFF
11	CRC (low bytes)	CRC low byte number 1 to byte number 7	0x00 … 0xFF
12	Stop byte	---	0x03

Split bytes:

Byte No.	Name	Function	Value
1	Configuration 1	Version number / Number of extension modules	---
2	Configuration 2	Switch settings extension module 1	
3	Configuration 3	Switch settings extension module 2	---
4	Configuration 4	Switch settings extension module 3	---
5	Configuration 5	Switch settings extension module 4	---
6	Configuration 6	Switch settings extension module 5	---
7	Configuration 7	Switch settings extension module 6	---
8	Configuration 8	Switch settings extension module 7	---
9	Configuration 9	Switch settings extension module 8	---
10	Configuration 10	Switch settings extension module 9	---
11	Configuration 11	Switch settings extension module 10	---
12	Configuration 12	EEPROM value extension module 1	---
13	Configuration 13	EEPROM value extension module 2	---
14	Configuration 14	EEPROM value extension module 3	---
15	Configuration 15	EEPROM value extension module 4	---
16	Configuration 16	EEPROM value extension module 5	---
17	Configuration 17	EEPROM value extension module 6	---
18	Configuration 18	EEPROM value extension module 7	---
19	Configuration 19	EEPROM value extension module 8	---
20	Configuration 20	EEPROM value extension module 9	---
21	Configuration 21	EEPROM value extension module 10	---
22	Configuration 22	Input with monitoring: extension modules 1 to 4	---
23	Configuration 23	Input with monitoring: extension modules 5 to 8	---
24	Configuration 24	Input with monitoring: extension modules 9 to 10	---
25	Input switch status 1	Faulty input switch: extension modules 1 to 4	---
26	Input switch status 2	Faulty input switch: extension modules 5 to 8	---
27	Input switch status 3	Faulty input switch: extension modules 9 to 10	---

9.3 CRC Generation (Code Examples)

CRC Calculation Basics

The CRC calculation is started by first preloading a 16-bit register to all 1's. Then a process begins of applying successive eight-bit bytes of the message to the current contents of the register. During generation of the CRC, each eight-bit character is XORed with the current register contents. The result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB is a 1, the register is XORed with a preset, fixed value. If the LSB was a 0, no XOR takes place. This process is repeated until eight shifts have been performed. After the last (eighth) shift, the above process repeats for the next byte in the message. After all bytes of the message have been applied, the final content of the register is the CRC value.

Step by Step:

1. Load a 16-bit register with 0xFFFF (all 1's). Call this the CRC register.
2. XOR the first eight-bit byte of the message with the low order byte of the 16-bit CRC register, putting the result in the CRC register.
3. Shift the CRC register one bit to the right (toward the LSB), zero-filling the MSB. Examine the LSB that was just shifted out from the register.
4. If the LSB is 0, repeat Step 3 (another shift). If the LSB is 1, EXOR the CRC register with the polynomial value 0xA001 (1010 0000 0000 0001).
5. Repeat Steps 3 and 4 until eight shifts have been performed. When this is done, a complete eight-bit byte will have been processed.
6. Repeat Steps 2 … 5 for the next eight-bit byte of the message. Continue doing this until all bytes have been processed.

Result:

The final content of the CRC register is the CRC value. When the CRC is placed into the message, its upper and lower bytes must be swapped as described in chapter 9-1 "Modbus Protocol" (CRC).

Example 1:

The following example calculates the CRC using the method described earlier.

Note: This function performs the swapping of the high/low CRC bytes internally. Therefore the CRC value returned from the function can be directly placed into the message for transmission.

The function returns the CRC as a type UINT16, and takes two arguments:

- `UINT8 *pabMessage;`

A pointer to the message buffer containing binary data to be used for generating the CRC.

- `UINT16 iLength;`

The quantity of bytes in the message buffer.

Typedefs

```
UINT8 = Unsigned 8 bit (e.g. unsigned char)
UINT16 = Unsigned 16 bit (e.g. unsigned short)
```

Source Code

```
UINT16 GenerateCrc( UINT8* pabMessage, UINT16 iLength )
{
   UINT16 iCRCReg = 0xFFFF;
   UINT8 bByteCount;
   UINT8 bBitCount, bCarryFlag;
   for( bByteCount = 0 ; bByteCount < iLength ; bByteCount++ )
   {
      *((UINT8*)&iCRCReg + 1) = pabMessage[ bByteCount ] ^ ( iCRCReg &
      0x00FF );
      for( bBitCount = 0; bBitCount < 8 ; bBitCount++ )
      {
         bCarryFlag = iCRCReg & 0x0001;
         iCRCReg = iCRCReg >> 1;
         if( bCarryFlag != 0 )
      {
      iCRCReg ^= 0xA001;
      }
   }
}
return( iCRCReg << 8 | iCRCReg >> 8 );
}/* end GenerateCrc */
```

Example 2

This example uses another approach to calculate the CRC; All of the possible CRC values are pre-loaded into two arrays, which are simply indexed as the function increments through the message buffer. One array contains all of the 256 possible CRC values for the high byte of the 16-bit CRC field, and the other array contains all of the values for the low byte. Indexing the CRC in this way provides faster execution than would be achieved by calculating a new CRC value with each new character from the message buffer.

Note: This function performs the swapping of the high/low CRC bytes internally. Therefore the CRC value returned from the function can be directly placed into the message for transmission.

The function returns the CRC as a type UINT16, and takes two arguments:

- `UINT8 *pabMessage;`

A pointer to the message buffer containing binary data to be used for generating the CRC.

- `UINT16 iLength;`

The quantity of bytes in the message buffer.

Typedefs

```
UINT8 = Unsigned 8 bit (e.g. unsigned char)
UINT16 = Unsigned 16 bit (e.g. unsigned short)
```

Source Code

```
UINT16 GenerateCrc( UINT8* pabMessage, UINT16 iLength )
{
static UINT8 abCrcHi[] =
{ 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80,
0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
```

```
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40
};
static UINT8 abCrcLo[] =
{
0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7,
0x05, 0xC5, 0xC4, 0x04, 0xCC, 0x0C, 0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E,
0x0A, 0xCA, 0xCB, 0x0B, 0xC9, 0x09, 0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9,
0x1B, 0xDB, 0xDA, 0x1A, 0x1E, 0xDE, 0xDF, 0x1F, 0xDD, 0x1D, 0x1C, 0xDC,
0x14, 0xD4, 0xD5, 0x15, 0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3,
0x11, 0xD1, 0xD0, 0x10, 0xF0, 0x30, 0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32,
0x36, 0xF6, 0xF7, 0x37, 0xF5, 0x35, 0x34, 0xF4, 0x3C, 0xFC, 0xFD, 0x3D,
0xFF, 0x3F, 0x3E, 0xFE, 0xFA, 0x3A, 0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38,
0x28, 0xE8, 0xE9, 0x29, 0xEB, 0x2B, 0x2A, 0xEA, 0xEE, 0x2E, 0x2F, 0xEF,
0x2D, 0xED, 0xEC, 0x2C, 0xE4, 0x24, 0x25, 0xE5, 0x27, 0xE7, 0xE6, 0x26,
0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x20, 0xE0, 0xA0, 0x60, 0x61, 0xA1,
0x63, 0xA3, 0xA2, 0x62, 0x66, 0xA6, 0xA7, 0x67, 0xA5, 0x65, 0x64, 0xA4,
0x6C, 0xAC, 0xAD, 0x6D, 0xAF, 0x6F, 0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB,
0x69, 0xA9, 0xA8, 0x68, 0x78, 0xB8, 0xB9, 0x79, 0xBB, 0x7B, 0x7A, 0xBA,
0xBE, 0x7E, 0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C, 0xB4, 0x74, 0x75, 0xB5,
0x77, 0xB7, 0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0,
0x50, 0x90, 0x91, 0x51, 0x93, 0x53, 0x52, 0x92, 0x96, 0x56, 0x57, 0x97,
0x55, 0x95, 0x94, 0x54, 0x9C, 0x5C, 0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E,
0x5A, 0x9A, 0x9B, 0x5B, 0x99, 0x59, 0x58, 0x98, 0x88, 0x48, 0x49, 0x89,
0x4B, 0x8B, 0x8A, 0x4A, 0x4E, 0x8E, 0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C,
0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46, 0x86, 0x82, 0x42, 0x43, 0x83,
0x41, 0x81, 0x80, 0x40
};
UINT8 bCrcHi = 0xFF;
UINT8 bCrcLo = 0xFF;
UINT16 iIndex;
while( iLength-- )
{
iIndex = bCrcHi ^ *pabMessage++;
bCrcHi = bCrcLo ^ abCrcHi[iIndex];
bCrcLo = abCrcLo[iIndex];
}
return( bCrcHi << 8 | bCrcLo );
}/* end GenerateCrc */
```

Annexure

Product Warranty and Disclaimer

The following is a partial statement of the product warranty and disclaimer, and is subject to the warranty terms and disclaimer included in the standard terms of sale/contract of the Seller.

1. Warranty

(a). Allen-Bradley / Rockwell Automation Hardware:
Seller warrants that new hardware Products furnished hereunder will be free from defects in material, workmanship and design for a period of one (1) year from the date of invoice from Seller or its appointed distributor, as the case may be. Repaired or replacement Products provided as a result of this warranty subparagraph are similarly warranted for a period of six (6) months from the date of shipment to Buyer or the remainder of the original warranty term for that particular Product, whichever is longer.

(b). Allen-Bradley and Rockwell Software Branded Software and Firmware:
Unless otherwise provided in a Seller or third party license, Seller warrants that standard software or firmware Products furnished hereunder, when used with Seller-specified hardware, will perform in accordance with published specifications prepared, approved, and issued by Seller for a period of one (1) year from the date of invoice from Seller or its appointed distributor, as the case may be. Seller makes no representation or warranty, express or implied, that the operation of the software or firmware Products will be uninterrupted or error free, or that the functions contained therein will meet or satisfy Buyer's intended use or requirements.

(c). Remedies:
Remedies under the above warranties will be limited, at Seller's option, to the replacement, repair, re-performance or modification of, or issuance of a credit for the purchase price, of the Products involved, and where applicable, only after the return of such Products pursuant to Seller's instructions. Replacement Products may be new, remanufactured, refurbished or reconditioned at Seller's discretion. Buyer requested on-site warranty service (consisting of time, travel and expenses related to such services) will be at Buyer's expense. The foregoing will be the exclusive remedies for any breach of warranty or breach of contract arising therefrom.

(d). General:
Warranty satisfaction is available only if (a) Seller is provided prompt written notice of the warranty claim and (b) Seller's examination discloses that any alleged defect has not been caused by misuse; neglect; improper installation, operation, maintenance, repair, alteration or modification by other than Seller; accident; or unusual deterioration or degradation of the Products or parts thereof due to physical environment or electrical or electromagnetic noise environment.

(e). Exclusion of Other Warranties:
The above warranties are in lieu of all other warranties and conditions, whether expressed, implied or statutory, including implied warranties of merchantability or fitness for a particular use, or performance or application warranties, to the fullest extent permitted by applicable law. Rights under the above warranties (subject to noted

limitations) extend to buyer's customers if buyer is a seller-appointed distributor for the products.

2. Disclaimer And Limitation Of Liability

To the fullest extent permitted by applicable law, seller will not be liable for any business interruption or loss of profit, revenue, materials, anticipated savings, data, contract, goodwill or the like (whether direct or indirect in nature) or for any other form of incidental, indirect or consequential damages of any kind. Seller's maximum cumulative liability relative to all other claims and liabilities, including obligations under any indemnity, whether or not insured, will not exceed the cost of the product(s) giving rise to the claim or liability. Seller disclaims all liability relative to gratuitous information or assistance provided by, but not required of seller hereunder. Any action against seller must be brought within eighteen (18) months after the cause of action accrues. These disclaimers and limitations of liability will apply regardless of any other contrary provision hereof and regardless of the form of action, whether in contract, tort (including negligence and strict liability) or otherwise, and further will extend to the benefit of seller's vendors, appointed distributors and other authorized resellers as third-party beneficiaries. Each provision hereof which provides for a limitation of liability, disclaimer of warranty or condition or exclusion of damages is severable and independent of any other provision and is to be enforced as such.