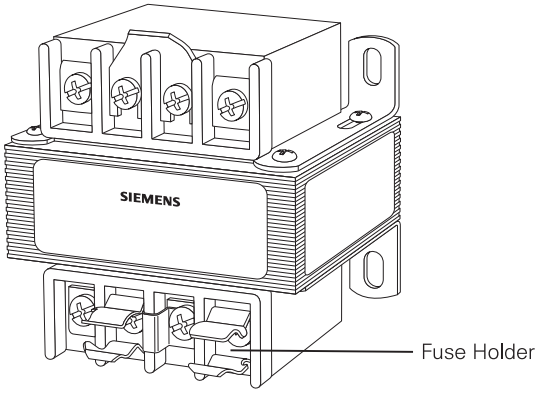
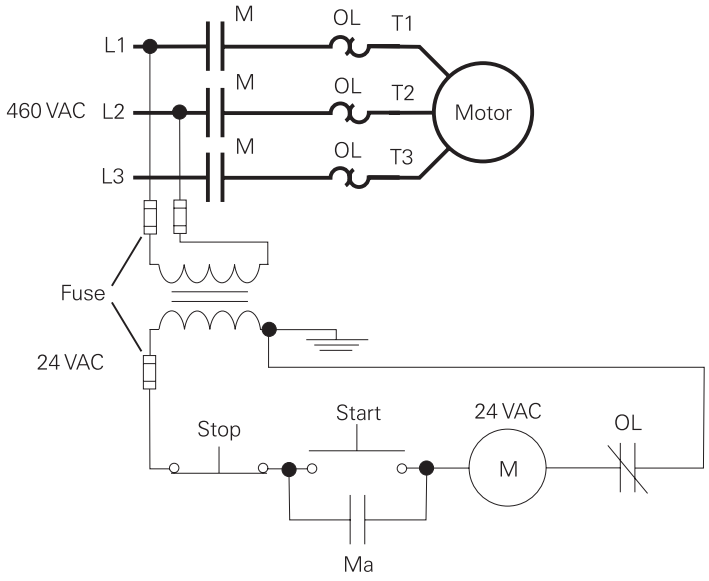
Control Transformers

It is often desirable to operate the control circuit at a lower voltage than the power circuit. **Control transformers** are used to step a voltage down to a lower level. Siemens Class MT, MTG and K control transformers are available in various primary and secondary voltages from 50 to 5000 VA.

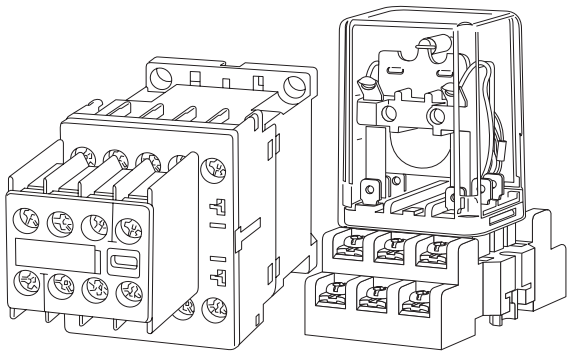


In the following example, the power circuit is 460 VAC. A control transformer is used to step the voltage down to 24 VAC for use in the control circuit. The electromagnetic coil voltage must be rated for 24 VAC. Fuses on the primary and secondary windings of the transformer provide overcurrent protection.



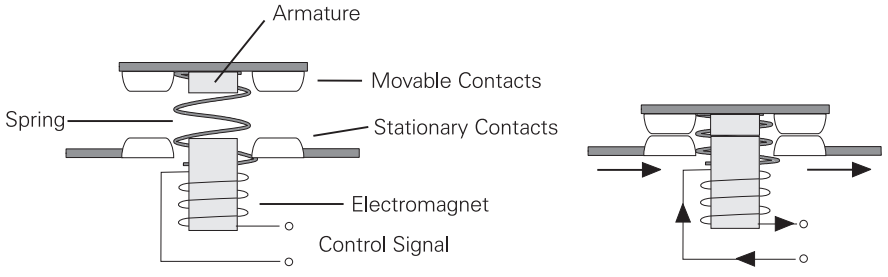
Control Relays

Relays are widely used in control circuits. They are used for switching multiple control circuits, and for controlling light loads such as starting coils, indicator lights, and audible alarms.



Relay Operation

The operation of a control relay is similar to a contactor. In the example below, a relay with a set of normally open (NO) contacts is used. When power is applied from the control circuit, an electromagnetic coil is energized. The electromagnetic field pulls the armature and movable contacts toward the electromagnet closing the contacts. When power is removed, spring tension pushes the armature and movable contacts away from the electromagnet, opening the contacts.



Contact Arrangement

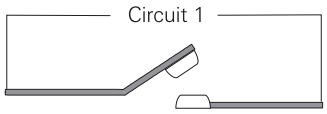
A relay can contain normally open, normally closed, or both types of contacts.

The main difference between a control relay and a contactor is the size and number of contacts. The contacts in a control relay are relatively small because they need to handle only the small currents used in control circuits. There are no power contacts. Also, unlike a contactor, each contact in a control relay controls a different circuit. In a contactor, they all control the starting and stopping of the motor. Some relays have a greater number of contacts than are found in the typical contactor.

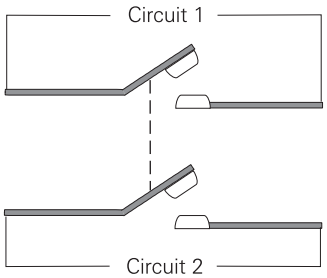
The use of contacts in relays can be complex. There are three key terms you will need to understand in dealing with relays.

Pole

Pole describes the number of isolated circuits that can pass through the relay at one time. A single-pole circuit can carry current through one circuit, while a double-pole circuit can carry current through two circuits simultaneously. The two circuits are mechanically connected so that they open or close at the same time.



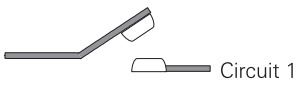
Single Pole



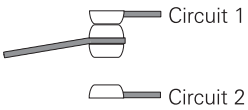
Double Pole

Throw

Throw is the number of different closed-contact positions per pole. This is equal to the total number of different circuits each pole controls.



Single-Throw



Double-Throw

The following abbreviations are frequently used to indicate contact configurations:

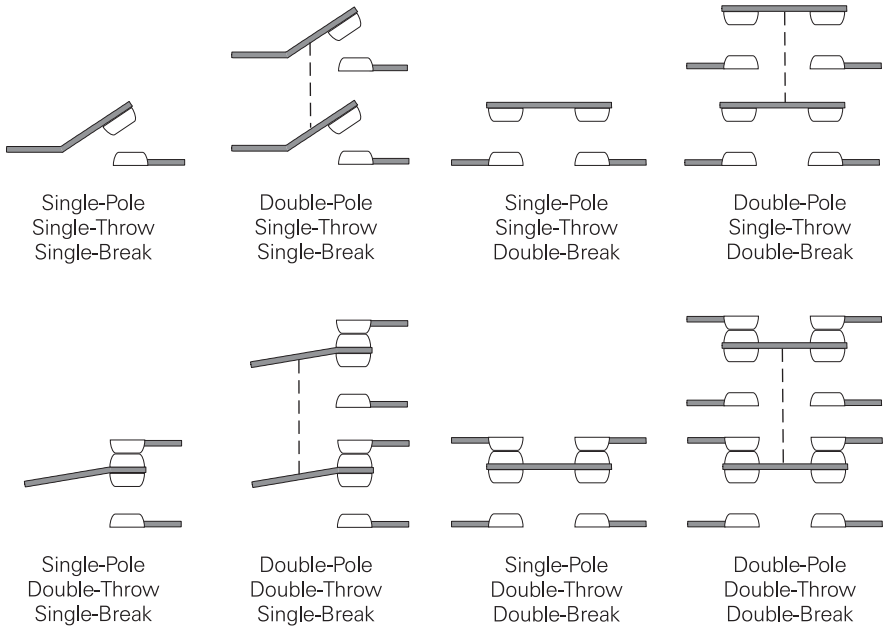
SPST Single-Pole, Single-Throw
SPDT Single-Pole, Double-Throw
DPST Double-Pole, Single-Throw
DPDT Double-Pole, Double-Throw

Break

Break is the number of separate contacts the switch contacts use to open or close individual circuits. If the switch breaks the circuit in one place, it is a single-break. If the relay breaks the circuit in two places, it is a double-break.

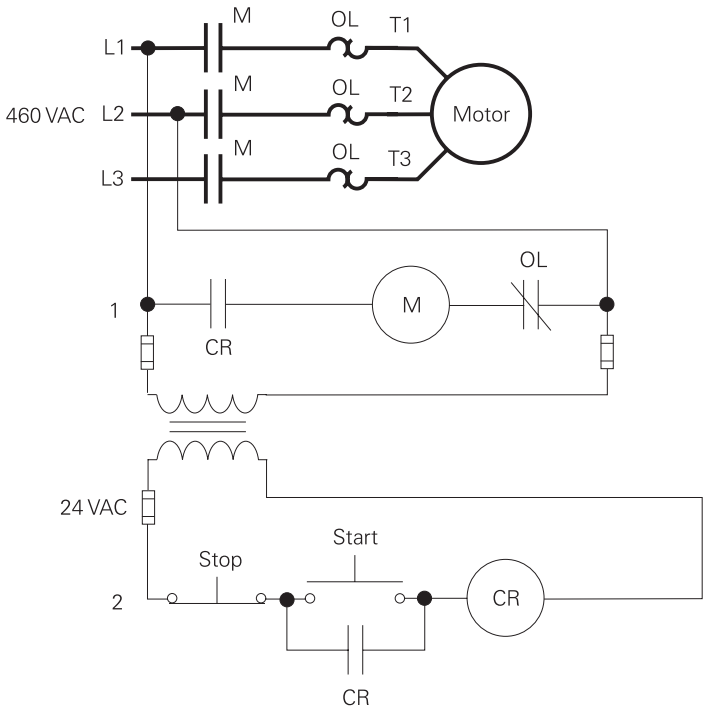
Single-Break **Double-Break**

The diagram below illustrates various contact arrangements.

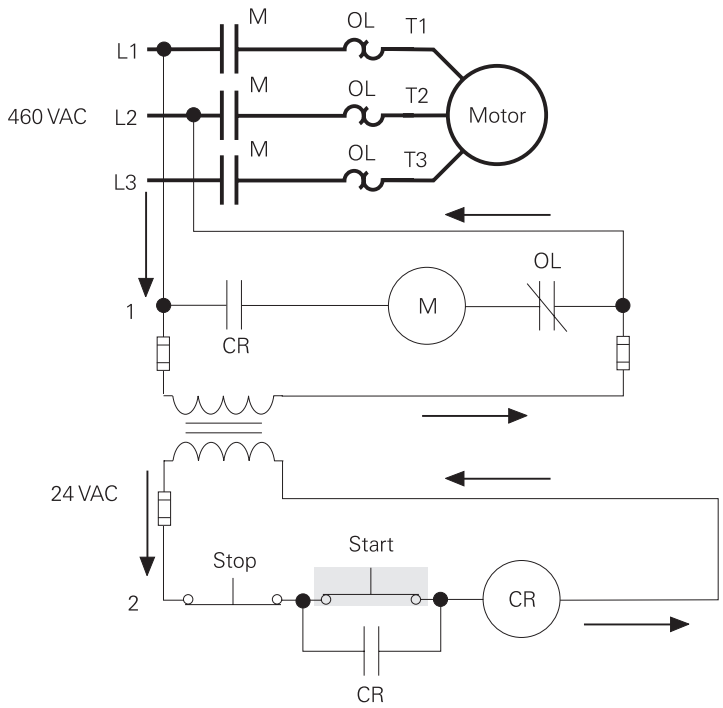


Interposing a Relay

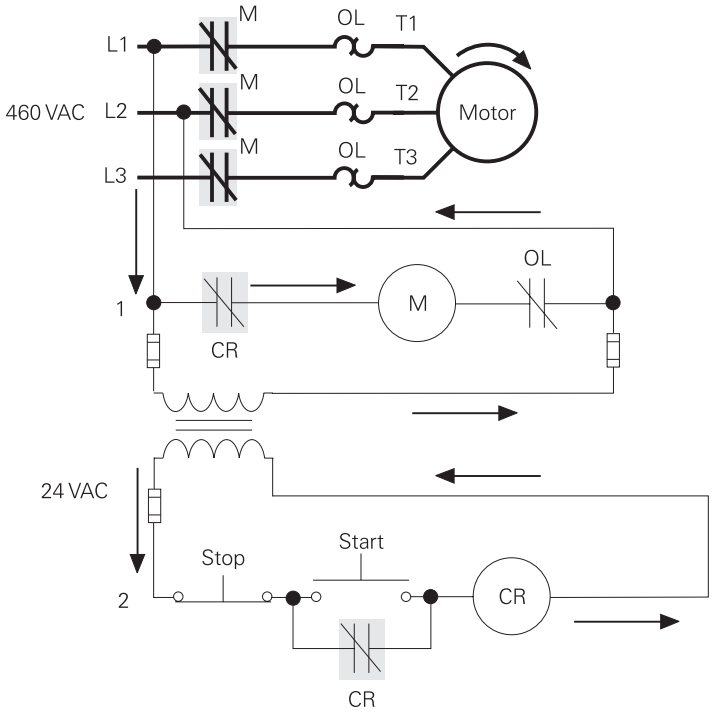
The following line diagram illustrates one way that a control relay might be used, in a circuit where a 24 VAC coil may not be strong enough to operate a large starter. In this example the electromagnetic coil of the “M” contactor selected is rated for 460 VAC. The electromagnetic coil of the control relay (CR) selected is 24 VAC. This is known as **interposing** a relay.



When the “Start” pushbutton in line 2 is momentarily depressed, power is supplied to the control relay (CR).

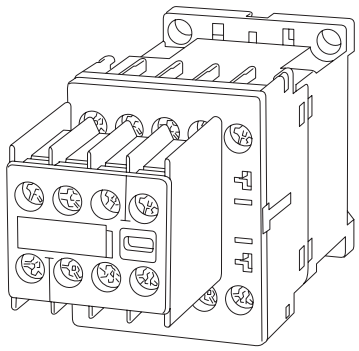


This causes the “CR” contacts in lines 1 and 2 to close. The “CR” contacts in line 2 maintain the start circuit, while the “CR” contacts in line 1 complete the path of current to the “M” motor starter. The “M” motor starter energizes and closes the “M” contacts in the power circuit, starting the motor. Depressing the “Stop” pushbutton de-energizes the “CR” relay and “M” motor starter.



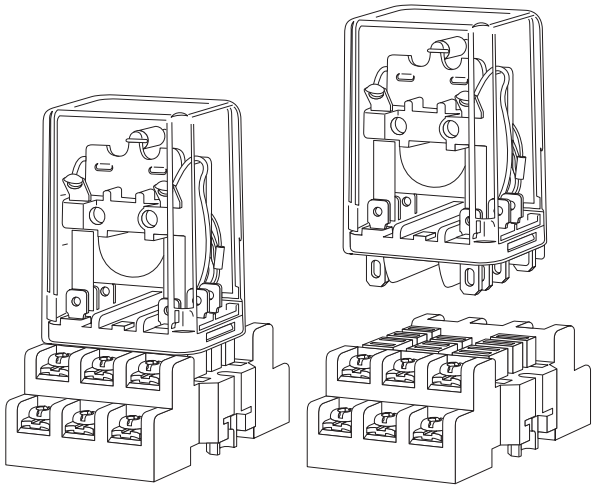
SIRIUS 3RH Control Relays

Siemens SIRIUS 3R modular system includes a complete line of control relays. For example, SIRIUS 3RH11 control relays and 3RH14 latching control relays are available with screw or spring-loaded terminals. Four contacts are available in the basic device. Four additional contacts can be added by attaching auxiliary switch blocks. Units are available for control supply voltages from 12 to 230 VDC and from 24 to 600 VAC. 3RH14 latching control relays have two coils, a relay coil and a release coil, that are rated for continuous duty operation.



3TX71
Plug-In Relays

Siemens offers a variety of 3TX71 plug-in relays for socket or flange mounting. Units are available for common AC and DC control supply voltages. The biggest benefit of this type of relay is that all the wiring stays in place if the relay needs to be replaced.



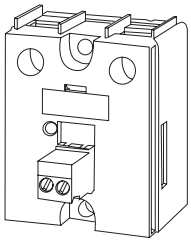
Solid-State Switching Devices

Conventional electromechanical switching devices are unsuitable for applications requiring high switching frequencies due to the wear on mechanical components. Electromechanical switching devices are also inherently noisy and, as a result, undesirable for use in noise-sensitive areas.

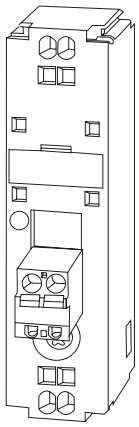
As a result, Siemens has developed three categories of SIRIUS SC solid-state switching devices, relays, contactors, and function modules. SIRIUS SC solid-state relays and contactors are intended for switching resistive loads, but some units are capable of switching slightly inductive loads.

SIRIUS SC Solid-State Relays

SIRIUS SC **solid-state relays** can be mounted on existing cooling surfaces. 3RF20 solid-state relays have a 45 mm assembly width, and 3RF21 solid-state relays have a 22.5 mm assembly width.



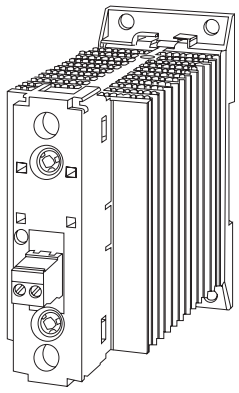
3RF20 Solid-State Relay (45 mm)



3RF21 Solid-State Relay (22.5 mm)

SIRIUS SC Solid-State Contactors

SIRIUS SC 3RF23 **solid-state contactors** incorporate a solid-state relay in an optimized heat sink to form a ready to use device with defined current ratings.



3RF23 Solid-State Contactor

SIRIUS SC Function Modules

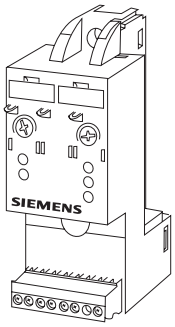
Many applications require extended functionality that can be accommodated by SIRIUS SC **function modules**.

Examples of SIRIUS 3RF29 function modules include:

Converter – Converts an analog control signal to a pulse-width modulated digital signal. This allows a SIRIUS SC solid-state relay or contactor to adjust power to a load based on an analog signal from a device such as a temperature sensor.

Load monitoring module – This module detects a variety of faults, such as a failed load element and provides for an LED fault indication and a PLC-compatible fault signal.

Power controller – This module combines load circuit monitoring capability with the ability to adjust power to the connected load.



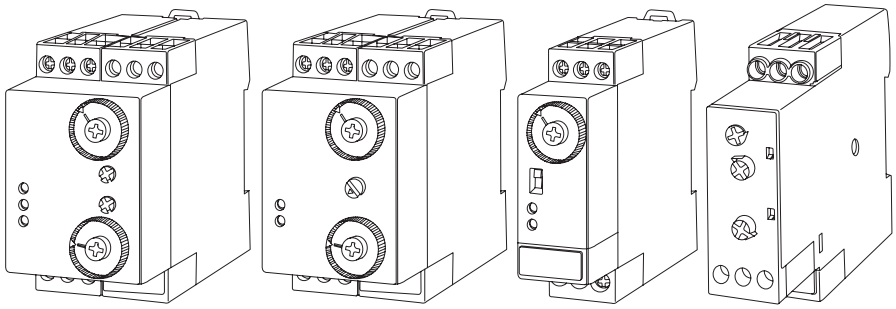
3RF29 Power Controller

Monitoring Relays

SIRIUS 3UG **monitoring relays** reduce machine and plant downtime by monitoring electrical and mechanical quantities and fault conditions, and providing appropriate diagnostic indications.

A variety of monitoring relays are available. Examples of functions performed by various monitoring relays include:

- Line monitoring for phase sequence, phase failure phase asymmetry, undervoltage, and overvoltage.
- Single-phase current monitoring.
- Single-phase voltage monitoring.
- Power factor monitoring.
- Insulation resistance monitoring.
- Filling level monitoring.
- Motor underspeed monitoring.
- Temperature monitoring.

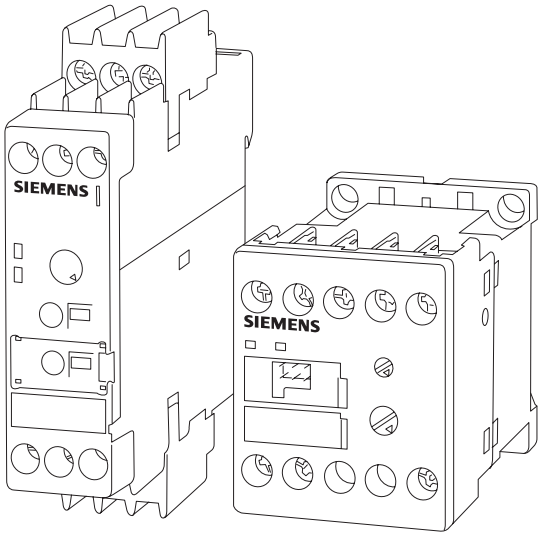


SIRIUS 3UG Monitoring Relays

Time Relays

Time relays, such as Siemens 3RP15 and 3RP20 solid-state time relays, are used in control switching operations involving time delay.

3RP15 time relays have a 22.5 mm assembly width, and 3RP20 time relays have a 45 mm assembly width. Most of these time relays have multiple time setting ranges. For example, a number of the 3RP15 and 3RP20 time relays have 15 time setting ranges covering the span from 0.05 seconds to 100 hours.



3RP15 3RP20

Time Delay

A time relay has two major functions: On-delay and Off-delay timing. An arrow is used to denote the function of the timer. An arrow pointing up indicates an On-delay timing action, while an arrow pointing down indicates an Off-delay timing action.

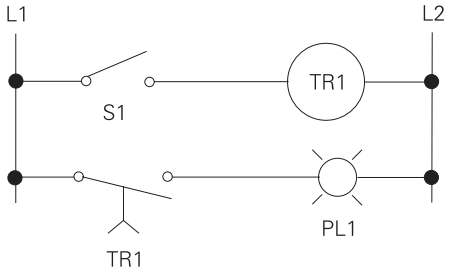
On-Delay
Arrow Points Up

Off-Delay
Arrow Points Down

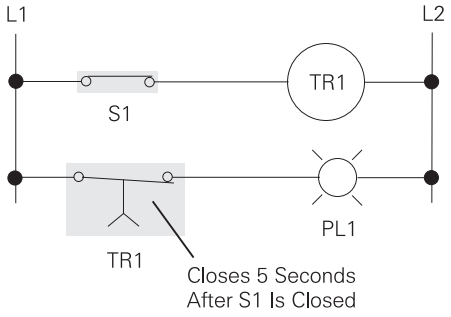
On-delay and Off-delay timers can turn their connected loads on or off, based on how the timer's output is wired into the circuit. **On-delay** indicates that once a timer has received a signal to turn on, a predetermined time (set by the timer) must pass before the timer's contacts change state. **Off-delay** indicates that once a timer has received a signal to turn off, a predetermined time (set by the timer) must pass before the timer's contacts change state.

On-Delay, Timed Closed

The following is an example of **On-delay, timed closed**, using a set of normally open (NO) contacts. This configuration is also referred to as **normally open, timed closed (NOTC)**.The timing relay (TR1) has been set for an On-delay of 5 seconds.

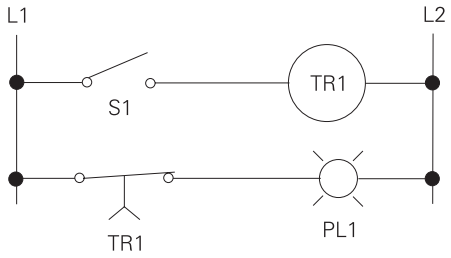


When S1 is closed, TR1 begins timing. When 5 seconds has elapsed, TR1 will close its associated normally open (NO) TR1 contacts, illuminating indicator light PL1. When S1 is open, de-energizing TR1, the TR1 contacts open immediately, extinguishing PL1.

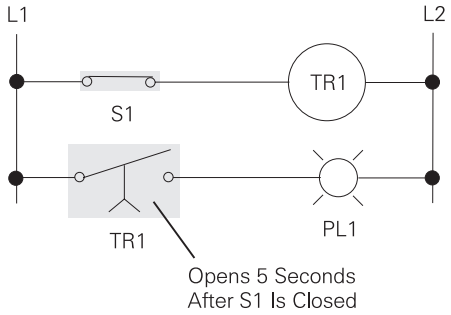


On-Delay, Timed Open

The following is an example of **On-delay, timed open**, using a set of normally closed (NC) contacts. This configuration is also referred to as **normally closed, timed open (NCTO)**. PL1 is illuminated as long as S1 remains open. The timing relay (TR1) has been set for an ON delay of 5 seconds.

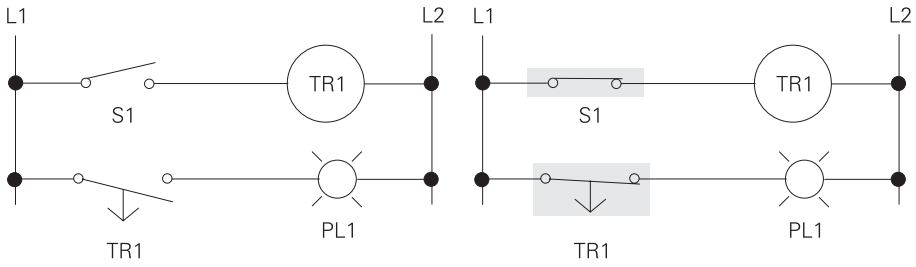


When S1 is closed, timing relay TR1 is energized. After a timed delay of 5 seconds, the associated normally closed TR1 contacts open, extinguishing PL1. When S1 is open, de-energizing TR1, the TR1 contacts close immediately, illuminating PL1.

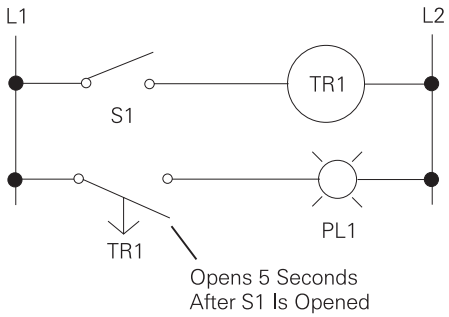


Off-Delay, Timed Open

The following is an example of **Off-delay, timed open**, using a set of normally open (NO) contacts. This configuration is also referred to as **normally open, timed open (NOTO)**. The timing relay (TR1) has been set for an off delay of 5 seconds. Closing S1 energizes TR1, causing its associated normally open TR1 contacts to close immediately and illuminate PL1.

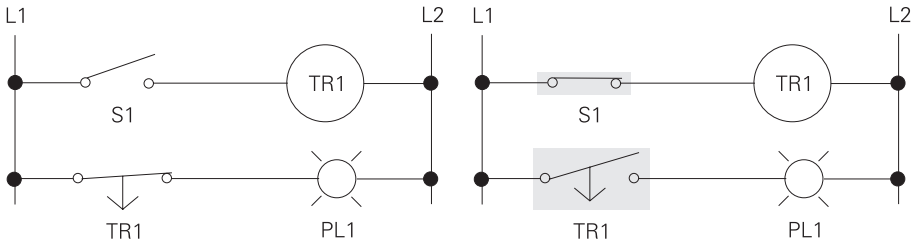


When S1 is opened, TR1 begins timing. When 5 seconds has elapsed, TR1 will open its associated normally open contacts, extinguishing indicator light PL1.

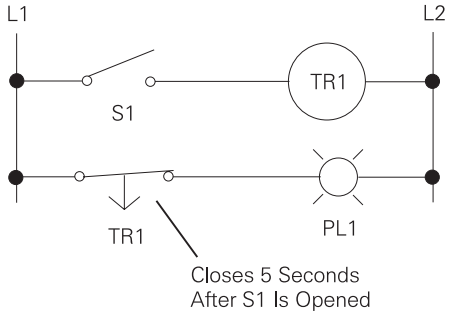


Off-Delay, Timed Closed

The following is an example of **Off-delay, timed closed**, using a set of normally closed (NC) contacts. This configuration is also referred to as **normally closed, timed closed (NCTC)**. The timing relay (TR1) has been set for 5 seconds. PL1 is on. Closing S1 energizes TR1, causing its associated contacts to open immediately and extinguishing PL1.

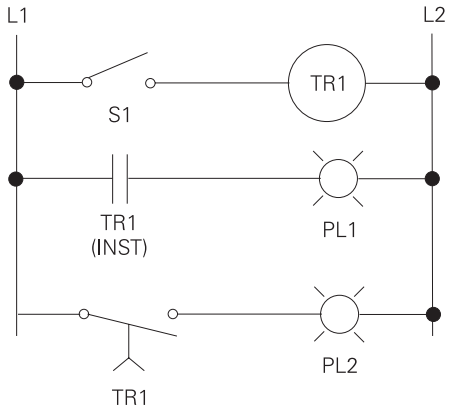


When S1 is opened, timing relay TR1 is de-energized. After 5 seconds, the associated normally closed contacts close, illuminating PL1.



Instantaneous Contacts

Timing relays can also have normally open or normally closed **instantaneous contacts**. In the following example, when switch S1 is closed, the TR1 instantaneous contacts will close immediately, illuminating PL1. After a preset time delay the TR1 timing contacts will close, illuminating PL2.



Terminal Blocks and Supplementary Protectors

Terminal Blocks

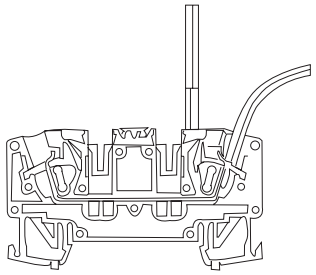
Siemens offers a broad range of spring-loaded and screw-type **terminal blocks** for space-saving connections. Examples of the types of terminal blocks are listed below.

8WA1 Terminals With Screw Connections

- Through-type terminals
- N isolating and branch terminals
- Ground and ground-neutral terminals
- Two-tier terminals
- Two-tier terminals with solid-state components
- Insta or three-tier terminals
- Flat-type and bolt-type terminals
- Fuse terminals
- Terminal for components
- Diode and isolating terminals
- Fuse terminals
- Sliding-link terminals
- Through-type plug connection
- Measuring transformer terminals
- Circuit breaker terminals for auxiliary circuits

8WA2 Spring-Loaded Terminals

- Through-type terminals
- Two-tier terminals
- Insta or three-tier terminals
- N isolating terminals
- Ground terminals
- Fuse terminals
- Terminal for components
- Diode terminals
- Sliding-link terminals

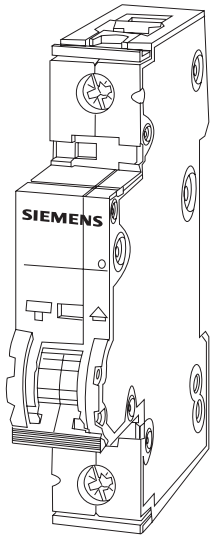


8WA2 Through-Type Terminal

Supplementary Protectors

Siemens UL1077 **supplementary protectors** are designed to trip faster than standard UL489 circuit breakers providing additional protection for more sensitive devices. In addition to providing supplementary branch circuit protection, supplementary protectors may also be used as a local disconnect means inside a panel when a branch circuit protection device is already present.

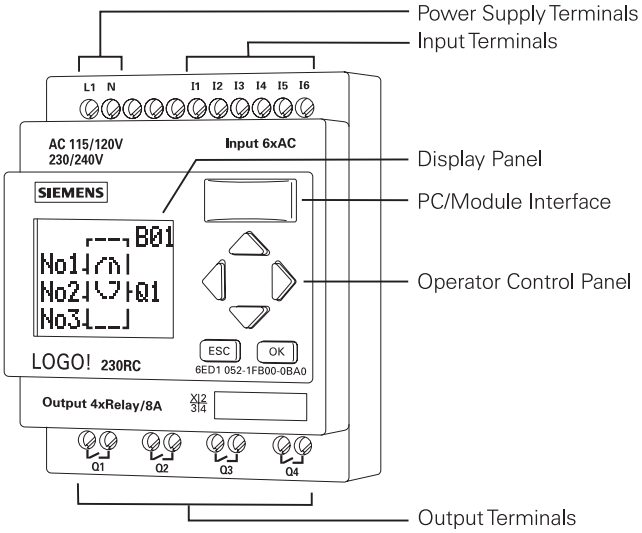
Siemens supplementary protectors are equipped with a thermal bimetal trip mechanism for low-current overloads and an instantaneous electromagnetic trip for high-current overloads and short circuits. Devices are available for single-pole and multiple-pole varieties with mounting depths of 55mm or 70 mm.



5SY4 Supplementary Protector (70 mm)

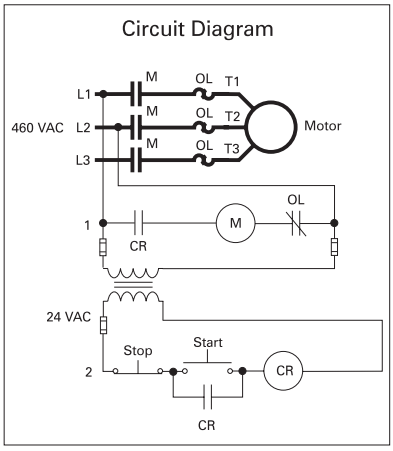
LOGO! Logic Module

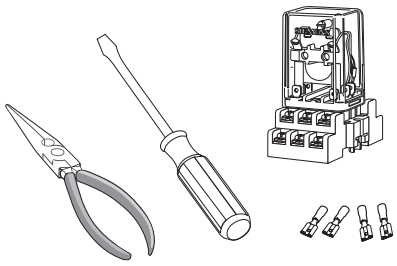
LOGO! is a logic module used to perform control tasks. The module is compact and user friendly, providing a cost-effective solution for the end user.



Hard-Wired Control

In the past, many of these control tasks were solved with contactor or relay controls. This is often referred to as **hard-wired control**. Circuit diagrams had to be designed and electrical components specified and installed. A change in control function or system expansion could require extensive component changes and rewiring.





Many of the same tasks can be performed with LOGO!. Initial hard-wiring, although still required, is greatly simplified. Modifying the application is as easy as changing the program via the keypad located on the front of the LOGO!. Likewise, control programs can be created and tested before implementation via a PC software program. Once the program is performing per specification, the transfer to LOGO! is as simple as plugging in a cable.

Basic LOGO! Operation

LOGO! accepts a variety of digital inputs, such as pushbuttons, switches, and contacts. LOGO! makes decisions and executes control instructions based on the user-defined program. The instructions control various outputs connected to virtually any type of load such as relays, contactors, lights, and small motors.

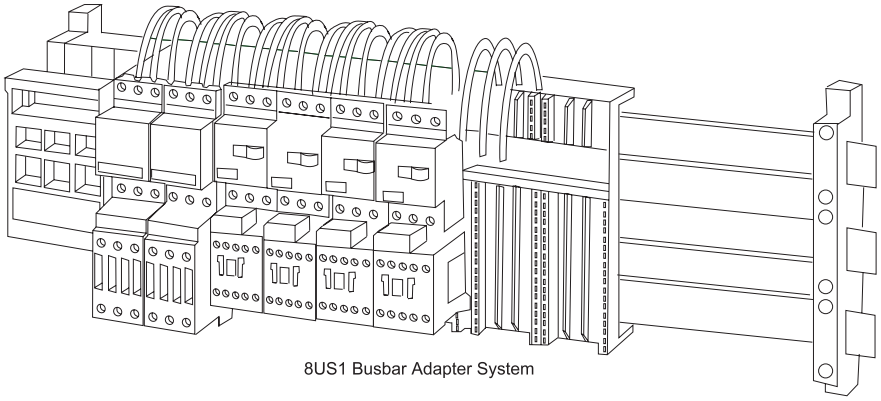
Design Features

Multiple versions of LOGO! are available for different supply voltages (12 VDC, 24 VDC, 24 VAC, or 115/230 VAC). Units are equipped with 8 digital inputs and 4 relay or solid-state outputs. Units are available with or without the display panel and keyboard. Expansion modules are available to increase the number of discrete inputs and outputs and to add analog inputs or outputs. A communication module for connection to the AS-Interface is also available.

Fastbus Busbar Adapter System

The **Fastbus** Multi-Motor Control system is a 3-phase, insulated busbar system used to reduce wire connections and hole drilling when building control panels. SIRIUS 3RV/3RT starter combinations build from components, and Siemens circuit breakers use Fastbus for convenient mounting.

Fastbus is not new to Siemens, but due to the narrower dimensions of SIRIUS components, more starters will fit on the same run of Fastbus. Components are available for busbar centerline spacings of 40 mm or 60 mm.

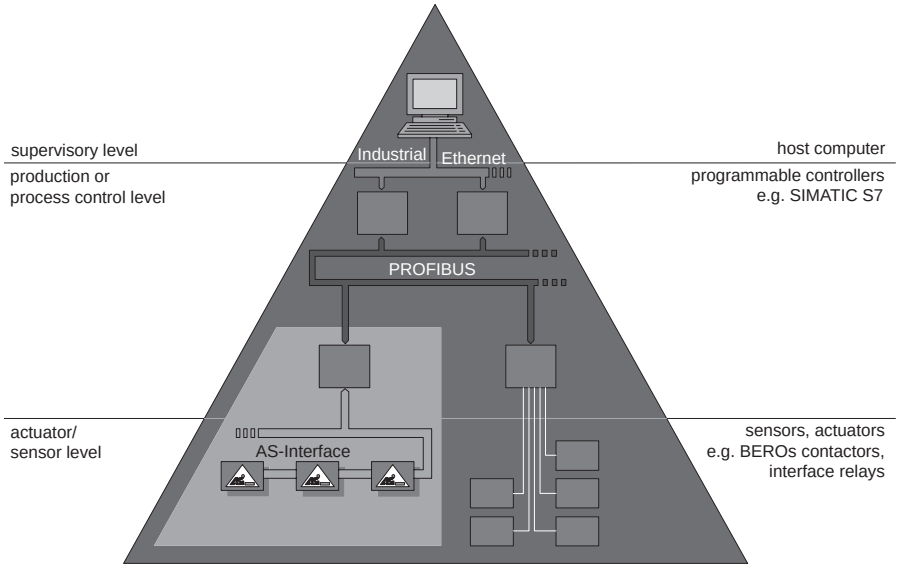


8US1 Busbar Adapter System

All This and More

In this course, you have learned about an extensive range of products, and you might be tempted to think that we have covered everything you need to know about Siemens control components and systems. However, Siemens offers many more components and systems than we can adequately describe in this course.

For example, Siemens sensors, variable speed drives, integrated safety products, and automation systems represent additional categories for further exploration. In addition, many of these products and systems are capable of communicating using a comprehensive networking structure that forms the backbone of Siemens Totally Integrated Automation capability.



Review 8

1. _____ is the total number of different circuits each pole controls.

2. _____ describes the number of isolated circuits that can pass through a relay at one time.

3. An SPDT relay has _____ pole(s) and _____ _____ closed contact position(s).

4. A timing relay that receives a signal to turn on, and then delays a predetermined amount of time before performing this action, is referred to as _____ delay.

5. _____ _____ relays and contactors eliminate the mechanical wear and noise characteristics of conventional electromechanical switching devices.

6. _____ _____ can monitor electrical and mechanical quantities and fault conditions, and provide appropriate diagnostic indications.

7. Siemens terminal blocks are available with either _____ connections or _____ _____ terminals.

8. Siemens UL1077 _____ _____ are designed to trip faster than standard UL489 circuit breakers, providing additional protection for more sensitive devices.

Review Answers

Review 1	(1) manually; (2) a; (3) b; (4) b; (5) c
Review 2	(1) left to right; (2) A - Node, B - Power Circuit, C - Power Load, D- Control Circuit; E - Control Device; F - Control Load
Review 3	(1) a; (2) overcurrent; (3) overload; (4) a; (5) bimetal; (6) reset; (7-1) heater elements; (7-2) phase loss; (7-3) insensitive
Review 4	(1) two; (2) low voltage protection (LVP); (3) 15; (4) 20; (5) motor starter; (6) combination starter
Review 5	(1) NEMA, IEC; (2) 5; (3) AC3; (4) 4, 3½; (5) three; (6) S00, S6; (7) 140ºF (60ºC)
Review 6	(1) consequent-pole motor; (2) progressive control; (3) reduced-voltage starting; (4-1) inrush current; (4-2) starting torque; (4-3) stress on mechanical linkage; (4) Autotransformer
Review 7	(1) power supply cycle; (2-1) current limit; (2-2) starting voltage; (2-3) starting and stopping times of the voltage ramp; (3) electrically held; (4) b; (5) magnetically held, mechanically latched; (6) Pilot device; (7-top) Three-Wire Control; (7-bottom) Two-Wire Control; (8) visual; (9) red, green
Review 8	(1) Throw; (2) Pole; (3) one, two; (4) ON; (5) Solid-State; (6) Monitoring Relays; (7) screw, spring-loaded; (8) Supplementary Protectors

Final Exam

The final exam is intended to be a learning tool. The book may be used during the exam. A tear-out answer sheet is provided. After completing the test, mail in the answer sheet for grading. A grade of 70% or better is passing. Upon successful completion of the test a certificate will be issued.

Questions

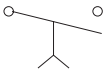
1. The standard method of showing a contact is by indicating the circuit condition it produces when the actuating device is in the _____ state.

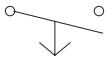
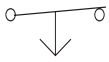
   a. normally closed b. normally open
   c. energized d. de-energized

2. A motor that is running would usually be indicated by a _____ indicator light.

   a. green b. red
   c. amber d. white

3. Which of the following symbols represents a normally closed, timed open (NCTO) contact?

   a.  b. 

   c.  d. 

4. With an increase of current, temperature will _____ .

   a. decrease b. increase
   c. remain the same d. fluctuate

5. The two circuits involved in the operation of a contactor are the _____ circuits.

   a. power and control
   b. power and armature
   c. control and electromagnetic
   d. control and starter

6. A motor starter is a combination of a/an _____.

a. electromagnet and armature
b. contactor and electromagnet
c. contactor and overload relay
d. overload relay and instantaneous contacts

7. Which of the following is not part of a contactor?

a. armature
b. electromagnetic coil
c. overcurrent sensing device
d. stationary contacts

8. One reason reduced-voltage starting may be used to start a motor is to _____ .

a. apply torque gradually
b. increase starting torque
c. get the motor to full speed faster
d. run the motor at a lower speed

9. A type of speed selection control that requires the operator to manually increment through each speed step to get to the desired speed is _____ control.

a. selective b. compelling
c. progressive d. consequent pole

10. The organization primarily concerned with the rating of contactors and starters used in many countries, including the U.S., is _____ .

a. NEMA b. UL
c. ICS d. IEC

11. _____ is a flexible, modular motor management system that provides multifunctional, solid-state protection for constant-speed motors.

a. SINAMICS b. LOGO!
c. MICROMASTER d. SIMOCODE Pro

12. A device used to provide visual information of the circuit's operating condition is a _____ .

a. pushbutton
b. selector switch
c. proximity switch
d. pilot or indicator light

13. A relay that has two isolated circuits and one closed contact position per pole is a _____ .

a. DPST
b. DPDT
c. SPST
d. SPDT

14. Which type of lighting and heating contactor is likely to produce a humming sound during normal operation, and is not recommended for a quiet area?

a. electrically-held
b. magnetically-held
c. mechanically-latched
d. both b and c

15. A NEMA Size 6 starter has a continuous amp rating of _____ amps.

a. 200
b. 540
c. 810
d. 1600

16. Siemens 8WD42 and 8WD44 signaling columns can be networked to other devices through an optional _____ adapter.

a. PROFIBUS
b. Ethernet
c. AS-Interface
d. proprietary network

17. Siemens Class 14 ESP100 starters are available with contactor ratings up to and including NEMA size ___ .

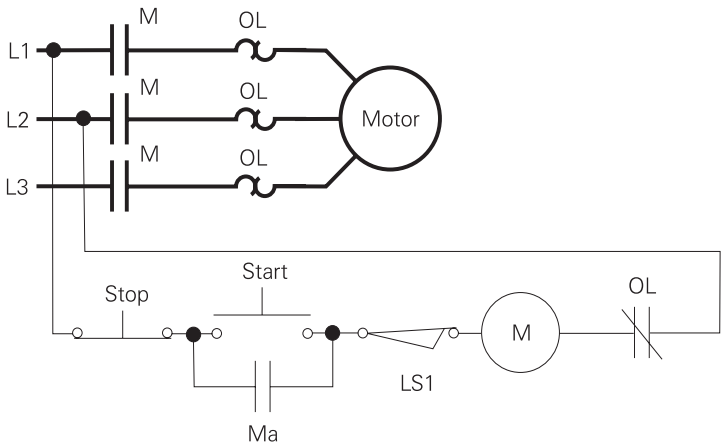
a. 4
b. 6
c. 8
d. 10

18. Another name for a solid-state reduced voltage starter is a(an) _____ starter.

a. soft
b. primary resistance
c. Wye-Delta
d. autotransformer

19. In the following diagram, the motor will stop when _____ .

a. the “Stop” button is depressed
b. limit switch “LS1” opens
c. the motor overload contact opens
d. all of the above



20. _____ solid-state contactors are made up of a solid-state relay and an optimized heat sink.

a. SIRIUS 3UG
b. SIRIUS 3RH11
c. SIRIUS SC
d. SIRIUS 3RW40

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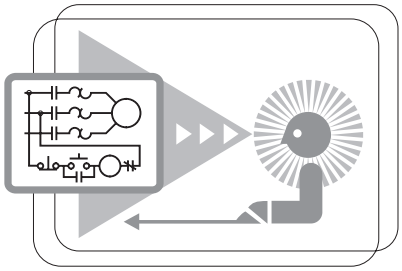

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