# Contactor and Starter Ratings

Contactors and motor starters are rated according to size and type of load they are designed to handle.

The National Electrical Manufacturers Association (NEMA) and the International Electrotechnical Commission (IEC) are two organizations that rate contactors and motor starters. NEMA is primarily associated with equipment used in North America. IEC is associated with equipment sold in countries worldwide (including the United States). International trade agreements, market globalization, and domestic and foreign competition have made it important for controls manufacturers to be increasingly aware of international standards.

**NEMA**

NEMA ratings are based on maximum horsepower ratings as specified in the National Electrical Manufacturers Association ICS2 standards. NEMA starters and contactors are selected according to their NEMA size, from size 00 to size 9.

| NEMA Size | Continuous Amp Rating | HP 230 VAC | HP 460 VAC |
|---|---|---|---|
| 00 | 9 | 1 | 2 |
| 0 | 18 | 3 | 5 |
| 1 | 27 | 5 | 10 |
| 2 | 45 | 15 | 25 |
| 3 | 90 | 30 | 50 |
| 4 | 135 | 50 | 100 |
| 5 | 270 | 100 | 200 |
| 6 | 540 | 200 | 400 |
| 7 | 810 | 300 | 600 |
| 8 | 1215 | 450 | 900 |
| 9 | 2250 | 800 | 1600 |

NEMA motor-control devices have generally become known for their very rugged, heavy-duty construction. Because of their rugged design, NEMA devices are physically larger than IEC devices.

NEMA motor starters and contactors can be used in virtually any application at their stated rating, from simple "ON" and "OFF" applications to more-demanding applications that include plugging and jogging. To select a NEMA motor starter for a particular motor, one needs only to know the horsepower and voltage of the motor. However, if there is considerable plugging and jogging duty involved, even a NEMA-rated device will require some derating.

**Motor Matched Sizes**

Siemens also has what are called Motor Matched sizes available on some Siemens motor starters. The ratings for these devices fall in between the ratings of normal NEMA sizes, allowing the user to more closely match the motor control to the actual application. Motor Matched sizes are beneficial because they cost less than larger NEMA size starters. The following table shows Motor Matched sizes available.

| MM Size | Continuous Amp Rating | HP 230 VAC | HP 460 VAC |
|---|---|---|---|
| 1¾ | 40 | 10 | 15 |
| 2½ | 60 | 20 | 30 |
| 3½ | 115 | 40 | 75 |

**IEC**

Not all applications require a heavy-duty industrial starter. In applications where space is more limited and the duty cycle is not severe, IEC devices represent a cost-effective solution.

IEC devices are rated for maximum operational current as specified by the International Electrotechnical Commission in publication IEC 158-1. IEC does not specify sizes. Utilization categories are used with IEC devices to define the typical duty cycle of an IEC device. AC-3 and AC-4 are the categories of most interest for general motor-starting applications.

| Utilization Category | IEC Category Description |
|---|---|
| AC1 | Non-inductive or slightly inductive rows |
| AC2 | Starting of slip-ring motors |
| AC3 | Starting of squirrel-cage motors and switching off only after the motor is up to speed. (Make LRA, Break FLA) |
| AC4 | Starting of squirrel-cage motors with inching and plugging duty. Rapid Start/Stop. (Make and Break LRA) |
| AC11 | Auxiliary (control) circuits |

## Definite Purpose

Definite Purpose (DP) contactors are designed for specific applications where the operating conditions are clearly defined. Operating conditions that must be considered include full load amps, locked rotor amps, noninductive amps (resisitive load), number of power poles, duty cycle, and the total number of expected operations.

DP contactors are sized by the motor full-load amps (FLA) and locked rotor amps (LRA). FLA is the amount of current the motor draws at full speed, under full mechanical load, at rated voltage. LRA is the maximum current the motor will draw at the instant full-line voltage is applied to the motor.

DP contactors are well suited for loads found in the following application areas:

- Heating, Ventilating, and Air Conditioning (HVAC)
- Farm Equipment and Irrigation
- Environmental Control Systems
- Office Equipment
- Pool and Spa Controls
- Welding Equipment
- Medical Equipment
- Food-Service Equipment

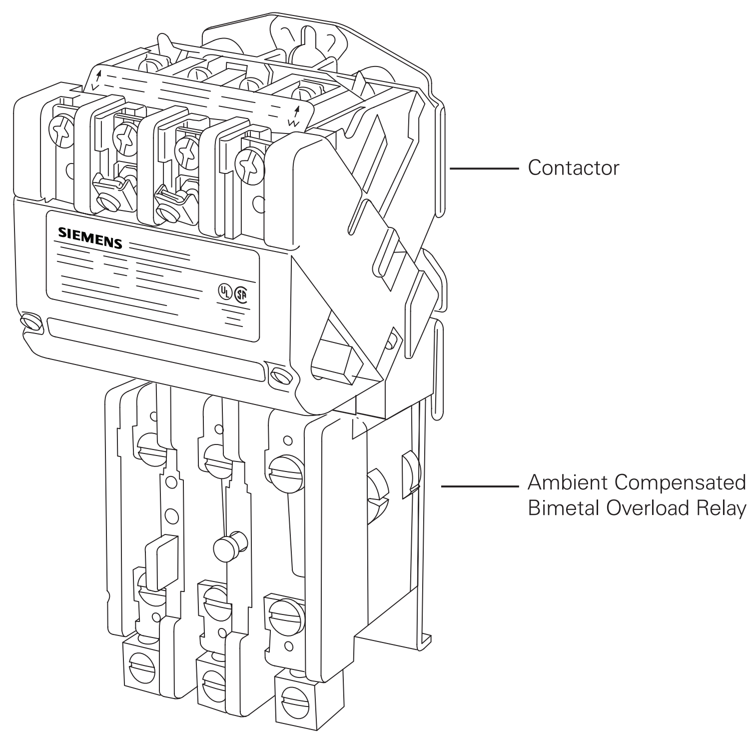
## Other Organizations

There are several other organizations that have developed standards and tests for electrical equipment. For example, contactors are tested by Underwriters Laboratory (UL) using test procedure UL508, which specifies a maximum horsepower rating for which a contactor can be used.

All Siemens contactors are rated in accordance with at least one of the previous organizations’ test procedures. Some carry multiple ratings. For example, Siemens NEMA starters meet or exceed NEMA, CSA, and UL standards, while Siemens SIRIUS starters meet or exceed IEC, CSA, and UL standards. Some SIRIUS starters also carry NEMA labeling.

# Class 14 NEMA Starters with Bimetal Overload Relays

NEMA starters are available in NEMA sizes 00 through 4. In addition to whole sizes, this range includes 1¾, 2½, and 3½ sizes, and are available up to 100 HP. These starters are available with Class 10 or 20 ambient-compensated bimetal overload relays.

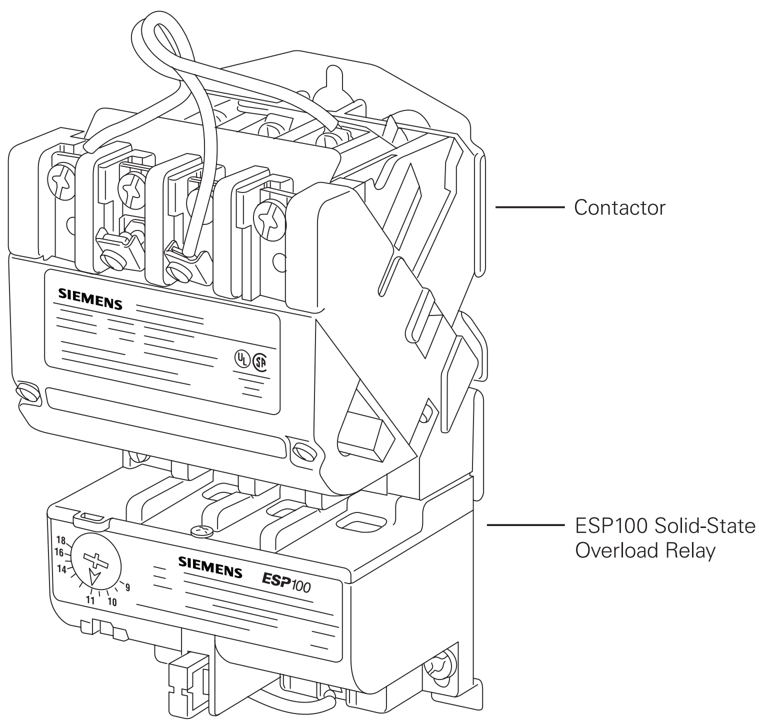


# Class 14 ESP100 Starters

Class 14 ESP100 starters use the same contactors as Class 14 NEMA starters equipped with bimetal overload relays (for NEMA sizes 00 through 4), but are supplied with a Class 10, 20, or 30 ESP100 solid-state overload relay. In addition, these starters are available with contactors up to and including NEMA size 8.

The ESP100 overload relay protects 3Ø motors with FLA of ¼ ampere through 1220 amperes, and 1Ø motors with FLA of ¾ ampere through 16 amperes. All ESP100 overload relays have an adjustable overload ampere range.

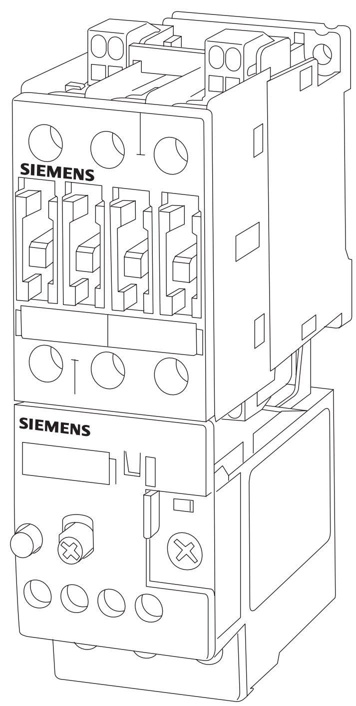
The ESP100 also protects the motor by tripping within three seconds if any of the three power phases is lost.



# SIRIUS Type 3R Starters

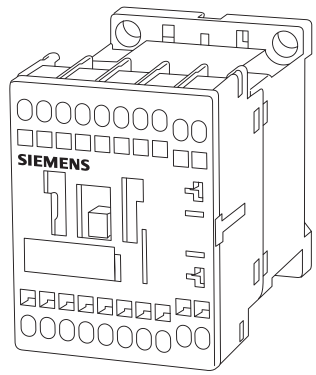
SIRIUS 3R is a complete modular, building-block system. The system includes a variety of components including a structured range of contactors and overload relays in seven frame sizes. These frame sizes are referred to as S00, S0, S2, S6, S10, and S12.

A feature of the SIRIUS product line is a narrow mounting width. Along with the ability of SIRIUS components to operate at ambient temperatures up to 140º F (60º C), this allows more units to be packed into a panel without overheating the components.

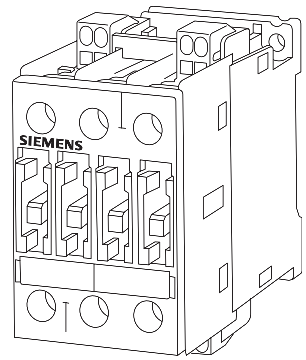


**Spring-Loaded Terminals**

Size S00 contactors and overload relays are equipped with spring-loaded power and control circuit terminals. Size S0 through size S12 contactors and overload relays have spring-loaded terminals on control-circuits only.



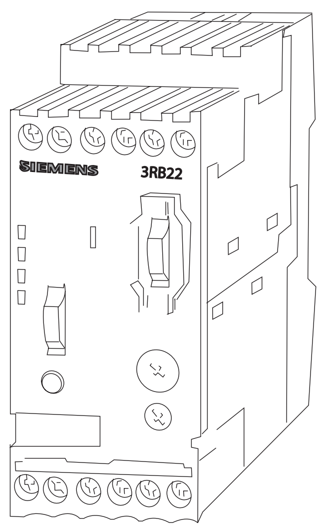

**Contactor with Spring-Loaded Terminals**




**Contactor with Screw Terminals**

**Overload Relays**

As previously described, the SIRIUS 3R system incorporates a broad range of thermal and electronic overload relays.



**Review 5**

1. ____________ is an organization primarily associated with rating equipment used in North America and ____ ________ is associated with rating equipment used in many countries worldwide including the U.S.

2. A NEMA Size ____________ starter is rated for 200 HP at 460 volts .

3. IEC utilization category ____________ applications are described as the starting of squirrel-cage motors and switching off only after a motor is up to speed.

4. Siemens Class 14 NEMA starters are available in NEMA sizes 00 through ____________, including sizes 1¾, 2½, and _____________.

5. The ESP100 trips within ____________ seconds of loss of one of the power-supply phases.

6. SIRIUS Type 3R starters are available in seven frame sizes: ________, S0, S2, S3, ________, S10, and S12.

7. SIRIUS 3R contactors and overload relays are designed to operate in ambient temperatures up to ____________________.

# Multi-Speed Starters

Full-voltage AC magnetic multi-speed controllers are designed to control squirrel-cage induction motors for operation at two, three, or four different constant speeds (based on motor construction). The speed of a constant-speed motor is a function of the supply frequency and the number of poles, and is determined using the following formula:

$$\text{Synchronous Speed in RPM} = \frac{120 \times \text{Frequency}}{\text{Number of Poles}}$$

The speed in RPM is the synchronous speed or the speed of the rotating magnetic field in the motor stator. Actual rotor speed is always less due to slip. The design of the motor and the amount of load applied determine the percentage of slip. This value is not the same for all motors. A motor with four poles on a 60 hertz AC line has a synchronous speed of 1800 RPM. This means that after allowing for slip, the motor is likely to run at 1650 to 1750 RPM when loaded.

$$1800 = \frac{120 \times 60}{4}$$

(In contrast, a two-pole induction motor on a 60 hertz AC line would run at twice that speed.)

When motors are required to run at different speeds, the motor's torque or horsepower characteristics will change with a change in speed. The proper motor must be selected and correctly connected for the application.There are three categories of such multi-speed applications:  constant torque, variable torque, and constant horsepower.

**Constant Torque (CT)** motors maintain constant torque at all speeds. Horsepower varies directly with speed.  This type of motor is used for conveyors, mills, and similar applications.

**Variable Torque (VT)** motors produce a torque characteristic which varies with the square of the speed. This type of motor is applicable to fans, blowers, and centrifugal pumps.

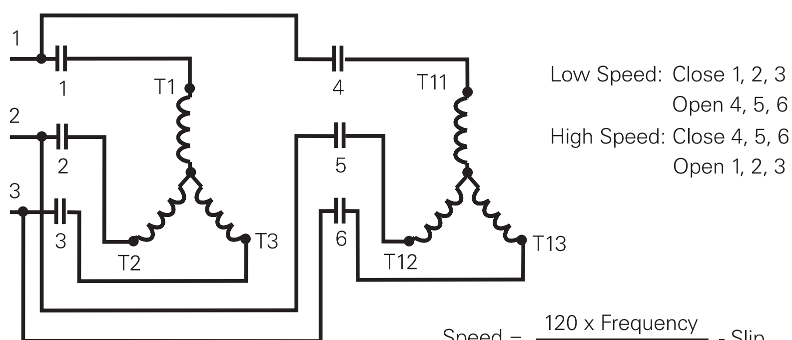
**Constant Horsepower** (CHP) motors maintain constant horsepower at all speeds, with torque varying inversely with speed. This type of motor is applicable to metal-working machines such as drills, lathes, mills, bending machines, punch presses, and power wrenches.

## Separate-Winding

There are two basic methods of providing multi-speed control using magnetic starters: separate-winding motors and consequent-pole motors.

**Separate-winding motors** have a separate winding for each speed, with the speed of each winding depending on the number of poles. The low-speed winding is wound for more poles than the high-speed winding.The motor cost is higher than consequent pole, but the control is simpler.

There are many ways multi-speed motors can be connected, depending on speed, torque, and horsepower requirements. The following schematic shows one possible connection for a two-speed, two-winding, wye-connected motor.

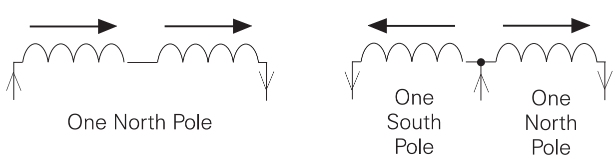



$$\text{Speed} = \frac{120 \times \text{Frequency}}{\text{Number of Poles}} - \text{Slip}$$

## Consequent-Pole Motors

**Consequent-pole motors** have a single winding for two speeds. Taps can be brought from the winding for reconnection for a different number of poles.

Two-speed, consequent-pole motors have one reconnectable winding. Low speed of a two-speed consequent-pole motor is one half the speed of high speed. Three-speed motors have one reconnectable winding and one fixed winding. Four-speed motors have two reconnectable windings.



## Speed Selection

There are three control schemes of speed selection for multi-speed motors: selective control, compelling control, and progressive control.

**Selective control** permits motor starting at any speed; to move to a higher speed, the operator depresses the desired speed pushbutton. **Compelling control** requires the motor to be started at the lowest speed, requiring the operator to manually increment through each speed step to the desired speed. With **progressive control,** the motor is started at the lowest speed and automatically increments to the selected speed.

## Class 30 Two-Speed Starters

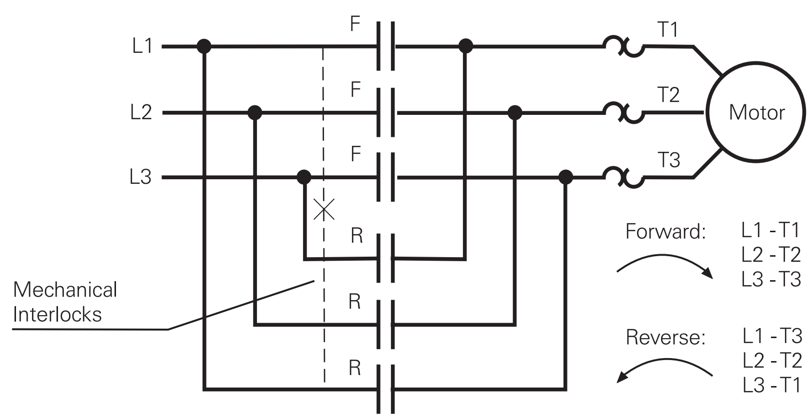
Siemens offers Class 30 two-speed starters for both separate-winding and consequent-pole motors for constant torque, variable torque, and constant horsepower applications.

Starters are available in NEMA sizes 0 through 4, including Siemens half-sizes. Overload protection is furnished with both ESP100 solid-state and ambient-compensated bimetal overload relays.

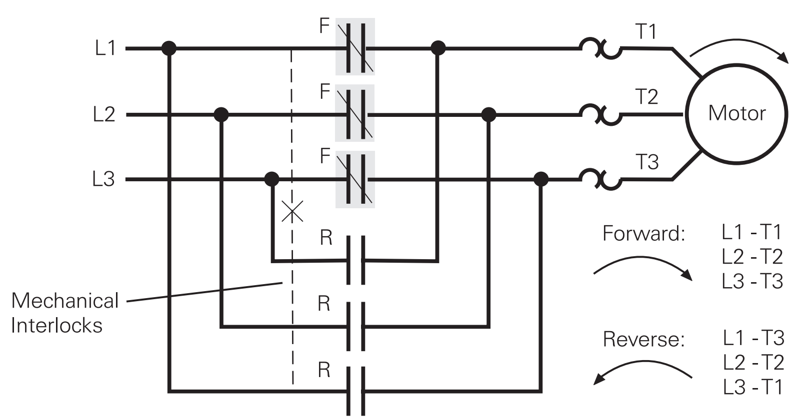
# Reversing Starters

Many applications require a motor to run in both directions. In order to change the direction of motor rotation, the direction of current flow through the windings must be changed. This is done on a three-phase motor by reversing any two of the three motor leads. Traditionally T1 and T3 are reversed.

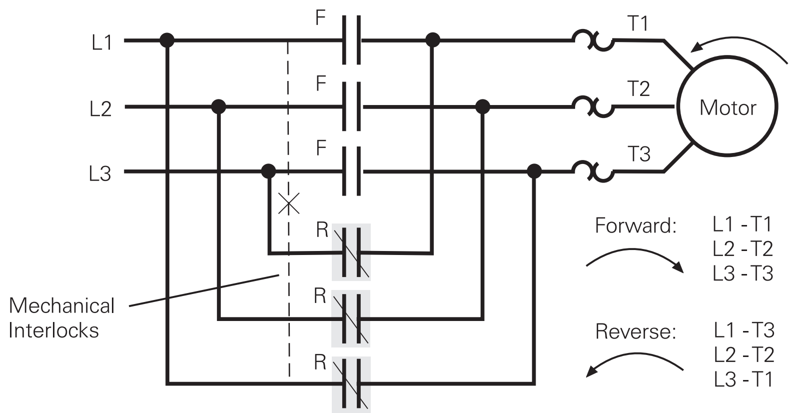
The following illustration shows a three-phase reversing motor circuit. It has one set of forward (F) contacts controlled by the "F" contactor, and one set of reverse (R) contacts controlled by the "R" contactor.




When the "F" contacts are closed, current flows through the motor causing it to turn in a clockwise direction.



When the “R” contacts are closed, current flows through the motor in the opposite direction, causing it to rotate in a counterclockwise direction. Mechanical interlocks prevent both forward and reverse circuits from being energized at the same time.




**Class 22 Reversing Starters**

Siemens offers Class 22 reversing starters in NEMA sizes 00 through 8 including Siemens half-sizes. Overload protection is furnished with both ESP100 solid-state and ambient compensated bimetal overload relays.

**Class 43 Reversing Contactors**

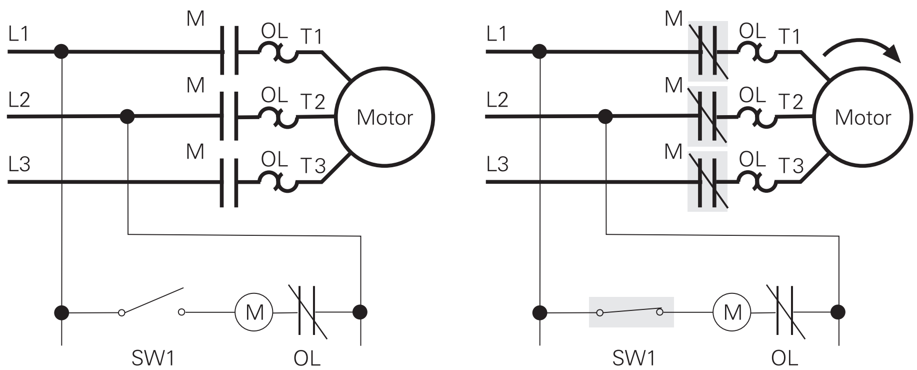
Siemens offers Class 43 reversing contactors in NEMA sizes 00 through 8, including Siemens half-sizes.

**3RA13 Reversing Contactors**

Siemens offers 3RA13 factory-assembled reversing contactors for SIRIUS frame sizes S00 through S3. Kits are available for field assembly of reversing contactors in SIRIUS frame sizes S6 through S12.

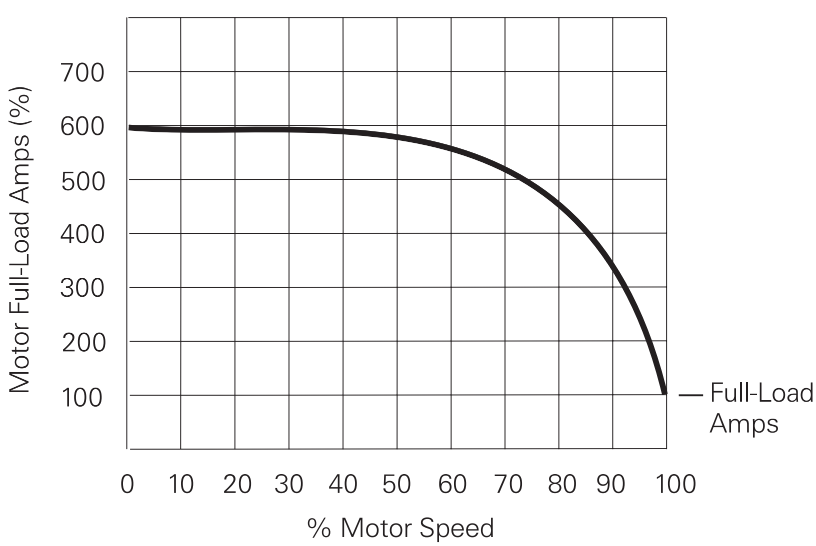
## Full-Voltage Starting

The most common type of motor starting is **full-voltage starting**, where the motor is placed directly across the line.

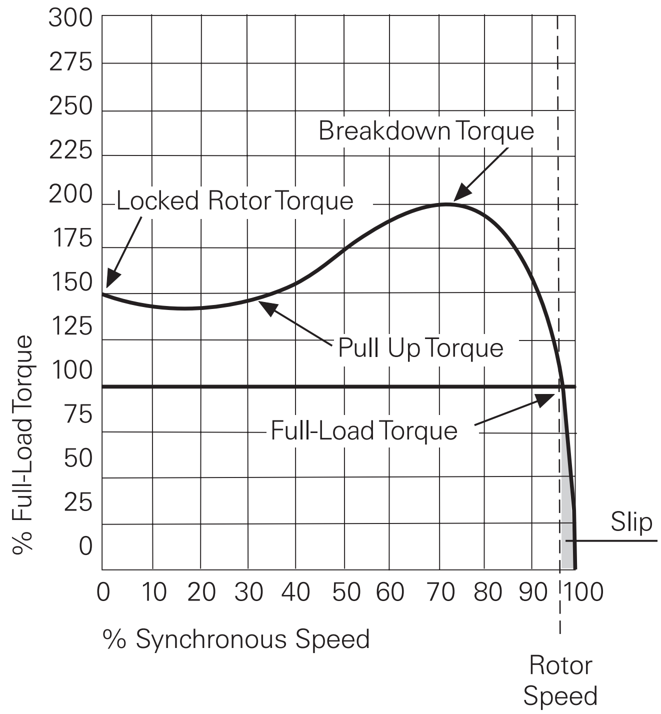



With this type of starter, the motor receives the full-line voltage immediately upon being energized. When a motor is started with full voltage, starting current can be as high as 600% of full-load current on standard squirrel cage motors. It can be as high as 1200% of full-load current for high efficiency motors.

There are situations where this method of starting is not acceptable. On large motors, the high starting current is reflected back into the power lines of the electric utility, causing lights to flicker and (in more serious situations) computers to malfunction. Many power companies in the U.S. require reduced-voltage starting on large-horsepower motors.



Another potential problem with full-voltage starts is the high torque developed when power is first applied to the motor (as high as 175% to 200% of full-load torque on a standard NEMA B type motor). Many applications require the starting torque to be applied gradually. For example, a conveyor belt requires the starting torque to be applied gradually to prevent belt slipping or bunching.




## Reduced-Voltage Starting

Starting methods which deviate from full-voltage starting by providing a lower starting voltage are referred to as **reduced-voltage starting**. Reduced-voltage starting should be used when it is necessary to limit the initial inrush of current, or it is desired to reduce the starting torque of a motor.

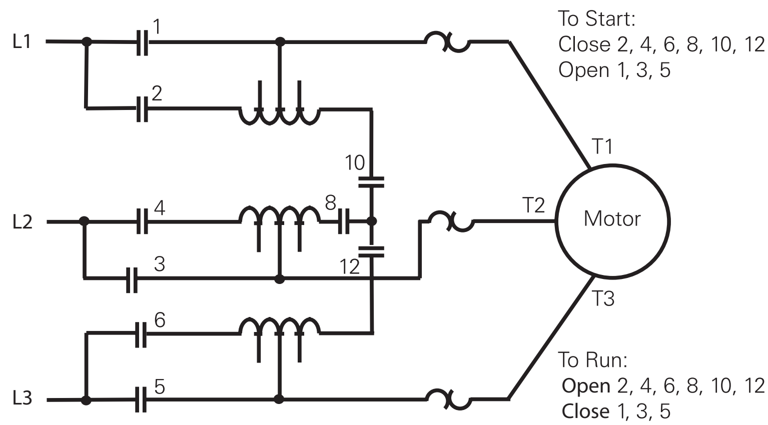
Reduced-voltage starting reduces the starting voltage of an induction motor in order to confine the rate of change of the starting current to predetermined limits. When the voltage is reduced to start a motor, It is important to remember that current is also reduced, reducing the amount of starting torque a motor can deliver. In addition to reducing inrush current and starting current, reduced-voltage starting also reduces the stress on mechanical linkage.

Several methods are available for reduced-voltage starting, usually selected based on the application or the type of motor. A few of the methods offered by Siemens are described below.

## Autotransformer Reduced-Voltage Starters

**Autotransformer reduced-voltage starters** provide the highest starting torque per ampere of line current and are typically used for applications where starting current must be reduced while retaining maximum starting torque. Autotransformers have adjustable taps to reduce starting voltage to 50%, 65%, or 80% of full-line voltage.

Applications: Crushers, Fans, Conveyors, Compressors, Mixers

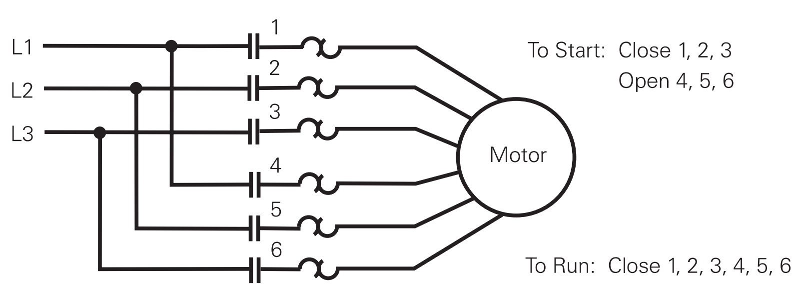



## Part-Winding Starters

**Part-winding, reduced-voltage starters** are used on motors with two separate parallel windings on the stator. The windings used during start draw about 65 - 80% of rated locked rotor current. During run each winding carries approximately 50% of the load current.

Part-winding, reduced-voltage starters are the least expensive type of reduced-voltage starters, and use a very simplified control circuit. However, they require special motor design, and are not suitable for high-inertia loads. There is no adjustment of current or torque.

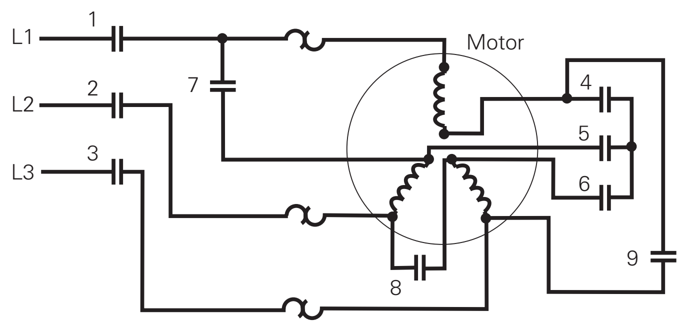
Applications: Low-inertia Fans & Blowers, Low-Inertia Pumps, Refrigeration, Compressors



**Wye-Delta Starters**

**Wye-delta, reduced-voltage starters** are applicable only with motors having stator windings not connected internally and all six motor leads available. Connected in a wye configuration, the motor starts with reduced starting line current, and is reconfigured to a delta connection for run. This type of starter is a good choice for applications requiring frequent starts, high-inertia loads, or long accelerating times. The starting torque is lower compared to other methods of reduced-voltage starters.

Applications: Central Air Conditioning Equipment, Compressors, Conveyors



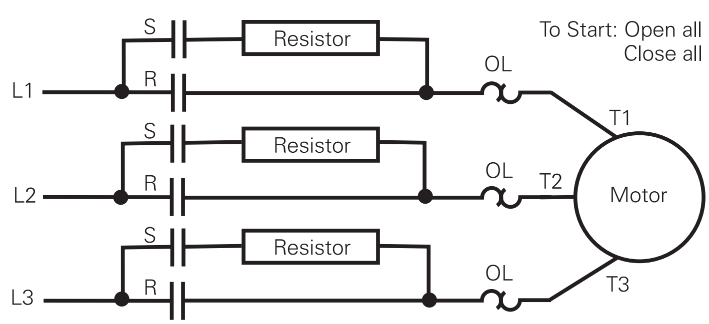

To Start: Close 1, 2, 3, 4, 5, 6
Open 7, 8, 9

To Run: Open 4, 5, 6
Close 7, 8, 9

**Primary Resistance Starter**

**Primary Resistance starters** provide simple and effective starting. The motor is initially energized through a resistor in each of the three incoming lines, dropping part of the voltage through the resistors and providing the motor with 70% to 80% of the full-line voltage. As the motor picks up speed, the motor sees more of the line voltage. At a preset time a time-delay relay closes a separate set of contacts, shorting out the resistors and applying full voltage to the motor. This type of reduced voltage starting is limited by the amount of heat the resistors can dissipate.

Applications: Conveyors, Belt-Driven and Gear Drive Equipment




To Start: Open all R Contacts
Close all S Contacts

To Run: Close all R Contacts

## Class 36 and 37 Reduced-Voltage Starters

Siemens offers Class 36 and 37 reduced-voltage starters in NEMA sizes 0 through 6 including Siemens half-sizes. The ESP100 solid-state overload relay is furnished as standard for overload protection.

## Review 6

1. A ____________ - ____________ ____________ provides multi-speed control by utilizing taps brought out from a reconnectable winding.

2. With ____________ ____________ the motor is started at the lowest speed and automatically increments to the selected speed.

3. Starting methods which deviate from full-voltage starting by providing a lower starting voltage are referred to as ____________ ____________ ____________ .

4. A reduced-voltage starter reduces all of the following during startup:
   1. ______________________________
   2. ______________________________
   3. ______________________________

5. ____________ reduced-voltage starters have adjustable taps to reduce starting voltage to 50%, 65%, or 80% of full-line voltage.

# SIRIUS Soft Starters

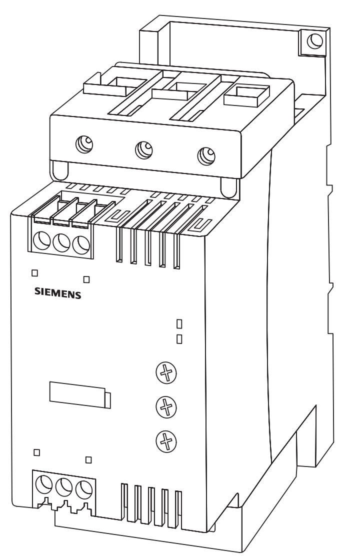
Solid-state, reduced-voltage controllers or **soft starters** limit motor starting current and torque by ramping up the voltage applied to the motor during the selectable starting time.

Soft starters accomplish this by gradually increasing the portion of the power supply cycle applied to the motor windings, a process sometimes referred to as **phase control**. Soft starters also allow this phase control process to be applied in reverse when the motor is being stopped. This controlled starting and stopping significantly reduces stress on connected devices and minimizes line voltage fluctuations.

The SIRIUS 3R modular system of components incorporates a broad range of soft starters that includes SIRIUS 3RW30/31 and 3RW40 soft starters for standard applications, and SIRIUS 3RW44 soft starters for high feature applications.

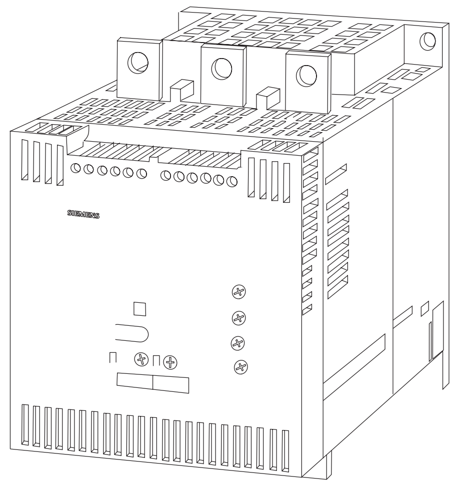
**SIRIUS 3RW30/31 Soft Starters**

SIRIUS 3RW30/31 soft starters have an especially compact design that saves space and easily integrates with other SIRIUS 3R components. SIRIUS 3RW30/31 soft starters are available for supply voltages up to 575 VAC and for operating current up to 100 amps at 40º C. Potentiometers on the front of the unit provide settings for starting time, starting voltage, and stopping time.



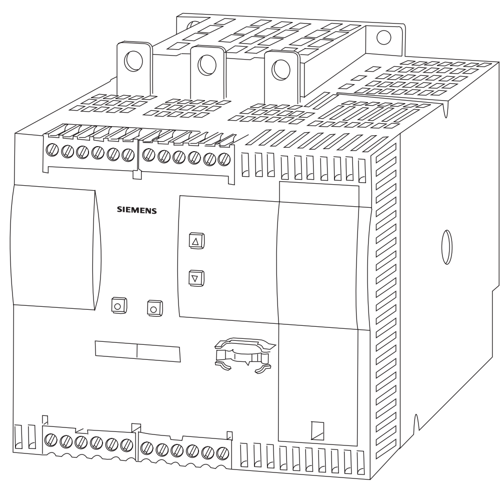
**SIRIUS 3RW40 Soft Starters**

SIRIUS 3RW40 soft starters have all the advantages of 3RW30/31 soft starters, but have more features and are available for operating current up to 432 amps at 40º C. Potentiometers on the front of the unit provide settings for current limit, starting voltage, and starting and stopping times of the voltage ramp.



**SIRIUS 3RW44 Soft Starters**

SIRIUS 3RW44 soft starters make soft starting and stopping attractive for difficult starting applications and combine a high degree of functionality, simplified operational settings, and extensive diagnostics. SIRIUS 3RW44 soft starters are available for operating current up to 1214 amps at 40º C, and can be equipped with a Profibus DP communication option.

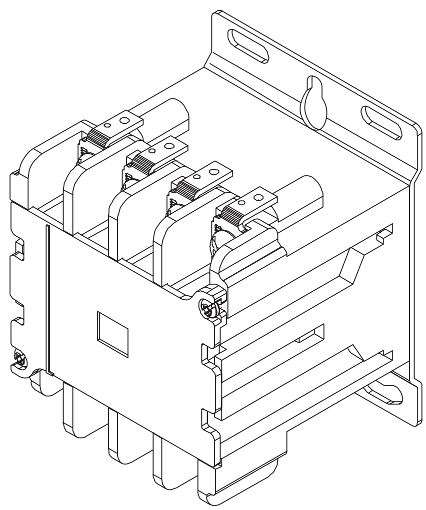


# Lighting and Heating Contactors

**Electrically Held Contactors**

Most lighting and heating applications require the use of a contactor to control the loads. One type of contactor is an **electrically held contactor**, which is similar to a magnetic starter. Unlike a magnetic starter, however, the lighting/heating contactor is designed for lighting and resistive heating loads rather than motor loads.

Siemens Class LE lighting and heating contactors are available with 2-12 poles rated from 20-400 amperes. They can be used on 480VAC tungsten and 600VAC ballast-type lighting loads as well as 600VAC resistive loads. Enclosures are also available.



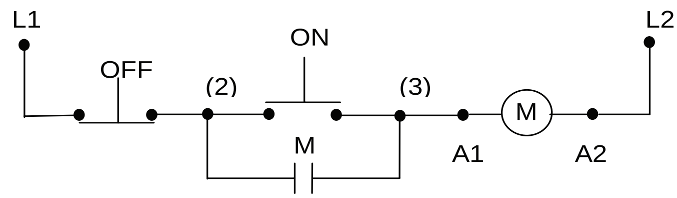
**Basic Contactor Operation**

Electrically held lighting contactors utilize the same operating principles as the magnetic contactors and starters that you learned about previously. This style of contactor will open when control power is lost.

**Some Typical Applications**

Electrically held contactors are typically used in applications where noise is not an issue. These contactors have an inherent hum due to the electromagnetic coil and the constant supply of voltage to it. This type of contactor is not recommended for locations where this humming can be heard, such as libraries, hospitals, and some commercial buildings.

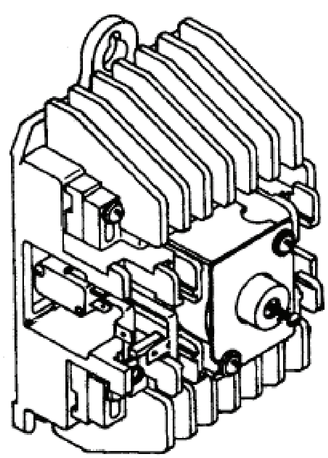
Here is a typical wiring schematic for an electrically held lighting/heating contactor with ON/OFF pushbuttons.




**Magnetically Held and Mechanically Latched Contactors**

**Mechanically held** and **mechanically latched contactors** are also used for lighting and heating applications and are designed for lighting and resistive heating loads.

Siemens Class CLM lighting and heating contactors are available with 2-12 poles, rated from 20-400 amperes. They can be used on 480VAC tungsten, 600VAC ballast, and general type lighting and resistive heating loads.



**Basic Contactor Operation (Magnetically Held)**

Each magnetically held contactor contains a permanent magnet that will maintain the contactor in its energized state indefinitely, without using control power.

When the contactor is energized, DC voltage is applied to produce a magnetic field that reinforces the polarity of the permanent magnet and closes the contactor. Current to the coil is then immediately disconnected by the coil clearing auxiliary contact.

To open the contactor, it is necessary to create a field through the OFF coil in reverse direction to the permanent magnet. This momentarily cancels the magnetic attraction, and the contactor drops out.

**Basic Contactor Operation (Mechanically Latched)**

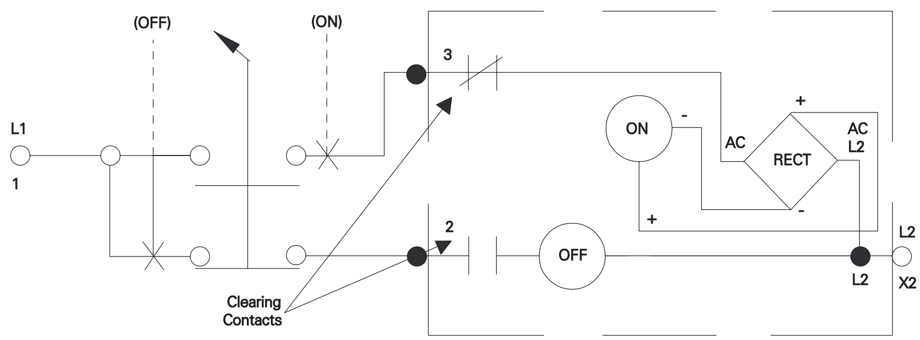
These contactors are latched mechanically and released electrically by means of an AC trip solenoid and clearing contact. It is similar to the magnetically held contactor in that it will remain in the closed state indefinitely. The contactor opens only when the trip solenoid receives a signal to release the mechanical latch.

**Some Typical Applications**

Magnetically held and mechanically latched contactors are typically used where noise is a concern, in locations such as libraries, hospitals, or stores. Such contactors are well-suited to these sites because they do not require a constant supply of voltage to the coil (thus eliminating the inherent humming noise typical of electrically held contactors).

These types of contactors are also used in parking lots and stadium lighting, since the contactor is not affected by loss of power. If power is lost, the contactor remains in the ON or closed state. When power is restored, the lights stay on without requiring someone to turn them on.

Here is a typical wiring schematic for a magnetically held and mechanically latched lighting contactor with ON/OFF selector switch.



# Pilot Devices

A **pilot device** directs the operation of another device (pushbuttons or selector switches) or indicates the status of an operating machine or system (indicator lights).

Siemens pilot device offerings include devices with a variety of features and mounting dimensions, with selections appropriate for a broad range of applications, including:

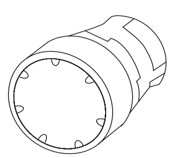
- 3SB2 devices with 16 mm mounting diameters
- SIGNUM 3SB3 devices with 22 mm mounting diameters, and
- Class 51/52 devices with 30.5 mm mounting diameters.

(In each case the mounting diameter refers to the size of the knockout hole (in millimeters) required to mount the devices.)

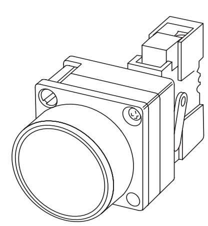
Class 51 devices are rated for hazardous locations such as Class I, Groups C and D and Class II, Groups E, F, and G. Class 52 devices are heavy duty products designed for harsh, industrial environments.

**Pushbuttons**

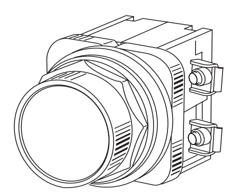
A **pushbutton** is a control device used to manually open and close a set of contacts. Pushbuttons may be illuminated or non-illuminated, and are available in a variety of configurations and actuator colors.



16 mm 3SB2 Pushbutton



22 mm SIGNUM 3SB3 Pushbutton

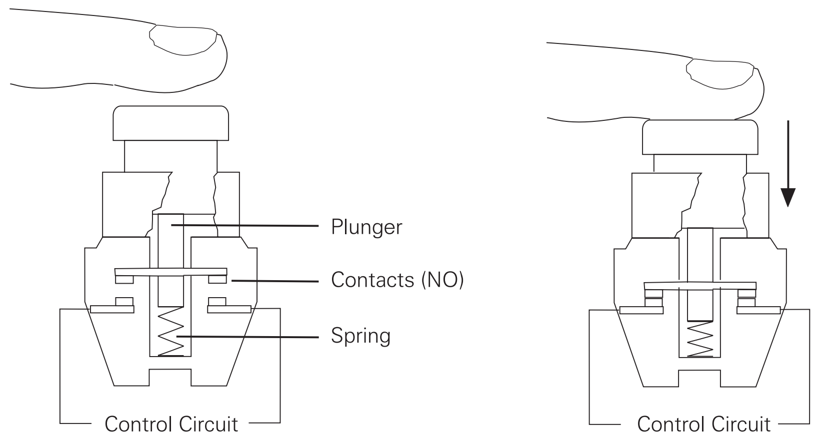


30 mm Class 52 Pushbutton

**Normally Open Pushbuttons**

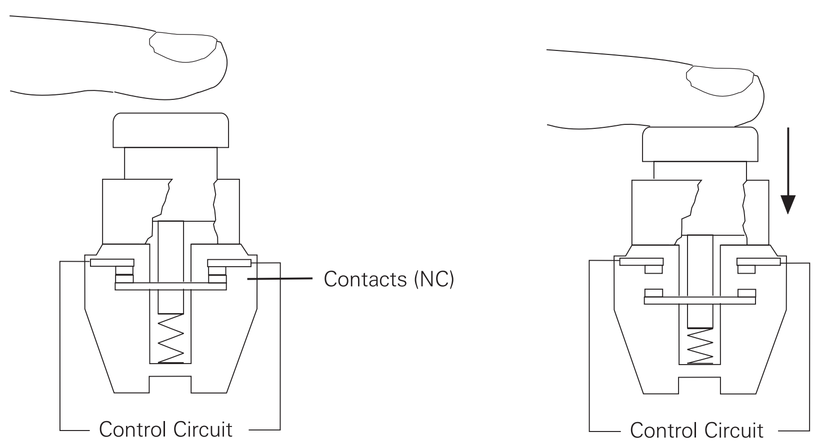
Pushbuttons are used in control circuits to perform various functions; for example, starting and stopping a motor.  A typical pushbutton uses an operating plunger, a return spring, and one set of contacts.

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**

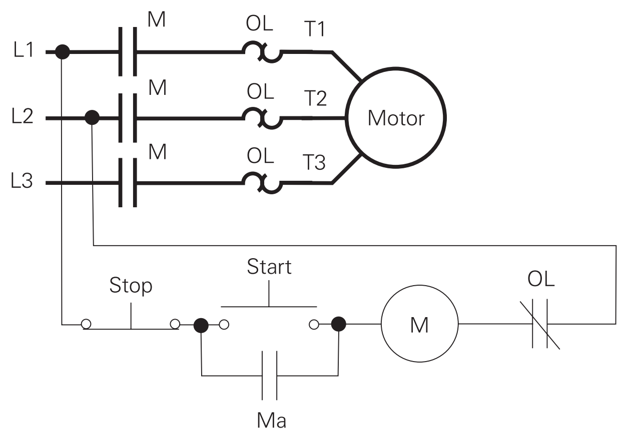
Normally closed (NC) pushbuttons, such as the one shown below, are also used to open and close a circuit. In this pushbutton's normal position, the contacts are closed to allow current flow through the control circuit. Depressing the button opens the contacts, preventing current flow through the circuit. 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.



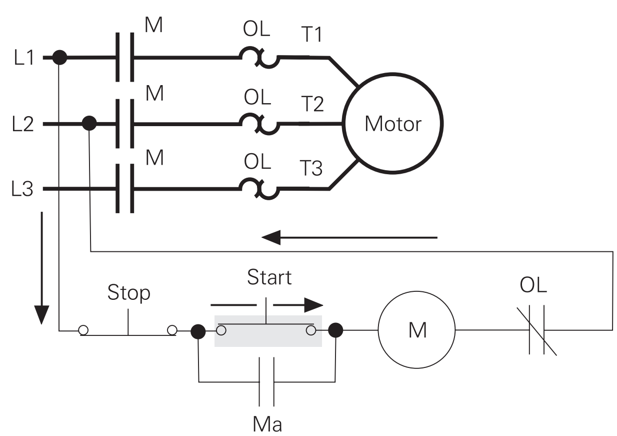
Pushbuttons are available with variations of the contact configuration. For example, a pushbutton may have one set of normally open and one set of normally closed contacts so that when the button is depressed, one set of contacts is open and the other set is closed. By connecting to the proper set of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

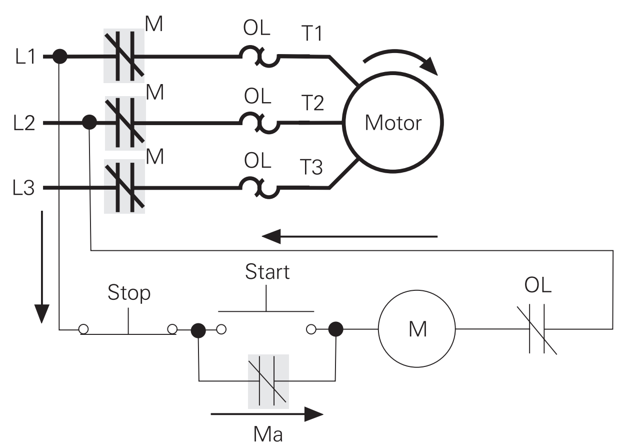


## Holding Circuit Three-Wire Control

Depressing the “Start” pushbutton 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”).

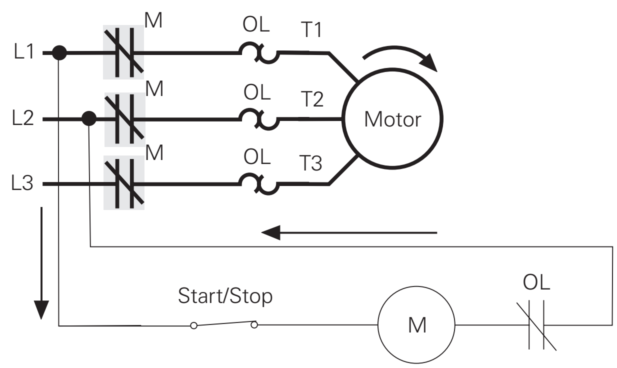
An advantage to three-wire control is **low-voltage protection**. If an overload causes the “OL” contacts in the control circuit to open, the “M” coil is de-energized and the motor shut down. When the overload is cleared, the motor will not suddenly restart on its own. An operator must depress the “Start” button to restart the motor.



## Two-Wire Control

A **two-wire control** circuit provides low-voltage release, but not low-voltage protection. Low-voltage release means that in the event of a power loss, the contactor will de-energize, stopping the motor. When the contacts of the control device open, the power is removed from the motor and it stops. However, when power is restored, the motor will restart without warning if the control device is still closed.

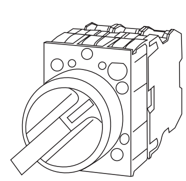
This type of control scheme is used for remote or inaccessible installations such as water-treatment plants or pumping stations. In these applications it is desirable to have an immediate return to service when power is restored.



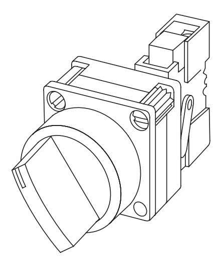

## Selector Switches

**Selector switches** are also used to manually open and close contacts. Types of selector switches are **maintained**, **spring return** or **key operated**. Selector switches are available in two-, three-, and four-position types.

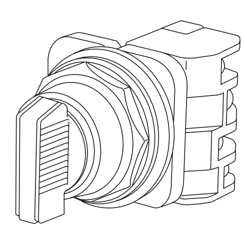
The basic difference between a push button and a selector switch is the operator mechanism. With a selector switch, the operator is rotated to open and close contacts. Contact blocks used on pushbuttons are interchangeable with those on used on selector switches. Selector switches are used to select 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.



16 mm 3SB2
Selector Switch



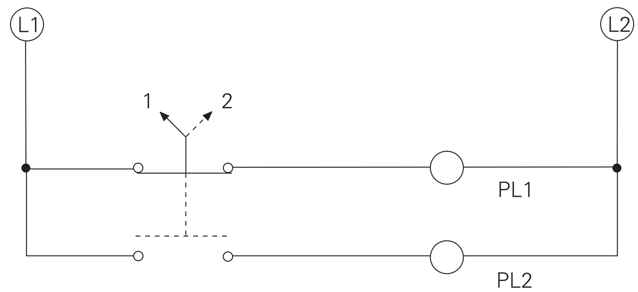
22 mm SIGNUM
3SB3 Selector Switch



30.5 mm Class 52
Selector Switch

## Two Position Selector Switch

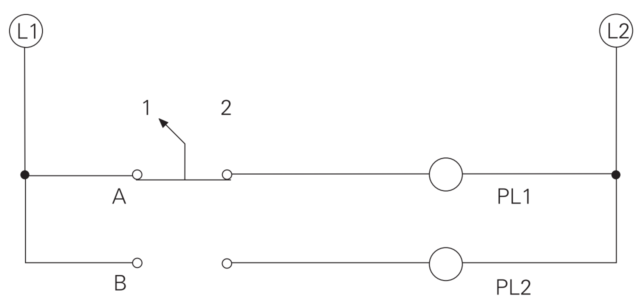
In the example below, PL1 is connected to the power source when the switch is in position 1, and PL2 is connected to the power source when the switch is in position 2. In this circuit, either PL1 or PL2 would be on at all times. If there was only one load, the selector switch could be used as an On/Off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

The second method uses **truth tables** (also known as target tables), where each contact is marked with a letter. An “X” in the truth table indicates which contacts are closed for a given switch position. In the example below, 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.




Contacts

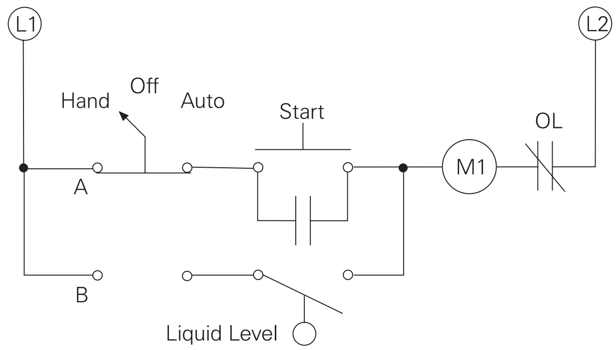
| Position | A | B |
|---|---|---|
| 1 | X | |
| 2 | | X |

2 Position
Selector Switch

**Three-Position Selector Switch**

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 (as illustrated below) 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 switch to the Off position.The liquid level switch has no effect in either the Hand or Off position. When the selector switch is set to Auto, the pump will be controlled by the liquid-level switch. The liquid level switch closes at a predetermined level, starting the pump. At another predetermined level the liquid level switch opens, stopping the pump.



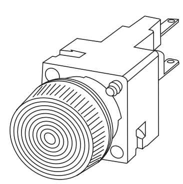

Contacts

| Position | A | B |
|---|---|---|
| 1 | X | |
| 2 | | |
| 3 | | X |

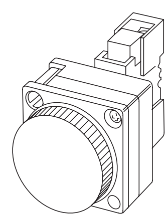
3 Position Selector Switch

**Indicator Lights**

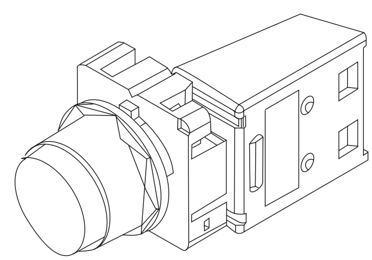
**Indicator lights** (sometimes referred to as pilot lights) provide visual information of the circuit's operating condition at a glance. Indicator lights are normally used for "ON/OFF" indication, caution, changing conditions, and alarm signaling.



16 mm 3SB2 Indicator Light

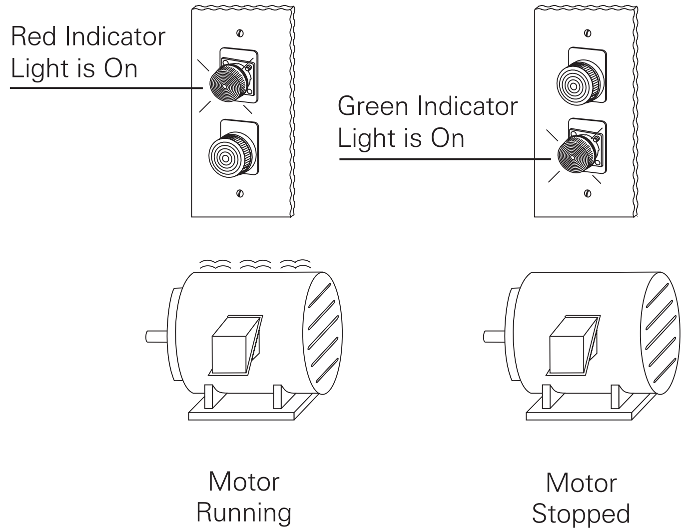


22 mm SIGNUM 3SB3 Indicator Light



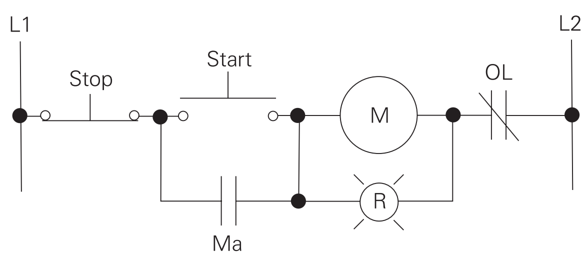
30.5 mm Class 52 Indicator Light

Indicator lights come with a color lens (typically red, green, amber, blue, white, or clear). A red indicator light normally indicates that a system is running. A green indicator light normally indicates that the system is off or de-energized. For example, a red indicator light located on a control panel would give visual indication that a motor was running, while a green indicator light would indicate that the motor was stopped.

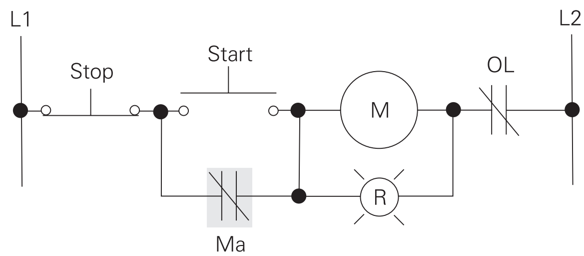



**Using an Indicator Light in a Control Circuit**

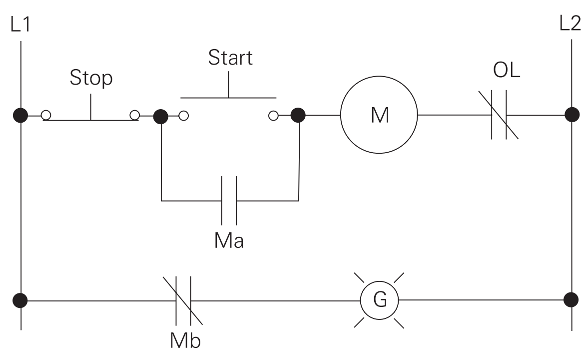
In the following line diagram, a red indicator light is connected in parallel with the “M” electromagnetic coil.



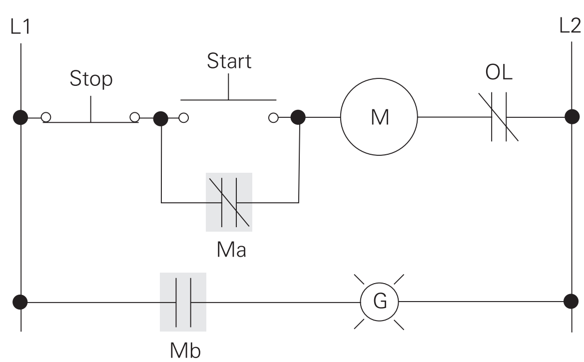
When the coil is energized, the light will illuminate to indicate that the motor is running. Even if the indicator light burns out, the motor will continue to run.




In the line diagram below, a green indicator light is connected through a normally closed "M" auxiliary contact (Mb). When the coil is de-energized, the indicator light is on to indicate the motor is <u>not</u> running.



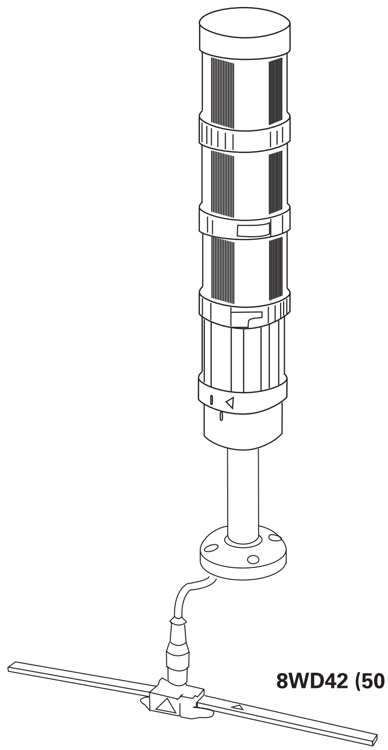

Depressing the "Start" pushbutton and energizing the "M" contactor opens the normally closed "Mb" contacts, turning the light off.



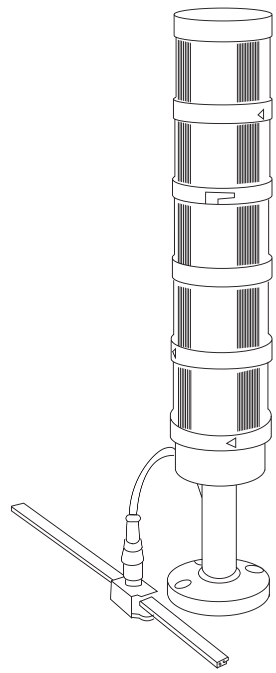
## Signaling Columns

**Signaling columns** allow operating personnel to monitor machine or process operation from a distance.

Columns are easily assembled by stacking elements to achieve the desired configuration. Various visual elements are available to provide steady, flashing, and rotating beacon indications in five colors: red, yellow, green, white, and blue. Buzzer or siren elements can be added to provide audible indications of machine or process conditions. Siemens 8WD42 and 8WD44 signaling columns also can be networked to other devices through an optional AS-interface adapter.



8WD42 (50 mm)



8WD43 (70 mm)

**Review 7**

1. Soft starters limit motor starting current and torque by gradually increasing the portion of the

   ______________ ________________ ______________ applied to the motor windings

2. Potentiometers on the front of SIRIUS 3RW40 soft starters provide settings for:
   1. ________________________________________
   2. ________________________________________
   3. ________________________________________

3. A (an) ______________ ______________ lighting and heating contactor is best used in applications where noise is not an issue.

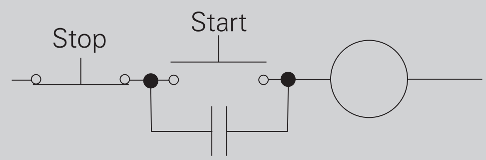
4. Lighting and heating contactors are rated by:
   a. Horsepower
   b. Amperes

5. ____________ ____________ and ____________ ____________ lighting and heating contactors are not affected by a loss of control power.

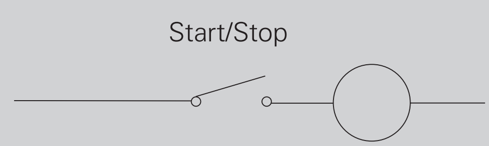
6. A ____________ ____________ directs the operation of another device, or indicates the status of the operating system.

7. Label each of the circuits below as representing either two-wire control or three-wire control.

____ - Wire Control




____ - Wire Control




8. Indicator lights provide ____________ information of the circuit's operating condition.

9. A ____________ indicator light normally indicates a motor is running, while a ____________ indicator light normally indicates that the motor is stopped.