User Manual

Original Instructions

A·B QUALITY **Allen-Bradley**

Guard**i**master®

MSR55P Back EMF Minotaur Safety Relay

Catalog Numbers 440R-S35011, 440R-S35012, 440R-S35013, 440R-S35014, 440R-S35015, 440R-S35016

Rockwell Automation

A·B *Allen-Bradley* • *Rockwell Software*

Important User Information

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

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

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

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

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

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

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

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

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

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

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

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

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

Table of Contents

This manual is a reference guide for MSR safety relays. It describes the procedures that you use to install, wire, and troubleshoot your relay. This manual explains how to install and wire your relay and gives an overview of the operation of the MSR safety relays

Who Should Use This Manual

Use this manual if you are responsible for designing, installing, programming, or troubleshooting control systems that use the MSR safety relays.

You must have a basic understanding of electrical circuitry and familiarity with safety-related control systems. If you do not, obtain the proper training before using this product.

Summary of Changes

This publication contains new and updated information as indicated in the following table.

Topic	Page
Updated Typical Applications in Table 2	8
Updated Enclosure Considerations section	10
Updated Surge Suppressors section	17
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Definitions

The following terms and abbreviations are used throughout this manual. For definitions of terms that are not listed here, refer to the Allen-Bradley Industrial Automation Glossary, publication AG-7.1.

- **N.C. (Normally Closed) -** An electrical contact whose normal state (that is, no pressure or electrical potential applied) is in the closed position.
- **N.O. (Normally Open) -** An electrical contact whose normal state (that is, no pressure or electrical potential applied) is in the open position.
- **PLC -** A programmable logic controller or a programmable automation controller.
- **Response Time -** Describes the time between the trigger of one input to the OFF state of the output. Throughout this manual, the safety outputs can be described as turning off immediately, which means that the safety outputs turn off within the response time.

- **OSSD (Output Signal Switching Device) -** Typically a pair of solid-state signals that are pulled up to the DC source supply. The signals are tested for short circuits to the DC power supply, short circuits to the DC common and shorts circuits between the two signals.

- **Outputs Energized/De-energized -** Table 1 describes that state of the outputs in this manual when the output is described as energized or de-energized.
  The exception is the semiconductor output ERR, which is not described in Table 1. The ERR semiconductor output is ON when an error is detected and OFF when no error is detected.

Table 1 - State of the Outputs

Terminal	De-energized	Energized	Type	Function
11/12	Closed	Open		Monitoring (non-safety)
23/24	Open	Closed	Voltage free	Safety related
33/34	Open	Closed		
43/44	Open	Closed		
53/54	Open	Closed		Status only
ON	Off	On	Semi-conductor	

Additional Resources

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

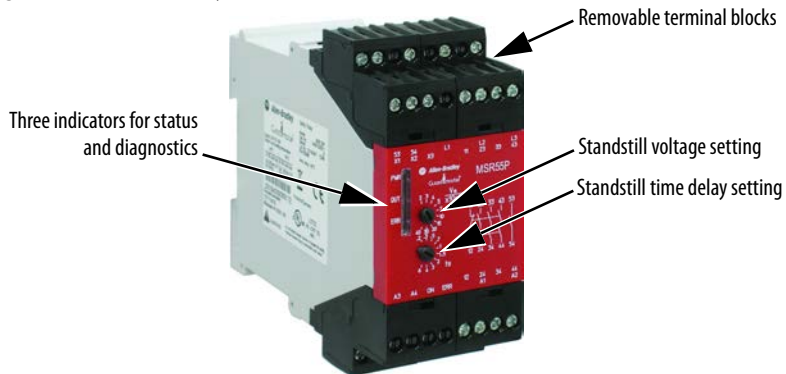| Resource	Description
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation® industrial system.
Product Certifications website: rok.auto/certifications	Provides declarations of conformity, certificates, and other certification details.

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

Overview

Safety Relay Features

Figure 1 - Overview of Key Features

Removable terminal blocks

Three indicators for status and diagnostics

Standstill voltage setting

Standstill time delay setting

MSR55P back electro-motive-force (EMF) safety relays monitor the voltage that motors generate after their drive voltage is removed and the motor coasts or brakes to a stop. MSR55P safety relays monitor either single- or three-phase motors. MSR55P safety relays operate with pulse width modulated (PWM) drives, smart motor controllers, and electromechanical contactors.

MSR55P safety relays are connected to the motor terminals and measure the induced back EMF as the motor spins to a stop. MSR55P safety relays create a two-channel system by measuring the voltage from L2 to L1 and the voltage from L3 to L1. If the back EMF voltage drops to a certain threshold simultaneously in both channels for a certain duration, standstill is considered achieved, and the outputs are energized.

If the voltage measured on terminals L1/L2/L3 of the MSR55P safety relay rises over the adjusted value plus hysteresis in at least one channel (the motor is switched on or the shaft turns mechanically), the forcibly guided output contacts are switched off immediately (contacts 23/24, 33/34 and 43/44 open while contact 11/12 closes). The monitoring relay de-energizes (53/54 opened), the semiconductor output ON goes off and the OUT indicator turns yellow (= V_m over adjusted value).

To accommodate many types of motors, you can make two adjustments in accordance with the machine risk assessment:

- The threshold of the back EMF voltage.
- A time delay to add additional assurance that the motor has stopped.

MSR55P safety relays can monitor external safety relays and contactors. By monitoring the normally closed contacts, MSR55P safety relays help prevent re-energization of its outputs if the safety relays or contactors have not de-energized. If feedback monitoring is not required, the monitoring circuit must be jumpered.

MSR55P safety relays perform internal tests on startup and during operation. Some faults are reset automatically when the fault is cleared. Other faults are reset manually, by a manually operated switch, or automatically by a jumper. See <u>Status Indicators and Diagnostics on page 25</u> and <u>Troubleshooting on page 33</u> for further details.

<u>Table 2</u> lists the six catalog numbers that are available. The key differences are the power supply to terminals A1/A2 and the setpoint voltage to determine safe standstill speed as the motor spins to a stop.

In general, select models that have the lower standstill monitoring voltage when induction motors are monitored. Servo motors, which have permanent magnets, generally create high voltages at slower revolutions, therefore, the higher standstill monitoring voltage is usually the preferred solution. You must evaluate your application and apply the risk assessment process to determine the proper relay for their specific application.

Table 2 - Model Selection

A1/A2 Supply Voltage	Standstill Monitoring Voltage Range	Typical Applications	Cat. No.
24V DC	20…400 mV	Induction motors with contactors	440R-S35011
115V AC	20…400 mV		440R-S35012
230V AC	20…400 mV		440R-S35013
24V DC	200 mV…4V	Induction and servo (permanent magnet) motors with variable frequency and servo drives	440R-S35014
115V AC	200 mV…4V		440R-S35015
230V AC	200 mV…4V		440R-S35016

Installation

Mounting Dimensions

MSR55P safety relays come standard with removable screw-type terminals. Spring-clamp terminals are offered as an option. Figure 2 shows the mounting dimensions.
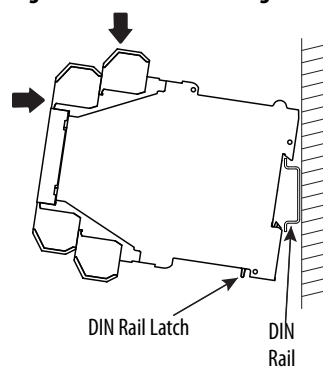
Figure 2 - Dimensions [mm (in.)]
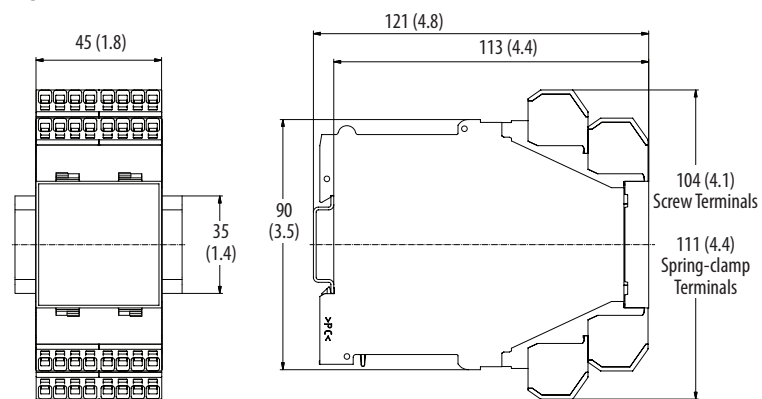
DIN Rail Mounting and Removal

MSR55P safety relays mount onto 35 mm (1.4 in.) DIN rails: 35x7.5x1 mm(1.4x0.3x0.03 in.) — EN 50022 - 5x7.5.

1. Hold the top at an angle (Figure 3).

2. Slide down until the housing catches the rail.

3. Swing the bottom down and push until the latch clips onto the rail.

Figure 3 - DIN Rail Mounting

DIN Rail Latch   DIN Rail

Removal

To remove the MSR55P safety relay, use a screwdriver to pry the DIN rail latch downwards until it is in the unlatched position. Then, swing the module up.
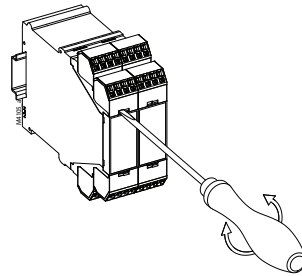
Spacing

MSR55P safety relays can be mounted directly next to other MSR and GSR safety relays.

Maintain a space of 50.8 mm (2 in.) above, below, and in front of the relay for adequate ventilation.

Removable Terminals

MSR55P safety relays have removable terminals to ease wiring and replacement.

Figure 4 - Removable Terminals

1. Insert the tip of a small screwdriver into the slot near the terminal screws.

2. To unlock the terminal block, rotate the screwdriver.

The terminal block can then be removed from the housing.

Spring Clamp Terminals

As an accessory, you can purchase removable terminals with spring clamps. The spring clamp terminals can directly replace the screw clamp terminals. See Table 10 on page 41 for the differences in wire size.

Enclosure Considerations

Most applications require installation in an industrial enclosure to reduce the effects of electrical interference and environmental exposure. Pollution Degree 2 is an environment where normally only non-conductive pollution occurs except that occasionally temporary conductivity from condensation can be expected. Overvoltage Category II is the load level section of the electrical distribution system. At this level, transient voltages are controlled and do not exceed the impulse voltage capability of the product insulation.

This equipment is intended for use in a Pollution Degree 2 industrial environment, in overvoltage Category II applications (as defined in IEC 60664-1), at altitudes up to 2000 m (6562 ft) without derating. This equipment is considered Group 1, Class A industrial equipment according to IEC/CISPR 11. Without appropriate precautions, there can be difficulties with electromagnetic compatibility in residential and other environments due to conducted and radiated disturbances.

This equipment is supplied as open-type equipment. The relays must be mounted within an enclosure that is suitably designed for those specific environmental conditions that are present and appropriately designed to help prevent personal injury as a result of accessibility to live parts. The interior of the enclosure must be accessible only by the use of a tool. Subsequent sections of this publication contain additional information regarding specific enclosure-type ratings that are required to comply with certain product safety certifications.

For more information, see:
- Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1, for additional installation requirements.
- NEMA Standard 250 and IEC 60529, as applicable, for explanations of the degrees of protection provided by different types of enclosure.

Prevent Excessive Heat

For most applications, normal convective cooling keeps the relay within the specified operating range. Verify that the specified temperature range is maintained. Usually, proper spacing of components within an enclosure is sufficient for heat dissipation.

In some applications, other equipment inside or outside the enclosure can produce a substantial amount of heat. In this case, place blower fans inside the enclosure to help with air circulation and to reduce hot spots near the controller.

Additional cooling provisions are necessary when high ambient temperatures are encountered. Do not bring in unfiltered outside air. Place the controller in an enclosure to help protect it from a corrosive atmosphere. Harmful contaminants or dirt could damage components or cause improper operation. In extreme cases, you may need air conditioning to help protect against heat buildup within the enclosure.

Notes:

Power, Ground, and Wire

Wiring Requirements and Recommendation

⚠ **ATTENTION:** Before you install and wire any device, disconnect power to the system.

⚠ **ATTENTION:** Calculate the maximum possible current in each power and common wire. Observe all electrical codes that dictate the maximum current allowable for each wire size. Current above the maximum rating causes wiring to overheat, which can cause damage.

- Allow for at least 50 mm (2 in.) between I/O wire ducts or terminal strips and the relay.
- Route incoming power to the relay by a path separate from the device wiring. Where paths must cross, their intersection must be perpendicular.
- Do not run signal or communications wiring and power wiring in the same conduit. Route wires with different signal characteristics by separate paths.
- Separate wiring by signal type. Bundle wiring with similar electrical characteristics together.
- Separate input wiring from output wiring.
- Label wiring to all devices in the system. Use tape, shrink-tubing, or other more dependable means to label wire. Use colored insulation as well to identify wiring by signal characteristics. For example, use blue for DC wiring and red for AC wiring.

Wire Size and Terminal Torque

See .

Terminal Assignment

The safety relays have eight terminal blocks: four on the top and four on the bottom. shows the front face marking of each of the relays, including the terminal and status indicator identifications. The difference between the two models is the standstill monitoring voltage, V_m. In

Figure 5, the monitoring voltage of the relay on the left is 200 mV...4V; the relay on the right has a monitoring voltage from 20...400 mV.

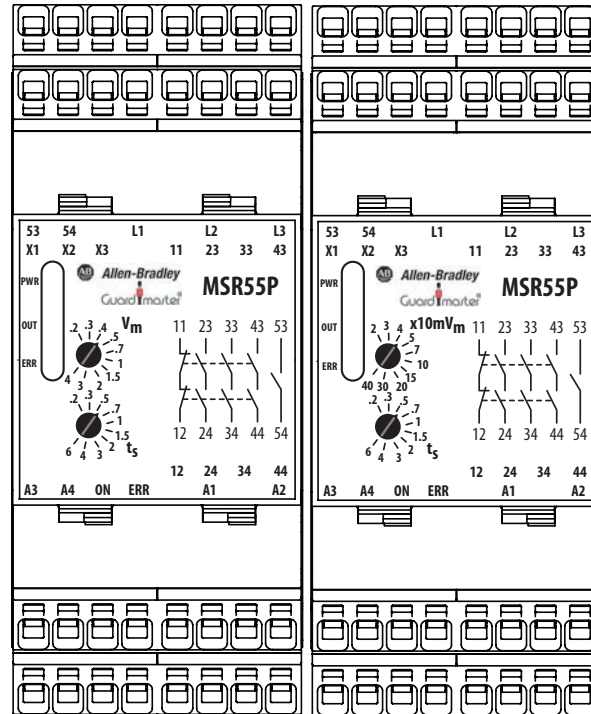**Figure 5 - Relay Face and Terminal Identification**

Table 3 lists the terminal functions.

Table 3 - Terminal Assignments and Functions

| Terminal	Function
A1(+)-A2(-)	Power supply
L1/L2/L3	Motor connections
11/12	Voltage-free redundant monitoring (non-safety) contacts (N.C.)
23/24, 33/34, 43/44	Voltage-free redundant safety contacts (N.O.)
53/54	Voltage-free monitoring (auxiliary) contact (N.O.)
X1/X2	Connection for feedback circuit
X3/X2	Reset for fault conditions.
A3(+) -A4(-)	Power supply for semiconductor outputs
ON	Semiconductor output indicates that safety outputs are ON.
ERR	Semiconductor output indicates fault condition.

Connect Power Supply

Power for the MSR55P safety relay depends on the model. The primary power supply is connected to terminals A1 and A2. An auxiliary (12...30V DC only) supply voltage can be connected to terminals A3/A4 to provide semiconductor diagnostics.

Depending on the model, the primary supply can be 24V DC, 115V AC or 230V AC. When an AC supply is used, both 50 Hz and 60 Hz are acceptable.

When powering with 24V DC in the European Union, the DC supply must have a Protective Extra-Low Voltage (PELV) rating. When powering with 24V DC in the United States, the DC supply must have both a PELV rating as well as an NEC Class 2 rating. Many of the Bulletin 1606 power supplies are PELV and Class 2 compliant.

Figure 6 shows the power supply connections. Power to A1 is required to operate the MSR55P safety relay. Power to A3 is only necessary if the solid-state auxiliary status signals (ON and ERR) are used.

Figure 6 - Power Supply Connections
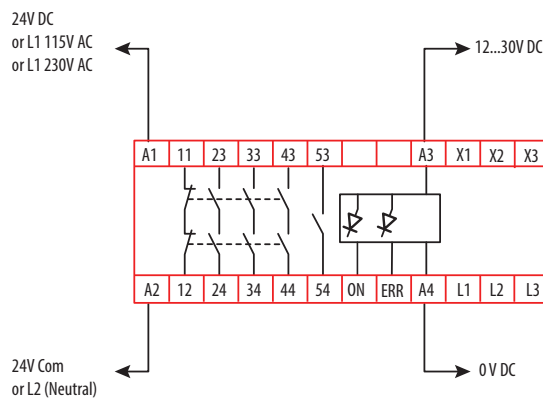
Motor Winding Inputs

The motor windings are connected to terminals L1, L2, and L3. The connections must be made directly at the motor with no electrical devices (like transformers and contactors) between the motor and the MSR55P safety relay. Figure 7 shows wiring for a single-phase, DC, and 3-phase motor.

| IMPORTANT	The three connections create two safety monitoring channels. L1 is the common to the two channels, which are L2 and L3.

Figure 7 - Motor Connections
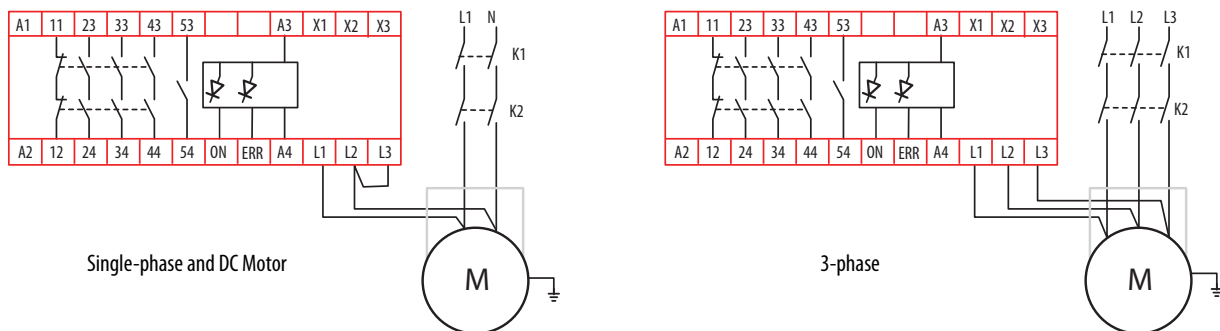
Safety Outputs

The safety outputs consist of two redundant positive-guided relays that are connected in series. Terminals 11/12 are normally closed monitoring (non-safety). Terminals 23/24, 33/34, and 43/44 are normally open. The outputs can drive loads that are either AC or DC powered. Figure 8 shows typical connections of the safety outputs to safety contactors.

Figure 8 - Safety Outputs
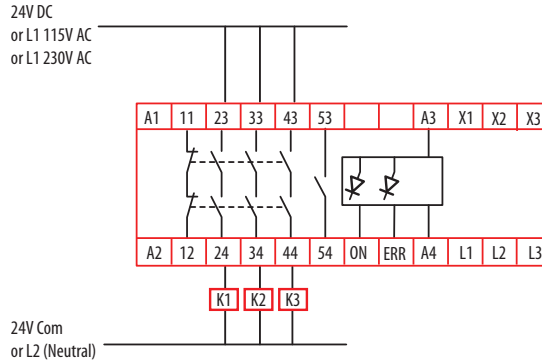
Derating Curve

The currents through the safety outputs are subject to derating. The derating depends on the current through each of the outputs and the ambient temperature. Figure 9 shows a graphical representation of the current limit over the ambient temperature range.
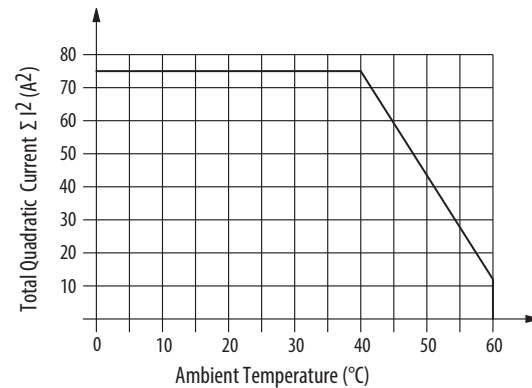
Calculate the total quadratic current, which is the sum of the squares of the currents through each of the safety outputs.

$$I_1^2 + I_2^2 + I_3^2 = \Sigma I^2 \ (A^2)$$

Variable	Description
I_1, I_2, I_3	The currents in contact paths 23/24, 33/34 and 43/44

Then, use the graph in Figure 9 to find the highest ambient temperature that is allowed.

Figure 9 - Safety Output Derating Curve

- Example 1: A 5-amp load through each of the three output circuits.

  $5^2 + 5^2 + 5^2 = 75$ A

  From the derating curve, the maximum permitted ambient temperature is 40 °C (104 °F).

- Example 2: A 2-amp load through each of the three output circuits.

  $2^2 + 2^2 + 2^2 = 12$ A

  From the derating curve, the maximum permitted ambient temperature is 60 °C (140 °F).

Surge Suppressors

Because of the potentially high current surges that occur when switching inductive load devices, such as motor starters and solenoids, the use of surge suppression is required. Adding a suppression device prolongs the life of the relay outputs and reduces the effects of voltage transients and electrical noise from radiating into adjacent systems.

Since this is a safety-related system, the surge suppression device must connected across the load device. The surge suppression device must not be connected across the MSR55P relay contacts.

Figure 10 shows examples of output contactors with a suppression device. We recommend that you locate the suppression device as close as possible to the load device.

For outputs that use 24V DC, we recommend 1N4001 (50V reverse voltage) to 1N4007 (1000V reverse voltage) diodes for surge suppression for the OSSD safety outputs, as shown in Figure 10. The diode must be connected as close as possible to the load coil.

For outputs that use 120V AC or 240V AC, we recommend metal oxide varistors.

Some devices, like the Bulletin 100S-C*xx*EJ and 100S-C*xx*QJ safety contactors have built-in suppression, therefore additional suppression devices are not needed.

**Figure 10 - Surge Suppression Components**
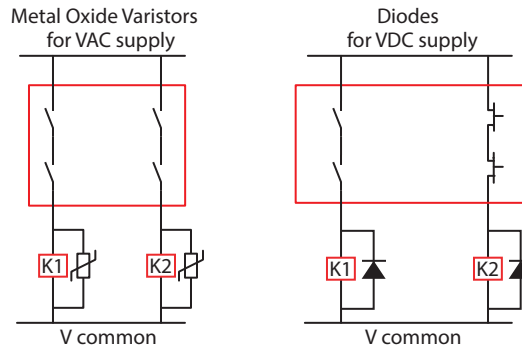
Auxiliary Outputs

Auxiliary contacts are intended to convey status information to the machine control system (programmable logic controller [PLC]) or to an indicator light. They must not be used in the safety-related circuits. Figure 11 shows an example of the auxiliary circuits.

MSR55P safety relays have one auxiliary voltage-free contact and two solid-state contacts.

The voltage-free contact is terminals 53/54. This contact can accommodate a DC or AC voltage up to 230V. Terminal 53/54 closes when the safety outputs are energized.

MSR55P safety relays have two semiconductor auxiliary outputs. The ON output turns on when the outputs are energized. The ERR output turns on when an error is detected by the MSR55P safety relay. The semiconductor outputs require a separate 24V DC connection and must have a common reference to the PLC.

Figure 11 - Example Auxiliary Circuits
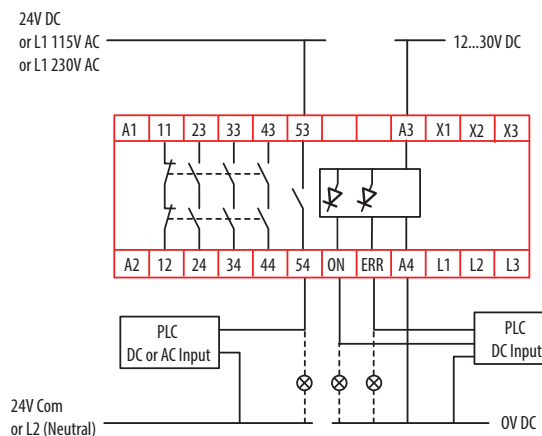
Monitoring Input

Monitoring of external devices, like safety control relays and safety contactors, can be accomplished by adding their normally closed contacts between X1 and X2. The safety outputs of the MSR55P safety relay are enabled only if the feedback loop X1/X2 is closed while standstill is detected, that is the external contactors/components are in initial state (N.C. contacts are closed).

The feedback circuit X1/X2 must be closed as long as the safety outputs are disabled. If not, the ERR indicator shows fault code 4.

In some applications, where monitoring cannot be done, install a jumper between X1 and X2. The jumper is shown in the No Monitoring diagram in Figure 12.

If additional devices must be controlled, safety control relays or contactors can be connected to the safety outputs of the MSR55P safety relay. The MSR55P safety relay can monitor the status of these devices by connecting their voltage-free contacts in series, as shown in the Contactor Monitoring diagram in Figure 12.

The MSR55P safety relay is shipped from the factory with a jumper from X1 to X2.

ATTENTION: Terminals X1-X2-X3 have electrical connections to measuring inputs L1-L2-L3. Voltage-free contacts that are rated for L1-L2-L3 voltage must be used for these connections.

Figure 12 - Examples of Feedback Monitoring Circuits

No Monitoring   Contactor Monitoring
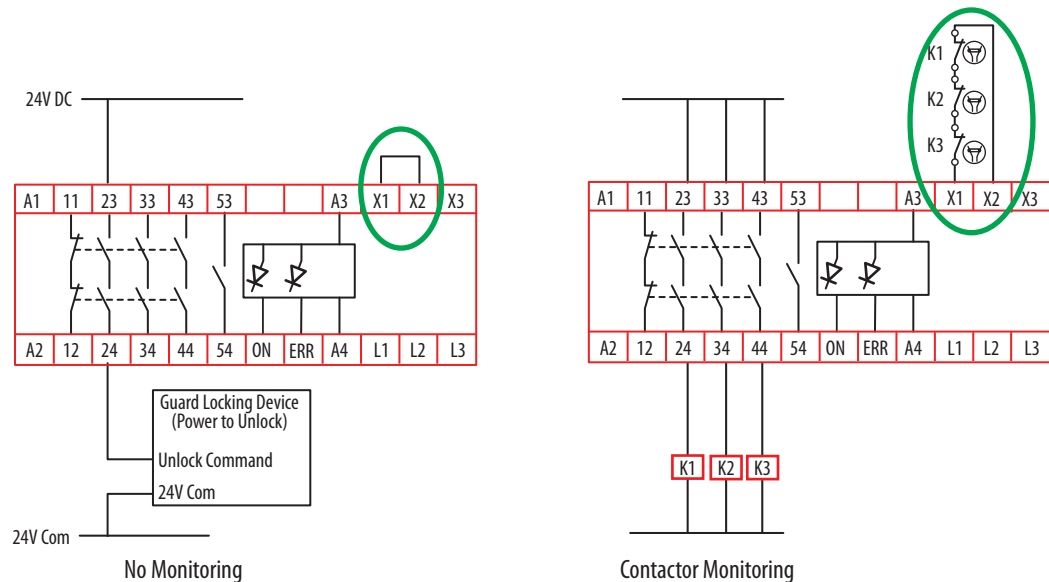
Fault Reset Input

The X2/X3 connection can reset some external faults. The reset can occur automatically or manually. The MSR55P safety relay is shipped from the factory with a jumper from X2 and X3 for automatic reset. A voltage-free contact can be used to reset a fault condition manually.

> ⚠️ **ATTENTION:** Terminals X1-X2-X3 have electrical connections to measuring inputs L1-L2-L3. Voltage-free contacts that are rated for L1-L2-L3 voltage must be used for these connections.

If control of terminal X3 must be by a push button or by a PLC via an interposing relay, the push button or relay must have the necessary insulation between the motor voltage and PLC potential. Figure 13 shows two typical connections to the fault reset input.

Figure 13 - Fault Reset Circuit Examples

Automatic Fault Reset

Manual Fault Reset
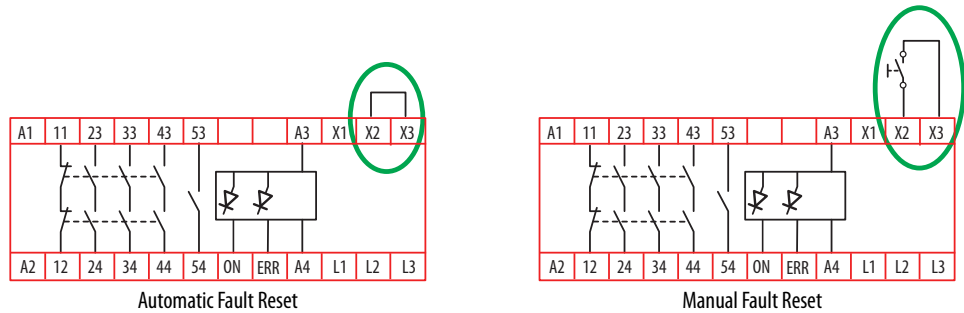
Configuration

The configuration of MSR55P safety relays is accomplished by adjusting the two switches on the front face. Each switch control knob rotates two potentiometers. The recommended practice is to set the switches to the minimum setting initially, and then adjust them as necessary to reduce nuisance tripping while maintaining a safe application.

V_m - Monitoring Voltage

The trip voltage of the back EMF is adjusted by the ten position V_m potentiometer. When the back EMF drops below the voltage level, the MSR55P safety relay begins the delay timer. When the voltage exceeds that voltage setting, the outputs are de-energized. Table 4 shows the settings of each of the catalog numbers.

Table 4 - V_m - Monitoring Voltage Settings

Position	440R-S35014, 440R-S35015, 440R-S35016 [Volts]	440R-S35011, 440R-S35012, 440R-S35013 [x10mV]
1	0.2	2
2	0.3	3
3	0.4	4
4	0.5	5
5	0.7	7
6	1.0	10
7	1.5	15
8	2.0	20
9	3.0	30
10	4.0	40

t$_s$ - Time Delay

When the back EMF of the motor drops below the V$_m$ voltage setting, the standstill delay timer starts. The delay time is set by the 10 position t$_s$ potentiometer. During the timing cycle, the OUT indicator flashes. Table 5 shows the delay time for each setting. After the delay expires, the outputs are energized.

Table 5 - Delay Time Settings

Position	Delay Time [seconds]
1	0.2
2	0.3
3	0.5
4	0.7
5	1.0
6	1.5
7	2.0
8	3.0
9	4.0
10	6.0

Timing Diagram

Timing Diagram Procedure

A typical timing diagram of MSR55P safety relays is shown in .

1. Upon power-up, the MSR55P safety relay performs internal safety checks.

2. With the motor at standstill, the outputs are energized.

3. When the motor is turned ON, the outputs are de-energized.

4. A motor stop command is issued, and the motor spins down.

5. The back EMF reaches the level of the V_m setting, the standstill delay timer starts. The position of the t_s potentiometer determines the duration of the delay.

6. When the timing cycle completes, standstill is considered achieved and the outputs are energized.

7. If one of the monitoring voltage signal lines break, the outputs are de-energized and the semiconductor ERR output turns ON after 2.5 seconds.

8. If the line is reconnected, no changes are noticed if the manual fault reset is used.

9. When the fault reset is closed, the outputs are energized.

10. The motor is turned back on, and the safety outputs are de-energized.

11. When voltage-free contacts control the motor, the MSR55P safety relay can detect line breakage on L2 and L3. After a 2.5 second delay, the semiconductor ERR signal turns ON. The ERR signal must be used to initiate a stop command to the motor. The outputs remain de-energized.

> **IMPORTANT** The MSR55P safety relay does not detect line breakage with motor running and connected to an electronic drive.

12. The line break is reinstated.

13. Upon closure of the reset signal, the outputs are energized.

Figure 14 - Typical Timing Diagram
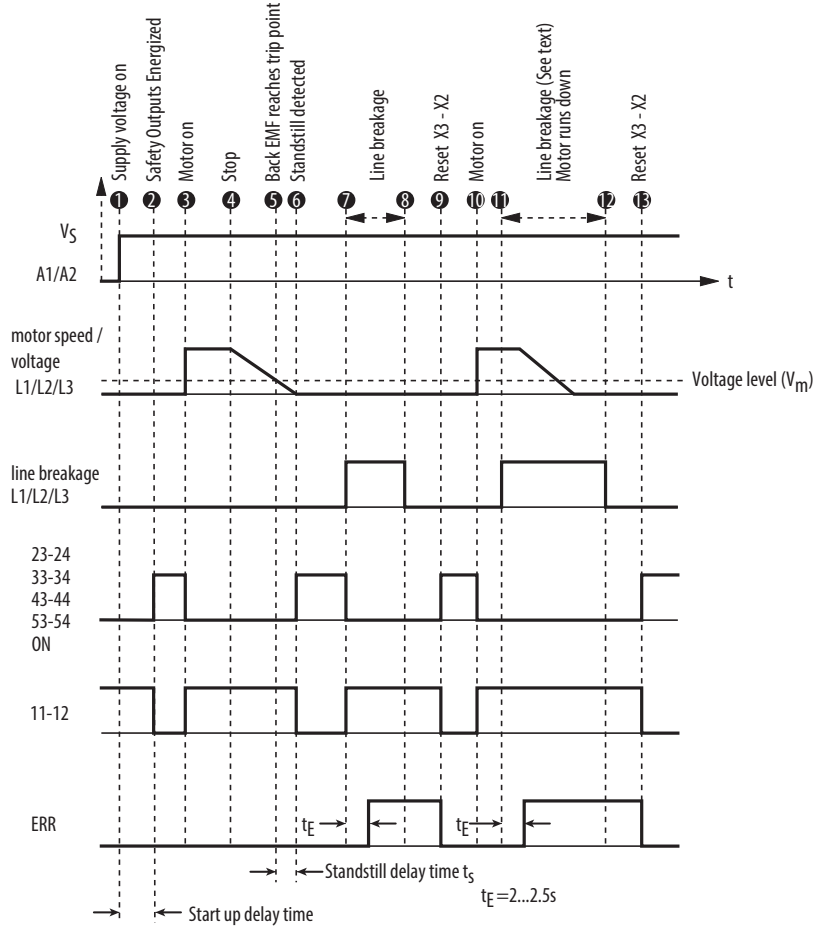
Status Indicators and Diagnostics

Three indicators on the front provide the operating status of the MSR55P safety relay. Table 6 describes the state of each indicator.

Table 6 - Status Indicators

Indicator	State	Description
V$_S$	Off	No power to A1
	Green	Normal operation
	Red	Internal Fault
OUT	Green	Safety outputs are energized
	Flashing green	In timing cycle
	Flashing orange	Intermittent crossing of the V$_m$ trip point
	Orange	Safety outputs are de-energized
	Off	Code 1 or code 5 error is present
ERR	Off	No faults exist; normal operation
	Flashing red	Fault is present. See ERR Flashing Codes on page 26.

MSR55P safety relays include a number of facilities to detect faults that could influence the safety function of the module. Checks are conducted on power-up of the unit and in cycles during normal operation. If a fault occurs, the output relays switch off. The fault state is indicated with the ERR indicator, the V$_S$ indicator, and the semiconductor output ERR.
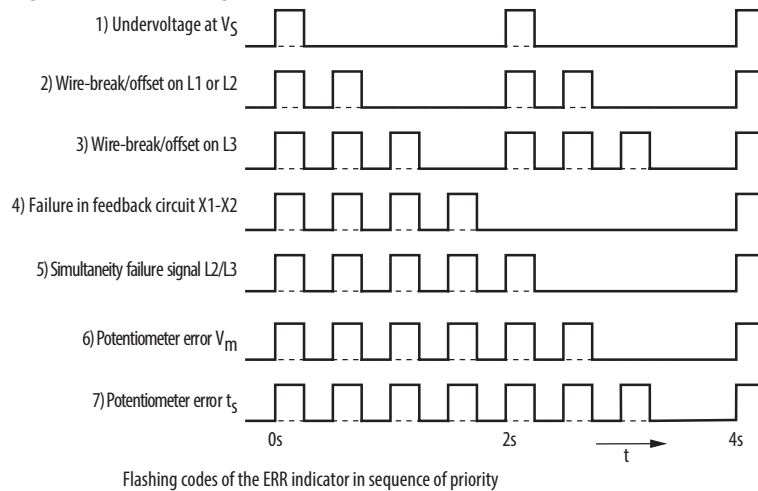
With safety relevant failures, your MSR55P safety relay differentiates between external failures (broken wire/offset, simultaneity failure, or feedback circuit failure) and internal failures.

Broken wire/offset failures and feedback circuit failures can be restored by using manual reset. They can also be reset automatically after removing the fault by placing a jumper from terminal X2 to X3.

The number of times the ERR status indicator blinks communicates diagnostics. When multiple faults exist simultaneously, the ERR indicator shows the highest priority. After the highest priority fault is corrected, the ERR shows the next highest priority fault. Figure 15 on page 26 shows the codes in order of priority.

ERR Flashing Codes

Figure 15 - ERR Flashing Codes

1) Undervoltage at V_S

2) Wire-break/offset on L1 or L2

3) Wire-break/offset on L3

4) Failure in feedback circuit X1-X2

5) Simultaneity failure signal L2/L3

6) Potentiometer error V_m

7) Potentiometer error t_s

0s   2s   t   4s

Flashing codes of the ERR indicator in sequence of priority

Line Breakage

Line breakage can be detected at standstill or with the motor spinning.

With Motor at Standstill

With the motor at standstill, the outputs of the MSR55P safety relay are energized. A break in the wires at L1, L2, and L3 is detected. The ERR indicator flashes and the ERR semiconductor output turns ON.

- L3 - The ERR indicator flashes three times.
- L2 - The ERR indicator flashes two times.
- L1 - The ERR indicator flashes two times.

With Motor Spinning

- Electronic Drive

  In the case where the motor is spinning under the command of an electronic drive, the outputs are de-energized. Line breakage is not detected by the MSR55P safety relay. This state is still considered a safe situation because the outputs of the MSR55P safety relay are de-energized. When the drive turns off, and the motor spins to a standstill; the line breakage is detected and the following occurs:

  – The outputs of the MSR55P safety relay remain de-energized.

  – The ERR output turns ON.

  – The ERR status indicator flashes the code that is associated with the breakage.

- Voltage-Free Contactor

  The MSR55P safety relay detects line breakage on L1, L2, and L3. The ERR semiconductor output turns ON and the ERR indicator flashes the appropriate number of times. The machine-controlled system continues to control the motor. This state is considered a safe situation because the outputs of the MSR55P safety relay are de-energized. The machine control system can respond to the ERR output and turn off the motor. When the contactor turns off, and the motor spins to a standstill; the line breakage is detected and the following occurs:

  – The outputs of the MSR55P safety relay remain de-energized.
  – The ERR output turns ON.
  – The ERR status indicator flashes the code that is associated with the breakage.

Simultaneity of Measuring Signals

As an additional safety feature, the two input signals (L2 and L3) are compared continuously. This feature allows the MSR55P safety relay to detect internal failures in one measuring signal.

If the signals are different for at least 2.5 s (one channel $>V_m$, the other $<V_m$), a simultaneity failure is detected. The semiconductor output ERR is switched on, the ERR status indicator flashes with failure code 5, and the OUT indicator is off.

If the measured signals return to the same level $<V_m$, the error remains stored and the outputs are disabled.

The simultaneity failure is only reset when both channels return to $>V_m$. If after that both channels drop below the setting value, $<V_m$, the output relays switch on.

Potentiometer Error

To achieve the required safety when adjusting the voltage threshold for standstill detection, each setting function is accomplished with two potentiometers having one common setting knob. If another setting is detected on the two corresponding potentiometers, the potentiometer error V_m or t_s is displayed.

To correct the fault, try to readjust the potentiometer. Make sure that you feel the detent.

Internal Device Failure

Internal failures are always stored independent of the reset input X3. Internal failures cause the output relays to switch off immediately, the semiconductor output ERR to switch on, and the V_S indicator to change from green to red.

Examples for internal failures include:

- Failure on safety relays (for example, welded output contacts).
- Internal failures on measuring channels and measuring circuits.
- Internal failures on control circuits for the safety relays.

Cycle power to terminal A1 to clear the fault.

Chapter **7**

Application and Wiring Examples

This chapter provides typical examples of applications and wiring diagrams to help you understand how the MSR55P safety relay can be applied. You must perform a risk assessment and make appropriate adjustments to these examples to provide the safety performance that is required for your application.

These applications show a focus on functional safety. You must also consider safety features including fuses, circuit breakers, and overload protection.

Guard Locking and E-stop with Electronic Drive

shows a typical application where the MSR55P safety relay monitors the speed of a motor. In this application, a PowerFlex® 525 drive controls the speed and direction of the motor. The MSR55P safety relay allows access to the hazard after the motor has achieved its standstill settings. The GSR DI safety relay monitors the MSR55P through contacts 11/12, the guard locking switch, and the E-stop push button. The DI safety relay enables the drive to restart after the gate is closed and locked and the E-stop is released.

The 440G switch can be replaced with the TLS-ZR switch if a higher gate-holding force is needed.

Shielded cable must be used for the motor-monitoring wires L1, L2, and L3. The shield must be grounded at the motor.

Table 7 - Guard Locking and E-stop with Electronic Drive

Application	Description
Safety Enable	Close the safety gate, release the E-stop, and press the Reset button.
Production Start	With the safety system enabled, press the Start button to energize the PowerFlex 525 drive-controlled motor.
Production Stop	A normal production stop is accomplished by pressing the Stop push button.
Safety Stop	A safety stop is initiated by pressing the E-stop push button.
Standstill Detection	When the motor spins down to a level below the point where it is generating less than 700 mV, the MSR55P safety relay starts its standstill time-delay timer. After 3 seconds, the MSR55P safety relay energizes its outputs, which allows the gate to be unlocked. The unlock circuit must pass through one of the safety outputs of the MSR55P (for example terminals 23/24).
Unlock the Safety Gate	Use the Lock/Unlock selector switch to unlock the gate and gain access to the hazardous area. The selector switch holds the 440G guard locking switch in the unlocked state. The 440G switch releases the lock and turns its safety outputs off. The DIS safety relay is set to AND logic, therefore, the DIS safety relay cannot be reset until both the gate is closed and lock, AND the E-stop is released.
Lock the Safety Gate	Close the gate. Use the Lock/Unlock selector switch to lock the gate. With the E-stop released, press the Reset button to enable the safety system and allow production to restart.
Safety Rating	This application has two safety functions: 1. Release of the guard locking only when the motor is stationary. This safety function meets Cat 4, PLe, SIL 3 due to the rating of the MSR55P. 2. STO of the drive when the gate is unlocked or the e-stop is pressed. This safety function is limited to Cat 3, PLd, SIL 2 due to the rating of the PF525. For guidance on safety system analysis with frequency drives, refer to https://www.dguv.de/medien/ifa/en/pub/rep/pdf/reports2013/ifar0713e/rep0713engl.pdf" IFA Report 7/2013e, "Safe drive controls with frequency converters."

Figure 16 - Example Schematic
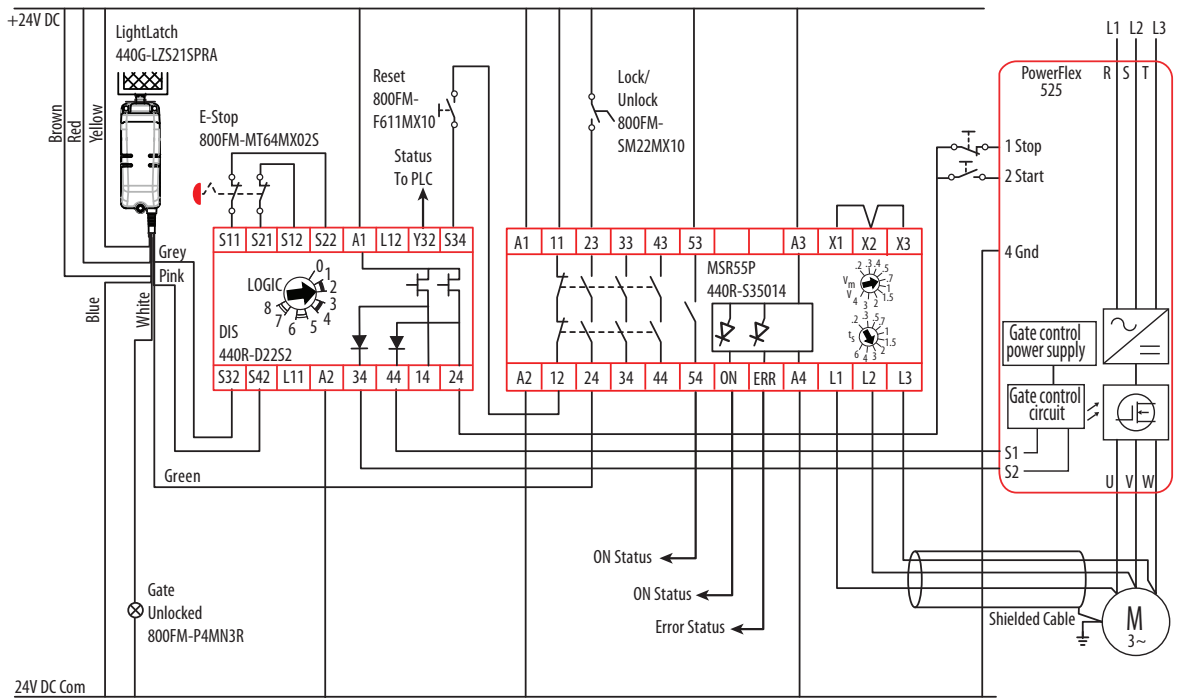
E-stop with Contactors

Figure 17 shows a typical application where the MSR55P safety relay monitors the speed of a motor that contactors turn on and off. When the MSR55P safety relay detects that the motor has achieved its standstill settings, the MSR55P safety relay energizes its outputs. You must perform a risk assessment to determine the proper settings of V_m and t_s.

An E-stop push button initiates a safety stop. A PLC turns the motor on and off, provided the safety system is enabled.

The SI safety relay monitors the contactors K1 and K2, the MSR55P through its contacts 11/12, and the E-Stop. The SI is set for monitored manual reset to prevent the motor from restarting when the e-stop button is released. The status of the SI relay (terminal Y32) must be monitored by the PLC. The PLC must turn OFF its outputs when the E-stop is pressed.

Table 8 - E-stop with Contactors

Application	Description
Safety Enable	Release the E-stop and press the Reset button.
Production Start/Stop	With the safety system enabled, the PLC can start and stop the motor.
Safety Stop	Press the E-stop to stop the motor; the motor coasts to a stop. When the motor spins down to a speed below the V_m setting of 70 mV, the MSR55P safety relay begins its timing sequence. After 3 seconds, the MSR55P safety relay energizes its outputs.
Safety Rating	The safety system has two functions (E-stop and speed monitoring). Both functions can be used in applications up to Category 4, PLe per ISO13849-1 and SIL CL 3 per IEC 60261. The speed monitoring rating of the system depends on how the outputs of the MSR55P safety relay are used. This application has two safety functions: 1. Enable safety devices only when the motor is stationary. This safety function meets Cat 4, PLe, SIL 3 due to the rating of the MSR55P. 2. Initiate a coast to stop by pressing the E-stop button. This safety function is limited to Cat 4, PLe, SIL 3 due to the rating of the SI relay, the redundancy, of the e-stop contacts, and the redundancy and monitoring of the contactors.

**Figure 17 - E-stop with Motor Controlled by Contactors**
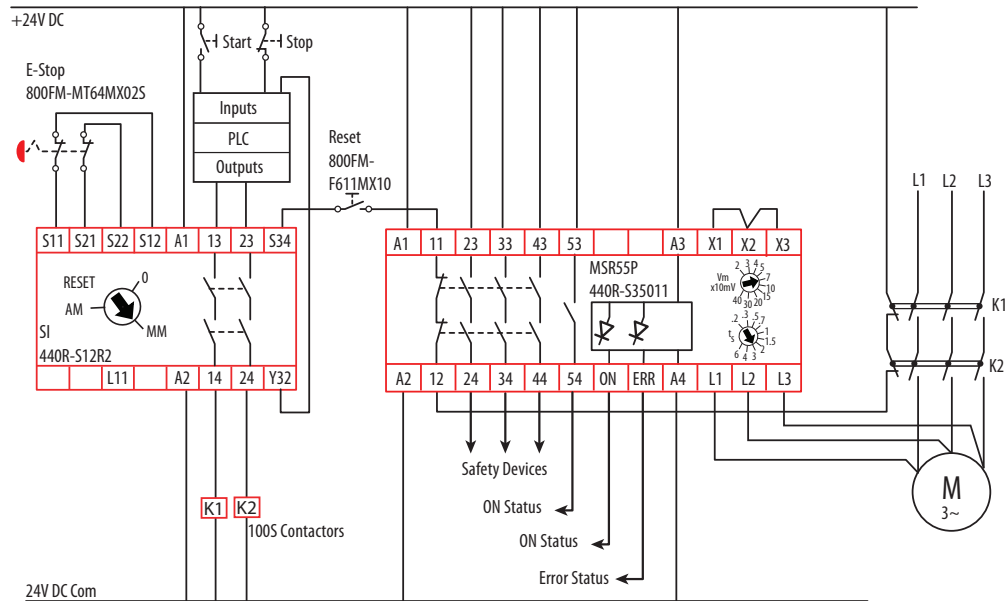
Wye-Delta Connections

Figure 18 shows a typical wye-delta application where the MSR55P safety relay monitors the speed of a motor that contactors turn on and off. When the MSR55P safety relay detects that the motor has achieved its standstill settings, the MSR55P safety relay energizes its outputs. You must perform a risk assessment to determine the proper settings of V_m and t_s.

Table 9 - Wye Delta Connections

Application	Description
Main Start	When the main switch is closed, the wye contactor (K2) energizes and allows a start.
Production Start	Press Start to pull in K1. The K1 contacts hold in the start circuit, starts the rotation of the motor and 700-FEY2QU23 timer relay begins timing. After the time expires, the 700-FEY2QU237 relay drops out the K2 wye contactor and pulls in the K3 delta contactor. The motor is now running at full speed and torque.
Production Stop	Press the Stop button. The K1 contactor drops out, the 700-FEY2QU237 opens its outputs, and the motor coasts to a stop. When the motor spins down to a speed below the V_m setting of 70 mV, the MSR55P safety relay begins its timing sequence. After 3 seconds, the MSR55P safety relay energizes its outputs.
Safety Stop	When the MSR55P safety relay energizes its outputs, K4 and K5 are used to execute the necessary safety stops.
Safety Rating	The speed monitoring function that is performed by the MSR55P safety relay meets the requirement of Category 4, PLe per ISO13849-1 and SIL CL 3 per IEC 60261. The rating of the safety functions initiated by K4 and K5 depends on additional circuitry that is not shown.

Figure 18 - Wye-delta Connections
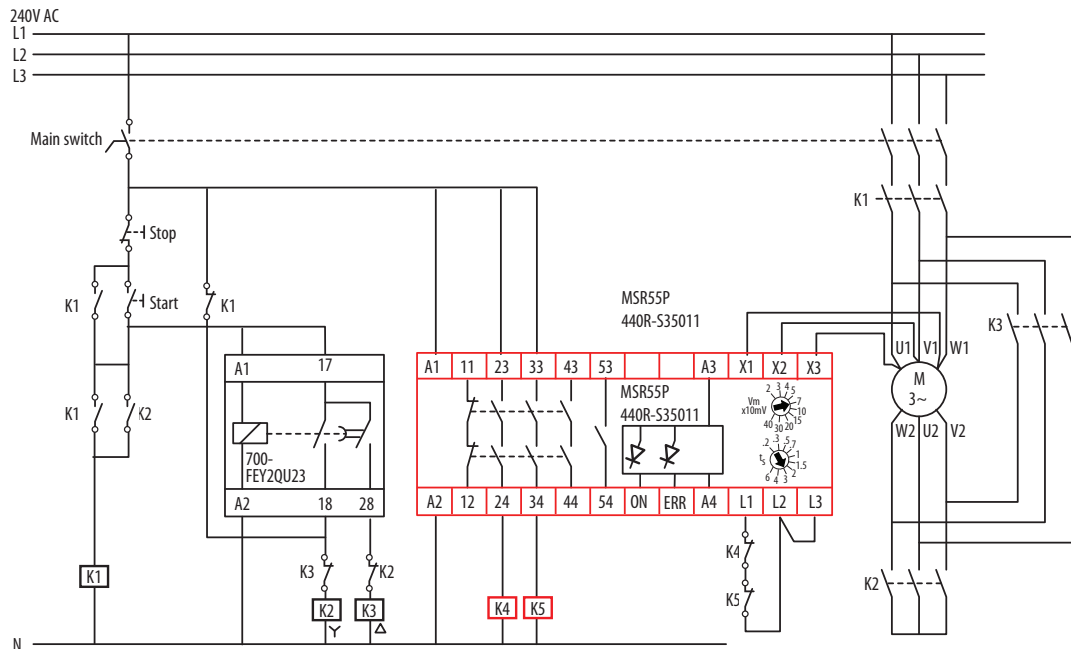
NOTES
1. K2 and K3 must be mechanically interlocked.
2. With "3-phase" connection of MSR55P the wye contactor, K2, must be closed after the motor is switched off to detect standstill.
If this is not the case the failure signal "broken wire" blocks the output contacts in off posisition.

IMPORTANT
- K2 and K3 must be mechanically interlocked.
- With 3-phase connection of MSR55P safety relay, the wye contactor (K2) must be closed after the motor is switched off to detect standstill. If not the failure signal "broken wire" blocks the output contacts in the off position.
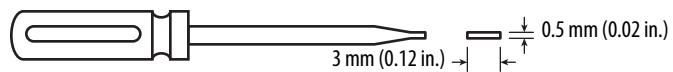
Troubleshooting

This chapter explains a systematic approach to determine the likely cause of the MSR55P safety relay being in a faulted state or not operating properly. It describes the procedures that you use to troubleshoot your relay.

Tools Needed

To troubleshoot your MSR55P safety relay, you need the following tools.

Required Tools

- **Medium-sized Screwdriver:** For terminal screws, to remove terminal blocks, and to configure the switches on the front face of the relays.

0.5 mm (0.02 in.)

3 mm (0.12 in.)

- **Digital Multimeter:** To measure signal levels and contact resistance.

Follow These Steps

To diagnose the condition of the MSR55P safety relay, follow the steps in Figure 19.

Figure 19 - Troubleshooting Flowchart
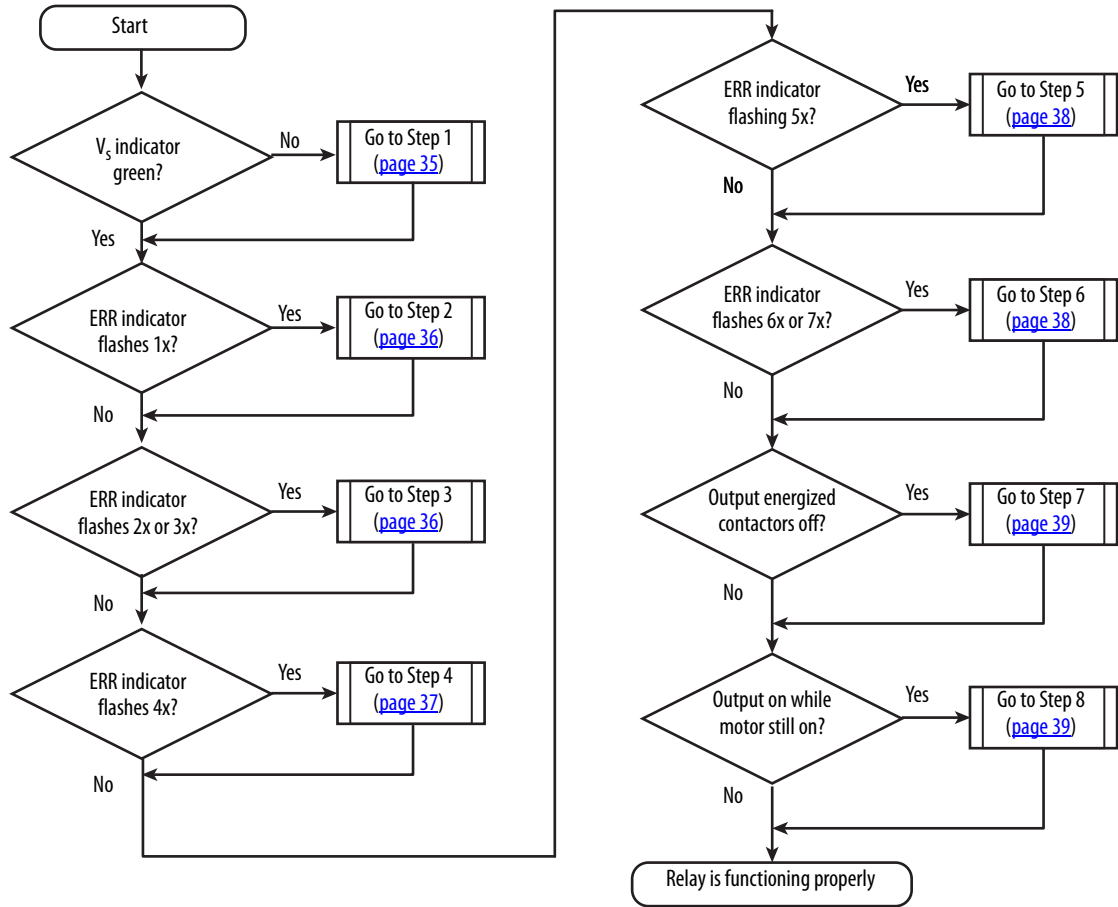
View PWR Indicator (Step 1)

The first troubleshooting step is to examine the PWR indicator on the front of your MSR55P safety relay.

The PWR status indicator has two possible states:

Status	Corrective Action
PWR indicator is OFF	Measure the voltage at terminal A1 to A2, as shown in Figure 20. If the voltage at the terminals is within specification, partially pop out the terminal blocks for A1 and A2 and then reinsert them. If the PWR indicator does not turn on, then you must replace the MSR55P safety relay.
PWR indicator is red	Cycle power to the MSR55P safety relay. If the PWR status indicator is still red after cycling the power, then you must replace the MSR55P safety relay.

Figure 20 - Measure Supply Voltage at the Terminals

Acceptable Ranges
21.6…28.8V DC
92…126.5V AC
184…253V AC
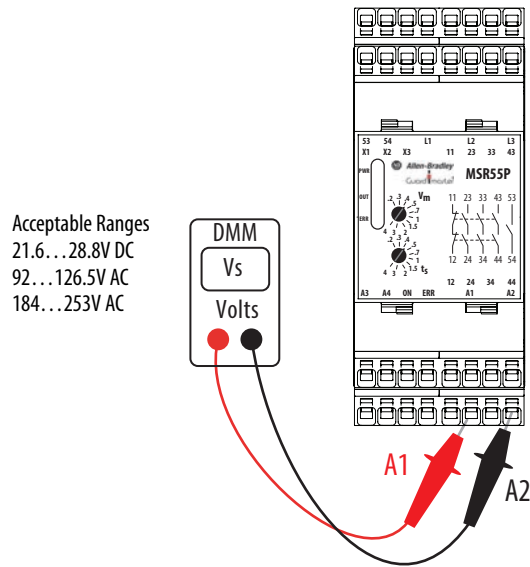
ERR Indicator Flashes One Time (Step 2)

Reset of an undervoltage event occurs automatically; regardless of the status of the fault reset input at terminal X3.

Two cases must be considered:

- Momentary
  The MSR55P safety relay resets itself automatically if a momentary undervoltage event occurs, regardless of the fault reset circuit. The momentary power dip can occur in the two cases:
  - Output energized (standstill state): The output de-energizes momentarily and the ERR semiconductor output turns ON. When the voltage returns to the normal level, the output is re-energized and the ERR semiconductor output turns OFF.
  - Output de-energized (non-standstill state): With the motor rotating faster than standstill, the outputs are already de-energized. When the voltage drops, the ERR indicator flashes 1x and the ERR semiconductor output turns ON. When the voltage returns to normal, the ERR indicator stops flashing and the ERR semiconductor output turns OFF.

  If the ERR semiconductor output is an input to the PLC that stops the process if there is an error with the MSR55P safety relay, a momentary voltage dip is difficult to trace to its cause.

- Sustained
  The ERR semiconductor output is ON and the ERR indicator is flashing 1X. An undervoltage exists at A1/A2. Measure the voltage at the terminal A1 to A2 as shown in . With your schematics, trace the voltage back to its source to determine what could be the cause of the undervoltage.

Wire Break at L1, L2, or L3 (Step 3)

Wire breakage is hierarchical. If both L2 and L3 are broken, then the MSR55P safety relay reports that L2 is broken. If L1 is broken, the MSR55P safety relay reports that L2 is broken as L2 has a higher priority than L3. When L2 is corrected, then the MSR55P safety relay reports the L3 broken.

Turn off the motor and allow it to achieve standstill.

⚠️ **ATTENTION:** Use an appropriate resistor network to discharge residual capacitance, if any.

Use an ohmmeter to measure the resistance of the motor windings at L2 or L3 to L1, as shown in .

- OK - a low resistance
- Not good - the meter shows an open circuit,

If an open circuit is detected, trace the wiring from the MSR55P safety relay to the motor connection, to determine where the open circuit exists.

**Figure 21 - Measure the Motor Resistance**

If an open circuit is detected, trace the wiring from the MSR55P safety relay to the motor connection, to determine where the open circuit exists.
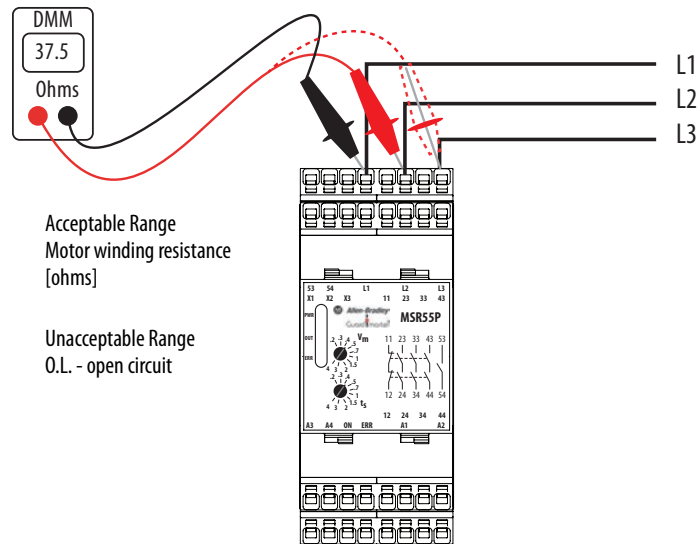
Feedback Circuit Open (Step 4)

The circuit between terminal X1 and X2 is open.

With motor turned OFF, measure the resistance between X1 and X2. The resistance must be close to 0 Ω. If the resistance shows an open circuit, trace the circuit through the components to find the open circuit.

If the circuit is closed (measures 0 Ω), try cycling the power to the MSR55P safety relay. If the ERR continues to show four flashes, then replace the MSR55P safety relay.

Figure 22 - Measure the Resistance in the Feedback Circuit
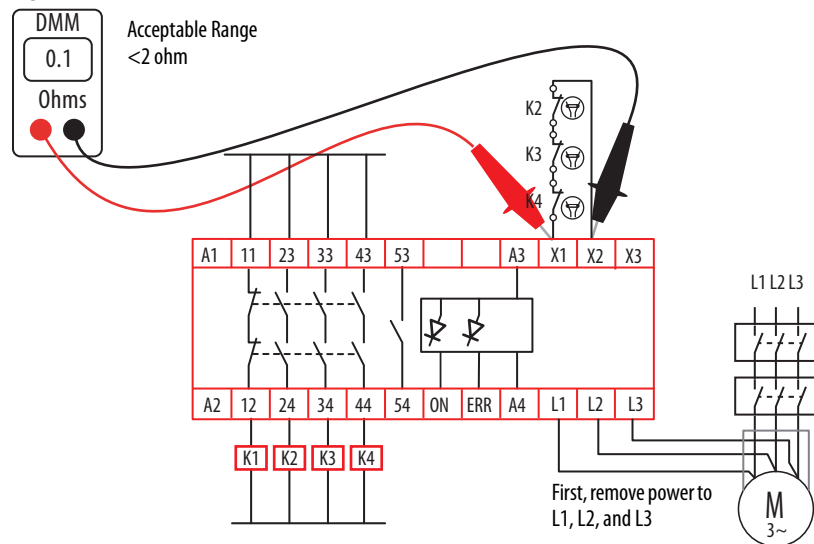
ERR Indicator Flashes 5 Times (Step 5)

The MSR55P safety relay checks for simultaneity of the signals at L2 and L3. If the signals are different for at least 2.5 s (one channel $>V_m$ and the other $<V_m$), a simultaneity failure is detected. The ERR semiconductor output turns on, the ERR status indicator flashes failure code 5, and the OUT status indicator turns off.

With power removed from the motor, measure the motor-winding resistance as shown in Figure 23. If the resistance is different between L2 and L3, check the wiring and measure the motor resistance at the motor.

If the motor resistance is the same on L2 and L3, then an internal fault exists and the MSR55P safety relay must be replaced.

When the fault is corrected, the motor must be rotated above V_m and then stopped to reset the MSR55P safety relay. The fault reset does not depend on the status of the X3/X2 connection; the reset occurs automatically.

Figure 23 - Simultaneous Error
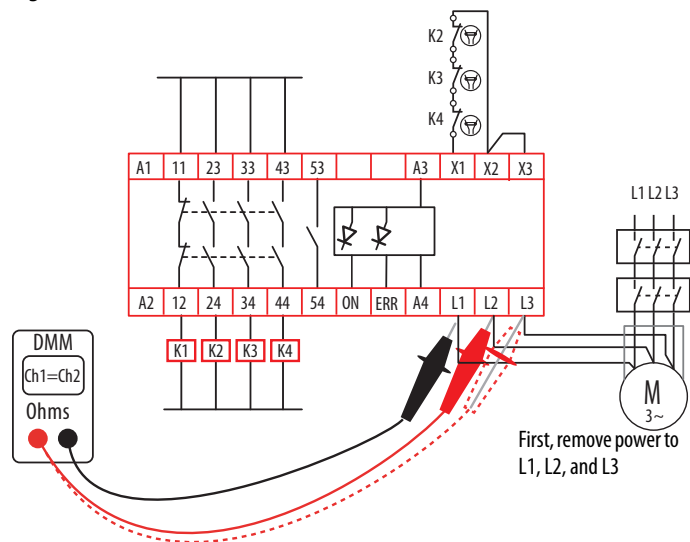
ERR Flashes 6 or 7 Times (Step 6)

Internally, the V_m and t_s adjustments rotate two potentiometers. When the two potentiometers are not set to the same level, the ERR flashes and the ERR semiconductor output turns ON.

To correct this situation, try to rotate the switch to a new position and then back to the desired position. If the fault is not corrected, then replace the MSR55P safety relay.

Output Is Energized but Contactors Are Off (Step 7)

Measure the voltage at the contactors. An example of the measurement points is shown in Figure 24. If voltage is not present at point 1, measure the voltage at points 2 and 3 in the circuit.

If voltage is not present at point 3, then following the wiring back to the source to detect the cause (blown fuse, tripled circuit breaker, open wire connection).

If the voltage is present at point 3 but is not available at point 2, check the wiring at the relay terminals. If the wiring is okay, then you must replace the MSR55P safety relay.

Figure 24 - Check the Output Wiring Voltage
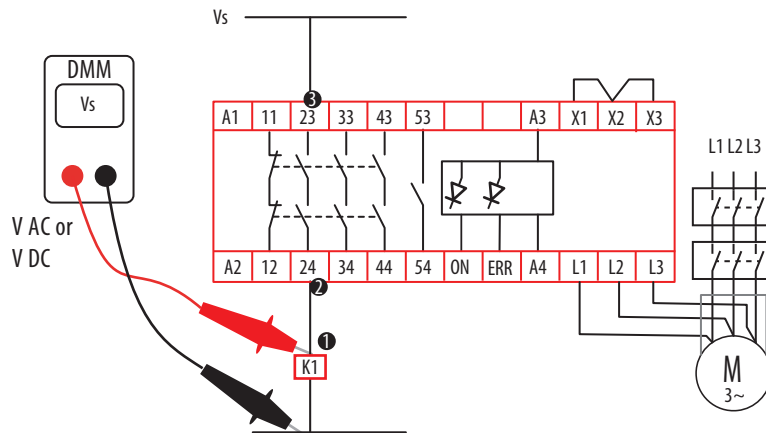
Output Is On While Motor Still Turns (Step 8)

Reduce setting of V_m if necessary to minimum. If the outputs are still enabled, a wiring problem on the measuring wires could be the reason (short circuit on terminals L2/L3 to L1) or the motor generates only a low voltage. Check connection of measuring inputs to motor winding according to the connection examples.

Increase the delay time t_s setting to allow the motor more time to spin to a stop.

Notes:

Specifications

General

Table 10 - General Specifications

Attribute	MSR55P Screw Terminals	MSR55P Spring Clamp Terminals
Dimensions, WxHxD [mm (in.)]	45 x 104 x 121 (1.77 x 4.09 x 4.76)	45 x 111 x 121 (1.77 x 4.37 x 4.76)
Shipping weight, approx. [g (lb)]	400 (0.88)	—
Wire size [mm² (AWG)]	1 x 0.2 …2.5 (24…14) 2 x 0.2…1.5 (24…16)	1 x 0.2 …2.25 (24…14)
Wire temperature [°C (°F)]	Solid copper that withstands 60 (140)	Stranded copper that withstands 75 (167)
Wire strip length [mm (in.)]	8 (0.31)	12 (0.47)
Terminal screw torque [N•m (lb•in)]	0.8 (7)	—
Terminal protection	IP20	
Enclosure protection	IP40	
Case material	Thermoplastic with V0 behavior according to UL94	

Environmental

Table 11 - Environmental Specifications

Attribute	Standard	Value
Temperature, operating [°C (°F)]	IEC/EN 60068-1	-25…+60 (-13…+140) See Figure 9 on page 16.
Temperature, storage [°C (°F)]	IEC/EN 60068-1	-40…+75 (-40…+167)
Vibration [Hz, mm]	IEC/EN 60068-2-6	10…55, 0.35
Climate [-°C / +°C / days]	IEC/EN 60068-1	25 / 060 /04
Electrostatic discharge, Air [kV]	IEC/EN 61000-4-2	8
RF immunity [V/m]	IEC/EN 61000-4-3	20
Fast transients [kV]	IEC/EN 61000-4-4	2
Voltage surge between L1/L2/L3 [kV] A1/A2 with AC supply [kV] A1/A2 with DC supply [kV]	IEC/EN 61000-4-5	2 2 1
Conducted immunity [kV]	IEC/EN 61000-4-6	10
Pollution degree	IEC/EN 60664-1	2
Rated impulse voltage [kV] 11/12,23/24,33/34,43/44 against all others 11/12,23/24,33/34,43/44 against each other 53/54 against all others A3/ON/ERR/A4 against all others A1/A2 AC against all others A1/A2 DC against all others X1/X2/X3 to L1/L2/L3	IEC/EN 60664-1	6 4 4 6 6 4 No galvanic separation

Power Supply (A1/A2)

Table 12 - Power Supply (A1/A2) Specifications

Attribute	DC	AC	AC
Power supply voltage, nominal	24V DC PELV, Class 2	115V AC	230V AC
Voltage range	0.9…1.2	0.8…1.1	
Power consumption [DC: W, AC: VA]	3	5	
Frequency range [Hz]	—	45…60	
Ripple, max [%]	10	—	
Fuse, slow blow [A]	2		
Start-up delay [s]	$0.8 + t_s$		

Inputs (L1/L2/L3)

Table 13 - Input (L1/L2/L3) Specifications

Attribute	Value							
Motor voltage, max [V AC]	690 (UL 600)							
Input resistance [kΩ]	500							
Monitoring trip value [mV] [V]	20… 400, adjustable 0.2…4, adjustable							
Response value dependent on frequency								
Input frequency [Hz]	50	100	200	400	600	1000	1500	2000
Multiplication factor for V_m	1.0	1.1	1.2	1.5	2.0	2.8	5.0	8.0
Hysteresis for detection of running motor [%]	100							
Release delay for detection of running motor [ms]	<100							
Standstill time delay, t_s [s]	0.2…6, adjustable							

Safety Outputs

Table 14 - Safety Output Specifications

Attribute		Value
Wiring terminals		23/24, 33/34, 43/44 redundant, positive guided, normally open 11/12 redundant, positive guided, normally closed
Switching capacity	UL rating at 40 °C (104 °F)	Pilot Duty B300, 5 A @ 250V AC, 5 A @ 24V DC
	UL rating at 60 °C (140 °F)	Pilot Duty B300, 2 A @ 250V AC, 2 A @ 24V DC
	AC15	N.O.: 3 A @ 230V AC, N.C.: 1 A @ 230V AC
	DC13	N.O.: 1 A @ 24V DC, N.C.: 1 A @ 24V DC
	DC13 at 0.1 Hz	N.O.: 4 A @ 24V DC, N.C.: 4 A @ 24V DC
Thermal current, up to 40 °C (104 °F) [A]		5
Fusing external, max		4AgL fuse or C6A circuit breaker
Operating frequency, max [ops/hr]		1200
Contact life at load [switching cycles] at 5 A 230V AC, cos φ=1		≥200,000
Mechanical life at no load [switching cycles]		≥50,000,000

Status Outputs

Table 15 - Status Output Specifications

Attribute	Value
A3/A4 power supply voltage range [V DC]	12…30 PELV/SELV or Class 2
Power consumption [W]	3
ON, ERR max current at 24V DC [mA]	100
53/54 contact rating [A/VAC]	3/250

Regulatory Approval

Agency Certification

- Functional Safety Type Approved by TÜV Rheinland
- UL Listed Industrial Control Equipment, certified for US and Canada
- CE marked for all applicable directives
- RCM marked for all applicable ACMA acts

For a complete listing of product certifications, see rok.auto/certifications.

Compliance to European Union Directives

This product has the CE marking and is approved for installation within the European Union and EEA regions. It has been designed and tested to meet the following directives.

EMC Directive

This product is designed and tested to meet the European Council Directive 2004/108/EC on Electromagnetic Compatibility (EMC) and the following standards:

- EN 61000-6-2:2005
  Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
- EN 61000-6-3:2007 + A1:2011
  Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments
- EN 61000-6-7:2015
  Electromagnetic compatibility (EMC) – Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations

This product is intended for use in an industrial environment.

Machine Safety Directive

This product is designed and tested to meet the European Council Directive 2006/42/EC on machinery and the following standards:

- IEC/EN 61508
  Functional safety of electrical/electronic/programmable electronic safety-related systems
- IEC/EN 62061
  Safety of machinery - Functional safety of safety-related electrical, electronic, and programmable electronic control systems
- EN ISO 13849-1
  Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design

This product is intended for use in an industrial environment.

The performance of the safety function is dependent on the structure of all devices that comprise the safety function. Table 16 and Table 17 provide the data that must be used to represent the relay when calculating the safety integrity level (SIL) or the Performance Level (PL).

The safety relay can be used in safety circuits according to DIN EN 60204-1/ VDE 0113 part 1. The following safety requirements are achievable in maximum based on the operation mode and wiring.

Specifications are applicable only if the safety function is demanded at least once within six months. All diagnostic tests are conducted at least before next demand. At mission time (TM), the proof test interval (PTI) is assumed. Components failure rates are according to SN29500.

SIL Rating

Safety relays meet the requirements in [Table 16](#) in accordance with IEC/EN 61508 and IEC 62061.

Table 16 - SIL Rating

Attribute	Rating
SIL CL [IEC/EN62061]	3
SIL [IEC/EN 61508, IEC/EN 61511]	3
Hardware Fault Tolerance, HFT	1
Diagnostic Coverage, DC_{avg} [%]	99.0
Safe Failure Fraction, SFF [%]	99.7
PFHD [/h]	$4.10E^{-10}$
PFD_{avg}	$1.42E^{-04}$
T [years]	20

Performance Level/Category

Safety relays can be used in safety systems that meet up to Category 4 and Performance Level PLe in accordance with ISO 13849-1. [Table 17](#) lists the pertinent ratings for ISO 13849-1.

Table 17 - Performance Level/Category

Attribute	Rating
Category	4
Performance Level	PLe
$MTTF_d$ [years]	93
Diagnostic Coverage, DC_{avg} [%]	99.0
Days, d_{op} [days/year]	365
Hours, h_{op} [hours/day]	24
t_{cycle} [s/cycle]	$28.8E^{+03}$
T [years]	20

Notes:

Rockwell Automation Support

Use the following resources to access support information.

Technical Support Center	Knowledgebase Articles, How-to Videos, FAQs, Chat, User Forums, and Product Notification Updates.	https://rockwellautomation.custhelp.com/
Local Technical Support Phone Numbers	Locate the phone number for your country.	http://www.rockwellautomation.com/global/support/get-support-now.page
Direct Dial Codes	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	http://www.rockwellautomation.com/global/support/direct-dial.page
Literature Library	Installation Instructions, Manuals, Brochures, and Technical Data.	http://www.rockwellautomation.com/global/literature-library/overview.page
Product Compatibility and Download Center (PCDC)	Get help determining how products interact, check features and capabilities, and find associated firmware.	http://www.rockwellautomation.com/global/support/pcdc.page

Documentation Feedback

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