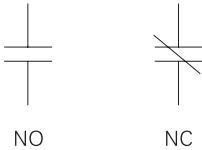


Electrical Symbols

Control circuits can be represented pictorially in various ways. One of the more common approaches is to use control logic diagrams which use common symbols to represent control components. Although control symbols vary throughout the world, the symbols used in this course are common in the United States and many other countries.

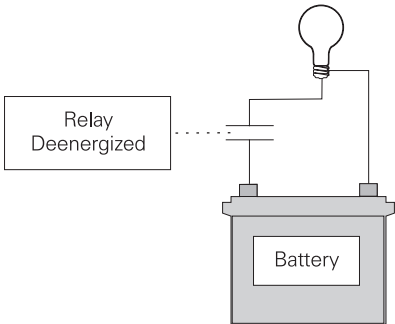
Contact Symbols

Various devices incorporate contacts to control the flow of current to other control components. When in operation, a contact may be either **open**, a condition which blocks current flow, or **closed**, a condition which allows current flow. Control logic diagrams, however, cannot show the dynamic operation of contacts. Instead, these diagrams show contacts as either **normally open (NO)** or **normally closed (NC)**.



The standard method of showing contacts is to indicate the circuit condition produced when the actuating device is in the **de-energized (off) state**.

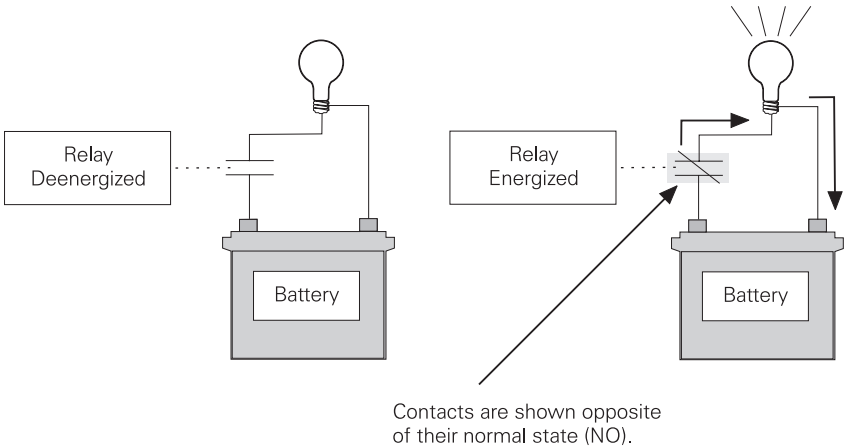
For example, in the following illustration, the contacts are part of a relay. The contacts are shown as normally open to indicate that, when there is no power applied to the relay's coil, the contacts are open. With the contacts open, there is no current flow to light.



Symbols on a control logic diagram are usually not shown in their energized (on) state. However, in this course, contacts and switches are sometimes shown in their energized state for explanation purposes. In such cases, the symbol is highlighted.

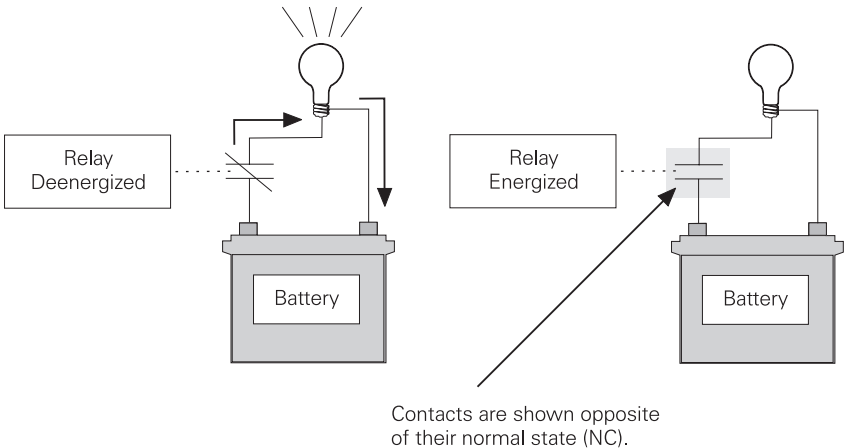
Normally Open Contact Example

For example, in the following illustration, the circuit is first shown in the de-energized state, and the normally open contacts are not highlighted. When the relay energizes, the contacts close, completing the path for current and illuminating the light. The contacts are then shown as highlighted to indicate that they are not their **normal** state. *Note: This is not a standard symbol.*



Normally Closed Contact Example

In the following illustration, when the relay is de-energized, the normally closed contacts are shown as closed and are not highlighted. A complete path of current exists at this time, and the light is on. When the relay is energized, the contacts open, turning the light off.



Switch Symbols

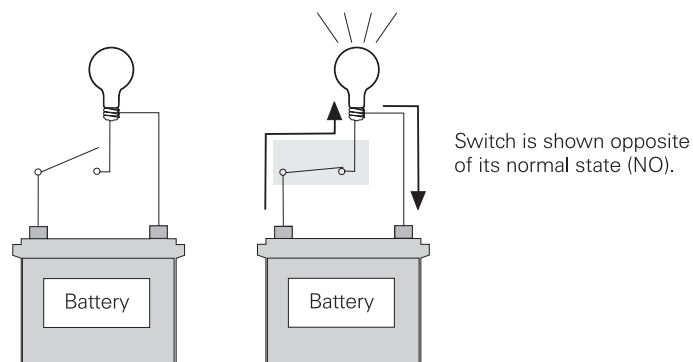
Various types of **switches** are also used in control circuits. Like the contacts just discussed, switches can also be normally open or normally closed and require another device or action to change their state. In the case of a manual switch, someone must change the position of the switch. A switch is considered to be in its normal state when it has not been acted upon.

Switch symbols, like the ones shown in the following illustration, are also used to indicate an open or closed path of current flow. Variations of these symbols are used to represent a number of different switch types.



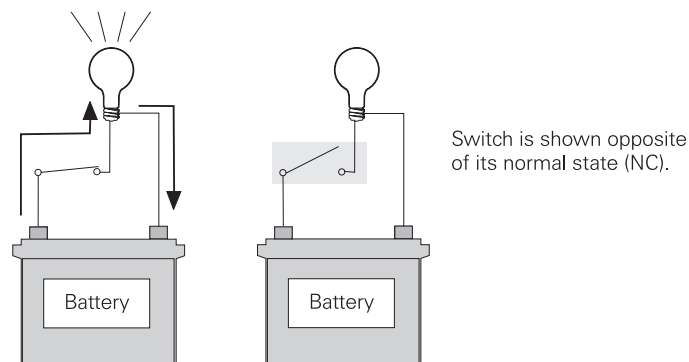
Normally Open Switch Example

In the following illustration, a battery is connected to one side of a normally open switch, and a light is connected to the other side. When the switch is open, current cannot flow through the light. When someone closes the switch, it completes the path for current flow, and the light illuminates.



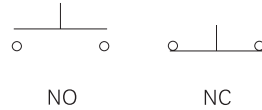
Normally Closed Switch Example

In the following illustration, a battery is connected to one side of a normally closed switch and a light is connected to the other side. When the switch is closed, current flows through the light. When someone opens the switch, current flow is interrupted, and the light turns off.



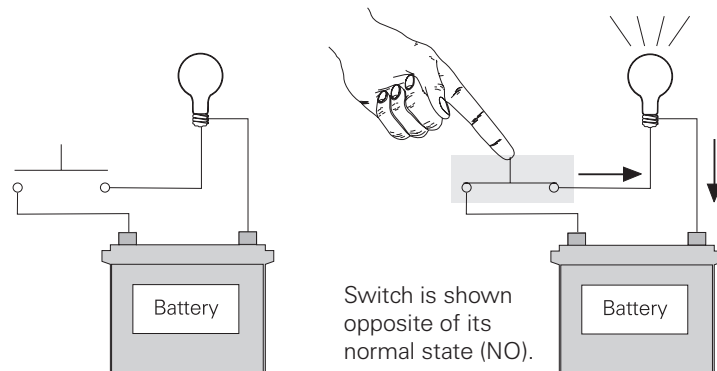
Pushbutton Symbols

There are two basic types of **pushbuttons**, **momentary** and **maintained**. The contacts of a momentary pushbutton change state, open to closed or vice versa, when the button is pressed. They return to their normal state as soon as the button is released. In contrast, a maintained pushbutton latches in place when pressed. It must be unlatched to allow it to return to its normal state.



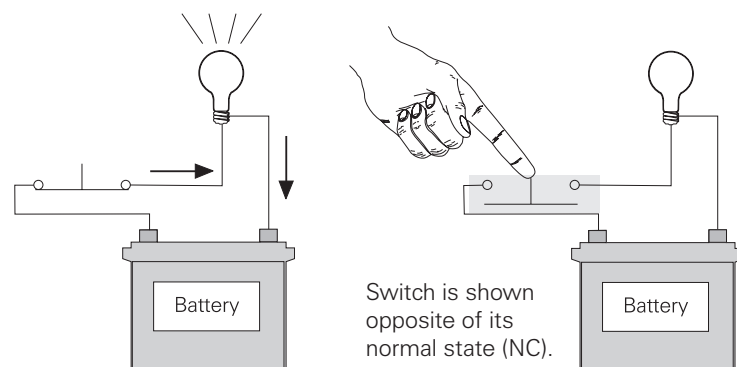
Normally Open Pushbutton Example

In the following illustration, a battery is connected to one side of a normally open pushbutton, and a light is connected to the other side. When the pushbutton is pressed, current flows through the pushbutton, and the light turns on.



Normally Closed Pushbutton Example

In the following example, current flows to the light as long as the pushbutton is not pressed. When the pushbutton is pressed, current flow is interrupted, and the light turns off.

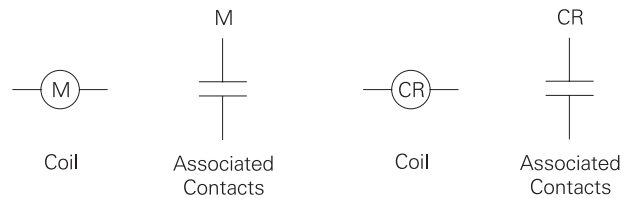


Coil Symbols

Motor starters, contactors, and relays are examples of devices that open and close contacts electromagnetically. The electromagnet in these devices is called a **coil**.

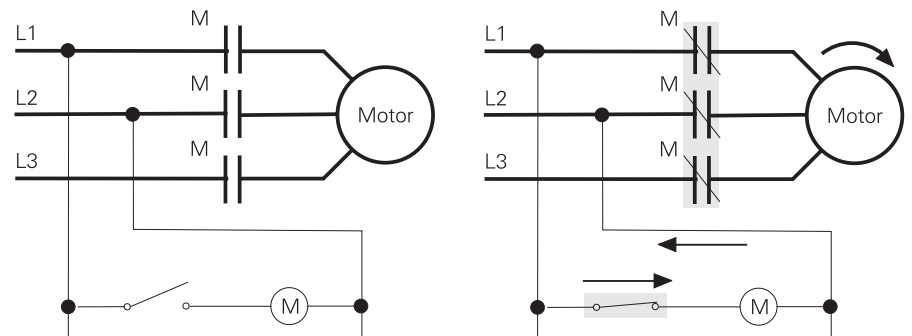
A coil is commonly symbolized as a circle with letters and number inside. The letters often represent the type of device, such as M for motor starter or CR for control relay. A number is often added to the letter to differentiate one device from another.

The contacts controlled by a coil are labeled with the same letter (and number) as the coil so that it is easy to tell which contacts are controlled by each coil. A coil often controls multiple contacts and each contact may be normally open or normally closed.



Coil Example Using Normally Open Contacts

In the following example, the “M” contacts in series with the motor are controlled by the “M” contactor coil. When someone closes the switch, current flows through the switch and “M” contactor coil. The “M” contactor coil closes the “M” contacts and current flows to the motor.



Overload Relay Symbols

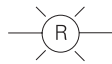
Overload relays are used to protect motors from overheating. When excessive current is drawn for a predetermined amount of time, the overload relay's contacts open, removing power from the motor. The following symbol is for contacts associated with a thermal overload relay. An overload relay used with a three-phase motor has three such contacts, one for each phase.



Thermal
Overload

Indicator Light Symbols

An **indicator light**, often referred to as a **pilot light**, is a small electric light used to indicate a specific condition of a circuit. For example, a red light might be used to indicate that a motor is running. The letter in the center of the indicator light symbol indicates the color of the light.



Red
Indicator Light

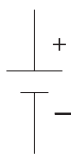
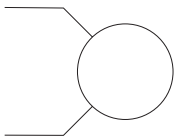
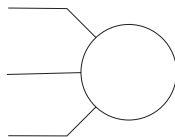
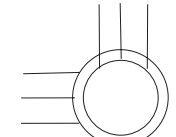
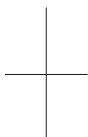
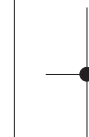
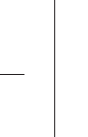
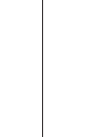
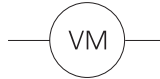


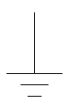




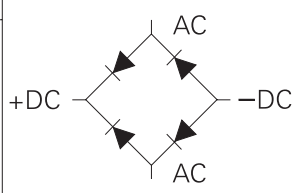
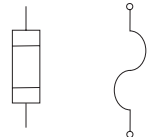


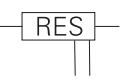
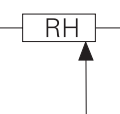














Amber
Indicator Light

Other Symbols

In addition to the symbols discussed here, there are many other symbols used in control circuits. The following charts show many of the commonly used symbols.

Switches																											
Disconnect		Circuit Interrupter		Circuit Breaker W/Thermal O.L.		Circuit Breaker W/Magnetic O.L.		Circuit Breaker W/Thermal and Magnetic O.L.																			
Limit Switches		Foot Switches		Pressure and Vacuum Switches		Liquid Level Switches																					
Normally Open	Normally Closed	NO		NC		NO		NC		NO																	
Held Closed	Held Open	NC		Temperature Actuated Switches		Flow Switches (Air, Water, Etc.)																					
Speed (Plugging)		Anti-Plug		Selector																							
				2 Position		3 Position		2 Pos. Sel. Pushbutton																			
				 J K A1 A2 X - Contact Closed		 J K L A1 A2 X - Contact Closed		 A B 1 2 3 4 <table border="1"> <tr><th colspan="2">Selector Position</th></tr> <tr><th>A</th><th>B</th></tr> <tr><th>Button</th><th>Button</th></tr> <tr><th>Free</th><th>Depres'd</th><th>Free</th><th>Depres'd</th></tr> <tr><td>1-2</td><td>X</td><td></td><td></td></tr> <tr><td>3-4</td><td></td><td>X</td><td>X</td></tr> </table>		Selector Position		A	B	Button	Button	Free	Depres'd	Free	Depres'd	1-2	X			3-4		X	X
Selector Position																											
A	B																										
Button	Button																										
Free	Depres'd	Free	Depres'd																								
1-2	X																										
3-4		X	X																								
Pushbuttons																											
Momentary Contact				Maintained Contact			Illuminated																				
Single Circuit		Double Circuit		Mushroom Head	Wobble Stick	Two Single Circuit		One Double Circuit																			
NO	NC	NO & NC																									
Pilot Lights				Contacts																							
Indicate Color by Letter				Instant Operating				Timed Contacts - Contact Action Retarded After Coil Is:																			
Non Push-to-Test		Push-to-Test		With Blowout		Without Blowout		Energized		Deenergized																	
				NO	NC	NO	NC	NOTC	NCTO	NOTO	NCTC																
Coils		Overload Relays		Inductors		Transformers																					
Shunt		Thermal		Magnetic		Iron Core		Auto		Iron Core		Air Core		Dual Voltage													
Series						Air Core		Current																			

AC Motors				Schematic Wiring			Battery
Single Phase	Three-Phase Squirrel Cage	Wound Rotor	Not Connected	Connected	Power	Control	
							
DC Motors				Meter	Meter Shunt	Wiring Terminal	Connections Mechanical
Armature	Shunt Field (Show 4 Loops)	Series Field (Show 3 Loops)	Comm. or Compens. Field (Show 2 Loops)	Indicate Type by Letter  		o	-----
Annunciator	Bell	Buzzer	Horn Siren, Etc.		Ground 		Mechanical Interlock 
				Capacitors			
				Fixed		Adjustable	
							
Resistors				Half Wave Rectifier	Full Wave Rectifier		Fuse
Fixed	Heating Element	Adj. By Fixed Taps	Rheostat Pot Or Adj. Tap				
							
Supplementary Contact Symbols				Terms			
SPST NO		SPST NC		SPDT			
Single Break	Double Break	Single Break	Double Break	Single Break	Double Break	SPST Single-Pole Single-Throw SPDT Single-Pole Double-Throw DPST Double-Pole Single-Throw DPDT Double-Pole Double-Throw NO Normally Open NC Normally Closed	
							
DPST 2 NO		DPST 2 NC		DPDT			
Single Break	Double Break	Single Break	Double Break	Single Break	Double Break		
							

Symbols For Static Switching Control Devices		
<p>Static switching control uses solid-state devices instead of electromechanical devices. Many of the symbols used with this type of control are the same as those shown on the previous page, but enclosed in a square as shown in the following examples.</p>		
Coil	Contact (NO)	Limit Switch (NO)

Control and Power Connections - 600 Volts or Less - Across-the-Line Starters (From NEMA Standard ICS 2-321A.60)				
		1 Phase	2 Phase 4 Wire	3 Phase
Line Markings		L1,L2	L1,L3-Phase 1 L2,L4-Phase 2	L1,L2,L3
Ground When Used		L1 is always Ungrounded	—	L2
Motor Running Overcurrent Units In	1 Element 2 Element 3 Element	L1 — —	— L1,L4 —	— — L1,L2,L3
Control Circuit Connected To		L1,L2	L1,L3	L1,L2
For Reversing Interchange Lines		—	L1,L3	L1,L3

Abbreviations

Abbreviations are frequently used in control circuits. The following list identifies commonly used abbreviations.

AC	Alternating Current	MTR	Motor
ALM	Alarm	MN	Manual
AM	Ammeter	NEG	Negative
ARM	Armature	NEUT	Neutral
AU	Automatic	NC	Normally Closed
BAT	Battery	NO	Normally Open
BR	Brake Relay	OHM	Ohmmeter
CAP	Capacitor	OL	Overload
CB	Circuit Breaker	PB	Pushbutton
CKT	Circuit	PH	Phase
CONT	Control	POS	Positive
CR	Control Relay	PRI	Primary
CT	Current Transformer	PS	Pressure Switch
D	Down	R	Reverse
DC	Direct Current	REC	Rectifier
DISC	Disconnect Switch	RES	Resistor
DP	Double-Pole	RH	Rheostat
DPDT	Double-Pole, Double-Throw	S	Switch
DPST	Double-Pole, Single-Throw	SEC	Secondary
DT	Double Throw	SOL	Solenoid
F	Forward	SP	Single-Pole
FREQ	Frequency	SPDT	Single-Pole, Double Throw
FTS	Foot Switch	SPST	Single-Pole, Single Throw
FU	Fuse	SS	Selector Switch
GEN	Generator	SSW	Safety Switch
GRD	Ground	T	Transformer
HOA	Hand/Off/Auto Selector Switch	TB	Terminal Board
IC	Integrated Circuit	TD	Time Delay
INTLK	Interlock	THS	Thermostat Switch
IOL	Instantaneous Overload	TR	Time Delay Relay
JB	Junction Box	U	Up
LS	Limit Switch	UV	Under Voltage
LT	Lamp	VFD	Variable Frequency Drive
M	Motor Starter	XFR	Transformer
MSP	Motor Starter Protector		