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Motor Control Fundamentals

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Siemens Control Products

Siemens offers a full range of products designed to meet the needs of virtually any construction or industrial related control application. This includes manual motor starters and switches, pilot devices, IEC and NEMA starters and contactors, lighting contactors, duplex motor controls, pump control panels, and reduced voltage starters.

Course Objectives

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Upon completion of this course you will be able to…

- State the purpose and general principles of control components and circuits
- State the difference between manual and automatic control operation
- Identify various symbols which represent control components
- Read a basic line diagram
- Describe the construction and operating principles of manual starters, electromagnetic contactors, and electromagnetic motor starters
- Explain the need for motor overload protection
- Briefly describe the operation of thermal and electronic overload relays
- Describe the advantages of reduced-voltage motor starting
- Describe the advantages of variable frequency drives

Energy Consumption by Electric Motors

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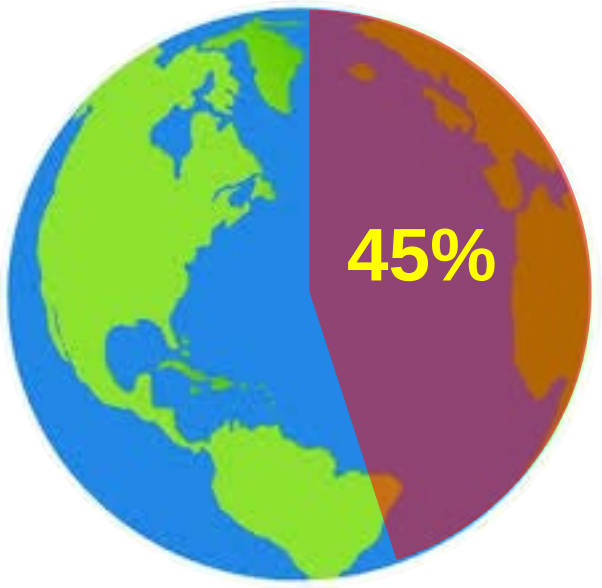
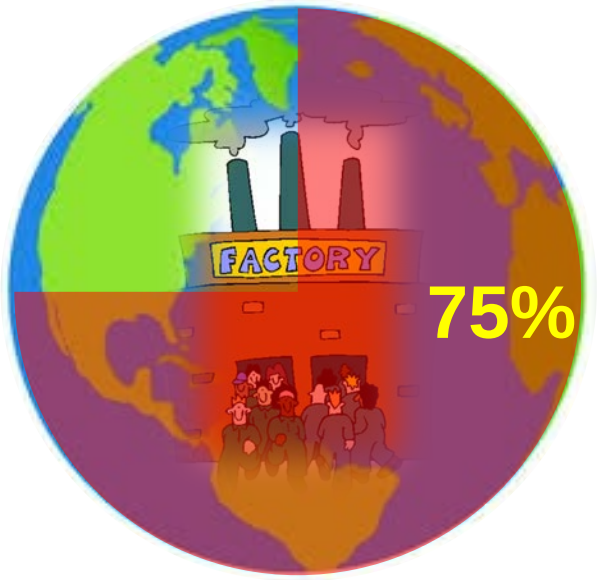
Global



According to the International Energy agency, electric motors account for approximately 45% of all electricity usage.

Industrial



According to the International Energy agency, electric motors account for approximately 75% of all industrial electricity usage.

AC Motor Construction

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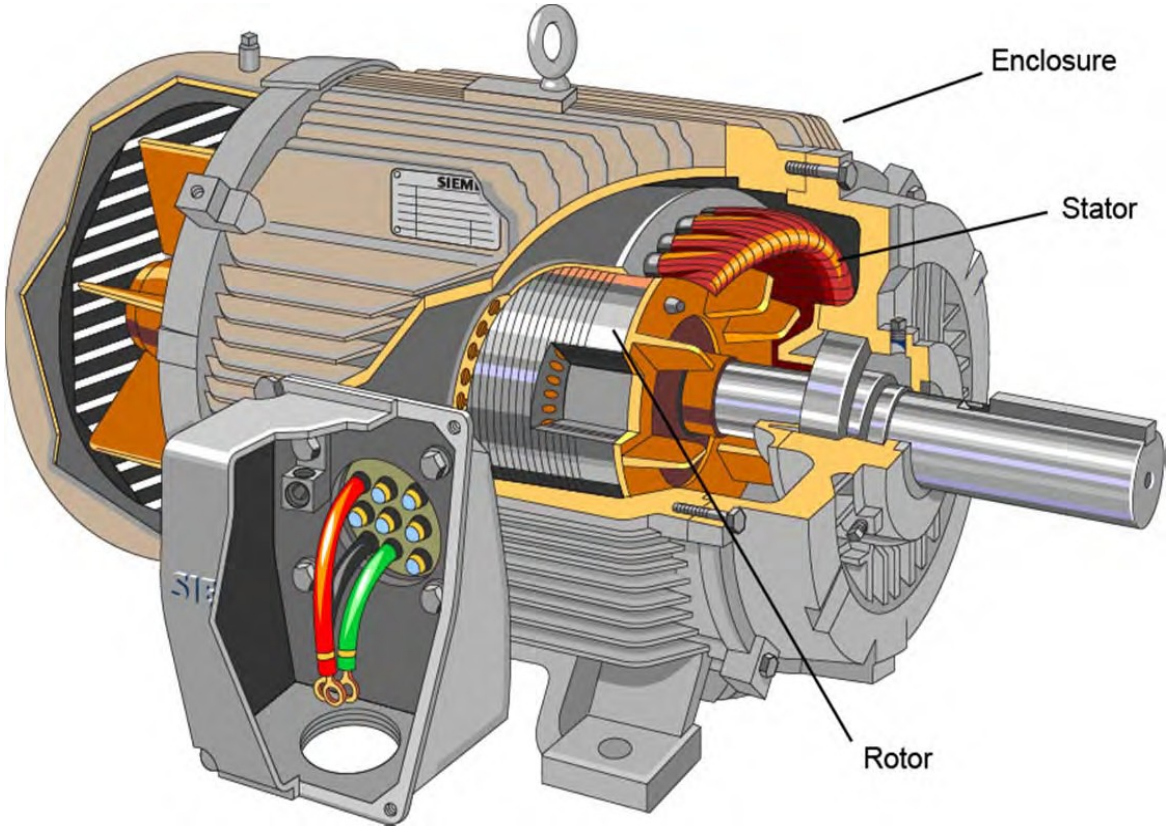
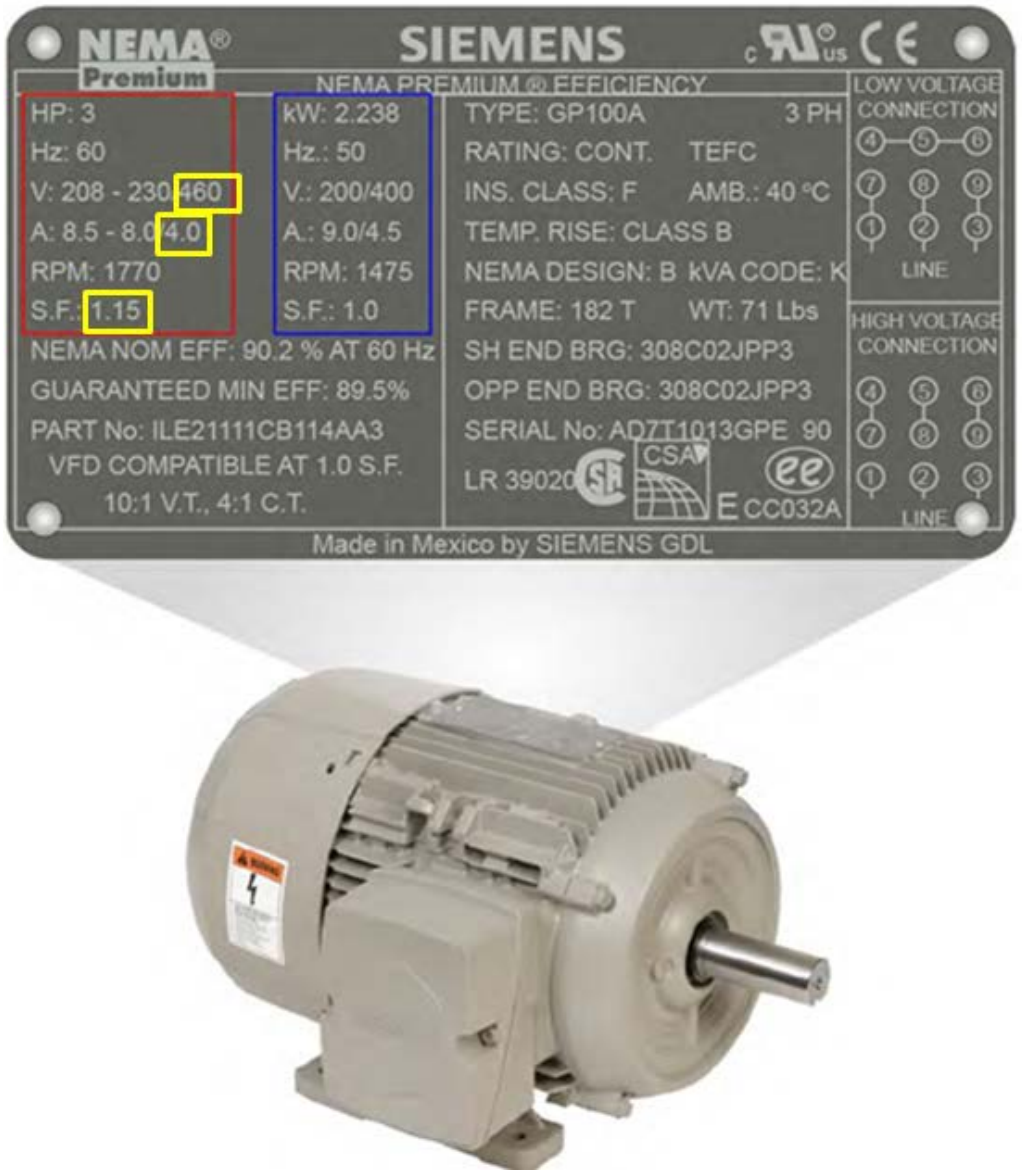
Three-phase induction motors are commonly used in industrial applications. This type of motor has the following three main parts: rotor, stator, and enclosure. The stator and rotor do the work, and the enclosure protects the stator and rotor.

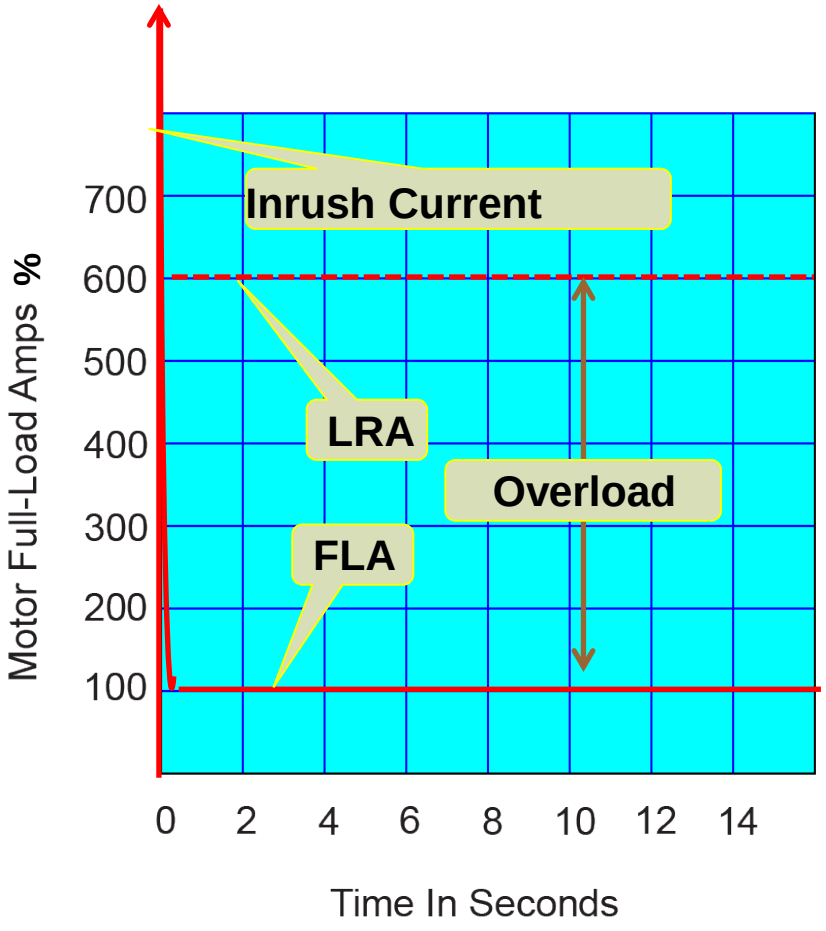


Motor Nameplate



All electric motors contain a rating nameplate containing various kinds of information. For motor control circuits, what is important is the Full Load Current (FLA) at the applied voltage and the service factor. As shown, the pictured motor has an FLA of 4.0A at 460VAC and a 1.15 service factor.

Motor Current
FLA and LRA



- Full Load Amp (**FLA**) current rating - the nominal current flow to the motor after motor start and under normal operation conditions. Used to calculate inrush current and select short circuit protective devices
- Locked Rotor Amps (**LRA)** – occurs when something prevents the motor from turning, typically 600% of the motor **FLA**.
- **Inrush Current** – occurs immediately after starting a motor. Circuit breakers and fuses must be sized to accommodate this current.

Overload protective relays, which we will discuss later in this presentation, provide projection for motor currents from 125% of the motor **FLA** up to the **LRA** of 600%.

Three Phase Power

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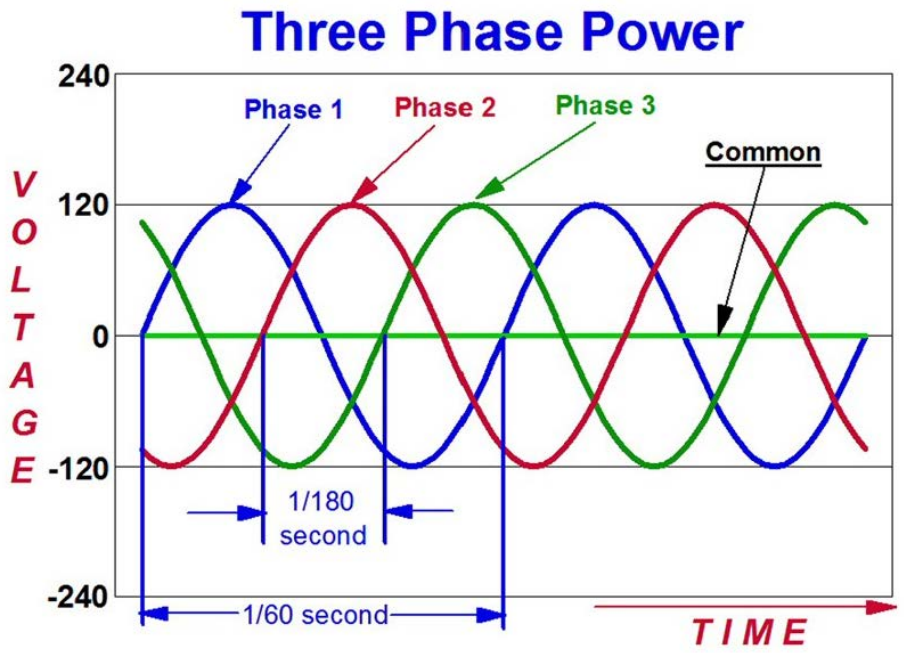
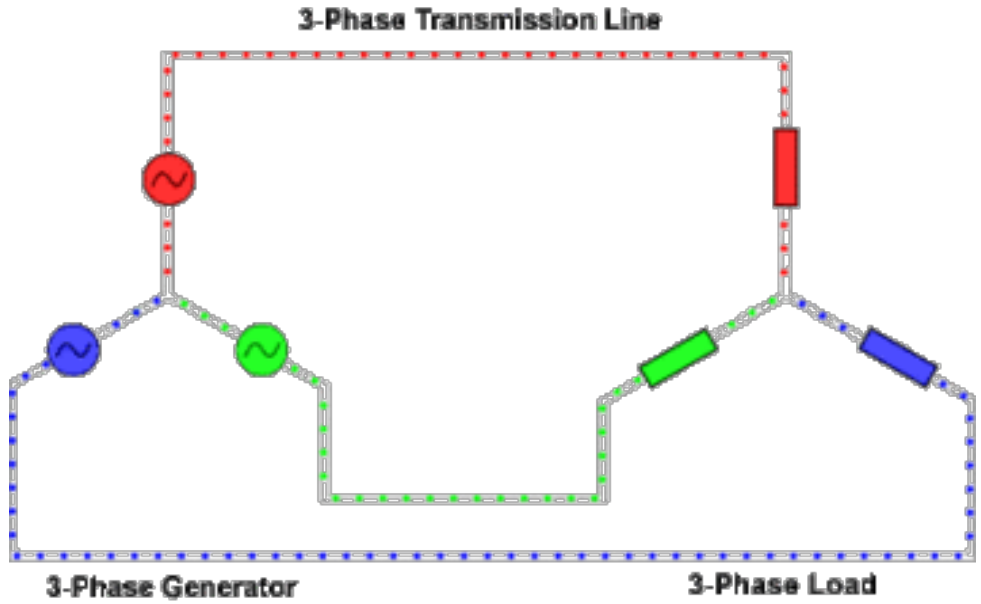
Electricity is generated as three phase. Compared to single phase power which uses two wires, three phase provides three times the power with one additional wire and is often used for motors. While there are occasional exceptions, load switching and protective devices, such as circuit breakers, MSPs, contactors and overloads, are 3 pole devices.





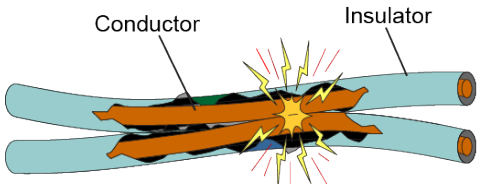
Motor Fundamentals

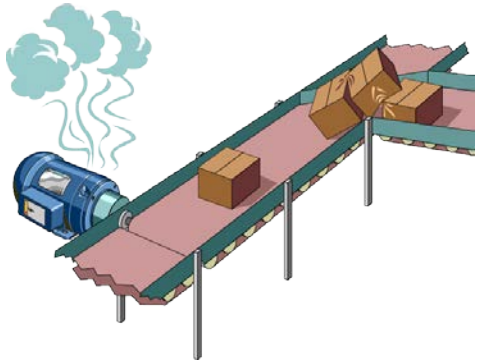
The amount of heat generated is proportional to both the amount of current flow and the resistance of the conductive path. Because conductors can be damaged by excess heat, each conductor has a continuous current rating, also called its ampacity.
The following are potential causes of overcurrent:

Short circuit - When two or more bare conductors touch causing the resistance between the two to drop

Overload - When the current exceeds the trip class of the device

Ground fault - Inadvertent contact between an energized conductor and ground or equipment frame





Control Devices
Contacts

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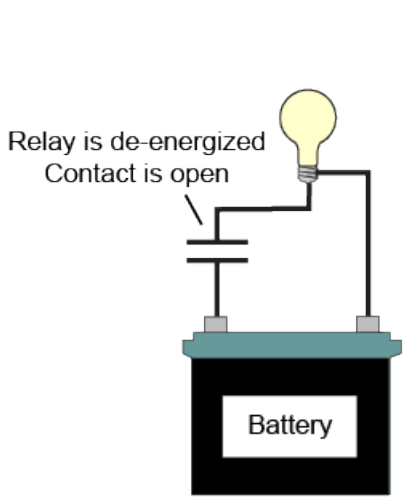
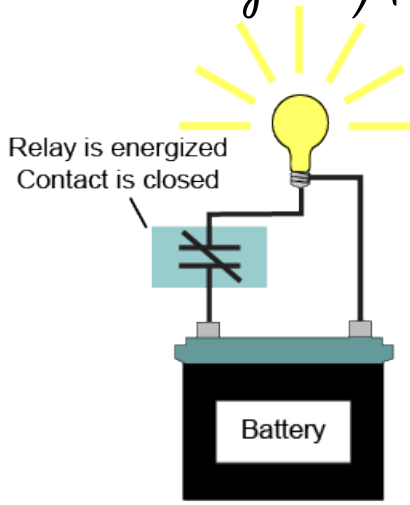
Normally Open Contacts (NO)

When not operated, they are open and the current is blocked. When the contacts close, current is allowed to flow.



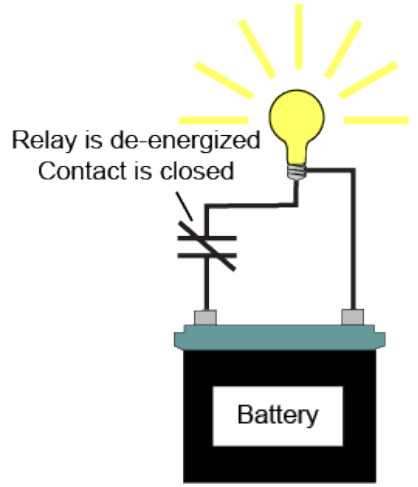
Not operated



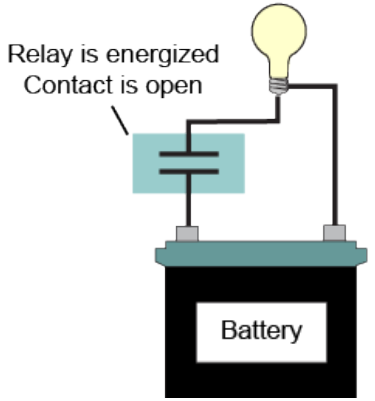
Operated

Normally Closed Contacts (NC)

When not operated, they are closed and the current is allowed to flow. When the contacts are operated, they open causing the current to stop.



Not operated



Operated

Control Devices
Electromagnetic Principles

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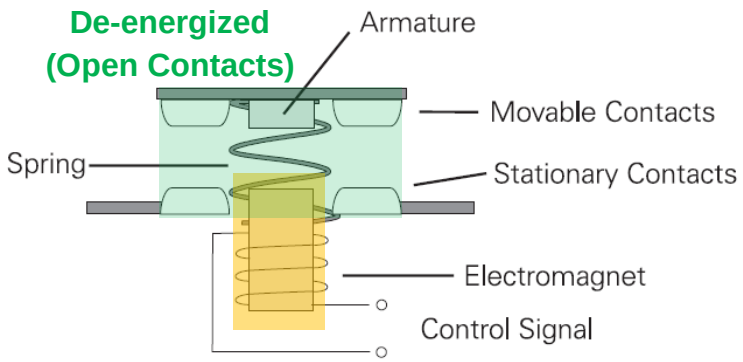
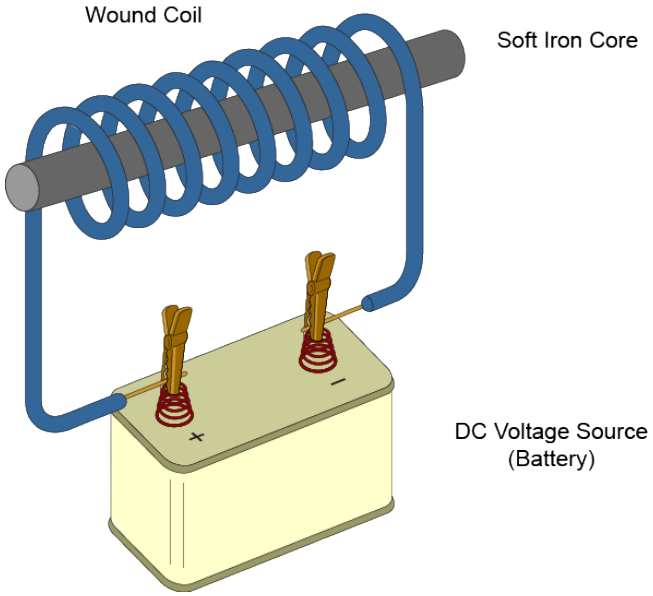
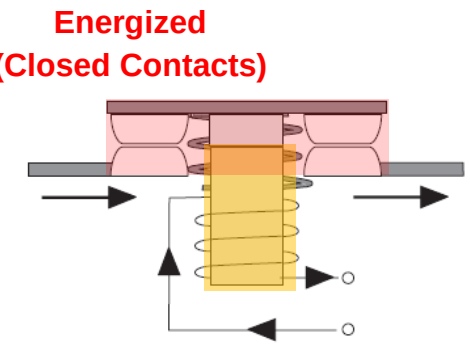
Contactors, starters and relays are electromagnetic devices and use an electromagnet to operate NO and NC contacts. Consider a simple electromagnet with a wire coil around a soft iron core connected to a voltage source. Current flowing through the wire coil magnetizes the iron core. When the coil is disconnected, the current stops and the iron core returns to its nonmagnetic state.







Control Devices
Pushbuttons and switches

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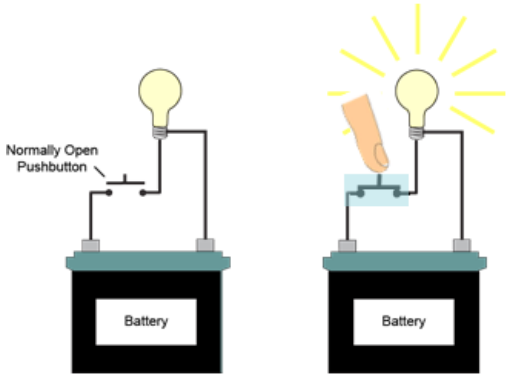
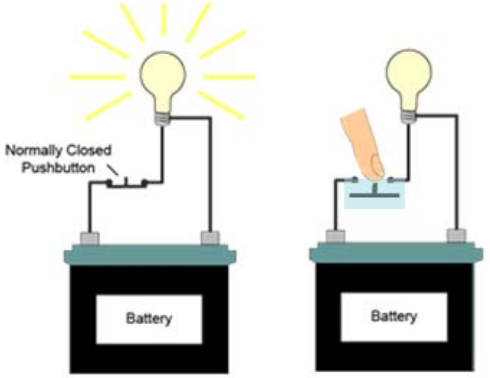
Pushbuttons

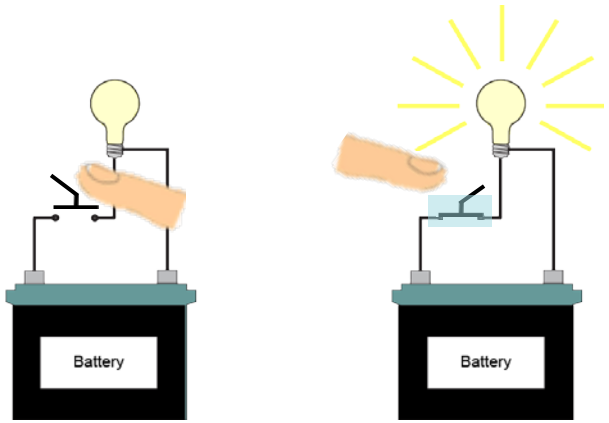


Momentary - return to their normal state as soon as the button is released.



Maintained - latches in place when pressed and must be unlatched to return it to its normal state.

Selector Switches



Unlike pushbuttons, selector switches are maintained devices and require manual operation to change their state.

Control Devices
Pushbuttons and switches rating

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Push buttons and switches are rated for control circuit use and have low current ratings. Contacts for Siemens Sirius Act pilot devices are rated A600/R300 per UL. The AC600 rating shows that the contact can close (Make) 10X the rated current and open (Break)1X the rated current. At 120V AC, these contact blocks can make 60A and break 6A. R300 is the rating for switching DC current.

AC-Control Circuit Classifications—NEMA

NEMA designates Control Circuit Rating with a code letter (for current) and a voltage code.

Ratings & Test Values for AC Control Circuit Contacts at 50 or 60Hz

Contact Rating Designation	Thermal Continuous Test Current, Amperes	Maximum Current, Amperes								Voltamperes	
		120 Volts		240 Volts		480 Volts		600 Volts			
		Make	Break	Make	Break	Make	Break	Make	Break	Make	Break
A150	10	60	6	—	—	—	—	—	—	7200	720
A300	10	60	6	30	3	—	—	—	—	7200	720
A600	10	60	6	30	3	15	1.5	12	1.2	7200	720
B150	5	30	3	—	—	—	—	—	—	3600	360
B300	5	30	3	15	1.5	—	—	—	—	3600	360
B600	5	30	3	15	1.5	7.5	0.75	6	0.6	3600	360
C150	2.5	15	1.5	—	—	—	—	—	—	1800	180
C300	2.5	15	1.5	7.5	0.75	—	—	—	—	1800	180
C600	2.5	15	1.5	7.5	0.75	3.75	0.375	3	0.3	1800	180
D150	1	3.6	0.6	—	—	—	—	—	—	432	72
D300	1	3.6	0.6	1.8	0.3	—	—	—	—	432	72
E150	0.5	1.8	0.3	—	—	—	—	—	—	216	36

Typical Control Symbols

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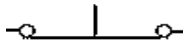
There are many types of control symbols, but some examples of symbols you will encounter later in this presentation are shown below:

NO (normally open) contact

NC (normally closed) contact

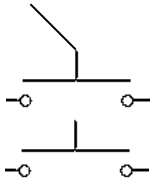
NO Push Button



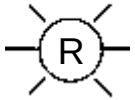
NC Push Button

NO Switch Contact

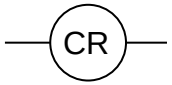
NO Switch Contact



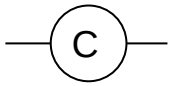
Selector Switch



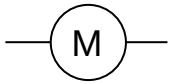
Pilot Light (PL) (Red)



Control Relay Coil



Contactor Coil

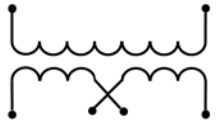


Motor Starter Coil

Overload Element (OL)

Molded Case Circuit Breaker (MCCB)

Fuse



Control Power Transformer (CPT)

Control Symbols
Coils and contacts

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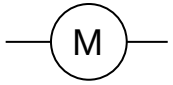
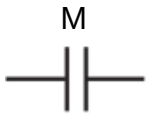
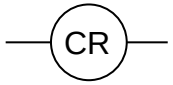
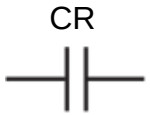
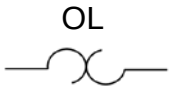
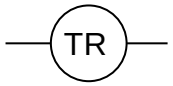
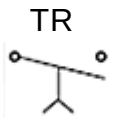
Operators	Associated Contacts
	
	
	
	

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 one or more letters or number inside. The letters often represent the type of device, such as M for motor starter, CR for control relay, OL for overload relay or TR for timing relay. Note that the sensing element for overload relays is symbolized differently as it does not have a traditional contactor relay coil.

The contacts controlled by an operator are labeled with the same letter (and number) as the operator. An operator often controls multiple contacts, and a combination of normally open and normally closed contacts may be used.

Circuits Diagrams

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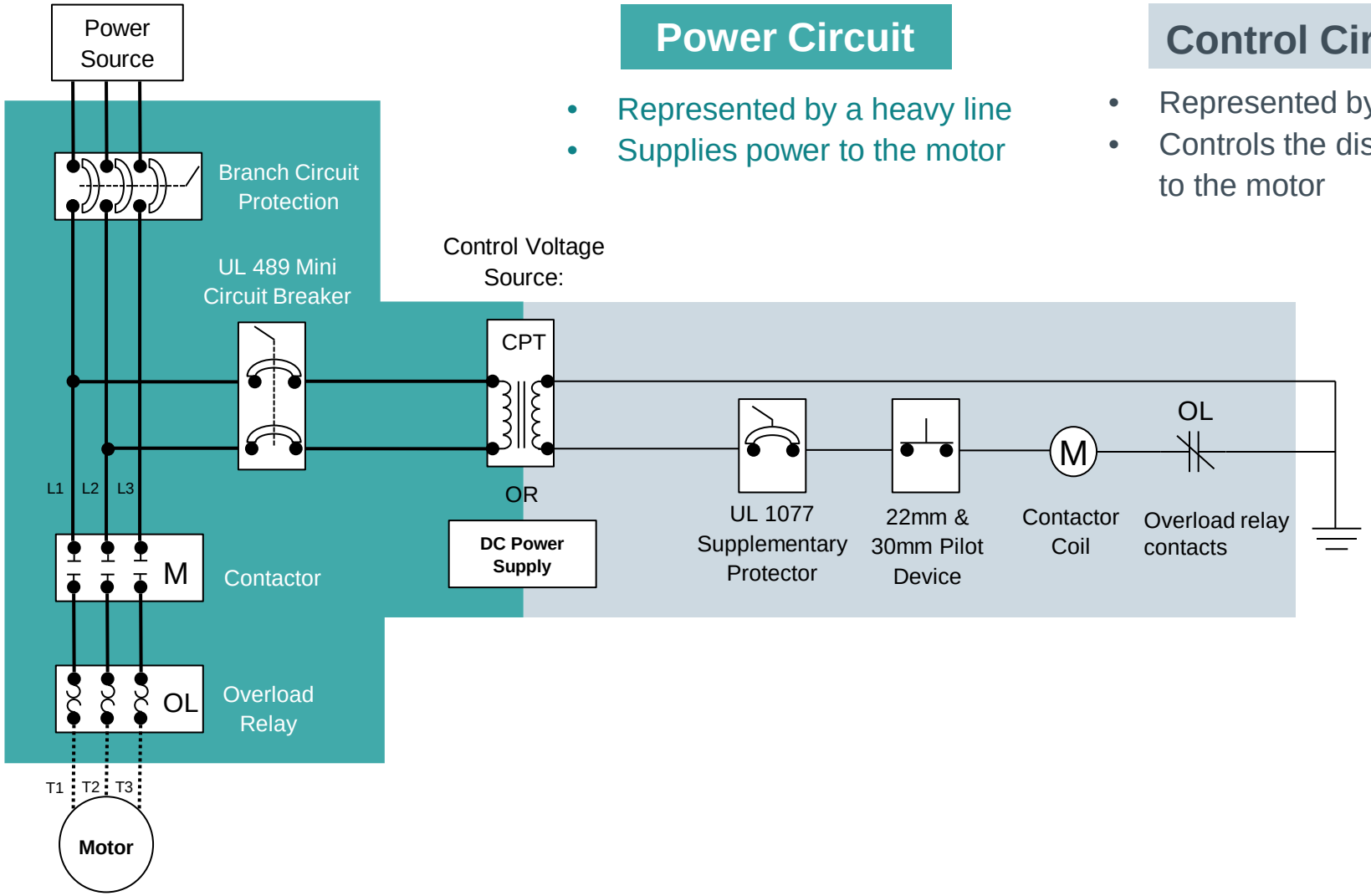
Power Circuit

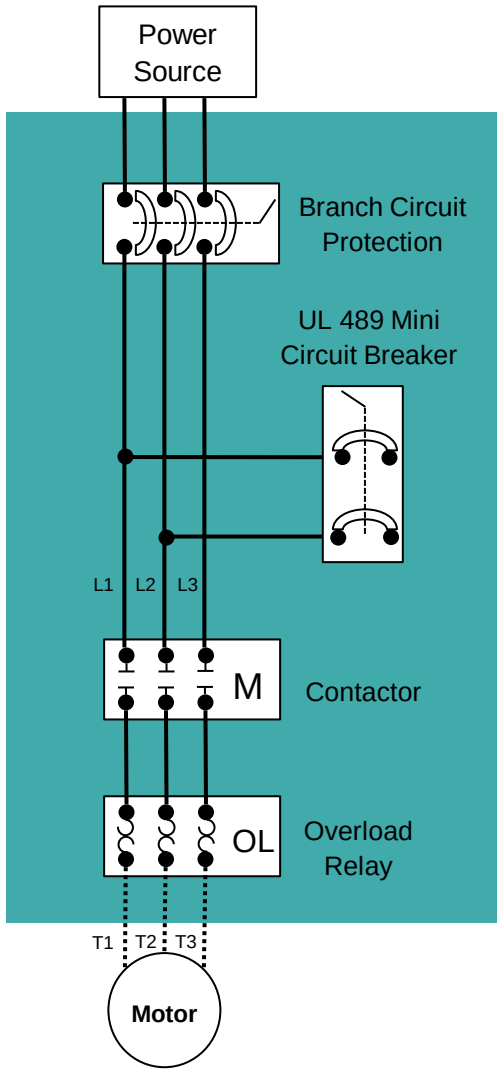
- Represented by a heavy line
- Supplies power to the motor

Control Circuit

- Represented by a light line
- Controls the distribution of power to the motor



Power Circuit



Power circuits provide protection for and control of load devices, typically motors. According to both the National Electrical Code (NEC) and Underwriters Laboratories (UL), power circuits require:

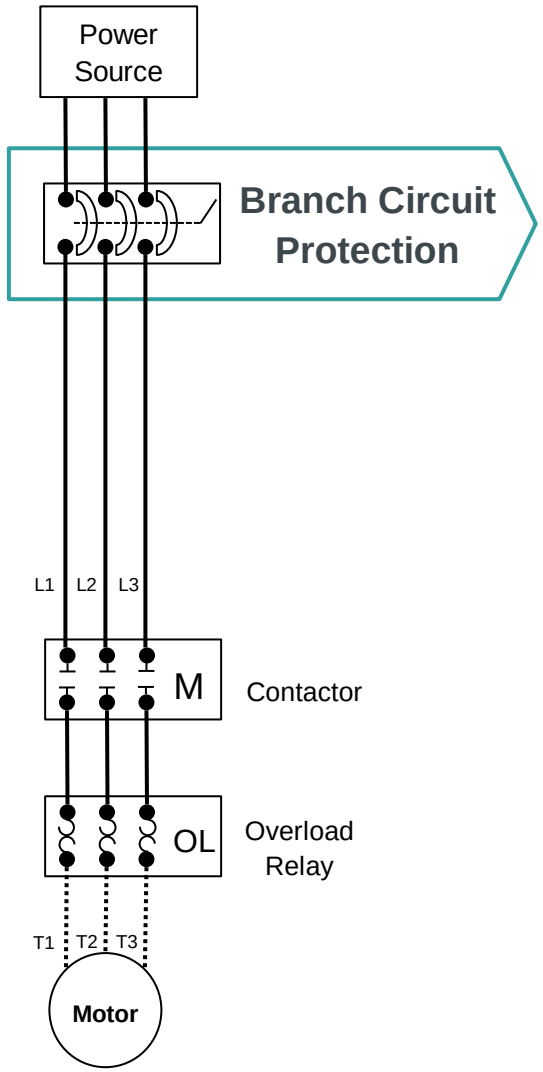
- Disconnect
- Short circuit protection
- Control
- Overload (running current) protection

To meet these requirements, a power circuit will be comprised of:

1. Branch circuit protection
2. Control device
3. Overload Protection

Typical Devices: contactors, motor starters, reduced voltage solid state starters (RVSS) and variable frequency drives.

1 Branch circuit protection

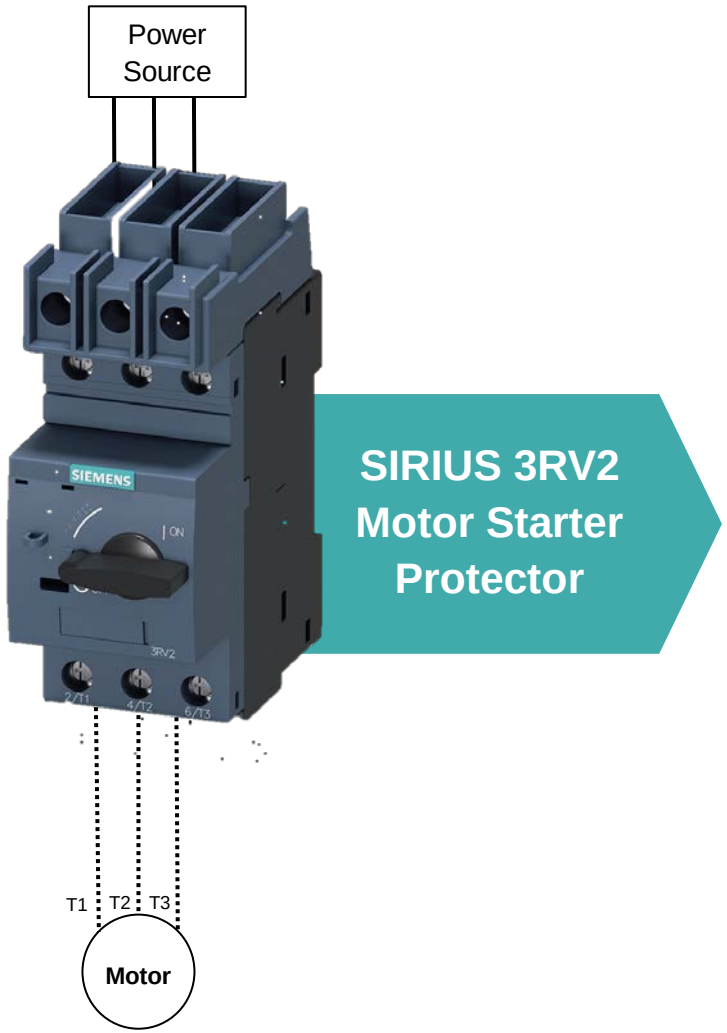


Motor Starter Protectors (MSP)

Molded Case Circuit Breakers (MCCB)

Fuses

1 Branch circuit protection – **Motor Starter Protector (MSP)**



SIRIUS 3RV2 Motor Starter Protector

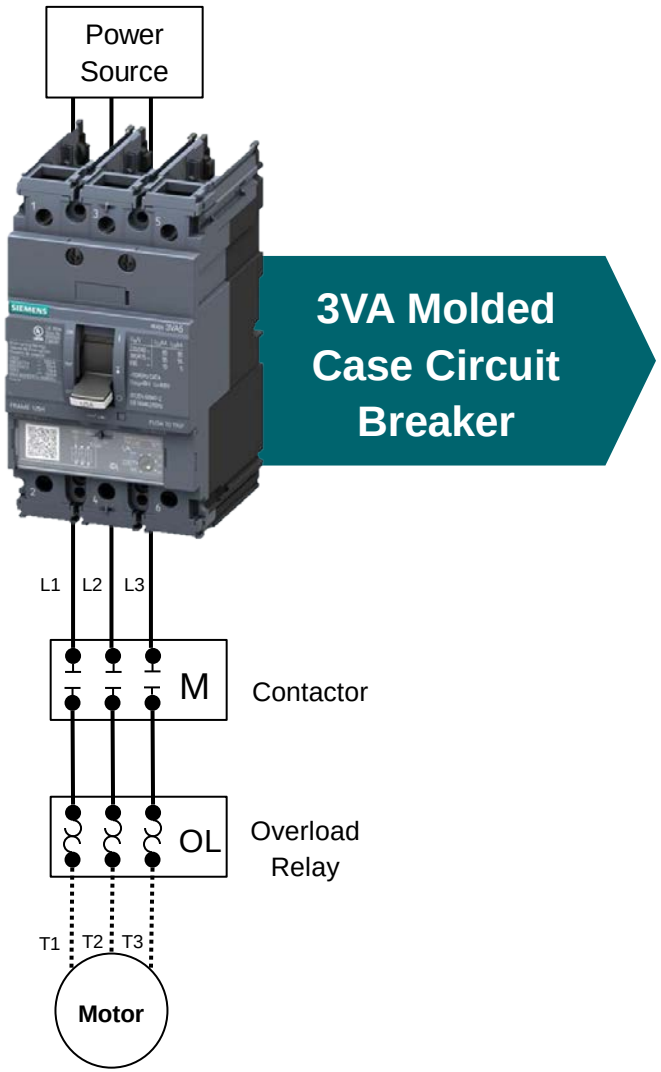
3RV2 MSPs are UL 508A Type E self-protected combination motor controllers. They provide all the required functions for a motor branch (disconnect, short circuit protection, manual motor control, and overload protection). They are suitable for group installation and provide tap conductor protection in compliance with the NEC.

Note: As a branch or self protected device the voltage ratings are 600/347, 480/277, or 240VAC. If the MSP is connected to a non-slash rated voltage supply, then the maximum allowed voltage is 347VAC.

3RV2 MSPs are also approved for use as follows:

- Manual Motor Controller: motor starter, motor disconnect, control and overload protection when provide with appropriate branch circuit protection.

1 Branch circuit protection – **Molded Case Circuit Breaker (MCCB)**



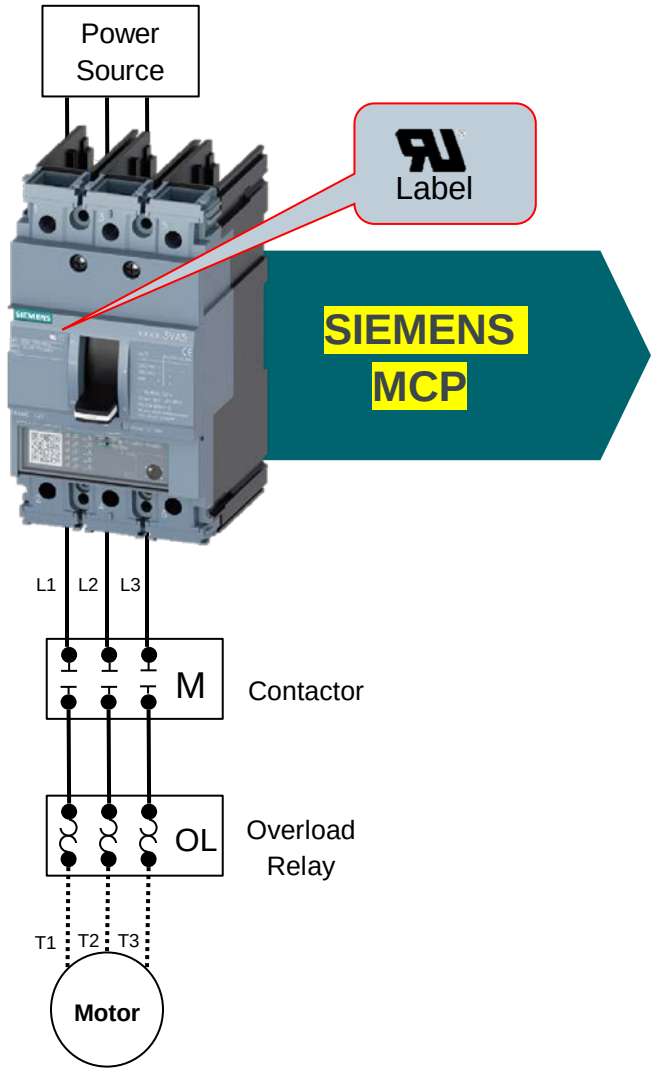
Thermal Magnetic or electronic trip MCCBs provide disconnect means, short circuit protection and overload protection.

The magnetic portion reacts rapidly to large currents to provide short circuit protection while the thermal portion reacts slowly to slightly increased currents, providing overload protection. However, motors contain a large amount of metal and heat and cool much more slowly than the conductors that are connected to it. For this reason, a thermal magnetic MCCB does not provide suitable overload protection for a motor. As a result, overload relays must be used for motor overload protection.

Electronic trip MCCBs uses a micro processor to emulate the thermal magnetic tripping functions and functions, such as monitoring and metering and communication.

MCCBs are not designed for frequent switching, and therefore must be used in conjunction with a control device such as a contactor or motor starter.

1 Branch circuit protection – **Molded Circuit Protectors (MCP)**



MCPs are MCCBs without the thermal overload protection. Unlike MCCBs that are UL listed, MCPs do not have thermal protection and have a UR label indicating that separate overload protection will have to be added.

1 Branch circuit protection – **Fuses**

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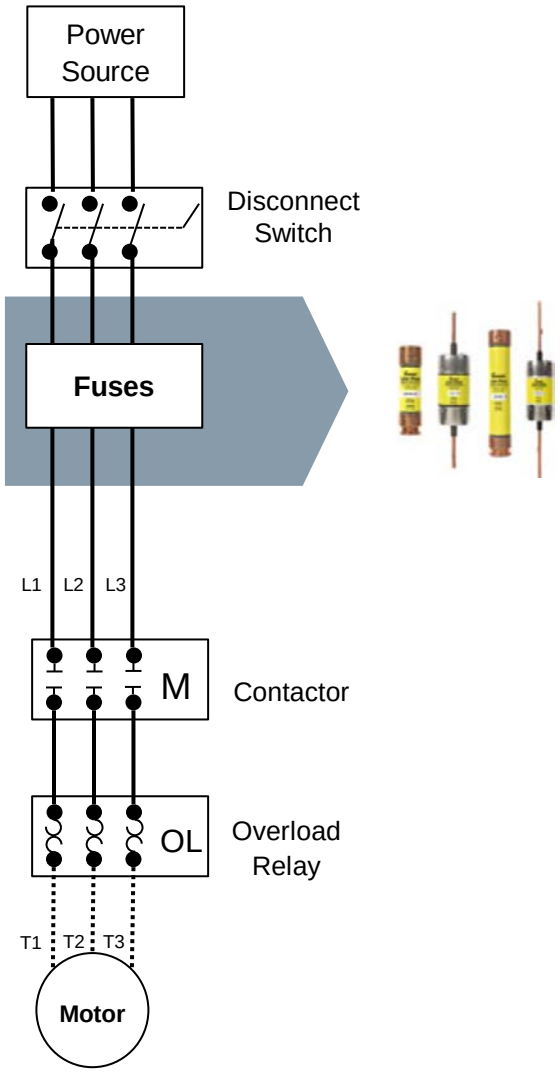


Fuses contain a metal wire or strip that is designed to melt at specific current values.

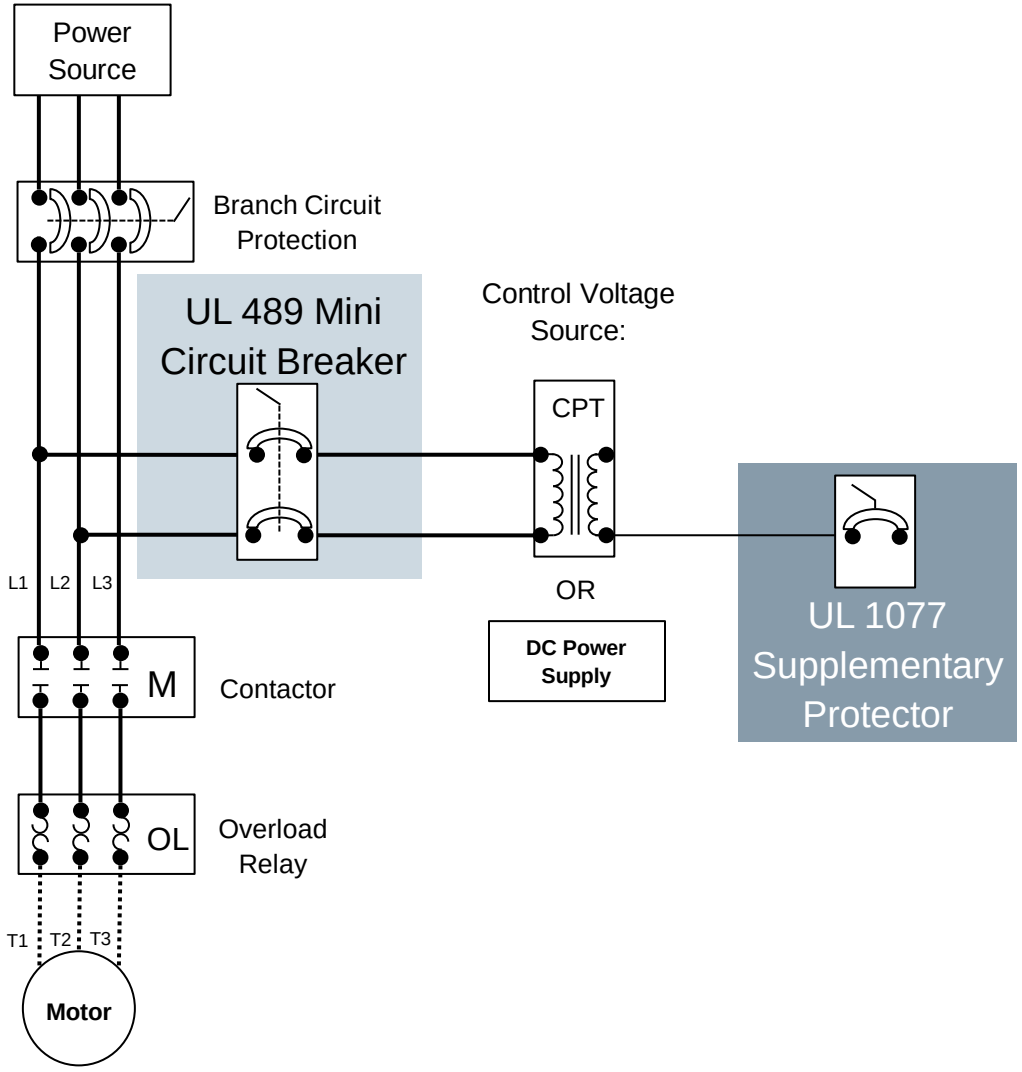
Single element fuses, provide short circuit protection and are only used for motor protection, in conjunction with an overload relay similarly to MCPs.

Dual Element Time-Delay Fuses provide overload protection for circuits but not motors similarly to MCCBs.

Fuses require a fuse block for mounting and a disconnect switch for disconnect and control. Once a fuse melts, it has to be replaced.

Fuses have high SCCRs and are easier to change than CBs if different ratings are required.

1 Branch circuit protection – **Additional Protection**



Mini circuit breakers according to UL 489 can be used as branch circuit protectors in branches inside distribution boards, control panels and controls in accordance with UL 508A.

In this case, it is used as branch circuit protection for the control voltage source (CPT or DC power supply).

These mini CBs are smaller and lower cost than MCCBs and are sometimes replaced by fuses.

Supplementary protectors (UL 1077) are designed to provide additional protection along with branch circuit protection devices. They trip faster than UL 489 MCCBs providing enhanced protection. Note that supplementary protectors are not suitable for use as a branch circuit protective device.

2 Control Device

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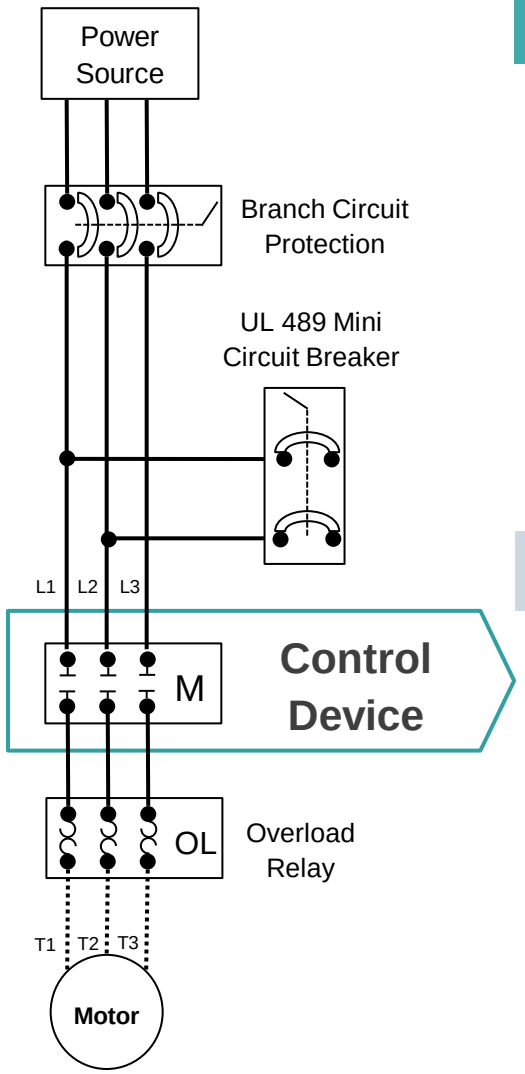


Contactors

Combination Starters

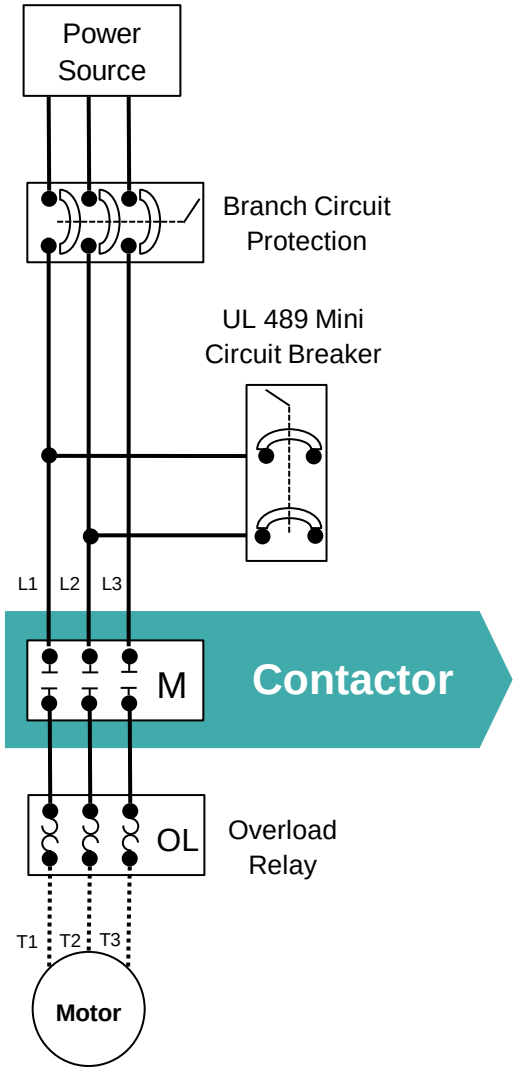
Soft Starters

Variable Frequency Drives

Hybrid Motor Starters

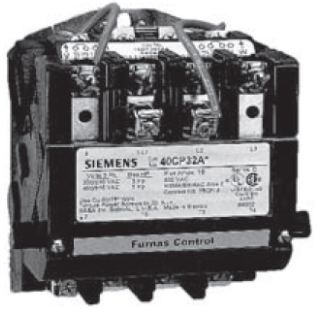
Compact Motor Starters

2 Control Device



Contactors are usually electromagnetic devices similar to relays, rated to switch current to various loads such as motors, lights and heaters. There are two design standards for electrical devices; IEC and NEMA. Contactors are power switching devices for control purposes that do not provide any type of protection.

IEC Contactor



NEMA Contactor

Solid State Contactor

2 Control Device – **IEC vs. NEMA Contactors**

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Use of either IEC or NEMA devices is often user preference. NEMA devices are more prevalent in stand alone combination starters and motor control centers in the US market. IEC devices are prevalent in industrial control panels and non US markets.

IEC designed contactors, and other components such as overload relays, are:

- Comparatively smaller than NEMA contactors
- Inherently touch safe
- Both IEC and UL listed and rated
- More application choices (25 catalog numbers from 3 – 400HP (480V))
- Not serviceable in lower HP ratings

NEMA designed contactors, and other components such as overload relays, are:

- Comparatively larger than IEC contactors
- Not inherently touch safe
- Only UL listed and rated
- Prevalent in enclosed starters and motor control centers (MCC)
- Six application choices from fractional to 400HP (480V))
- Serviceable (replaceable contacts and coils in all Siemens NEMA sizes)

2 Control Device - **Basic Contactor Circuit**

SIEMENS
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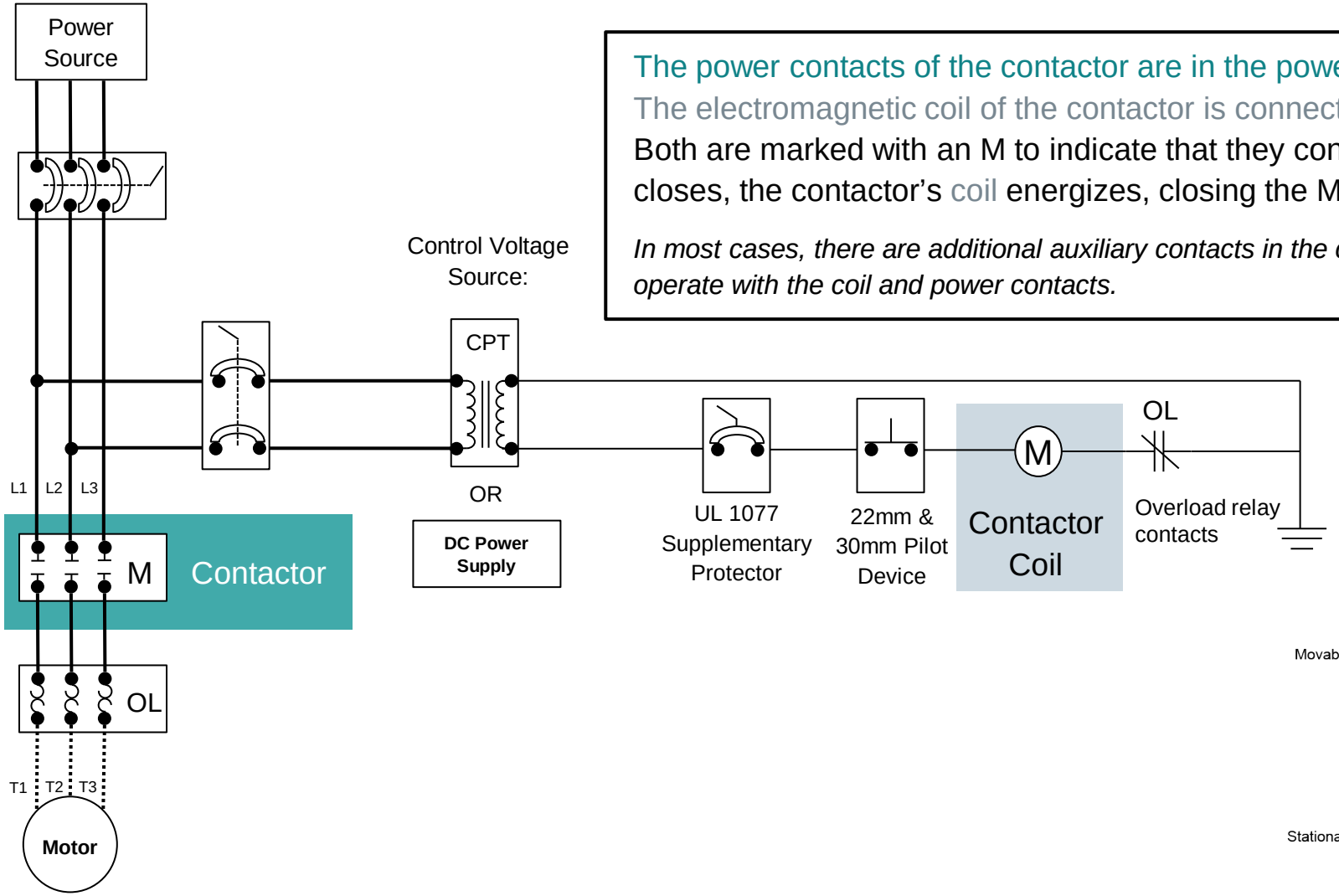
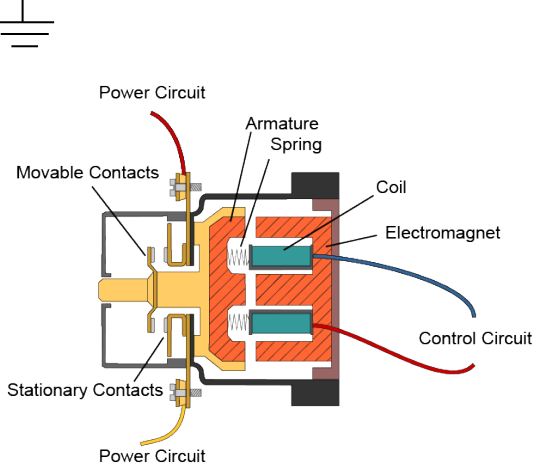
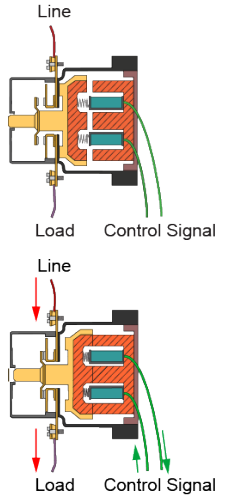
The power contacts of the contactor are in the power circuit for the motor.
The electromagnetic coil of the contactor is connected in the control circuit.
Both are marked with an M to indicate that they control the motor. When the control circuit closes, the contactor's coil energizes, closing the M contacts and applying power to the motor.

In most cases, there are additional auxiliary contacts in the control circuit not shown in this diagram that operate with the coil and power contacts.





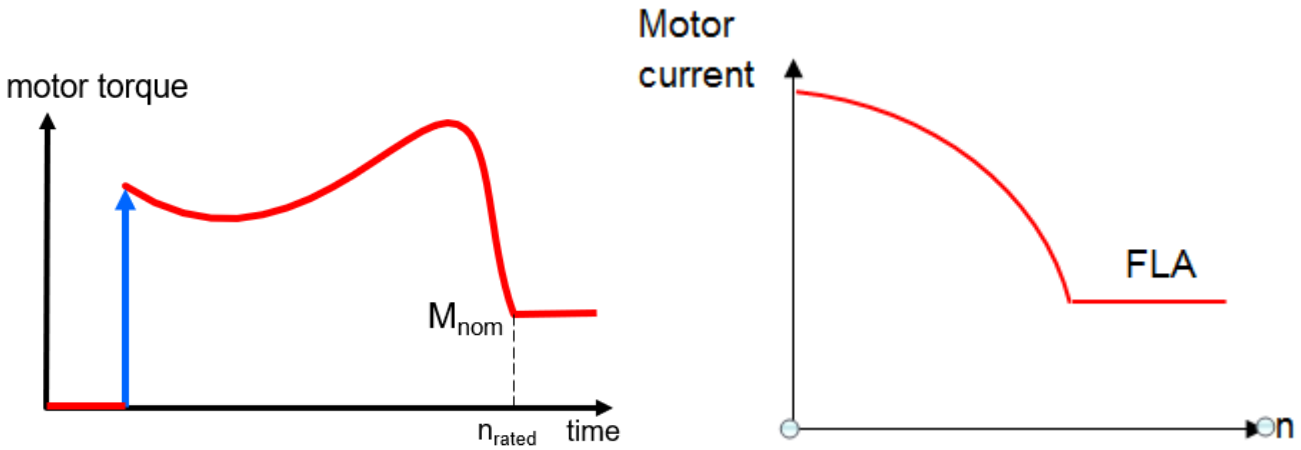


2 Control Device – **Combination Starters**

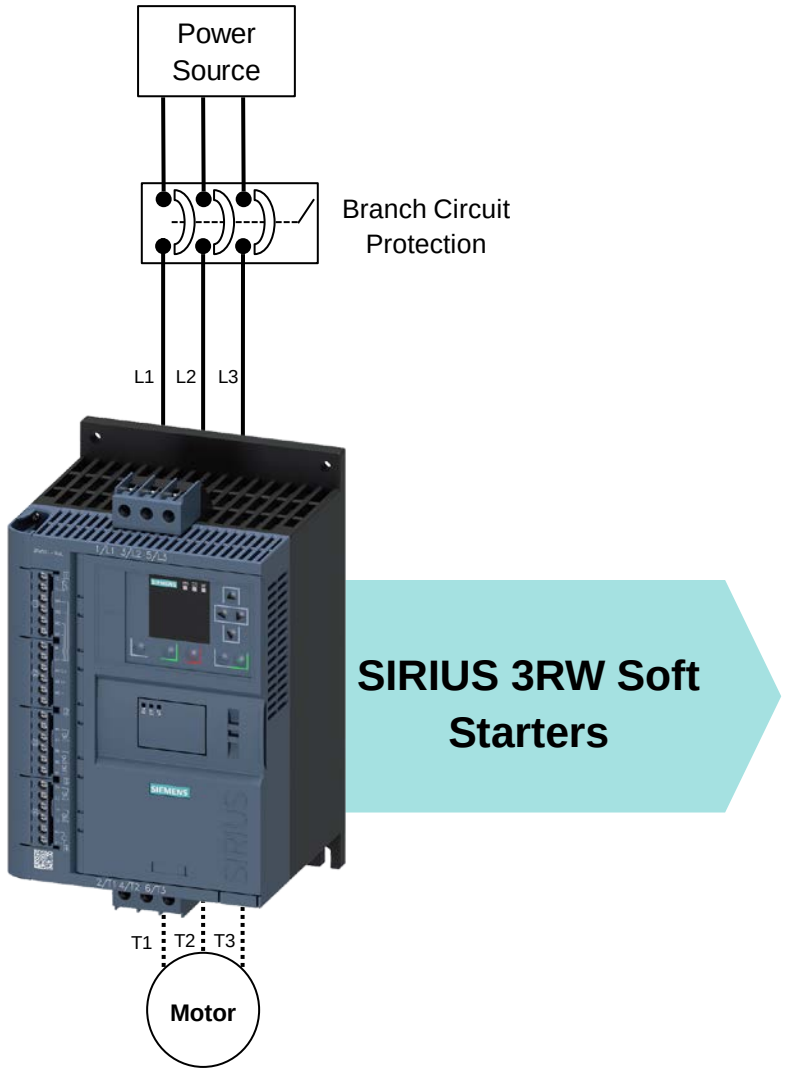
SIRIUS 3RA2 Combination Starter

3RA2 Combination starters are UL508A Type F self-protected combination motor controllers. They consist of a 3RV2 MSP and a 3RT contactor, offering remote control as well as circuit and overload protection in one unit.

The Type F controller should be used over a Type E controller when remote control is desired.



2 Control Device – **Soft Starters**



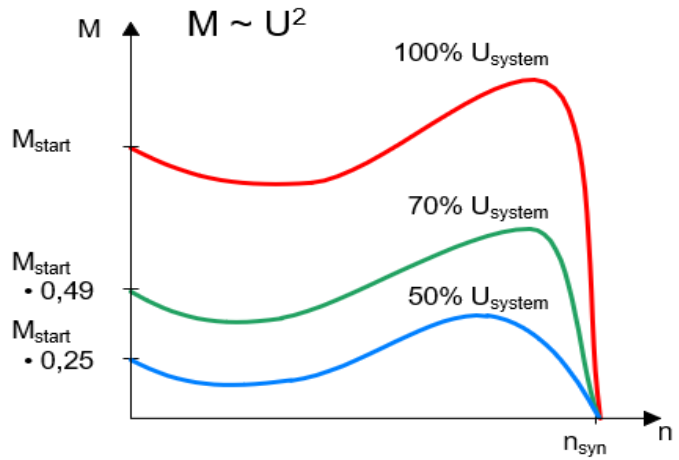
SIRIUS 3RW Soft Starters

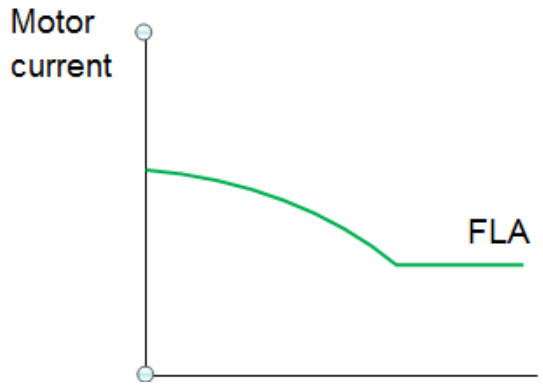
Soft starters are used to provide a reduced voltage motor start. This may be required to reduced the inrush current and is often determined by the electric utility.

Soft starters are also used for reduced torque motor start when required by the application. An example of this could be a bottling conveyor where a sudden start or stop could damage the bottles.

Note that soft starters cannot vary the speed of the motor.

Soft starters typically have built in overload protection but require branch circuit protection.





2 Control Device – **Variable Frequency Drives (VFD)**

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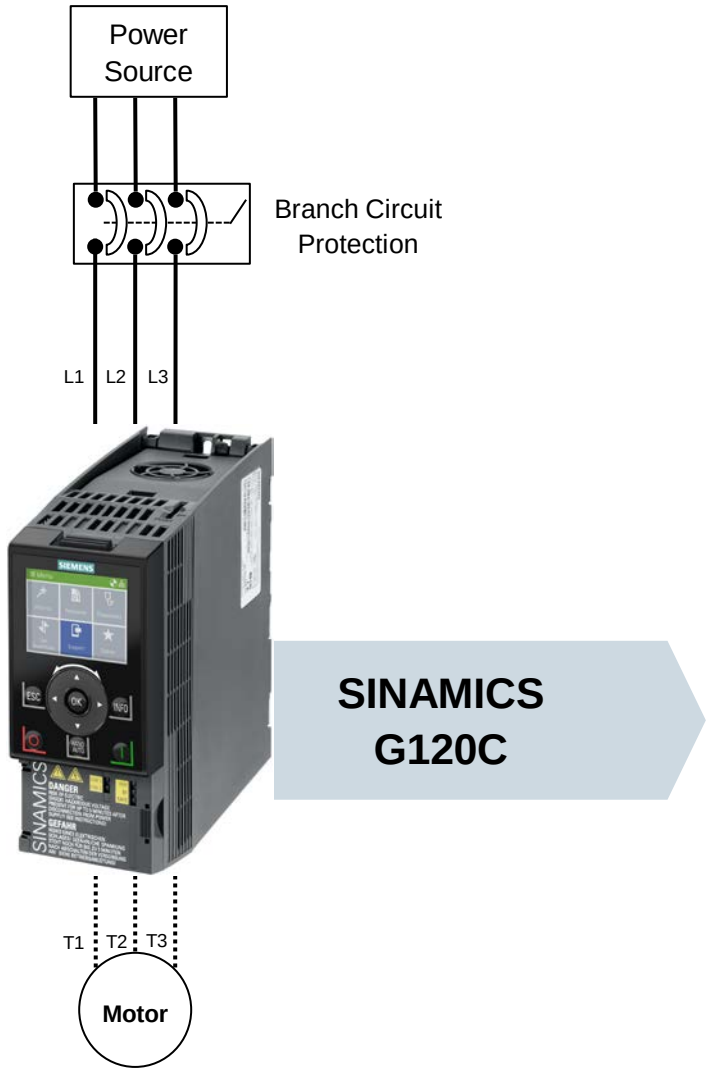
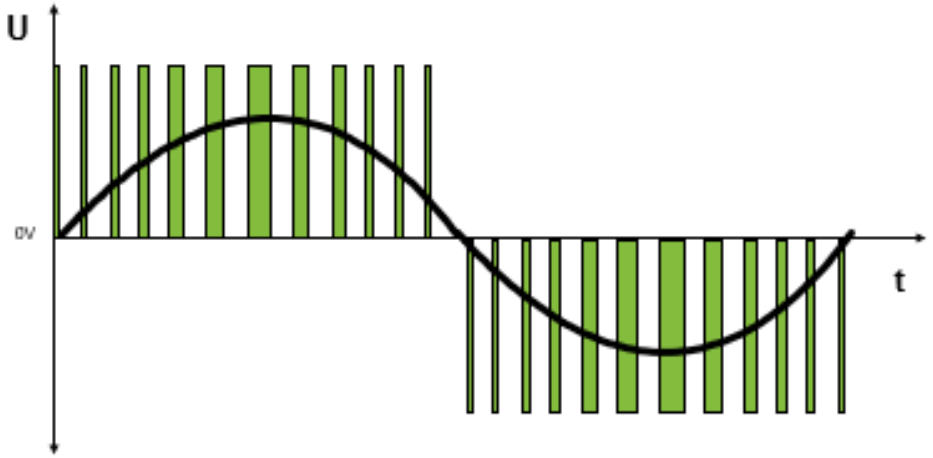


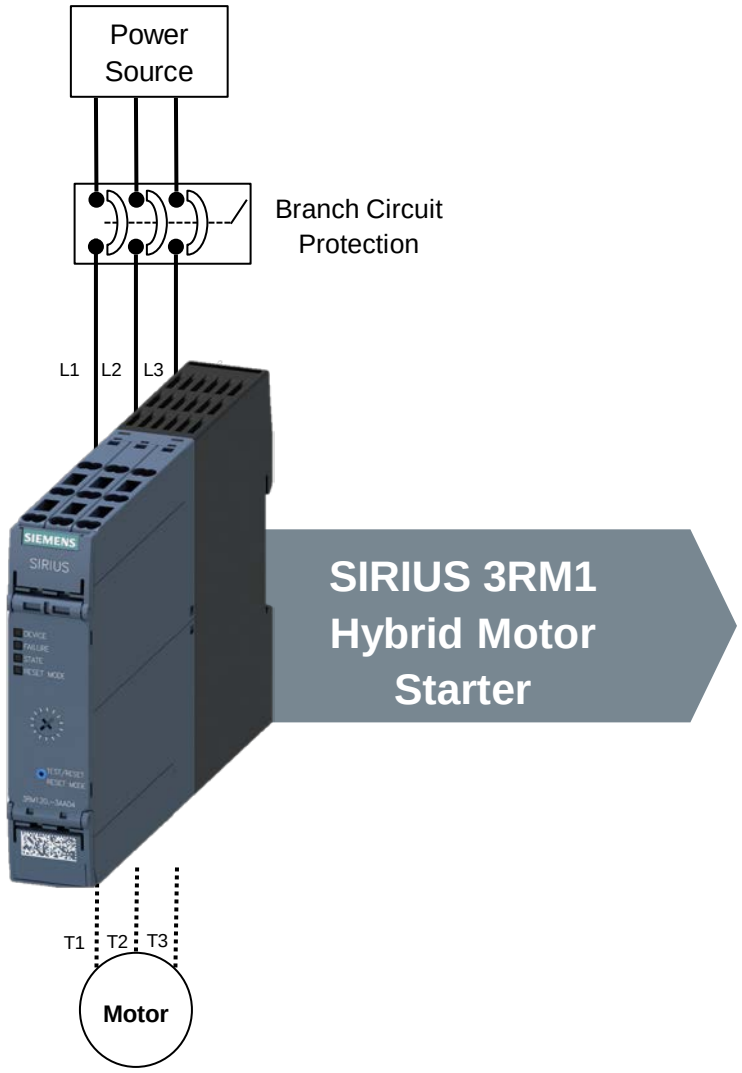
SINAMICS G120C

Variable frequency drives are used when the speed of the motor needs to be varied. Furthermore, reducing the speed of the motor reduces its energy consumption. An example application could be a water pump with integrated flow control.

VFDs typically have built in overload protection but require branch circuit protection.



2 Control Device – **Hybrid Motor Starters**



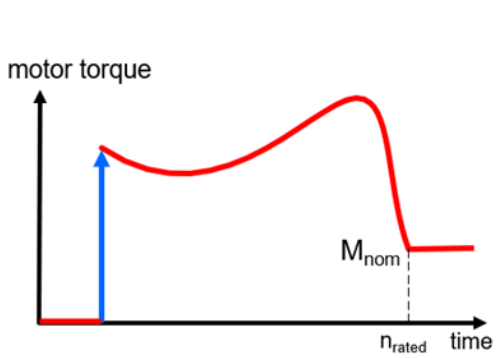
SIRIUS 3RM1 Hybrid Motor Starter

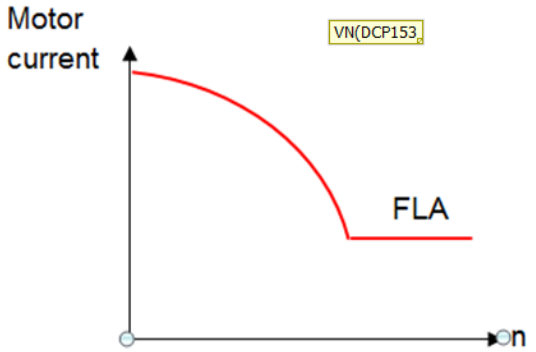
Hybrid motor starters use solid-state start that is bypassed by relay for run.

Hybrid motor starters are compact solutions for small motors and are available with safety functions.

As most motors are small, hybrid motor starters are suitable for many applications.

Hybrid motor starters have built in overload protection but require branch circuit protection. They are available non-reversing and reversing configurations.



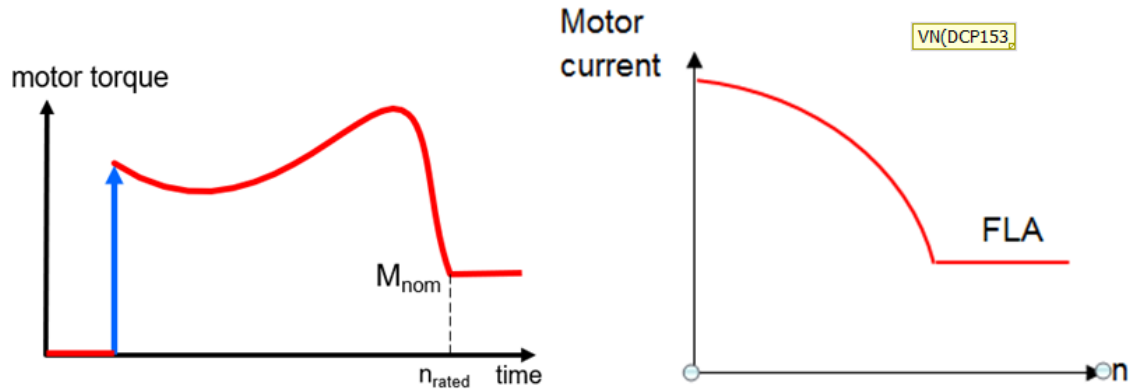


2 Control Device – **Compact Motor Starter**

SIRIUS 3RA6 Compact Motor Starter

Compact motor starters provide disconnect means, short circuit protection, remote control, and overload protection in one device. They are available in non-reversing and reversing configurations. They are also available with on-board AS-Interface and IO-Link communication.

They can be mounted on an infeed bus distribution system. They allow for rapid replacement and provide a contactor end of life indication to enhance maintenance.



3 Overload Protection

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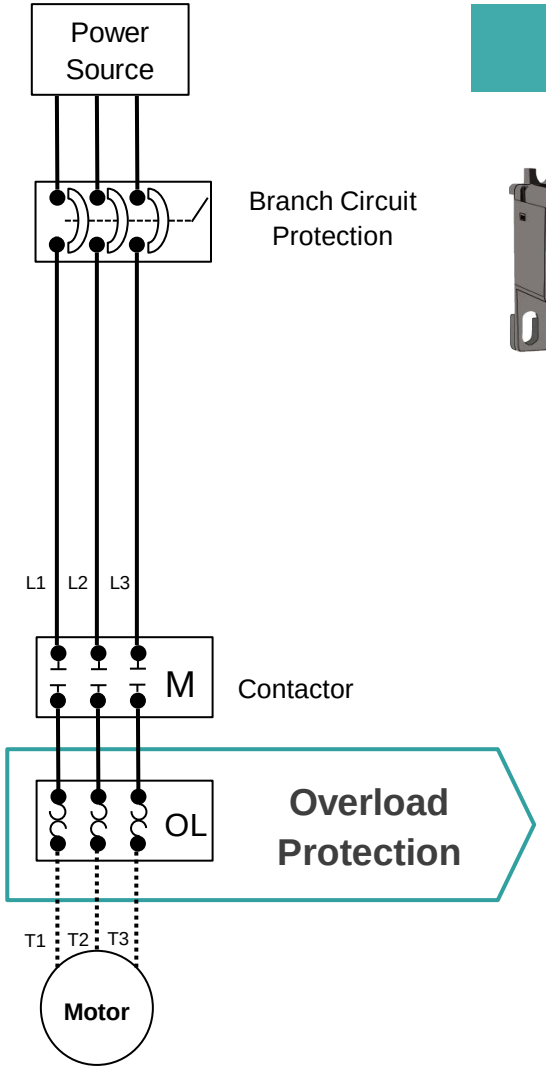
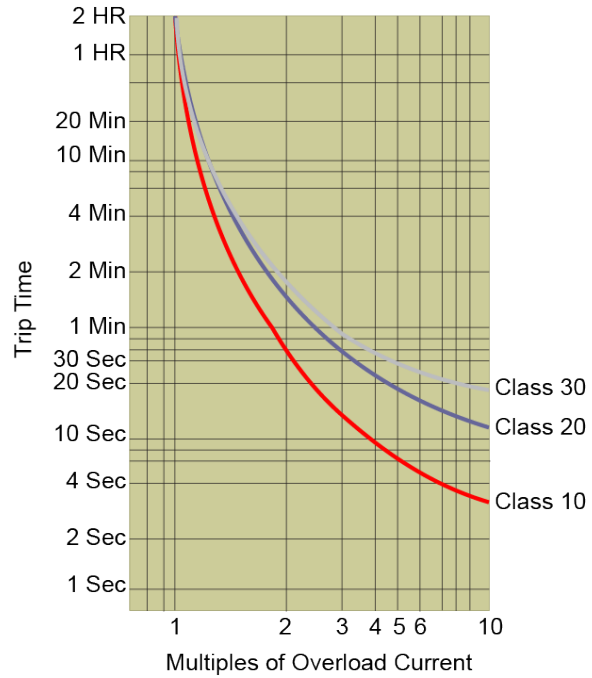
Ingenuity for life



Overload Relays

Motor Starters

Overload Trip Curve



3 Overload Protection – **Overload Relay Circuit**

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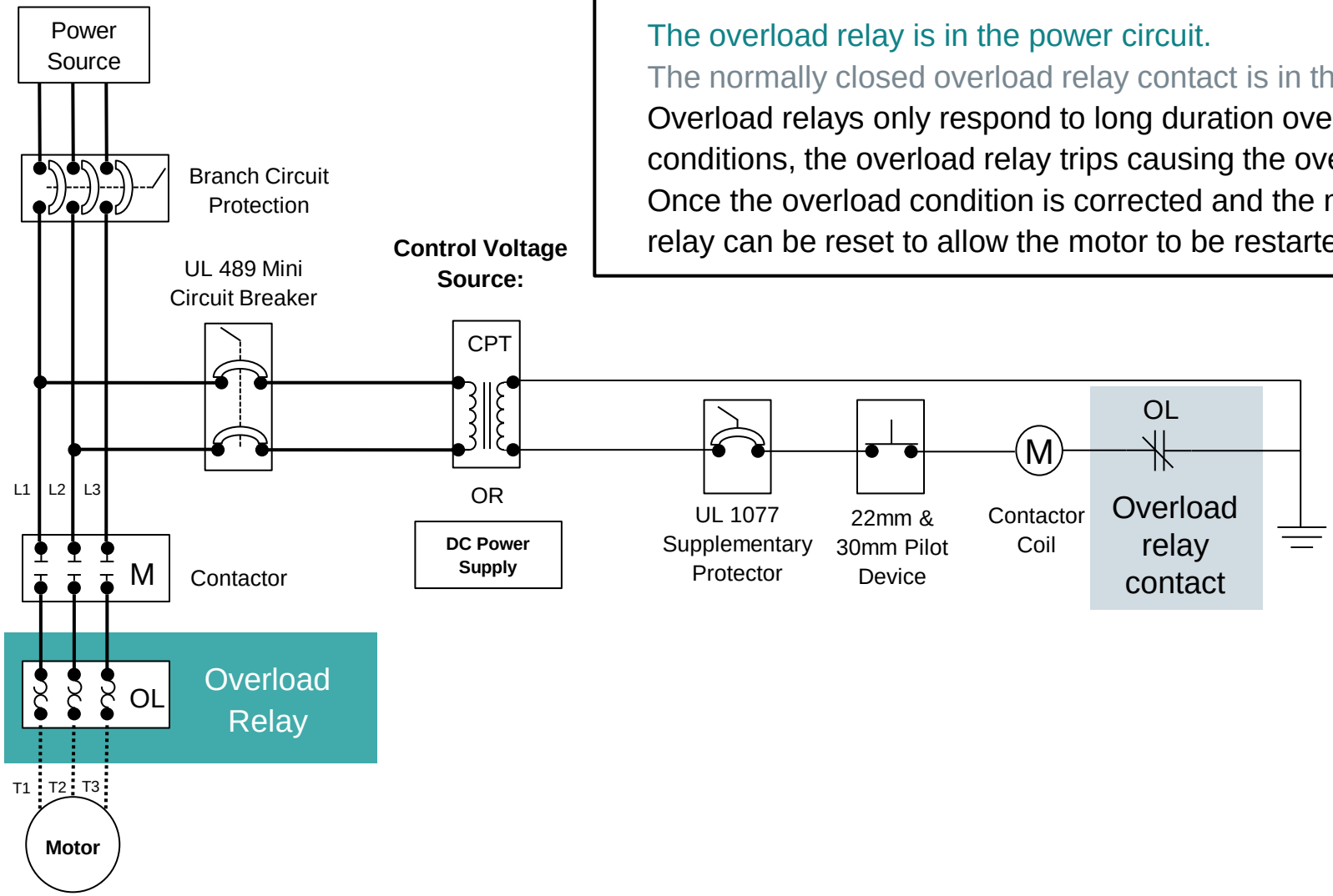
The overload relay is in the power circuit.
The normally closed overload relay contact is in the control circuit.
Overload relays only respond to long duration overload currents. During these overload conditions, the overload relay trips causing the overload relay (OL) contacts to open. Once the overload condition is corrected and the motor has cooled down, the overload relay can be reset to allow the motor to be restarted.



3 Overload Protection – **Thermal vs. Solid State Overload Relays**

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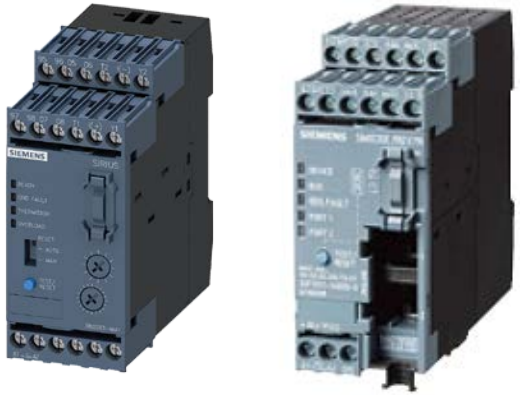
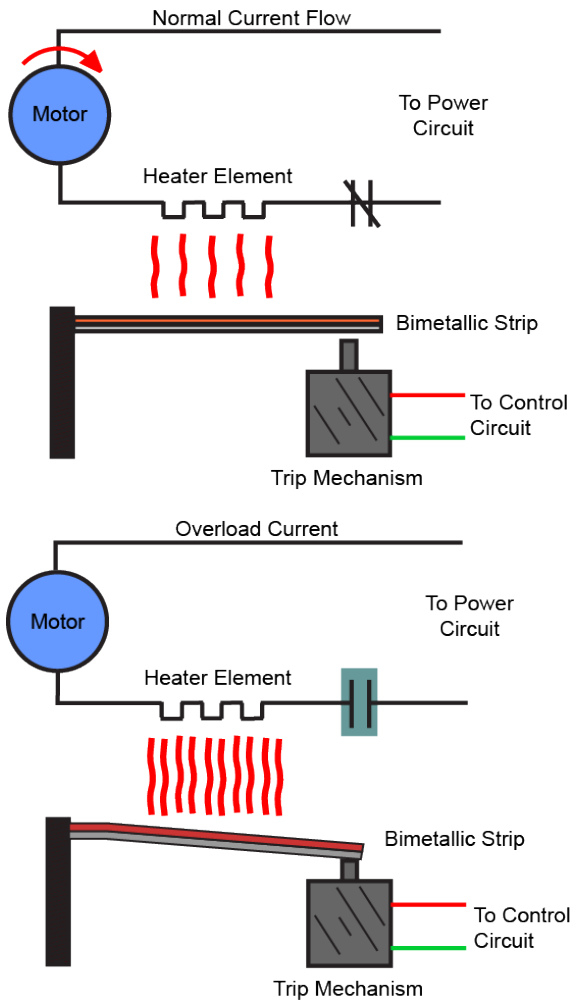
Thermal overload relays use thermal heating elements to trip a bimetallic element in the event of an overload. Modern overload relays use solid state and microprocessor technology to provide protection. Some of the solid overloads have communication capabilities. Communicating overloads, though designed as IEC devices, are often used with NEMA contactors.

	Thermal	Solid State	Communicating Solid State
IEC			
NEMA			

3 Overload Protection – **Thermal Overload Relays**



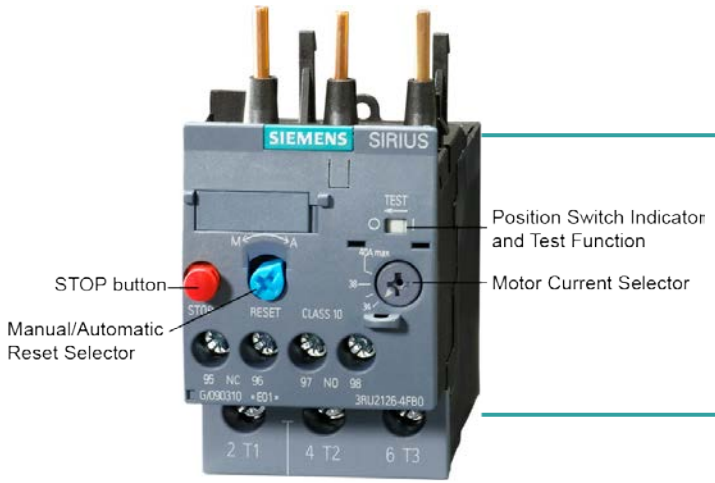
A thermal overload relay incorporates a small heater element wired in series with the motor and a bimetallic strip. For simplicity, the accompanying graphic shows only one circuit phase.

The bimetallic strip functions as a trip lever. It is made of two dissimilar metals with different thermal expansion characteristics bonded together causing the bimetallic strip to bend when heated.

Under normal operating conditions, the heat generated by the heater element causes the bimetallic strip to bend only slightly, not enough to trip the overload relay.

If an overload occurs and persists long enough, the bimetallic strip bends until the overload relay is tripped. This causes the overload relay's contacts to open, removing power from the motor.

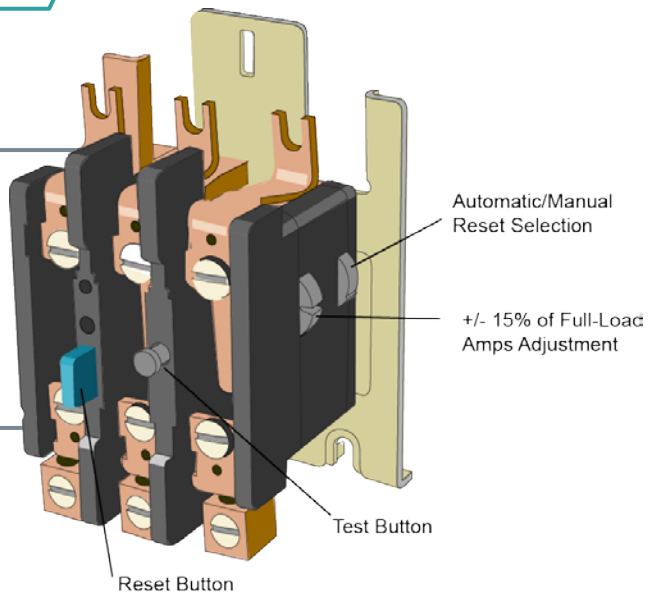
3 Overload Protection – **IEC vs. NEMA Thermal Overload Relays**



SIRIUS 3RU2 Thermal Overload Relay

IEC Designed thermal overload relays have internal heater elements that can be adjusted to cover a range of motor loads.

NEMA Designed thermal overload relays utilize separate heater elements that must be changed as the motor load requirements change. They are usually installed in the field and require additional maintenance.



3 Overload Protection – **IEC vs. NEMA Electronic Overload Relays**

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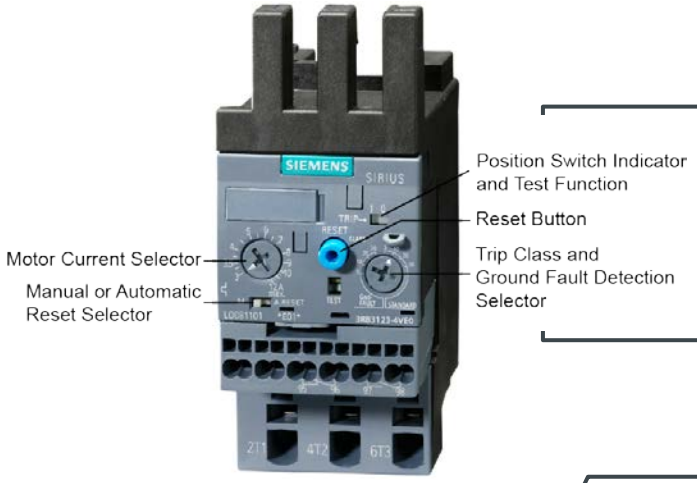
Electronic overload relays are CPU based and use a mathematical algorithm to determine if the current is in overload condition. They have additional protection functions such as ground fault and adjustable trip class.

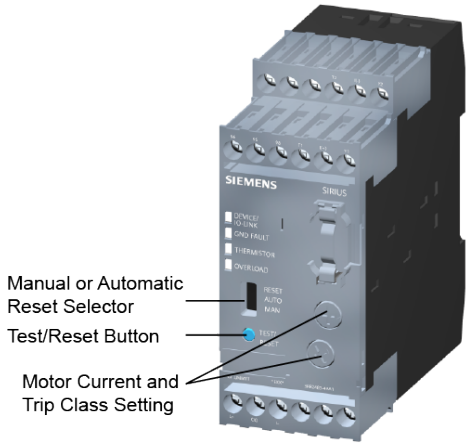


3RB31 Electronic Overload Relay

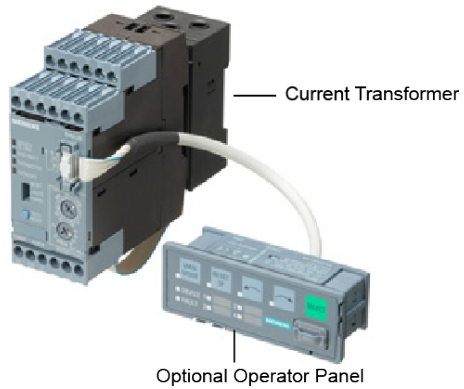
IEC designed electronic overload relays are designed to fit with IEC contactors.

NEMA Designed electronic overload relays are designed to fit with NEMA contactors.

3 Overload Protection – **Electronic Overload Relays**



3RB24 Electronic Overload Relay

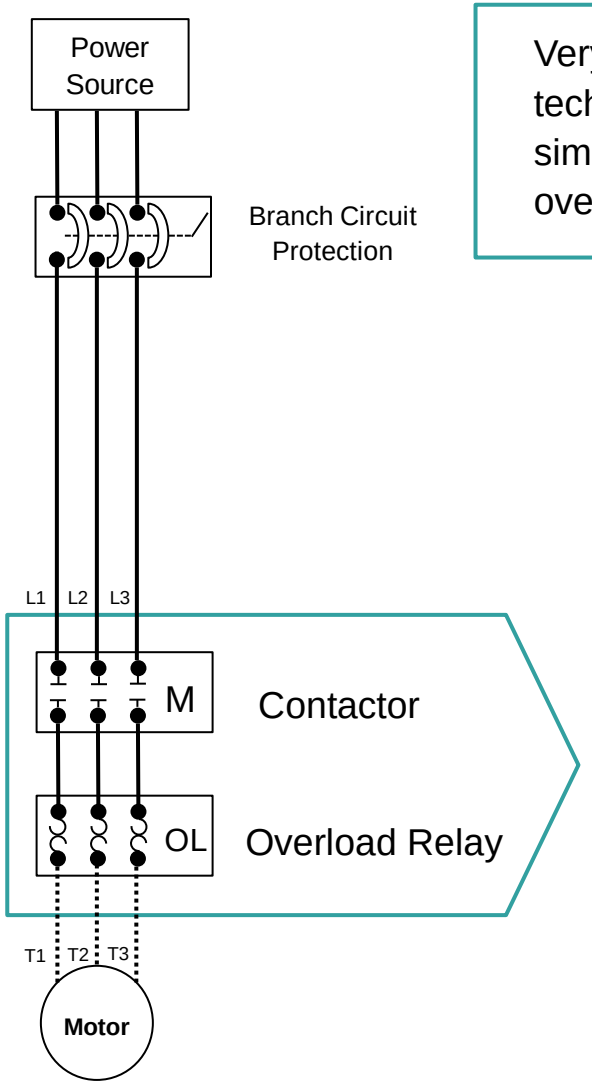


SIRIUS 3RB22/23 electronic overload relays provide trip class adjustments from class 5 to 30 and ground fault, phase imbalance, and phase loss protection.

In addition to sensing current, 3RB22/23/24 overload relays directly sense motor winding temperature via a thermistor sensor.

SIRIUS 3RB22/23/24 have communication capabilities via AS-Interface and the 3RB24 has IO-Link communication capability.

3 Overload Protection – **Motor Starters**



Very often, contactors and combined with an overload relay to make a Motor Starter. There is no technical advantage for using motor starters over contactors and overload relays. However, they simplify ordering (one part number for the motor starter vs. two part numbers for the contactor and overload relay).

IEC

NEMA

SIEMENS
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Break

Circuits Diagrams – Control Voltage Source

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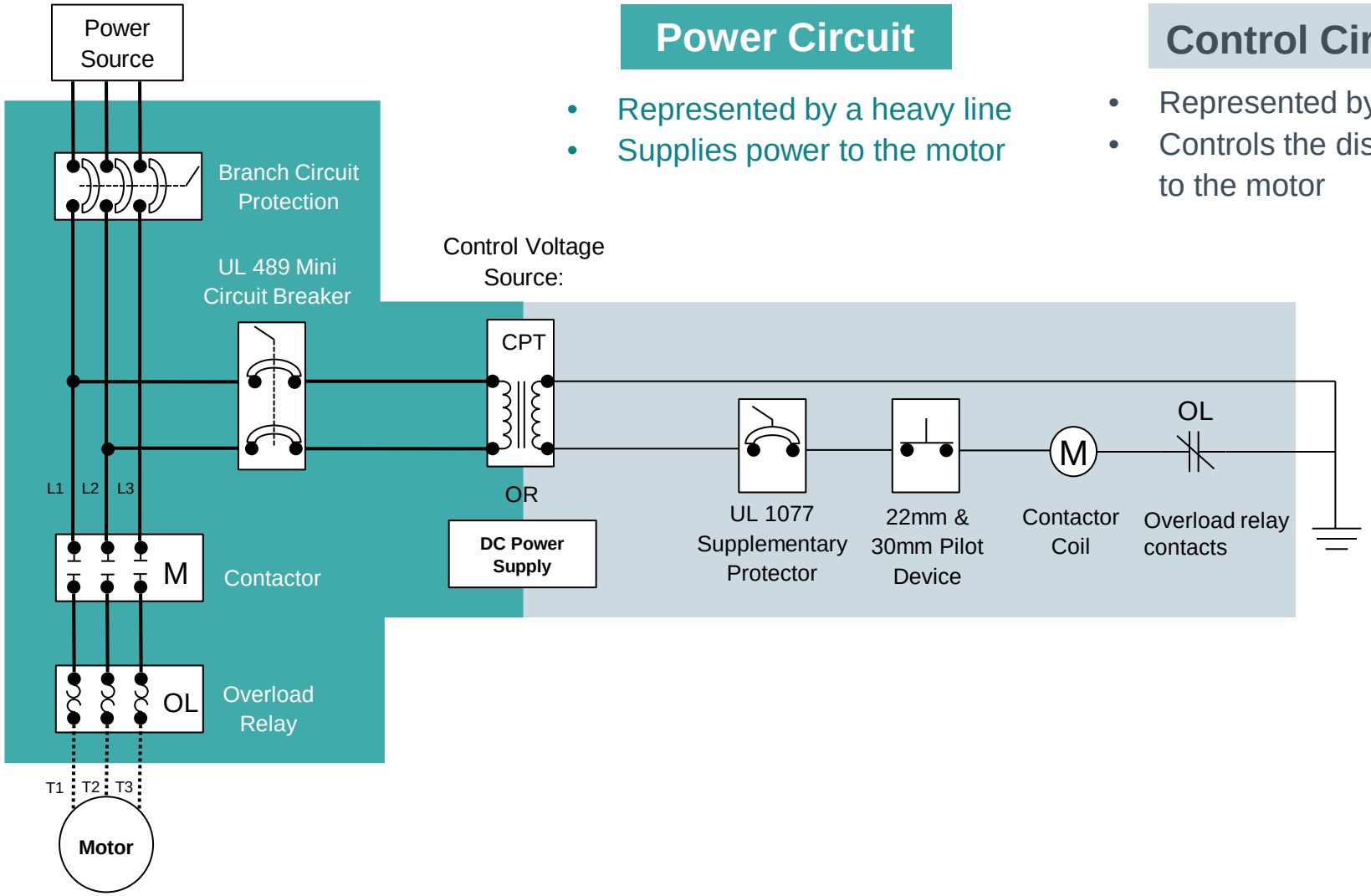
Power Circuit

- Represented by a heavy line
- Supplies power to the motor

Control Circuit

- Represented by a light line
- Controls the distribution of power to the motor



Circuits Diagrams – Control Voltage Source

SIEMENS
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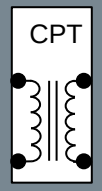
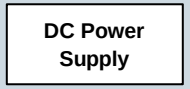


Control Power Transformer

CPTs are used when AC voltage is required for the control circuit.

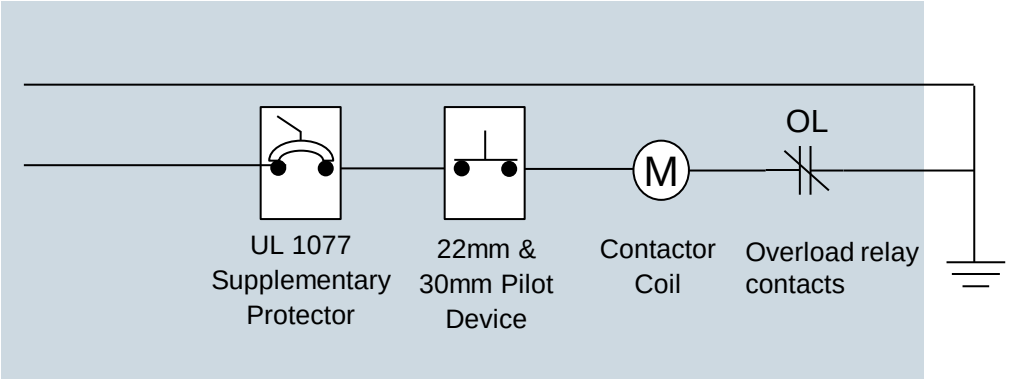


DC Power Supply

DC Power supplies are used when DC voltage is required for the control circuit.

Note that both AC and DC control voltages may be supplied by a source separate from the branch circuit.

Control Circuit

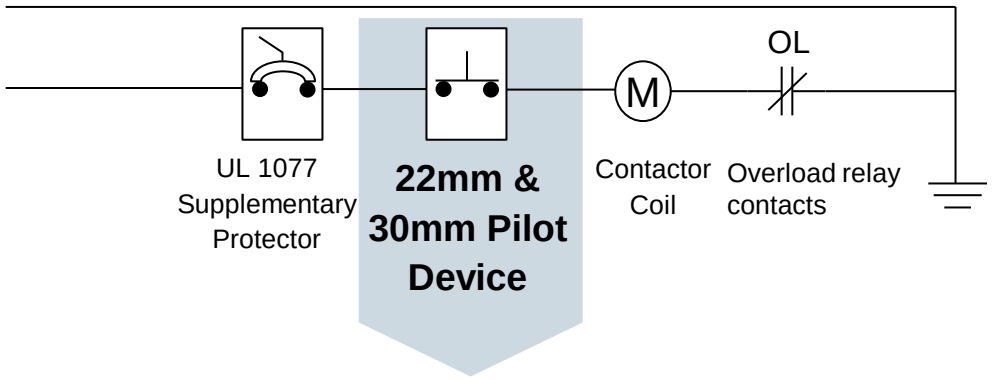


It is important to understand the difference between control circuits and power circuits. According to UL508A: A control circuit carries the electric signals directing the performance of a controller and does not carry the main power circuit. A control circuit is, in most cases, ***limited to 15 amperes.***

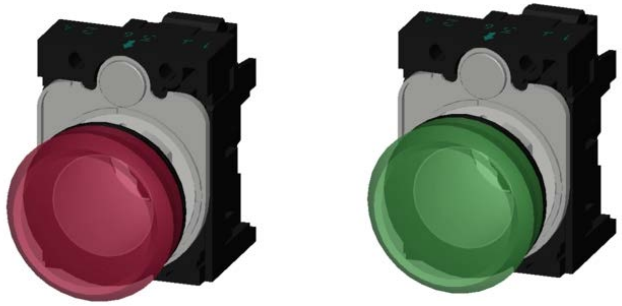
Typical Devices: push buttons, selector switches, pilot lights, relays, converters & coupling, timers, etc.

For this presentation, we will not go over converters and couplings, or signaling devices as they do not pertain directly to motor control. These are also in the control circuit.

Control Circuit
Pilot Devices



Pilot devices include command devices such as push buttons and selector switches and signaling devices such as lights.



As recommended by NFPA 79, a red light indicates that the motor is ON and that caution needs to be exercised. A green light indicates that the motor is OFF.

Control Circuit
Load Connections

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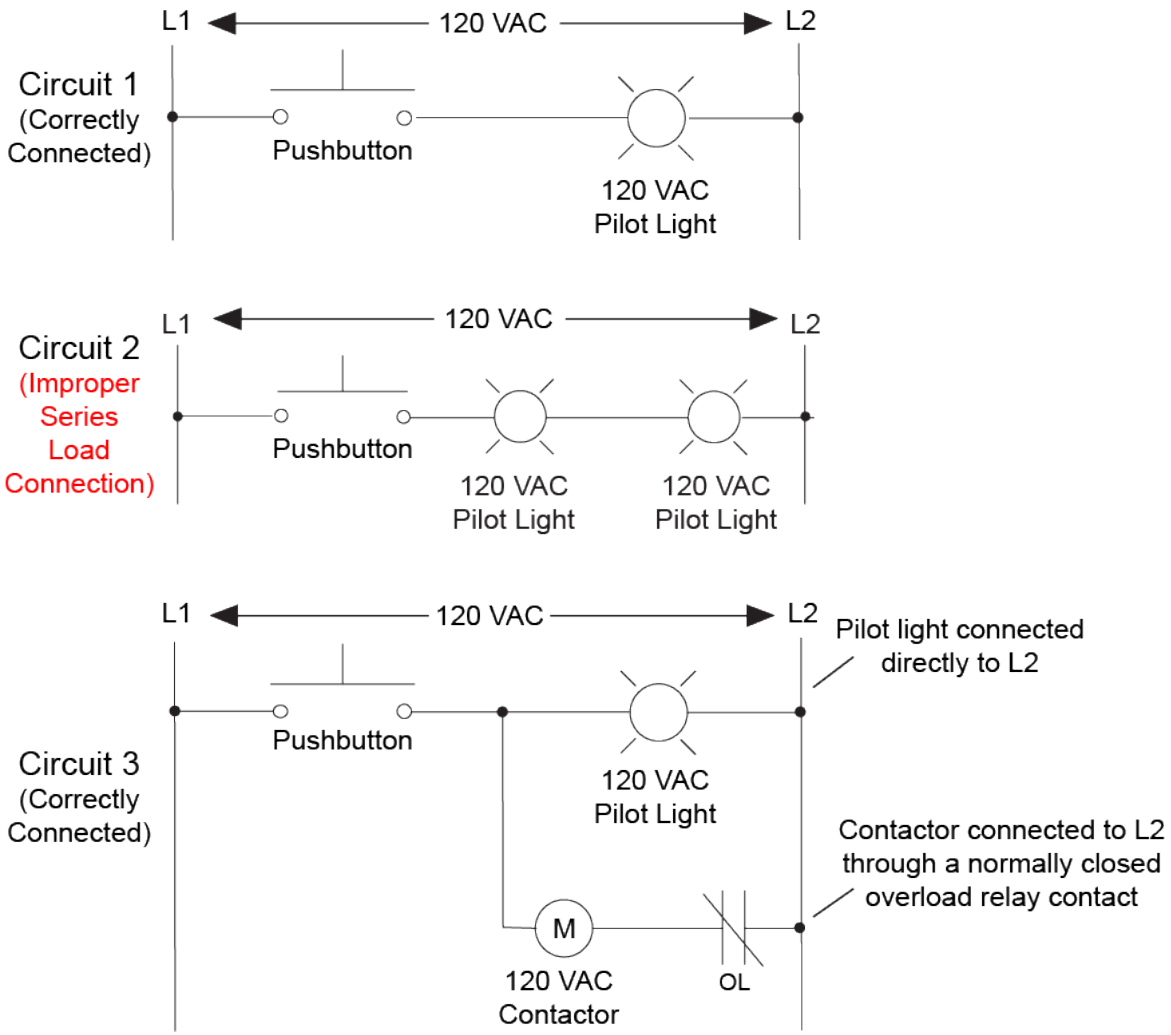

A typical control circuit includes a control load and one or more components that determine when the control load will be energized. Some control loads, such as relays and contactors, activate other devices, but other control loads, such as indicator lights, do not.

For example, in the accompanying graphic, circuit 1 shows the connection of a pilot light and a pushbutton, which are connected in series. However, loads such as pilot lights or contactors cannot be wired in series as shown in circuit 2.

Circuit 3 shows that if a light is wired alongside a load such as contactor coil, it must be wired in parallel.

Control Circuit
Device Connections

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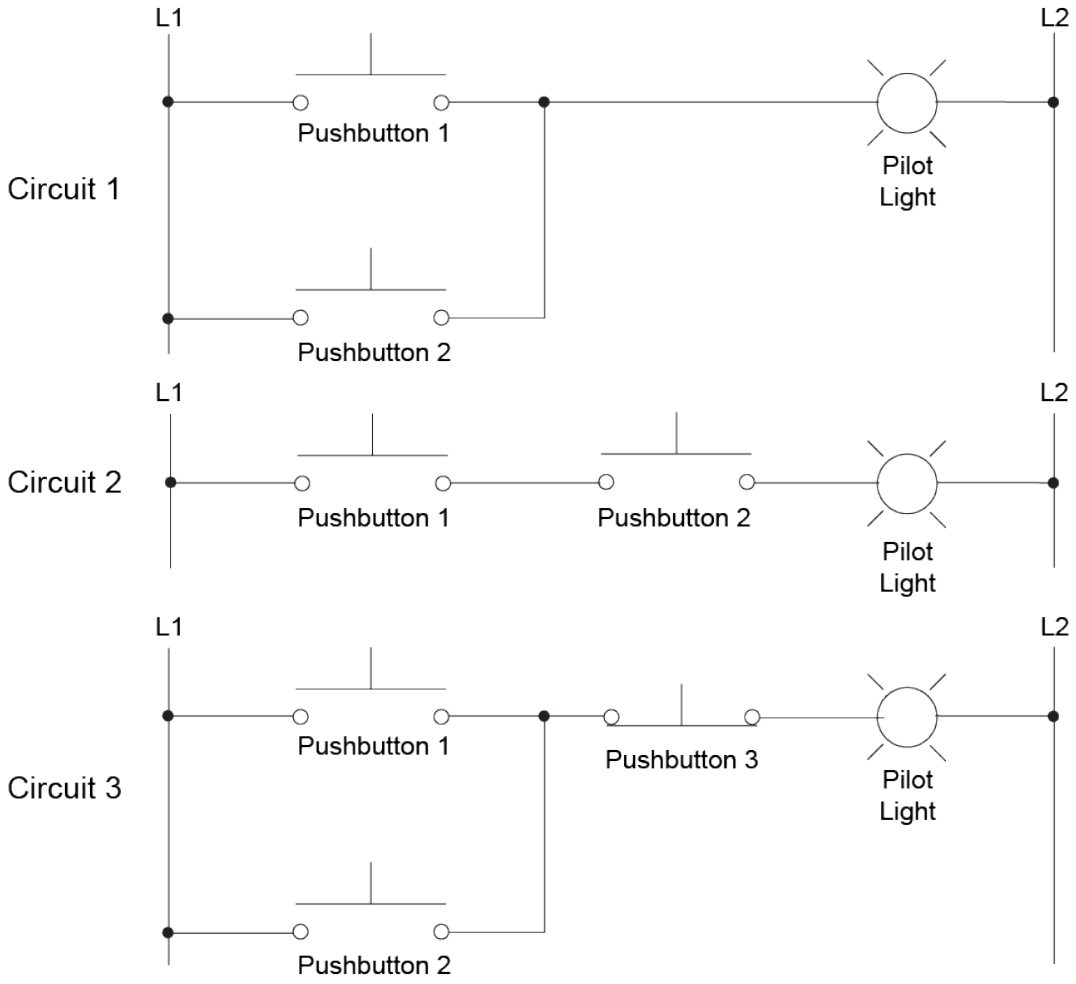
Ingenuity for life



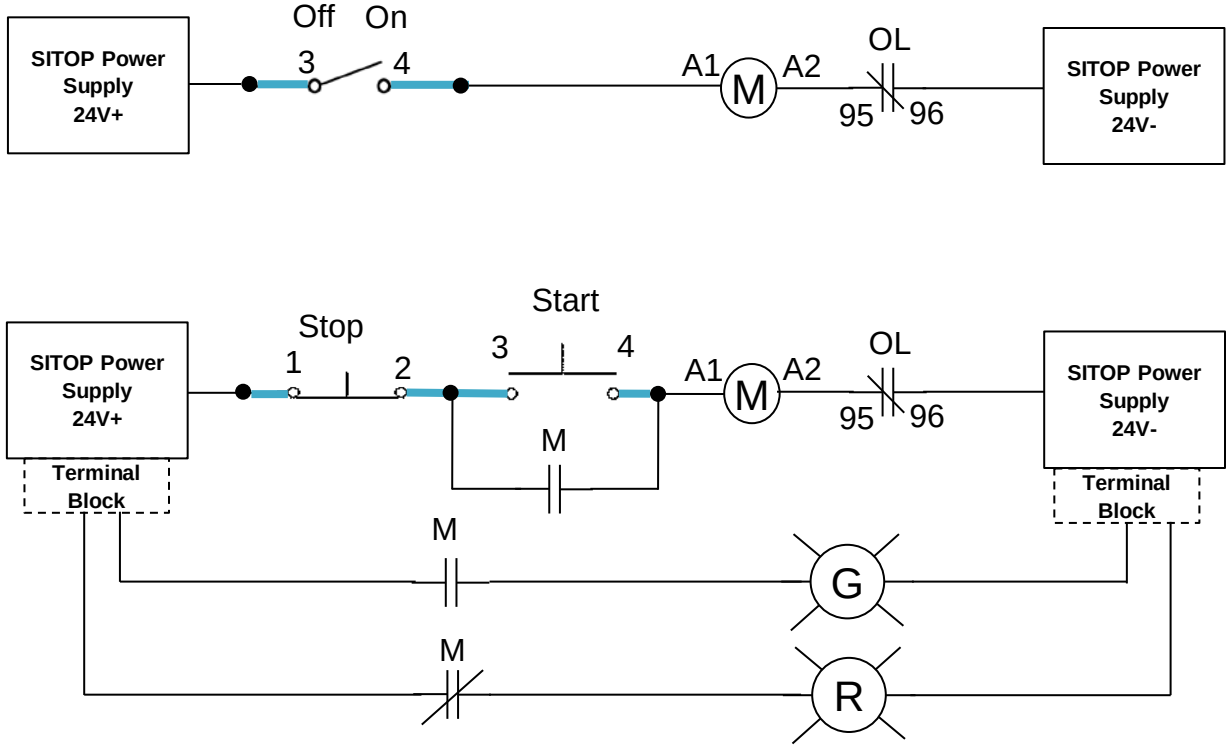
Often a control load is controlled by more than one control device. These control devices may be connected in series, parallel, or in a combination series-parallel circuit.

For example, in circuit 1 two normally open pushbuttons are connected in parallel. Pressing either pushbutton or both pushbuttons allows current to flow.

In circuit 2, two normally open pushbuttons are connected in series. Both pushbuttons must be pressed at the same time to allow current to flow.

In circuit 3, if either pushbutton 1 or 2 or both are pressed, current flows, unless pushbutton 3 is pressed. When pushbutton 3 is pressed, no current can flow regardless of the states of pushbuttons 1 and 2.

Control Circuit
2 Wire vs 3 Wire control



2 Wire control

Adding a 2 position selector switch to the control circuit requires connection to 2 terminals. Because 2 wires are required, this is referred to as 2 wire control.

When the Off On switch is in the On position, the circuit applies voltage to the contactor coil (M) and the coil energizes, operating all of the "M" contacts in the power circuit. This will start the motor.

3 Wire control

When Stop Start buttons are used for controlling a FVNR starter, they are connected into the circuit to three terminals, hence the term 3 wire control.

When the Start button is pressed, the "M" coil energizes operating all of the "M" contacts.

In both cases, if the overload relay trips, the NC OL contact in the control circuit opens, turning the motor off.

Fast Bus (SENTRON 8US)

SIEMENS
Ingenuity for life

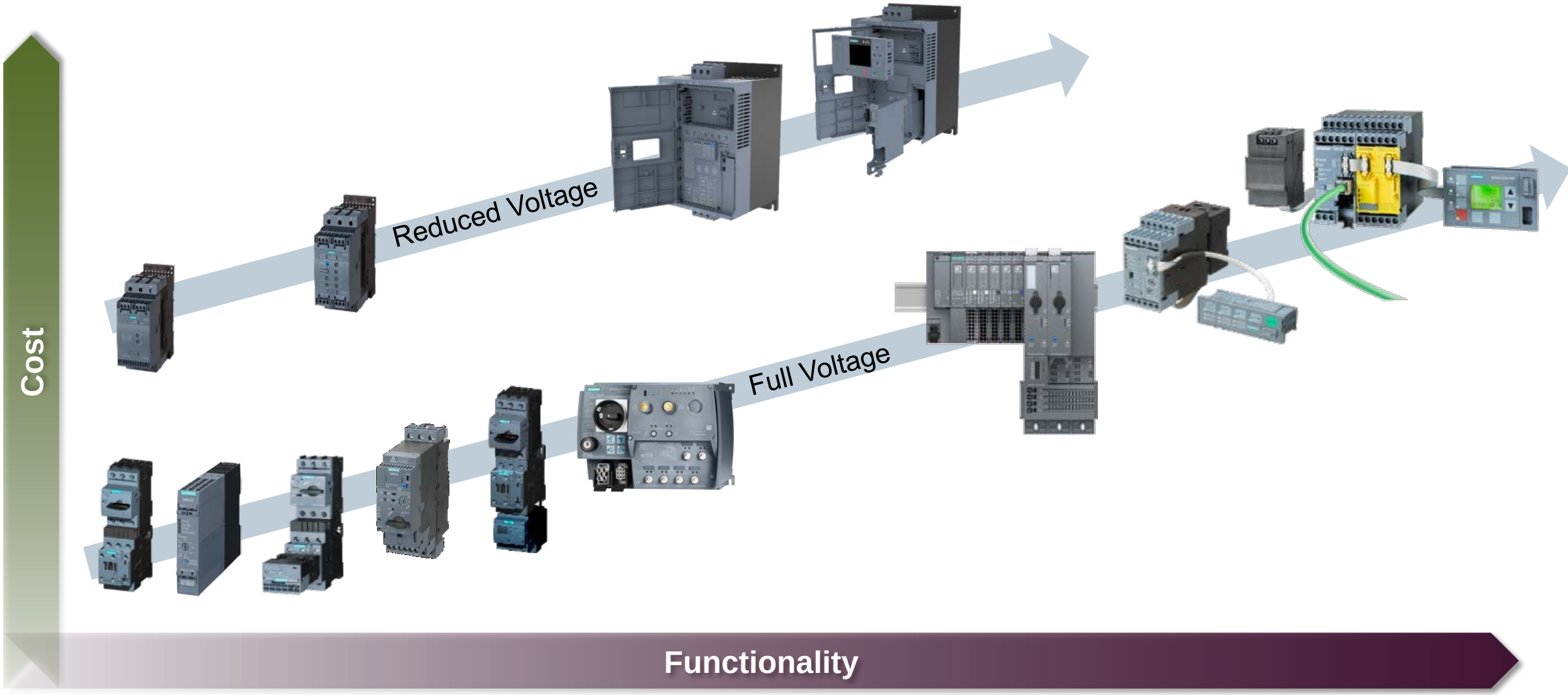
The Fast Bus Multi-Motor Control system is a 3-phase insulated busbar system and is ideal for space saving in panel designs, motor control centers, and power distribution systems. SIRIUS 3RV/3RT starter combinations and Siemens circuit breakers are all adaptable to Fast Bus.

Benefits:

- Reduced space requirements
- Reduced time and costs associated with system expansion
- Reduced mounting and wiring time and provides trouble free connections
- Protection for maintenance personnel

Motor Control Portfolio

SIEMENS
Ingenuity for life



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Hands-On

Demo Kit Components

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Two-position switch

Red button (STOP)

Black button (START)

Green pilot light

Red pilot light

Metal Holders

Normally open contact (screw)

Normally closed contact (screw)

Normally open contact (spring)

Green LED (screw)

Red LED (screw)

Contactor 24V DC

Overload Relay

SITOP power supply 2A, 24V DC

5SJ Circuit Breaker

Screw and Spring Terminals

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Screw terminals:

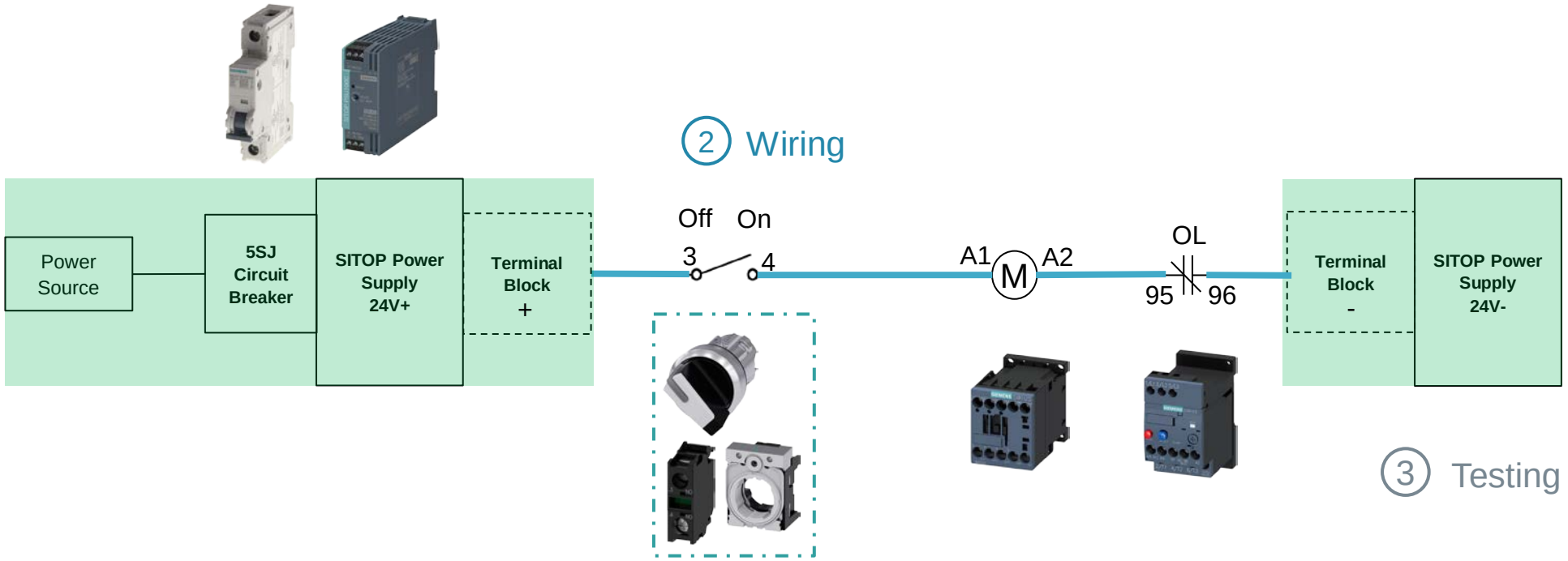
Loosen and tighten the screw above the terminal to open and close it.

Spring terminals:

1. Insert the screwdriver into the slot

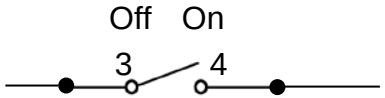
2. Move the screwdriver in the opposite direction from the terminal to open it. Simply remove the screwdriver to close the terminal.

Part 1: Two Wire Control



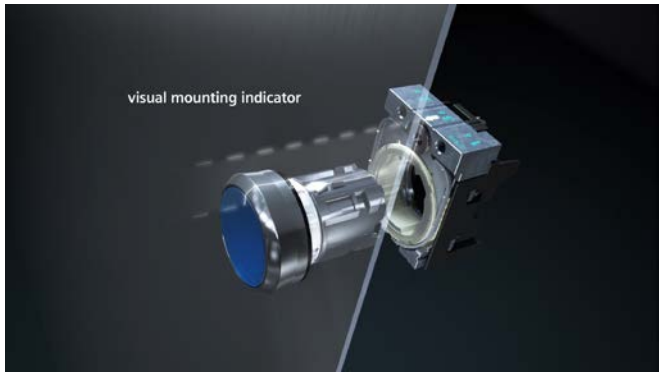
Prewired on Hands-On demo

① Two position switch assembly

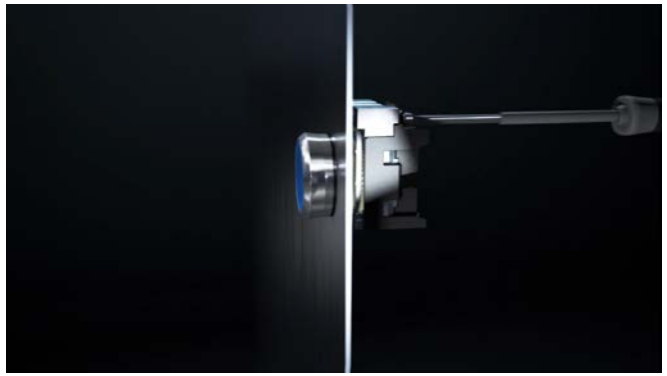


Steps

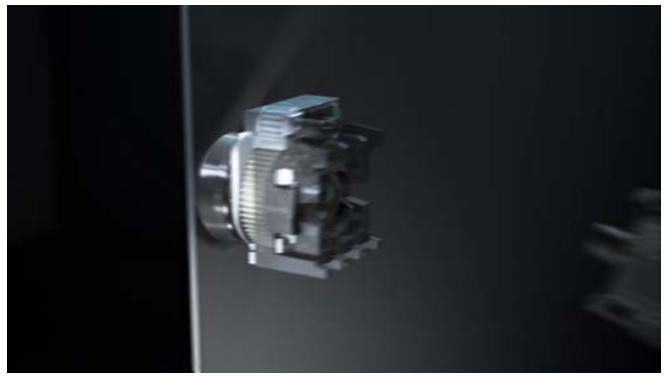
1. Align the arrows on pilot device with the arrows on the holder



2. Tighten the screw on the holder



3. Mount the contact or LED module on the middle slot for easy access



② Wiring 1

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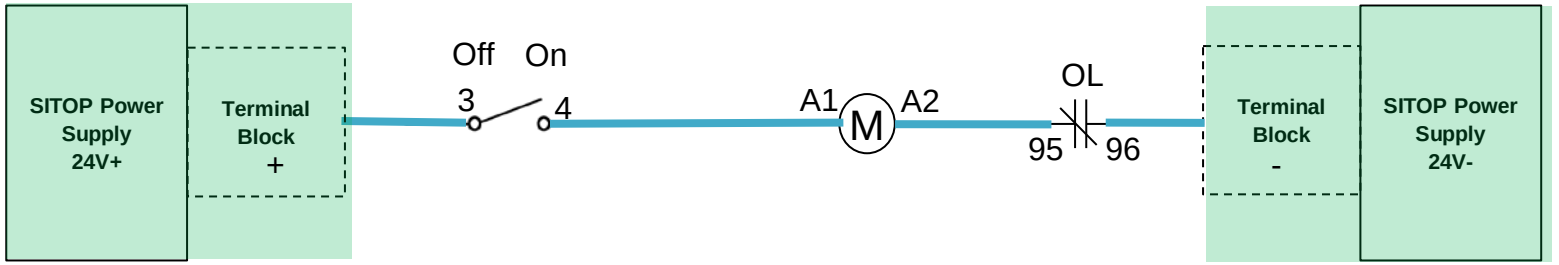
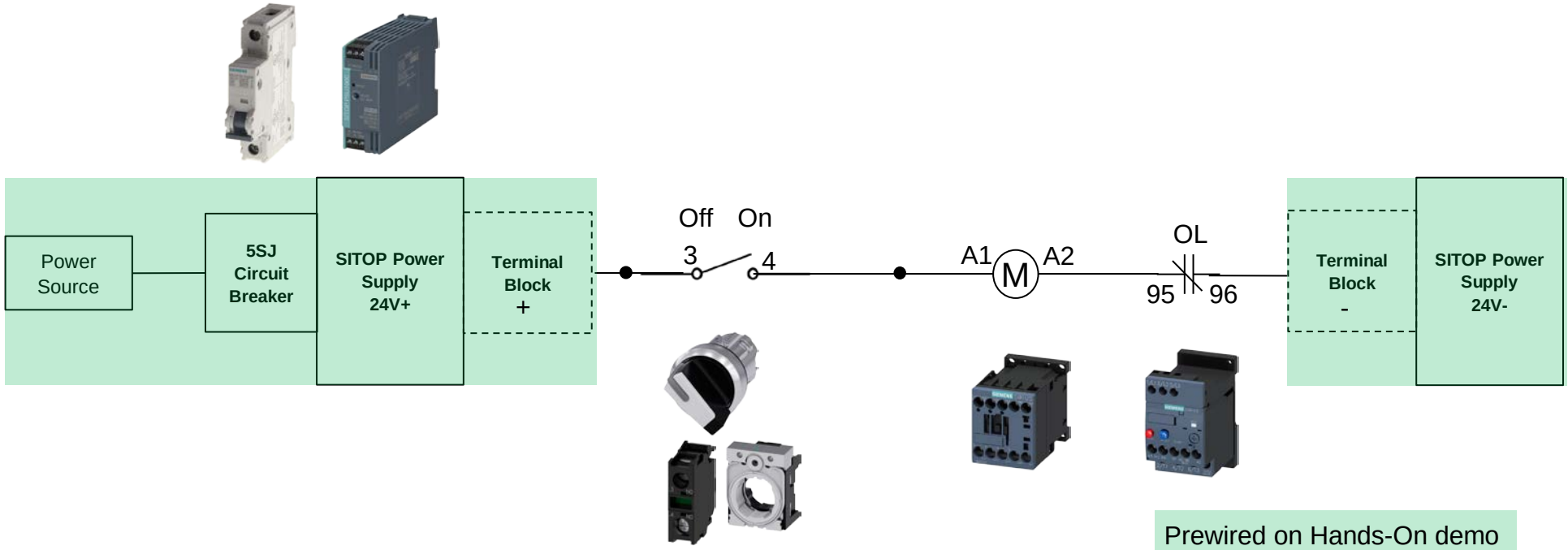


1. Turn Off the circuit breaker.
2. Loosen top and bottom screws of the NO contact on the back of the selector switch
3. Connect the top connection (3) into the positive side of the terminal block (left side) and the bottom connection (4) into the contactor connection A1
4. Connect contactor connection A2 is to the overload relay connection 95 on.
5. Connect the overload relay connection 96 to the negative side of the terminal block (right side) to complete the circuit.

Prewired on Hands-On demo

3 Testing 1

1. Ensure that the selector switch is on the left position.
2. Turn On the circuit breaker
3. Turn the selector switch to the right. You should hear the contactor energize, or engage.
4. Turn the selector switch back to the left and the contactor should de-energize.
5. Turn the selector switch back to the right position. Press and release the red STOP button on the overload relay and observe the operation of the contactor.



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Part 2: Three Wire Control

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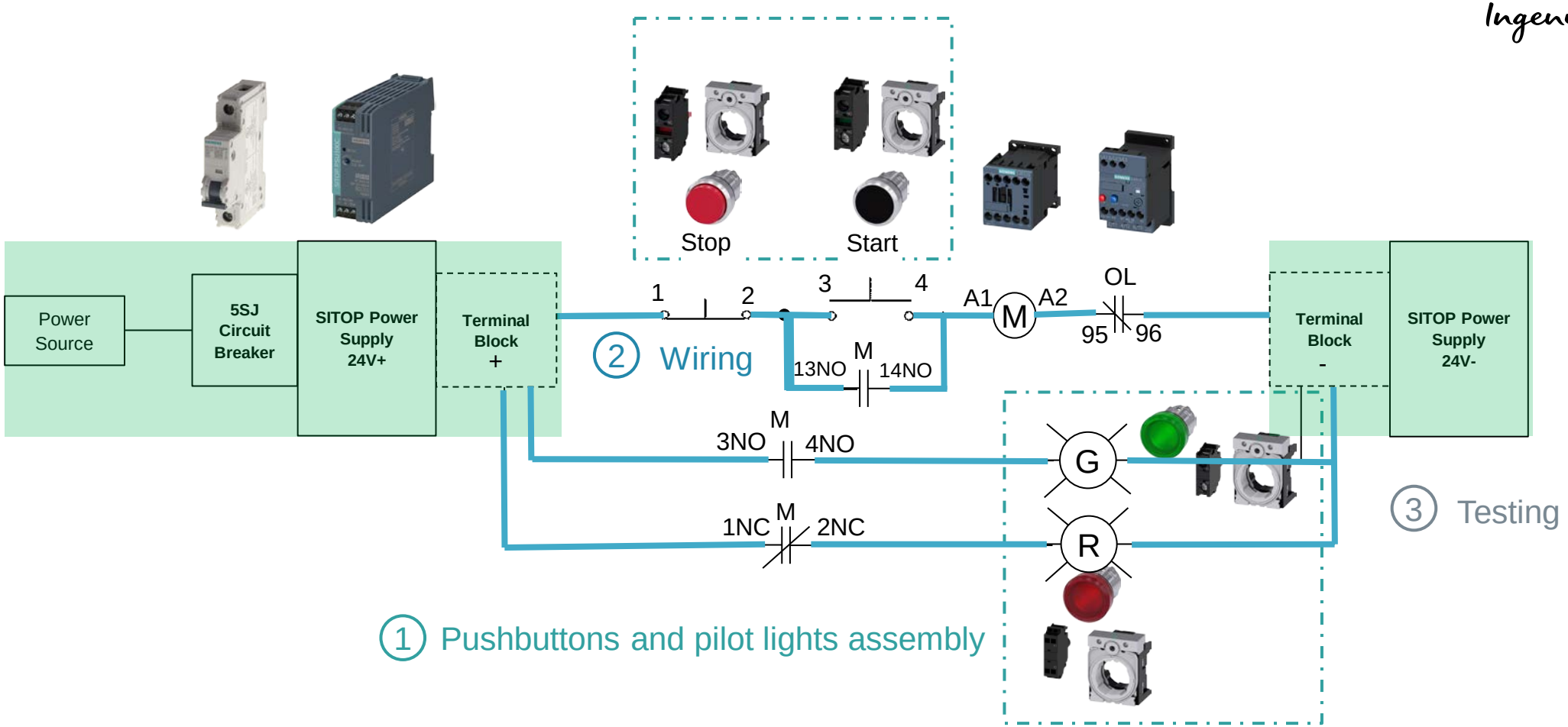

Prewired on Hands-On demo

① Pushbuttons and pilot lights assembly

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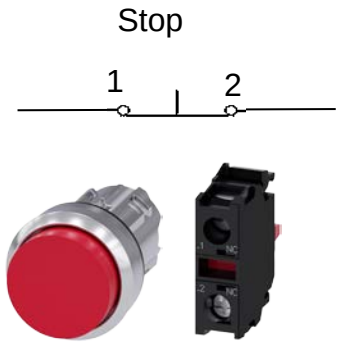
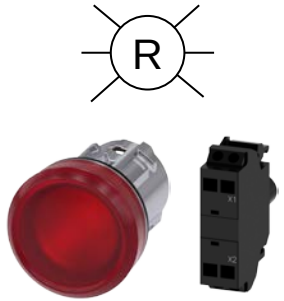


STOP button with NC contact

START button with NO contact

Green LED

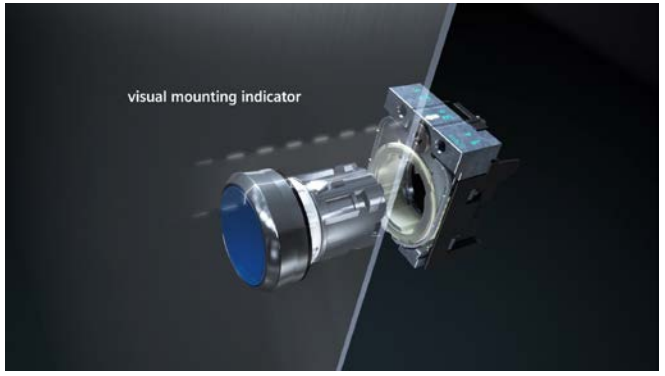


Red LED

Holder for each device

Steps

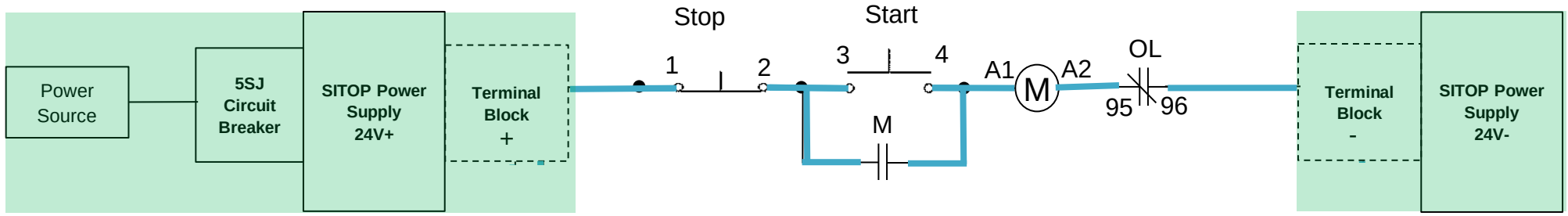
1. Align the arrows on pilot device with the arrows on the holder



2. Tighten the screw on the holder

3. Mount the contact or LED module on the middle slot for easy access

② Wiring 2



1. 1 Turn the circuit breaker Off
2. Remove the wiring to the 2 position selector switch, and wire the 3 wire Start Stop circuit as shown.

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3 Testing 2

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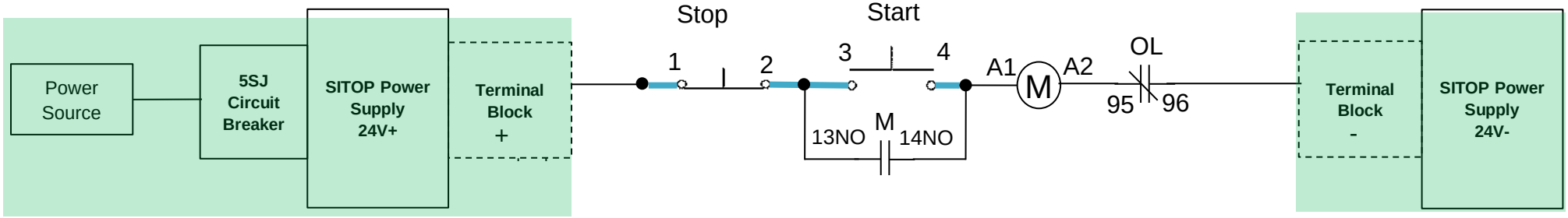
1. Turn the circuit breaker on.
2. Press the Start button and release. You should hear the contactor energize and stay energized.
3. Press the Stop button, The contactor should deenergize immediately when the Stop button is pressed.
4. Press the Start button and release to energize the contactor. Press and release the red STOP button on the overload and observe the operation of the contactor.



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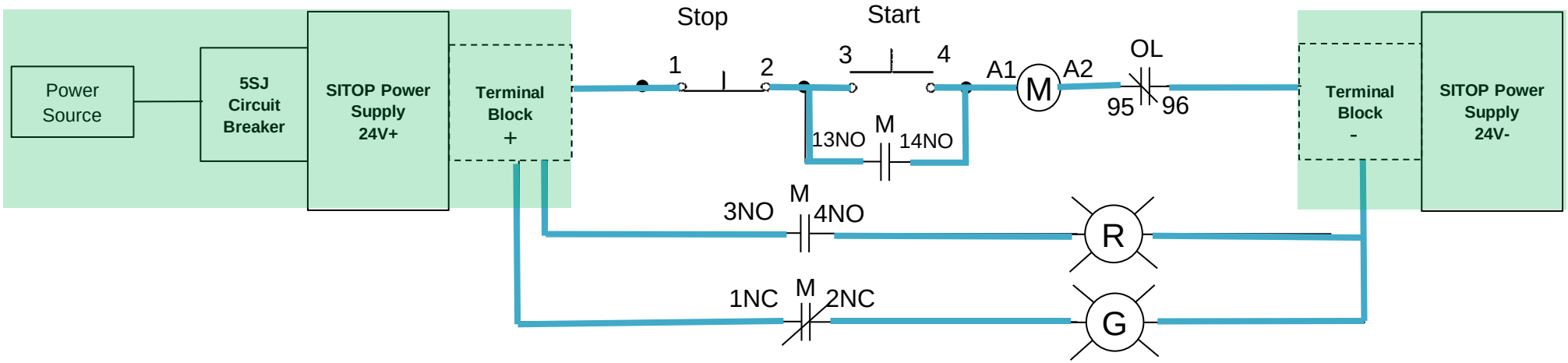
② Wiring 3



1. Turn Off the circuit breaker.
2. Add the wiring for the Red and Green pilot lights to the 3 wire control circuit. The NO and NC M contacts are located on top of the contactor.

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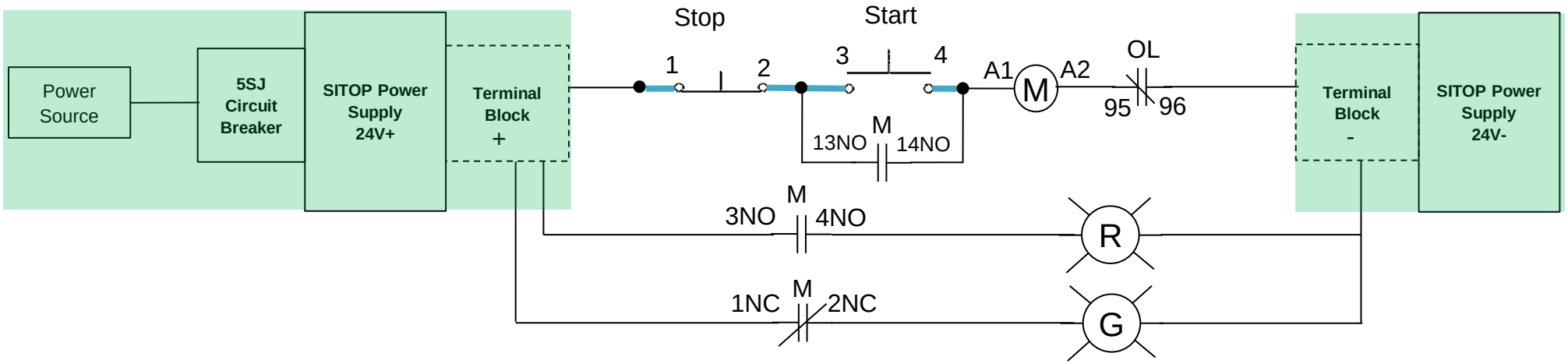
3 Testing 3

1. Turn the circuit breaker on
2. Press the Start button and release. You should hear the contactor energize and stay energized.
3. Press the Stop button, The contactor should deeneergize immediately when the Stop button is pressed.
4. Observe the function of the pilot lights when the Start and Stop buttons are pressed.



Prewired on Hands-On demo

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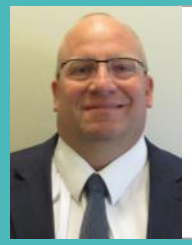

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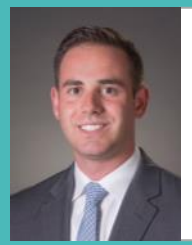

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Thank you and closing slide

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Now that we have completed the course, you should be able to…

- State the purpose and general principles of control components and circuits
- State the difference between manual and automatic control operation
- Identify various symbols which represent control components
- Read a basic line diagram
- Describe the construction and operating principles of manual starters, electromagnetic contactors, and electromagnetic motor starters
- Explain the need for motor overload protection
- Briefly describe the operation of thermal and electronic overload relays
- Describe the advantages of reduced-voltage motor starting
- Describe the advantages of variable frequency drives

Thanks you for your attention. Have a great day!.

Questions

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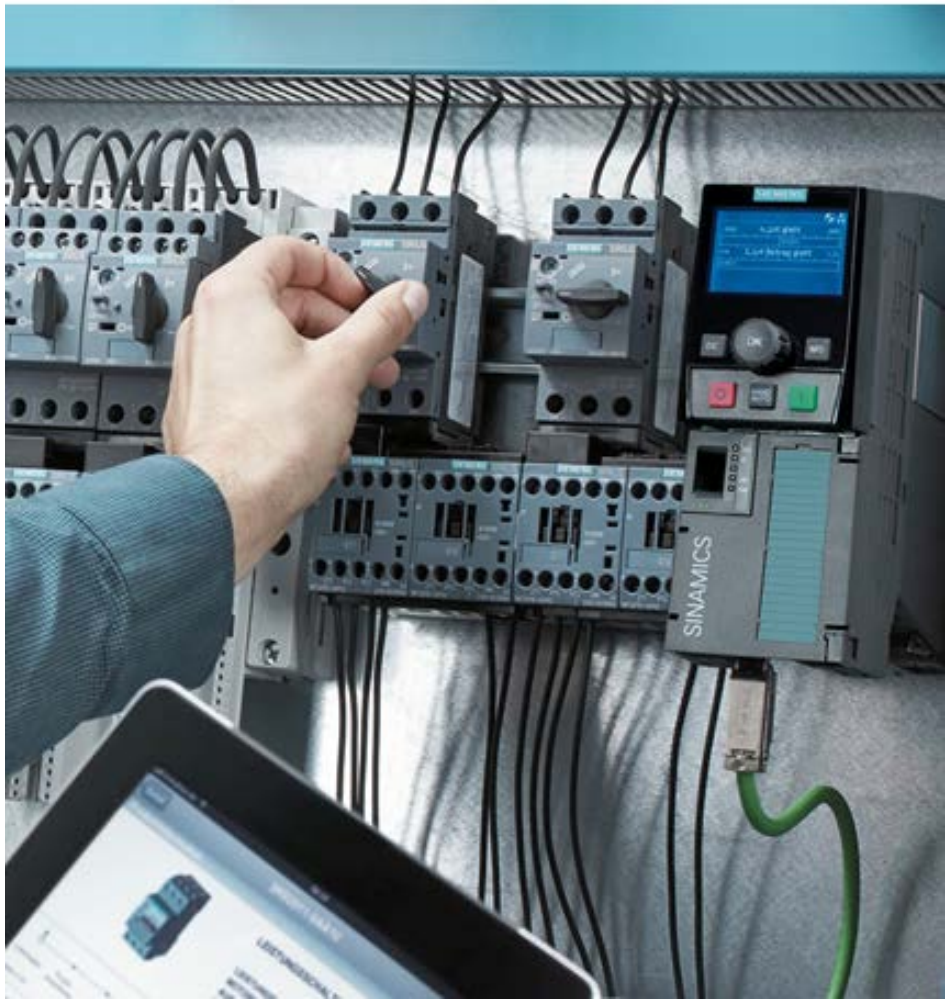
Motor Control Fundamentals



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