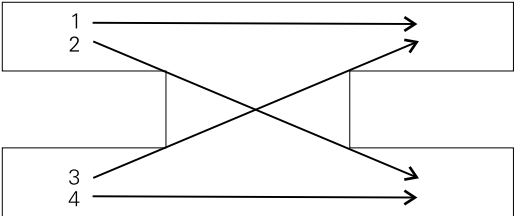


# Pilot Devices

A pilot device directs the operation of another device (pushbuttons and selector switches) or indicates the status of the operating system (pilot lights). This section discusses Siemens 3SB and Furnas Class 51/52 pushbuttons, selector switches, and pilot lights. 3SB devices are available in 22 mm diameters. Class 51/52 pilot devices are available in 30 mm diameter. The diameter refers to the size of the knockout hole required to mount the devices. Class 51 devices are rated for hazardous locations environments such as Class I, Groups C and D and Class II, Groups E, F, and G. Class 52 devices are heavy duty for harsh, industrial environments.

## Bifurcated Contacts

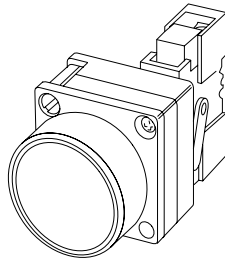
Whether one chooses the 3SB or the Class 51/52 pilot devices, the fine silver contacts have a 10 A/600 V continuous-current rating and can be used on solid state equipment. The 3SB and the Class 51/52 devices use bifurcated movable contacts. The design of the bifurcated contacts provides four different pathways for current to flow, thus improving contact reliability.



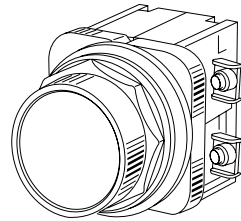
Bifurcated Contact  
Four Paths of Current Flow

## Pushbuttons

A pushbutton is a control device used to manually open and close a set of contacts. Pushbuttons are available in a flush mount, extended mount, with a mushroom head, illuminated or nonilluminated. Pushbuttons come with either normally open, normally closed, or combination contact blocks. The Siemens 22 mm pushbuttons can handle up to a maximum of 6 circuits. The Furnas 30 mm pushbutton can handle up to a maximum of 16 circuits.



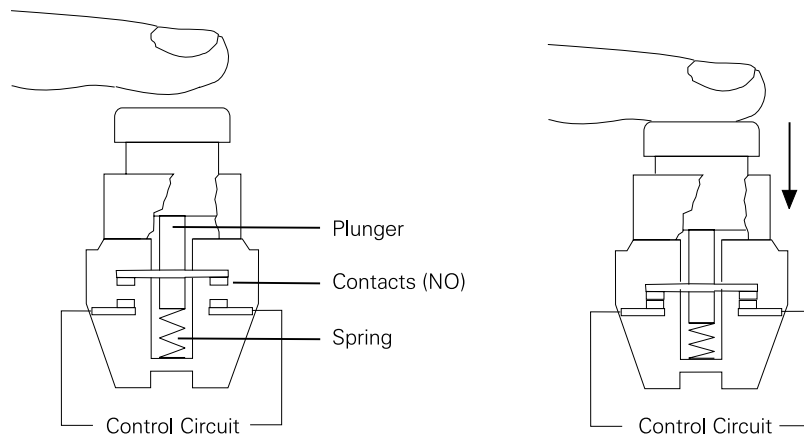
**Siemens  
22 mm Diameter  
Pushbutton**



**Furnas  
30 mm Class 52  
Pushbutton**

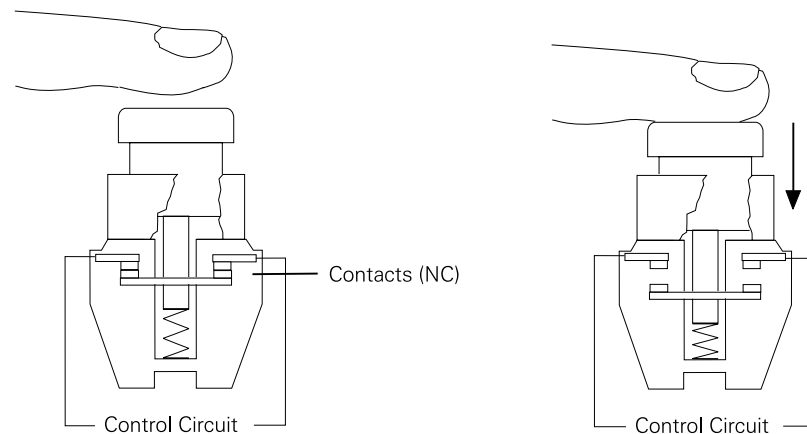
## Normally Open Pushbuttons

Pushbuttons are used in control circuits to perform various functions. For example, pushbuttons can be used when starting and stopping a motor. A typical pushbutton uses an operating plunger, a return spring, and one set of contacts. The following drawing illustrates a normally open (NO) pushbutton. Normally the contacts are open and no current flows through them. Depressing the button causes the contacts to close. When the button is released, the spring returns the plunger to the open position.



## Normally Closed Pushbuttons

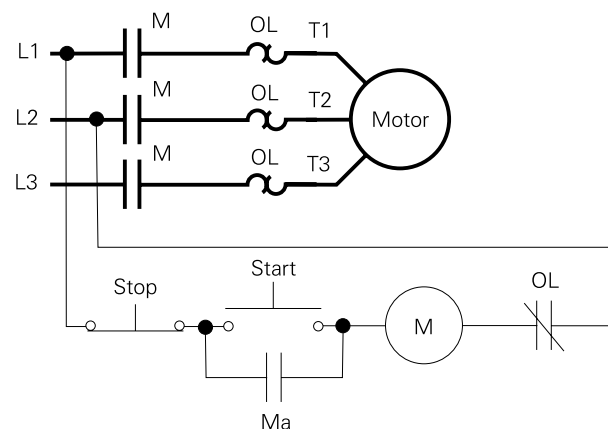
Normally closed (NC) pushbuttons, such as the one shown below, are also used to open and close a circuit. In the pushbutton's normal position the contacts are closed to allow current flow through the control circuit. Depressing the button opens the contacts preventing current flow through the circuit. These types of pushbuttons are momentary contact pushbuttons because the contacts remain in their activated position only as long as the plunger is held depressed.



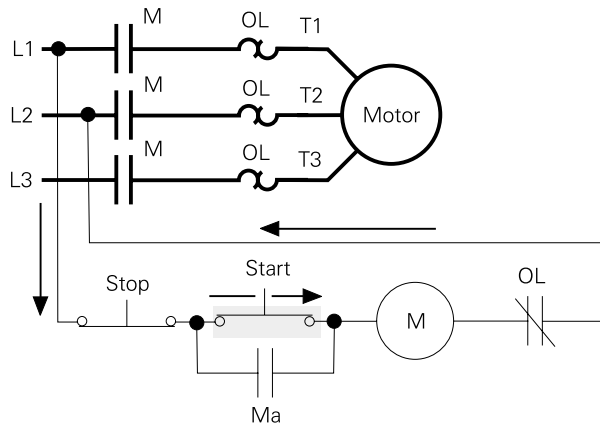
Pushbuttons are available with variations of the contact configuration. For example, a pushbutton may have one set of normally open and one set of normally closed contacts so that when the button is depressed, one set of contacts is open and the other set is closed. By connecting to the proper set of contacts, either a normally open or normally closed situation exists.

## Using Pushbuttons in a Control Circuit

The following line diagram shows an example of how a normally open and a normally closed pushbutton might be used in a control circuit.

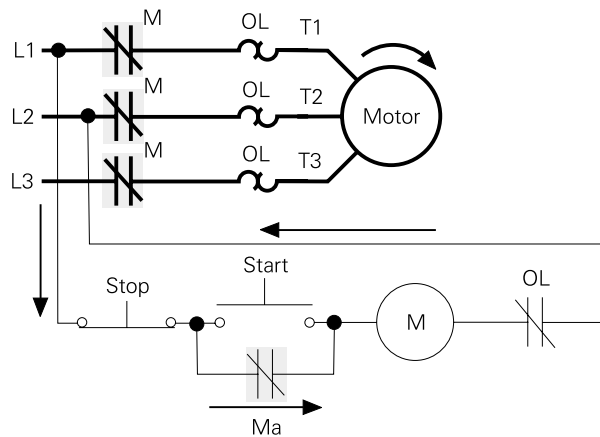


Momentarily depressing the "Start" pushbutton completes the path of current flow and energizes the "M" contactor's electromagnetic coil.



### Holding Circuit Three-Wire Control

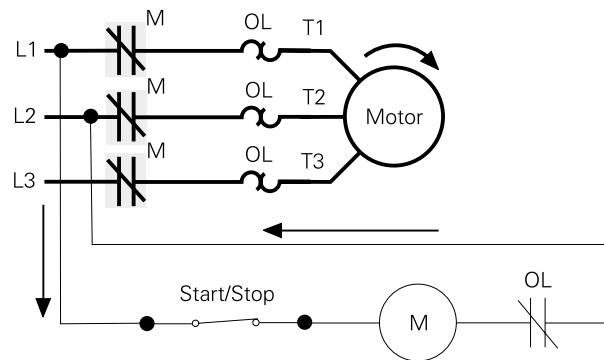
This closes the associated normally open "M" and "Ma" contacts. When the "Start" pushbutton is released a holding circuit exists to the "M" electromagnetic coil through the auxiliary contacts "Ma". The motor will run until the normally closed "Stop" pushbutton is depressed, breaking the path of current flow to the "M" electromagnetic coil and opening the associated "M" and "Ma" contacts. This is referred to as three-wire control because there are three wires or three connection points required to connect the "Start" and "Stop" pushbuttons and the holding circuit ("Ma"). An advantage to three-wire control is low-voltage protection. If an overload causes the "OL" contacts in the control circuit to open, the "M" coil is deenergized and the motor shut down. When the overload is cleared, the motor will not suddenly restart on its own. An operator must depress the "Start" button to restart the motor.



## Two-Wire Control

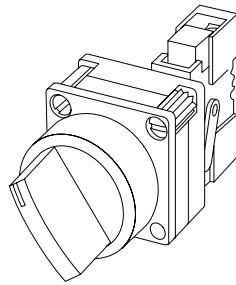
In comparison, a two-wire control has only two connection points for the "Start/Stop" circuit. When the contacts of the control device close, they complete the coil circuit of the contactor, causing it to be energized and connect the load to the line through the power contacts. When the contacts of the control device open, the power is removed from the motor and it stops.

A two-wire control circuit provides low-voltage release but not low-voltage protection. This means that in the event of a power loss the contactor will deenergize, stopping the motor. This is low-voltage release. However, when power is restored, the motor will restart without warning if the control device is still closed. This type of control scheme is used for remote or inaccessible installations such as water-treatment plants or pumping stations. In these applications it is desirable to have an immediate return to service when power is restored.

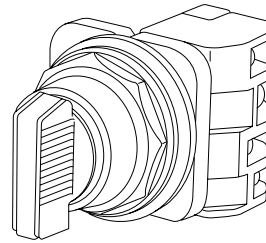


## Selector Switches

Selector switches are also used to manually open and close contacts. Selector switches can be maintained, spring return or key operated. Selector switches are available in two-, three-, and four-position types. The basic difference between a push button and a selector switch is the operator mechanism. With a selector switch the operator is rotated to open and close contacts. Contact blocks used on pushbuttons are interchangeable with those used on selector switches. Selector switches are used to select one of several circuit possibilities such as manual or automatic operation, low or high speed, up or down, right or left, and stop or run. The Siemens 22 mm selector switches can handle up to a maximum of 6 circuits. The Furnas 30 mm selector switch can handle up to a maximum of 16 circuits.



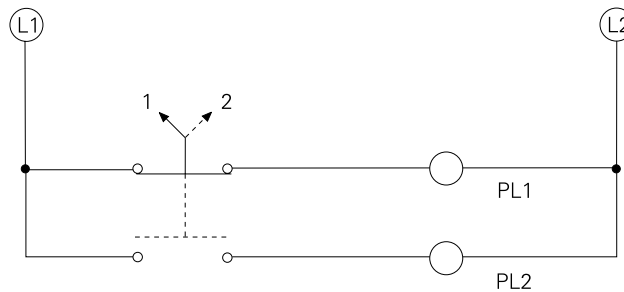
**Siemens  
22 mm Diameter  
Selector Switch**



**Furnas  
30 mm Class 52  
Selector Switch**

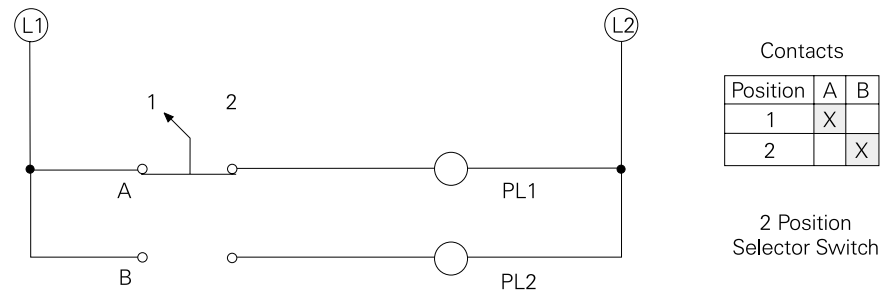
## Two Position Selector Switch

In the following example PL1 is connected to the power source when the switch is in position 1. PL2 is connected to the power source when the switch is in position 2. In this circuit either PL1 or PL2 would be on at all times. If there were only one load, then the selector switch could be used as an On/Off switch.



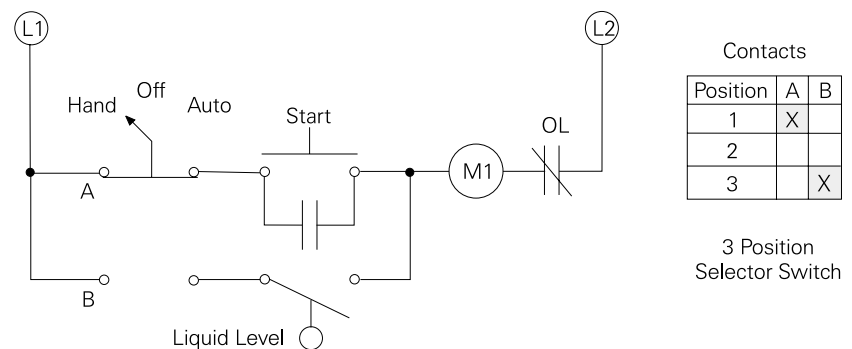
## Contact Truth Tables

There are two accepted methods of indicating contact position of a selector switch in a circuit. The first method uses solid and dashed lines to denote contact position as shown in the previous example. In the second method truth tables, also known as target tables, are used. Each contact is marked with a letter. An "X" in the truth table indicates which contacts are closed for a given switch position. In this example contact A is closed, connecting PL1 to the power source, when the switch is in position 1. Contact B is closed, connecting PL2 to the power source, when the switch is in position 2.



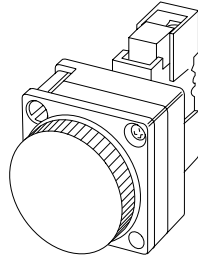
## Three-Position

A three-position selector switch can be used to select either of two sets of contacts or to disconnect both sets of contacts. Hand/Off/Auto is a typical application for a three-position selector switch used for controlling a pump. In the Hand (manual) position the pump will start when the Start pushbutton is pressed. The pump can be stopped by switching the stop button. When the selector switch is set to Auto, the pump will be controlled by the liquid-level switch. At a predetermined level the liquid level switch closes, starting the pump. At a predetermined level the liquid level switch opens, stopping the pump.

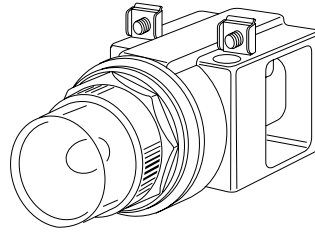


## Pilot Lights

Pilot lights provide visual information at a glance of the circuit's operating condition. Pilot lights are normally used for "ON/OFF" indication, caution, changing conditions, and alarm signaling.

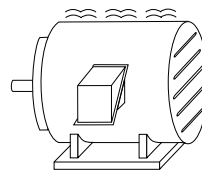
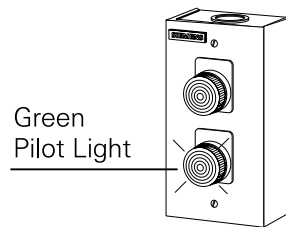
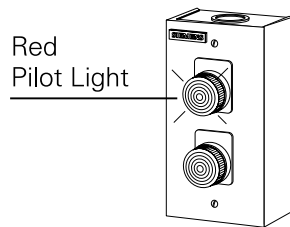


**Siemens  
22 mm Diameter  
Pilot Light**

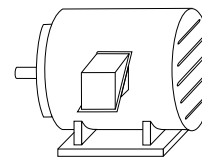


**Furnas  
30 mm Class 52  
Pilot Light**

Pilot lights come with a color lens, such as red, green, amber, blue, white, or clear. A red pilot light normally indicates that a system is running. A green pilot light normally indicates that the system is off or deenergized. For example, a red pilot light located on a control panel would give visual indication that a motor was running. A green pilot light would give visual indication that a motor was stopped.



**Motor  
Running**

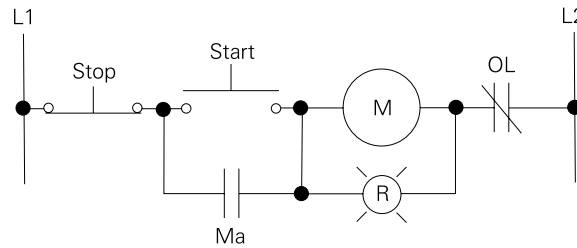


**Motor  
Stopped**

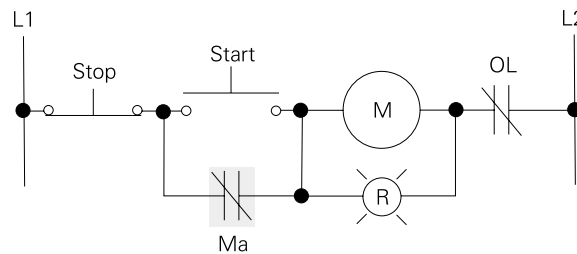


## Using a Pilot Light in a Control Circuit

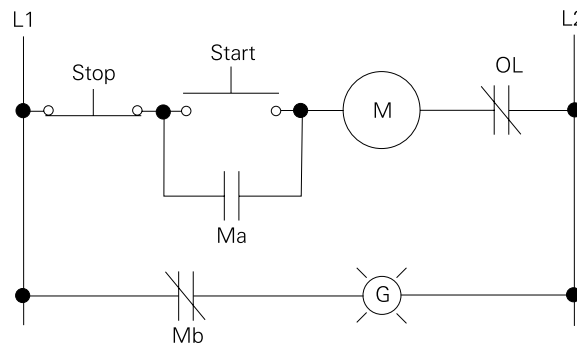
In the following line diagram, a red pilot light is connected in parallel with the "M" electromagnetic coil.



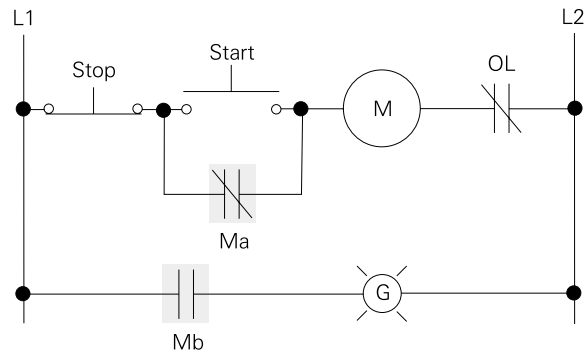
When the coil is energized, the light will illuminate to indicate the motor is running. In the event the pilot light burns out the motor will continue to run.



In the following line diagram a green pilot light is connected through a normally closed "M" auxiliary contact (Mb). When the coil is deenergized, the pilot light is on to indicate the motor is not running.

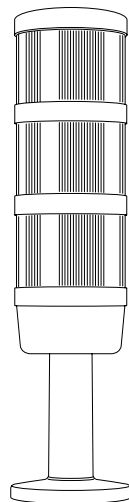


Depressing the "Start" pushbutton and energizing the "M" contactor opens the normally closed "Mb" contacts, turning the light off.

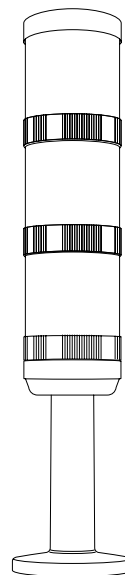


## Signalling Columns

Signalling columns can be mounted locally on individual machines, making it possible for the operating personnel to monitor production stations from a distance. Individual modules, or elements, are connected together. Various visual elements are available, including strobe lights, steady or flashing lights, and incandescent or LED lights. Lenses for the light elements are available in red, yellow, green, blue, and clear. Audible elements for the 8WD43 include a siren and a buzzer. Audible elements for the 8WD42 include a buzzer. In addition, a communication element is available allowing the signalling column to communicate with PLCs or computers through the Actuator Sensor Interface (ASI) network. Up to 10 elements can be used on a signalling column.



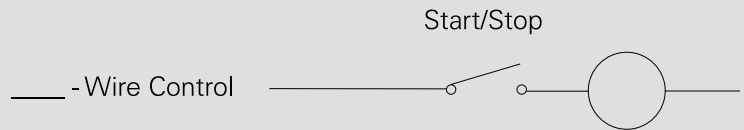
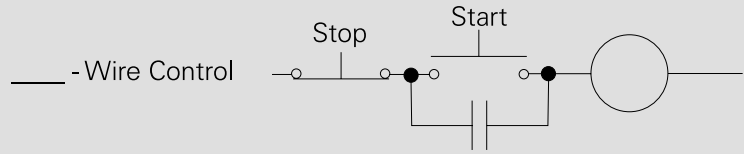
**8WD43 (70 mm)**



**8WD42 (50 mm)**

## Review 7

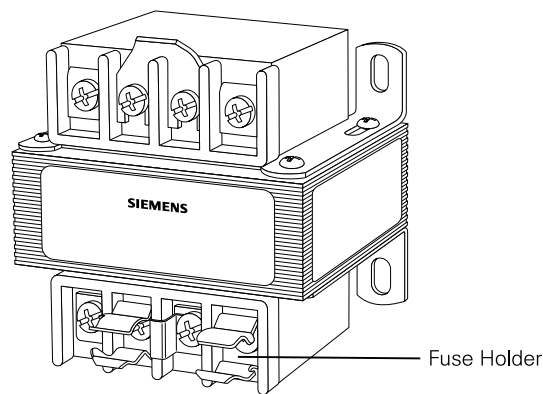
1. A \_\_\_\_\_ \_\_\_\_\_ directs the operation of another device.
2. Which of the following circuits represents a two-wire control and which represents a three-wire control?



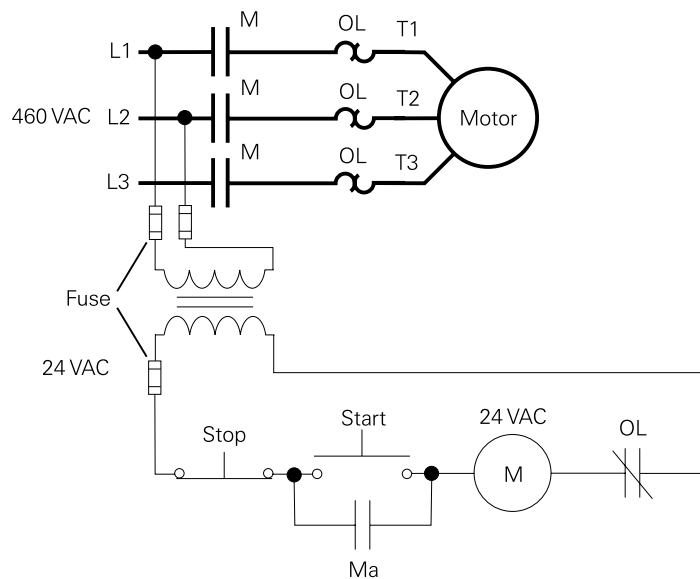
3. Pilot lights provide \_\_\_\_\_ information of the circuit's operating condition.
4. A \_\_\_\_\_ pilot light normally indicates a motor is running and a \_\_\_\_\_ pilot light normally indicates a motor is stopped.

# 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 control transformers are available in various primary and secondary voltages from 50 to 5000 VA.

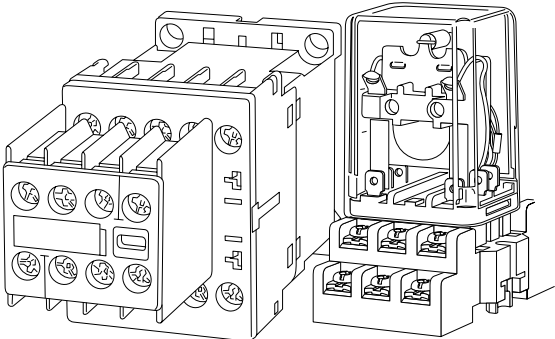


In the following example, the power circuit is 460 VAC. A control transformer is used to step the voltage down to 24 VAC for use in the control circuit. The electromagnetic coil voltage must be rated for 24 VAC. Fuses on the primary and secondary windings of the transformer provide overcurrent protection.



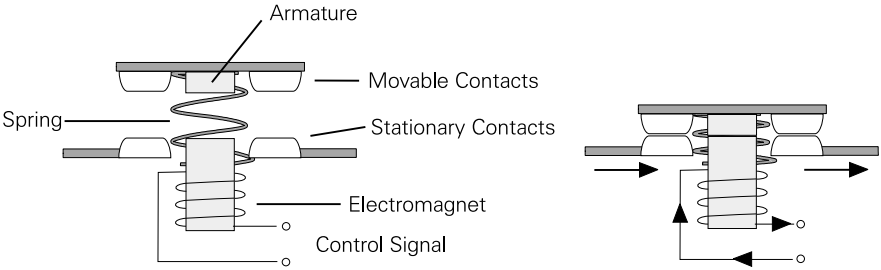
# Control Relays

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



## Relay Operation

The operation of a control relay is similar to a contactor. In the following example 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 resultant 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.

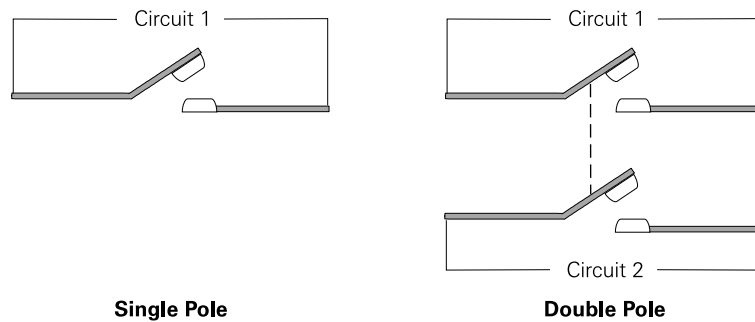


## Contact Arrangement

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 words which must be understood when dealing with relays.

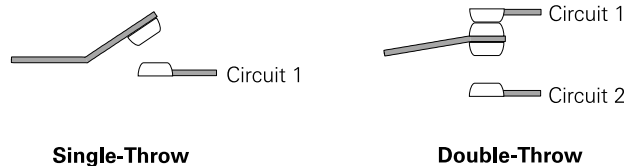
## Pole

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. 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.



## Throw

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

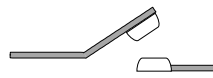


The following abbreviations are frequently used to indicate contact configurations:

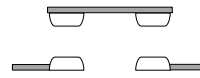
- SPST Single-Pole, Single-Throw
- SPDT Single-Pole, Double-Throw
- DPST Double-Pole, Single-Throw
- DPDT Double-Pole, Double-Throw

## 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.

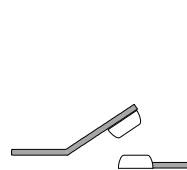


**Single-Break**

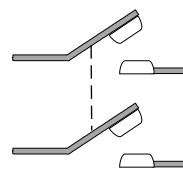


**Double-Break**

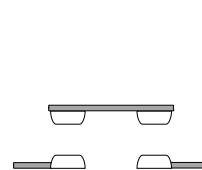
The following illustrates various contact arrangements.



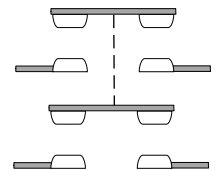
Single-Pole  
Single-Throw  
Single-Break



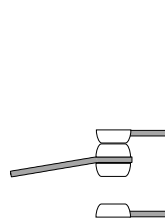
Double-Pole  
Single-Throw  
Single-Break



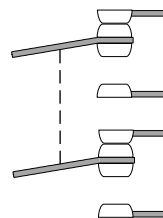
Single-Pole  
Single-Throw  
Double-Break



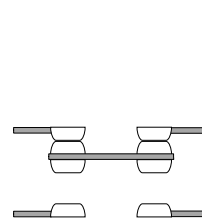
Double-Pole  
Single-Throw  
Double-Break



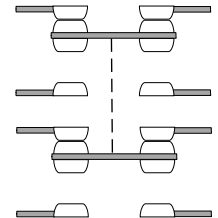
Single-Pole  
Double-Throw  
Single-Break



Double-Pole  
Double-Throw  
Single-Break



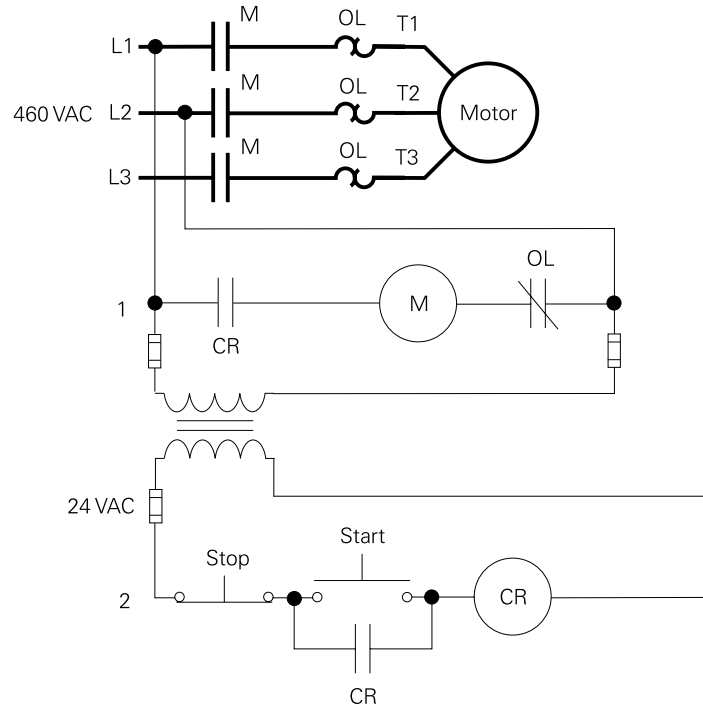
Single-Pole  
Double-Throw  
Double-Break



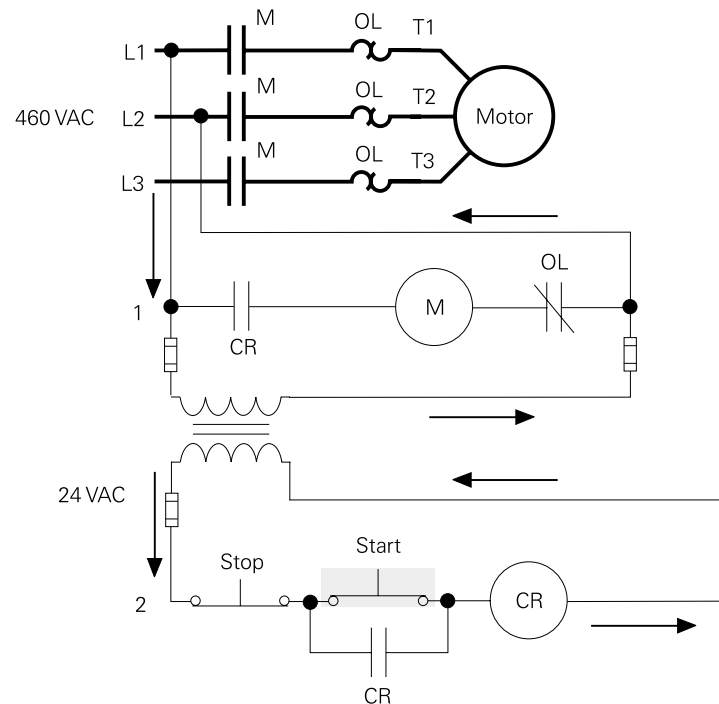
Double-Pole  
Double-Throw  
Double-Break

## Interposing a Relay

The following line diagram illustrates one way a control relay might be used in a circuit. 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.

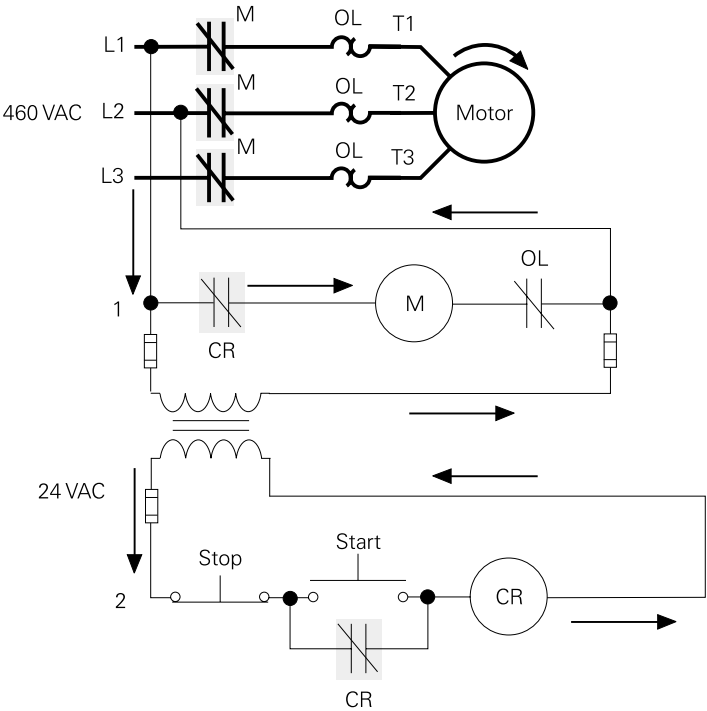


When the "Start" pushbutton in line 2 is momentarily depressed, power is supplied to the control relay (CR).



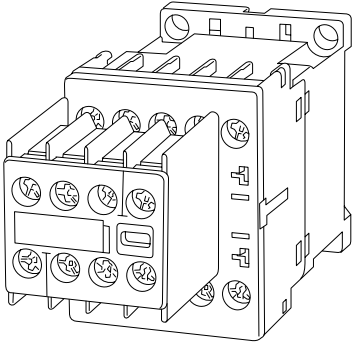


The "CR" contacts in lines 1 and 2 close. The "CR" contacts in line 2 maintain the start circuit. The "CR" contacts in line 1 complete the path of current to the "M" motor starter. The "M" motor starter energizes and closes the "M" contacts in the power circuit, starting the motor. Depressing the "Stop" pushbutton deenergizes the "CR" relay and "M" motor starter.



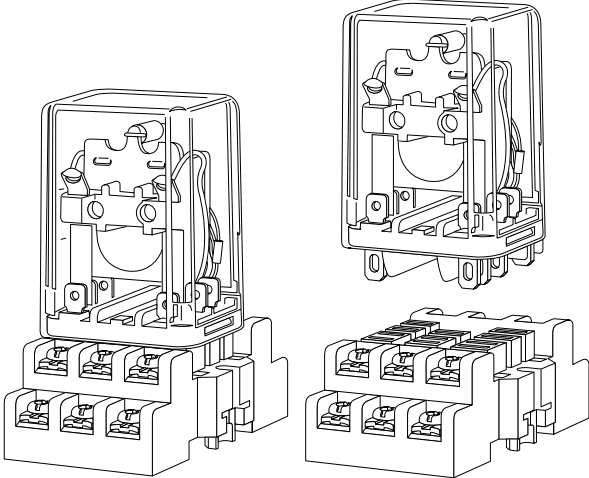
**SIRIUS 3RH11  
Control Relays**

Siemens has a complete line of industrial-control relays. SIRIUS 3RH11 relays are available with screw terminal or Cage Clamp. The screw terminal version is shown in the following illustration. Four contacts are available in the basic device. Four additional contacts in the form of a snap-on device can be added to the front of the relay. Some SIRIUS 3RH11 relays are specifically designed to interface directly with PLCs and other solid-state control devices. SIRIUS 3RH11 relays are rated for switching both AC and DC circuits. Coil voltages range from 12 VDC to 230 VDC and 24 VAC to 600 VAC.



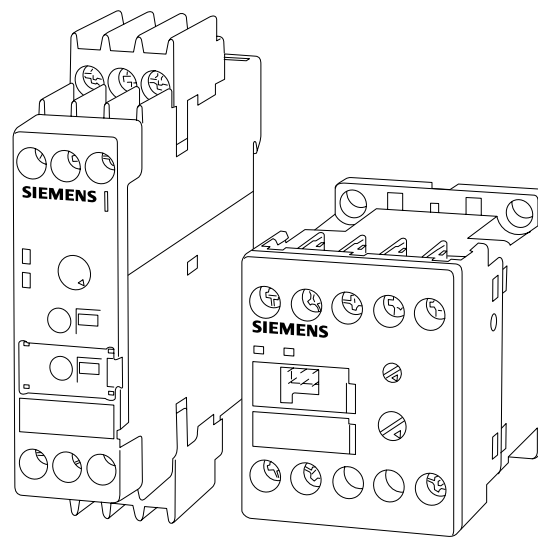
**General-Purpose Relays  
(Plug-In Relays)**

Siemens also manufactures a variety of general-purpose relays for socket and flange mounting. Coil voltages are available in 24 VAC, 120 VAC or 24 VDC. The biggest benefit of this type of relay is all the wiring stays in place with the socket if the relay needs to be replaced with a new one.



# Timing Relays

Timing relays, such as the SIRIUS 3RP timing relays, are used in control switching operations involving time delay. SIRIUS 3RP1 timing relays have timing ranges available from .05 seconds to 10 hours. SIRIUS 3RP15 have timing ranges from .05 seconds to 100 hours.

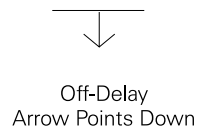
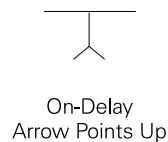


**3RP15**

**3RP1**

## Time Delay

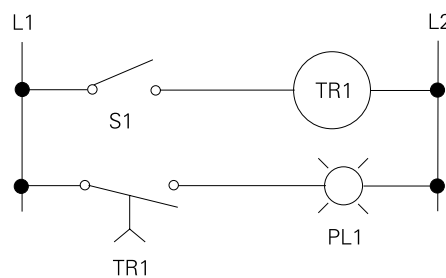
A timing relay has two major functions: On-delay and Off-delay timing. An arrow is used to denote the function of the timer. An arrow pointing up indicates an On-delay timing action. An arrow pointing down indicates an Off-delay timing action.



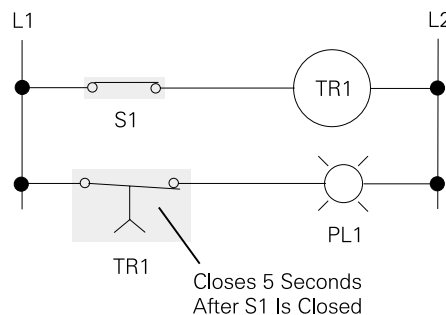
On-delay and Off-delay timers can turn their connected loads on or off, depending on how the timer's output is wired into the circuit. On-delay indicates that once a timer has received a signal to turn on, a predetermined time (set by the timer) must pass before the timer's contacts change state. Off-delay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

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

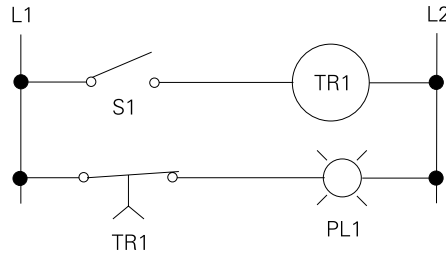


When S1 is closed, TR1 begins timing. When 5 seconds has elapsed, TR1 will close its associated normally open (NO) TR1 contacts, illuminating pilot light PL1. When S1 is open, deenergizing TR1, the TR1 contacts open immediately, extinguishing PL1.

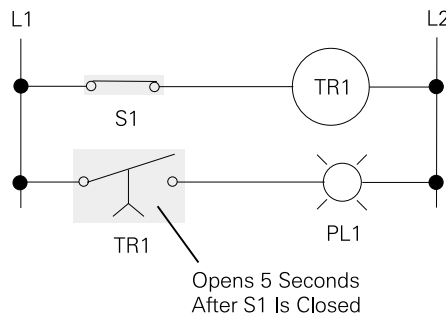


## On-Delay, Timed Open

The following is an example of On-delay, timed open. For this example a set of normally closed (NC) contacts is used. This 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.

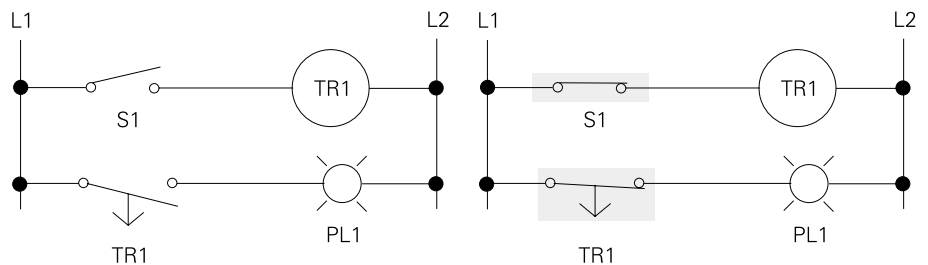


When S1 is closed, timing relay TR1 is energized. After a timed delay of 5 seconds, the associated normally closed TR1 contacts open, extinguishing PL1. When S1 is open, deenergizing TR1, the TR1 contacts close immediately, illuminating PL1.

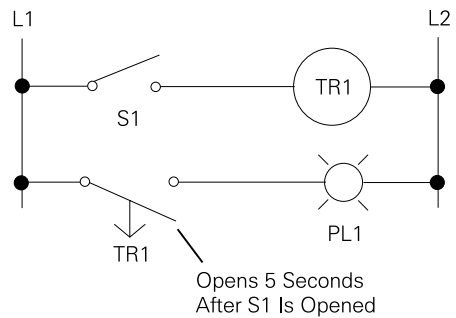


## Off-Delay, Timed Open

The following is an example of Off-delay, timed open. For this example a set of normally open contacts (NO) is used. This 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, illuminating PL1.

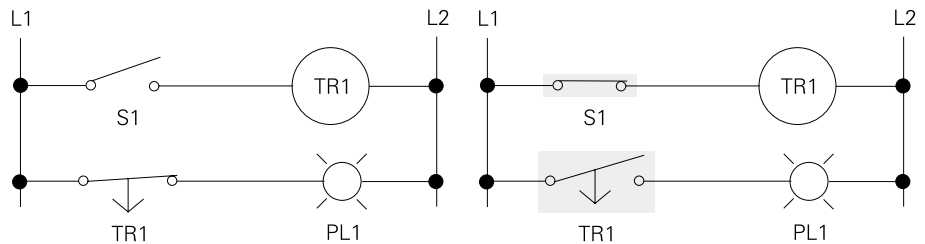


When S1 is opened, TR1 begins timing. When 5 seconds has elapsed, TR1 will open its associated normally open contacts, extinguishing pilot light PL1.

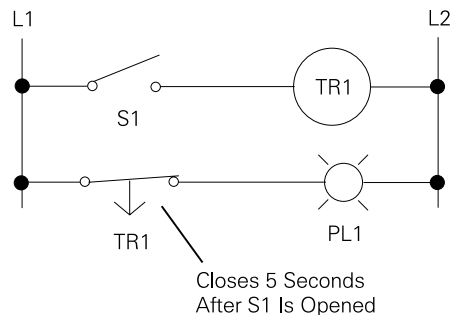


### Off-Delay, Timed Closed

The following is an example of Off-delay, timed closed. For this example a set of normally closed (NC) contacts is used. This 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, extinguishing PL1.

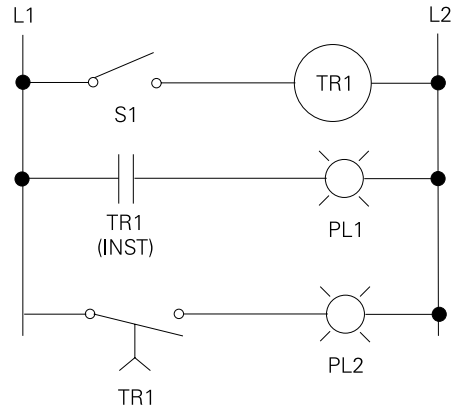


When S1 is opened, timing relay TR1 is deenergized. After 5 seconds, the associated normally closed contacts close, illuminating PL1.



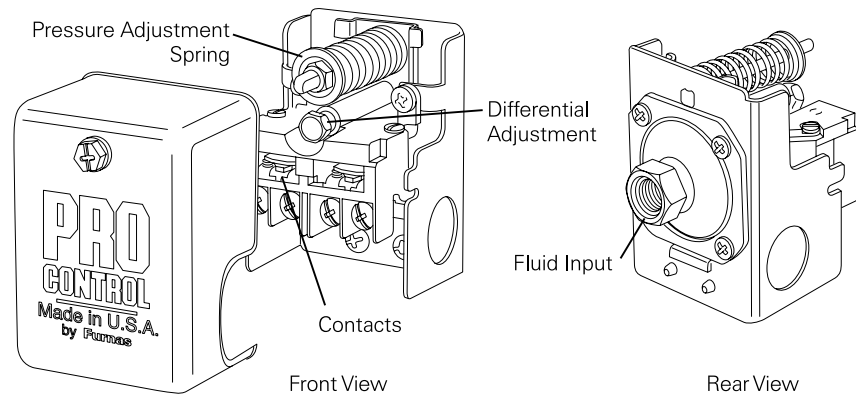
## Instantaneous Contacts

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.



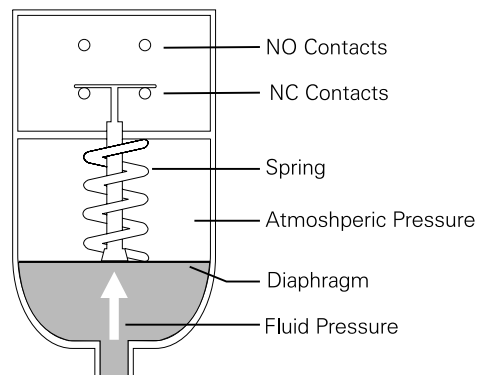
# Pressure Switches

Pressure switches are control devices that respond to changes in pressure of liquid or air. The liquid or air is referred to as fluid pressure. They open or close electrical contacts in response to pressure changes by either turning on or off a motor, opening or closing louvers, or signaling a warning light or horn. For loads up to 5 HP the pressure switches may handle the current directly. For larger loads the pressure switch is used to energize relays, contactors, or motor starters, which then energize the load.



## Pressure Switch Components

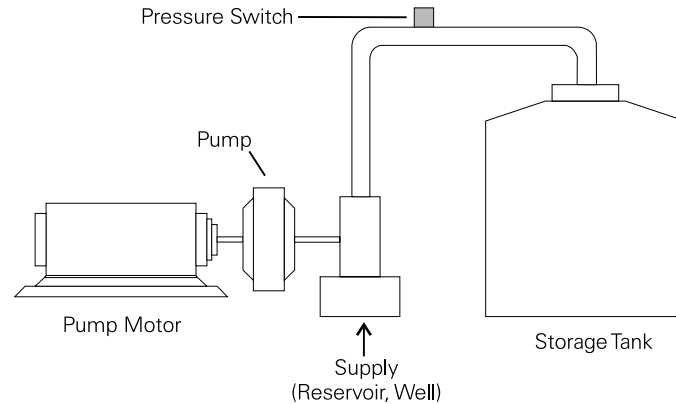
The basic components of a pressure switch are illustrated below. Electrical contacts are operated by the movement of a diaphragm against the force of a spring. The contacts may be normally open (NO) or normally closed (NC). The spring setting determines how much fluid pressure is required to operate the contacts.





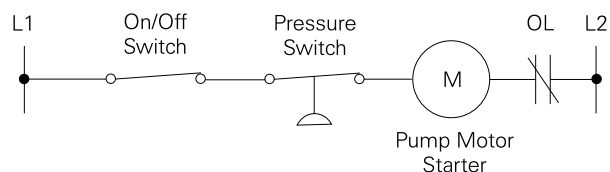
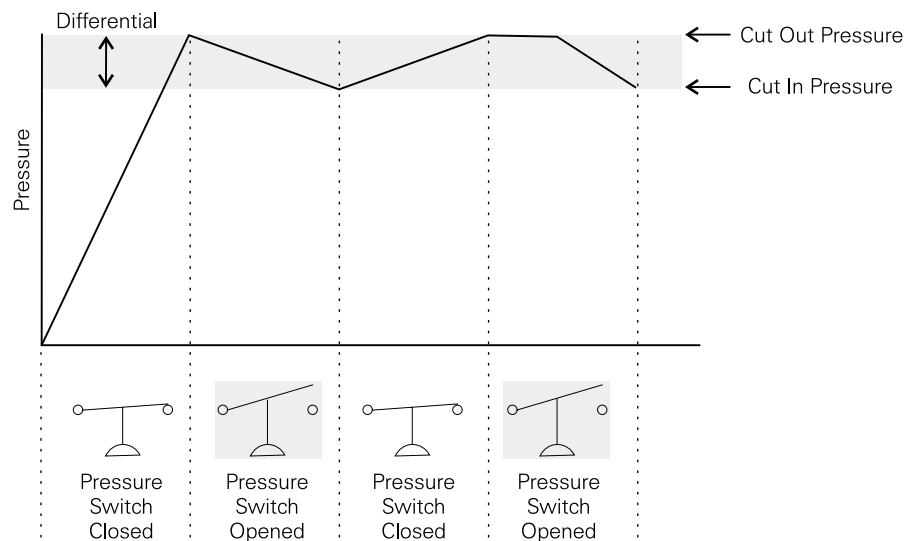
## Application

Pressure switches are frequently used to maintain a specified pressure range in a storage tank. Storage tanks can be used to hold a liquid, such as water, or a gas, such as air.



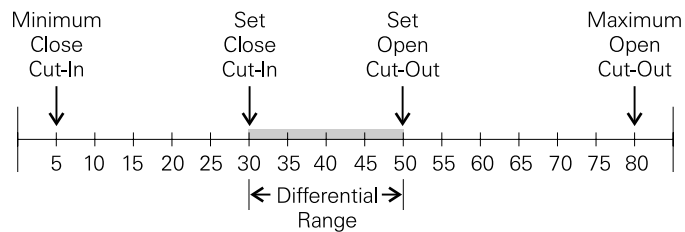
## Operation

In this example a normally closed pressure switch is used. The pump starts as soon as power is applied to the circuit. When the pressure in the storage tank has reached a predetermined level, the contacts in the pressure switch open, removing power from the pump motor. As the contents of the storage tank are used, the pressure in the tank decreases. At a predetermined level the pressure switch will close its contacts, applying power to the pump motor.



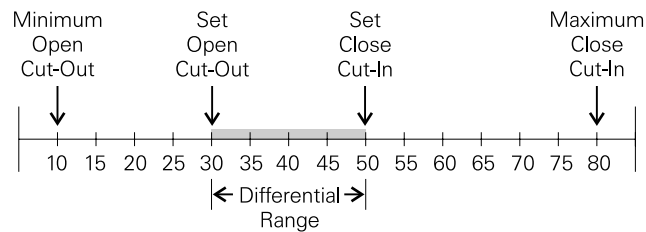
## Pressure Range

Pressure switches are designed to operate within a specified pressure range, usually given in pounds per square inch (PSI). In the following example, a Furnas Class 69ES water pressure switch operates within a range of 10 to 80 PSI. The minimum close, or cut-in pressure, is 10 PSI. This is the point at which fluid pressure on the diaphragm causes the contacts to close. The maximum open, or cut-out pressure, is 80 PSI. This is the point at which fluid pressure on the diaphragm causes the contacts to open. Pressure differential is the difference between these two settings. The Furnas Class 69ES pressure switch can have a differential range of 15-25 PSI. In this example the cut-in pressure has been set to 30 PSI. The cut-out pressure has been set to 50 PSI. The pressure differential is 20 PSI. The pressure switch will regulate the pressure between 30 and 50 PSI.



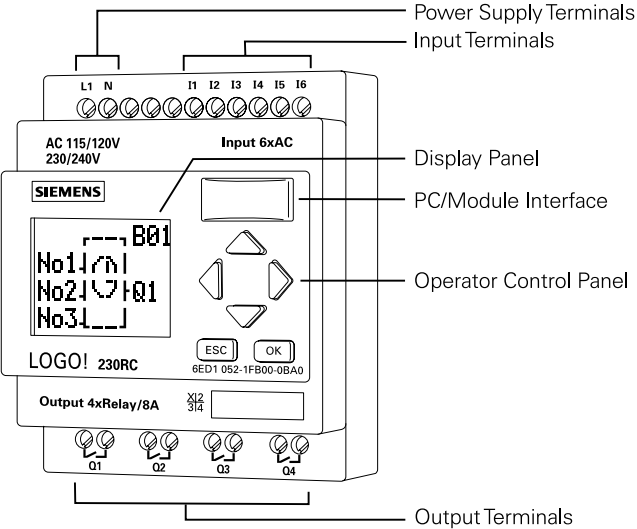
## Reverse Action

Reverse action pressure switches cut-in on a rising pressure. They are designed to ground the ignition on gas engine driven pumps and compressors when the maximum pressure has been reached. In the following example a Furnas Class 69WR5 reverse action pressure switch has been selected. The 69WR5 has a minimum open (cut-out) of 10 PSI and a maximum close (cut-in) of 80 PSI. The differential is set so that the switch opens at 30 PSI and closes at 50 PSI.



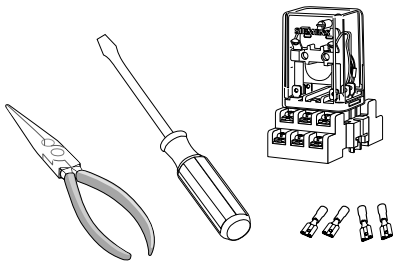
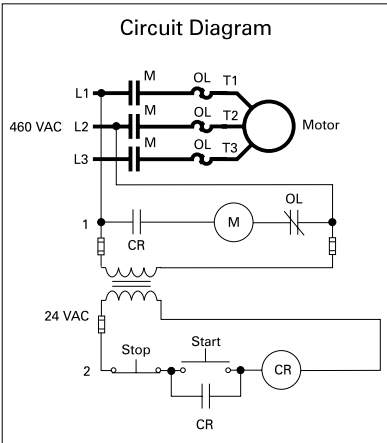
# LOGO! Logic Module

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, though 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. The outputs can be connected to virtually any type of load such as relays, contactors, lights, and small motors.



## Design Features

LOGO! is available in many different versions for different supply voltages (12 VDC, 24 VDC, 24 VAC or 115/230 VAC).

All models have:

- Relay outputs with maximum 10 amp output current (not LOGO! 24/24L models)
- Integrated clock (not LOGO! 24/24L models)
- Integrated display
- Integrated keypad
- Integrated basic and special functions
- Integrated EEPROM for storing programs and setpoints
- Optional program module
  - Yellow Module for simple program duplication
  - Red Module for program backup and protection
- Basic AND, OR, NOT, NAND, NOR, and XOR functions
- AND and NAND functions with positive and negative edge detection
- Special ON delay, latching ON delay, OFF delay, pulse relay, latching relay, clock pulse generator, and counter (up/down) functions (total of 21 special functions)

Basic version features:

- Six digital inputs, four digital outputs for AC models
- Eight digital inputs, four digital outputs for DC models with two inputs capable of accepting analog inputs

Pure version features:

- LOGO! Basic without display

L model features:

- Twelve digital inputs, eight digital outputs
- Four additional inputs and outputs on the AS-i modules

The maximum possible options for every model version are as follows:

- 16 Timers
- 24 Counters
- Eight Time Switches
- Three Operating Hour Counters
- 42 Current Impulse Relays
- 42 Latching Relays
- Four Markers for Program Continuation
- 56 Total Function Blocks

## 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 has received a signal to turn on, and then delays a predetermined amount of time before an action takes place is referred to as \_\_\_\_\_ delay.

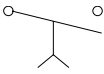

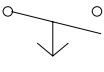
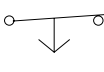
# Review Answers

- 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) excess; 3) overload; 4) a; 5) bimetal.
- Review 4** 1) 2; 2) LVP; 3) 10, 5; 4) 20; 5) motor starter.
- Review 5** 1) NEMA, IEC; 2) 5; 3) AC3; 4) 4; 5) 3; 6) 50; 7) 3UA66.
- Review 6** 1) Consequent-pole motor; 2) progressive control; 3) reduced-voltage starting; 4) Autotransformer.
- Review 7** 1) pilot device; 2) Three-Wire Control, Two-Wire Control; 3) visual; 4) red, green.
- Review 8** 1) Throw; 2) Pole; 3) one, two; 4) ON.

# 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. deenergized
  
2. A motor that is running would usually be indicated by a \_\_\_\_\_ pilot 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. increase and decrease
  
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

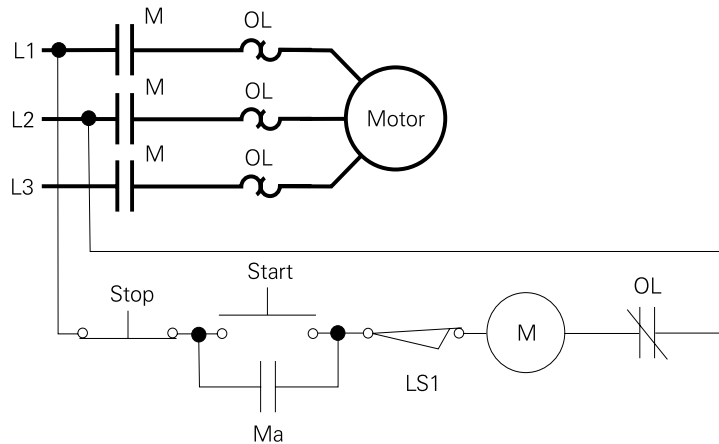
6. A motor starter is a combination of a/an \_\_\_\_\_ .
- a. electromagnet and armature
  - b. contactor and electromagnet
  - c. contactor and overload relay
  - d. overload relay and instantaneous contacts
7. Which of the following is not part of a contactor?
- a. armature
  - b. electromagnetic coil
  - 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 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. The proper overload relay for a World Series 3TF50 contactor is \_\_\_\_\_ .
- a. 3UA50
  - b. 3UA54
  - c. 3UA58
  - d. 3UA60



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 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. The point at which fluid pressure on the diaphragm of a pressure switch causes the contacts to open is referred to as \_\_\_\_\_ .
- a. cut-out pressure                b. cut-in pressure  
c. pressure range                 d. pressure differential
15. A NEMA Size 6 starter has a continuous amp rating of \_\_\_\_\_ amps.
- a. 200                                    b. 540  
c. 810                                    d. 1600
16. Audible elements for the 8WD42 signalling column include a \_\_\_\_\_ .
- a. siren                                 b. buzzer and siren  
c. buzzer                                d. horn
17. Furnas INNOVA PLUS™ starters are available up to \_\_\_\_\_ HP.
- a. 25                                        b. 50  
c. 100                                      d. 250
18. SIRIUS Type 3R motor starters are available for loads up to \_\_\_\_\_ amps.
- a. 95                                        b. 135  
c. 200                                      d. 270

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. The \_\_\_\_\_ overload relay integrates with PROFIBUS-DP.

- a. 3RB10
- b. ESP 100
- c. 3UF5
- d. 3RU11