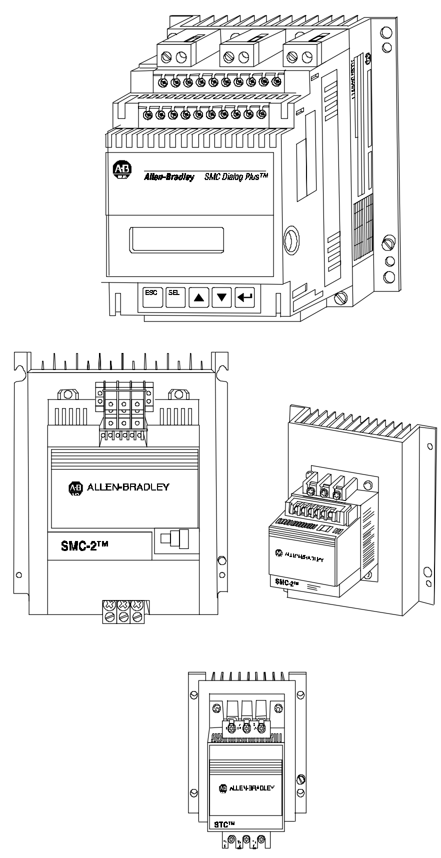
Rockwell Automation

SMC Controllers™

Bulletin 150

Application and Product Guide



Please Read!

This manual is intended to *guid* qualified personnel in th installation and operation of this product.

Because of the variety of uses for this equipment and because of the differences between this solid-state equipment and electromechanical equipment, the user of and those responsible for applying this equipment must satisfy themselves as to the acceptability of each application and use of the equipment. In no event will Allen-Bradley Company, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The illustrations shown in this manual are intended solely to illustrate the text of this manual. Because of the many variables and requirements associated with any particular installation, the Allen-Bradley Company, Inc. cannot assume responsibility or liability for actual use based on the illustrative uses and applications.

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For Smart Motor Controller technical support, contact your Allen-Bradley representative.

In the United States and Canada you may also call 1-800-765-SMCS (765-7627) for assistance during the hours of 8:00 AM to 12:00 noon and 1:00 PM to 4:30 PM (Central Time Zone) from Monday through Friday.

Important User Information

The information in this manual is organized in numbered chapters. Read each chapter in sequence and perform procedures when you are instructed to do so. Do not proceed to the next chapter until you have completed all procedures.

Throughout this manual we use notes to make you aware of safety considerations:

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.

Attentions help you:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is especially important for successful application and understanding of this product.

Chapter 1 STC Starting Torque Controller

Chapter 2 SMC-2 Smart Motor Controller

Chapter 3 SMC Dialog Plus Smart Motor Controller

Chapter 3 (cont.)

Chapter 4 Application Profiles for the SMC Dialog Plus Controller

Chapter 5 SMC Dialog Plus Controller Special Application Considerations

Chapter 6 SMC Product Line Applications Matrix

Chapter 7 Design Philosophy

Chapter 8 Reduced Voltage Starting

Chapter 9 Solid-state Starters Using SCRs

Chapter 10 Reference

Chapter 10 (cont.)

SMC Controllers

The Allen-Bradley SMC Controller™ lines offer a broad range of products for starting or stopping AC induction motors from 1/3 HP to 6,000HP. The innovative features, compact design, and available enclosed controllers meet world-wide industry requirements for controlling motors. Whether you need to control a single motor or an integrated automation system, our range of controllers meet your required needs with the Starting Torque Controller (STC) and Smart Motor Controller family (SMC-2, SMC PLUS, and SMC Dialog Plus).

Features	STC™ Controller		SMC–2™ Controller	SMC Dialog Plus™ Controller
	100–240V 1-phase 1–22A	200–600V 3-phase 1–22A	200–600V 1–97A	200–600V 1–1000A
Soft Start	★	★	★	★
Kickstart				★
Current Limit Start			★	★
Dual Ramp Start				★
FullVoltage Start			★	★
Energy Saver			★	★
Soft Stop			★	★
Pump Control				★
Preset Slow Speed				★
SMB™ Smart Motor Braking				★
Accu-Stop™				★
Slow Speed with Braking				★①
Single-phase Operation	★			
Normal/Up-to-speed Aux				★
Fault Contact				★
Modular Design				★
Overload Protection				★
Metering				★
Communication				★
Backlit LCD Display				★
Programming Keypad				★
Phase Reversal				★
Phase Rebalance				★
Jam Detection				★
Underload Detection				★

★ = Available

① Included with the Accu-Stop option

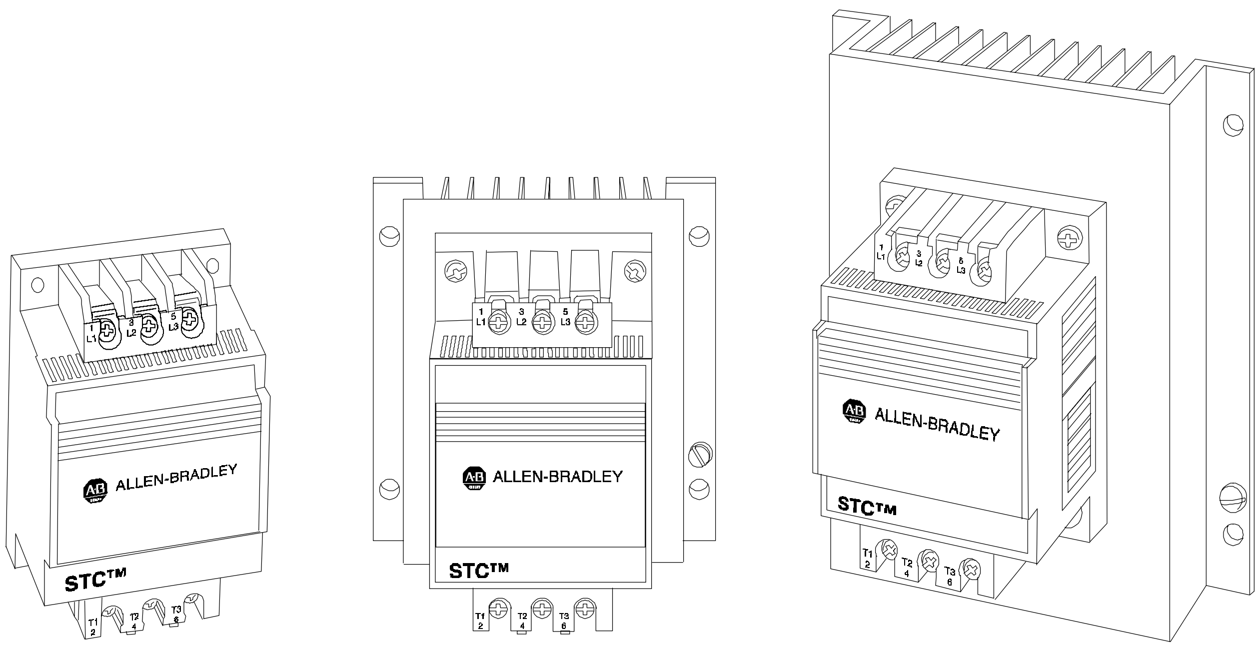
STC Starting Torque Controller

Description

The STC™ Starting Torque Controller is designed for low horsepower single-phase and three-phase squirrel cage induction motors. It is intended to relieve the starting torque surge encountered in typical across-the-line starting. This will provide smoother starts and decrease downtime due to shock and vibration related problems.

The STC is a global product available in three current rated sizes: 11, 16, and 22 Amp, with voltage ranges from 100–600V, 50/60 Hz., UL Listed, CSA Approved, and CE labeled. Its compact design makes new installations as well as retrofitting easy. Setting the initial torque and ramp time of the controller is accomplished with digital rotary switches.

Figure 1.1 STC Controller (11, 16, and 22 Amps)

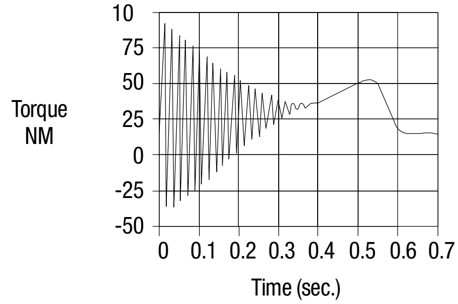


Modes of Operation

Across-the-Line Response

Excessive motor starting torque can damage the motor and driv equipment. Figure 1.2 illustrates the torque developed in a typical across-the-line start.

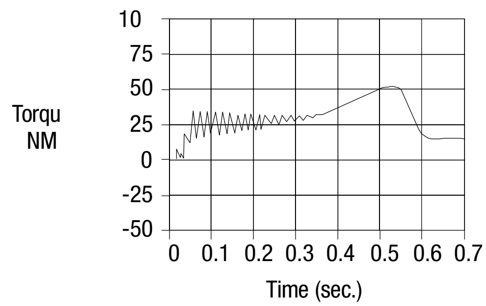
Figure 1.2 Torque Developed in a Typical Across-the-Line Start



STC Controller Response

The STC controller reduces the magnitude of starting torque surges as illustrated in Figure 1.3. This limits the starting shock to the motor and drive train.

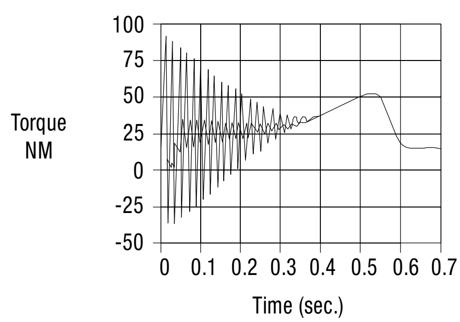
Figure 1.3 STC Controller Respons



Across-the-Line Response Versus STC Controller Response

Figure 1.4 compares a typical across-the-line start response and the STC controller response.

Figure 1.4 Across-the-Line Response Versus STC Controller Response

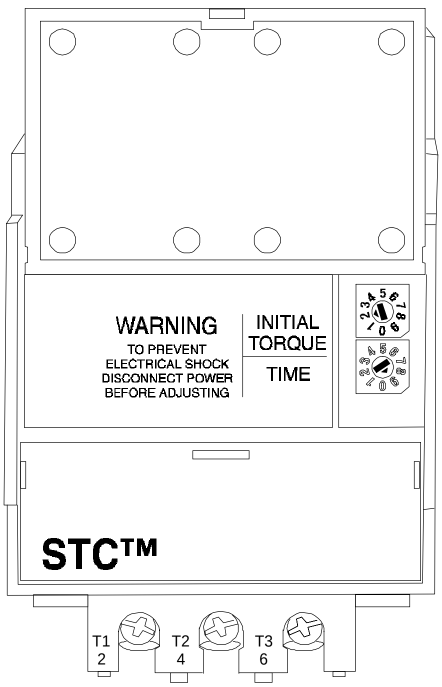


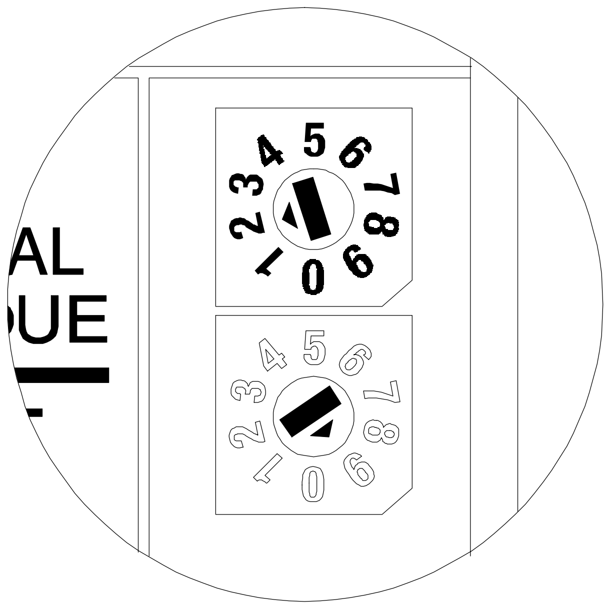
Features

The STC controller is a compact device with feed through wiring for ease of installation. To set up the controller, adjust the digital rotary switches. The initial torque value is set between 10 and 80% of locked rotor torque. The voltage ramp time is adjustable from 0.1 to 4.5 seconds. This flexible combination enables the STC controller to be installed in a wide variety of applications.

Adjustments

Figure 1.5 STC Controller Adjustments





Digital Rotary switches for easy adjustments

Table 1.A Initial Torque Level (Nominal)

Position	0	1	2	3	4	5	6	7	8	9
% of Locked Rotor Torque	10	15	20	25	30	40	50	60	70	80

Table 1.B Voltage Ramp Time (Nominal) (With Initial Torque Set At 0)

Position	0	1	2	3	4	5	6	7	8	9
Time (Seconds)	0.1	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5

Wiring Diagrams

Figure 1.6 Typical Wiring Diagrams for STC Controller in Three-phase Applications

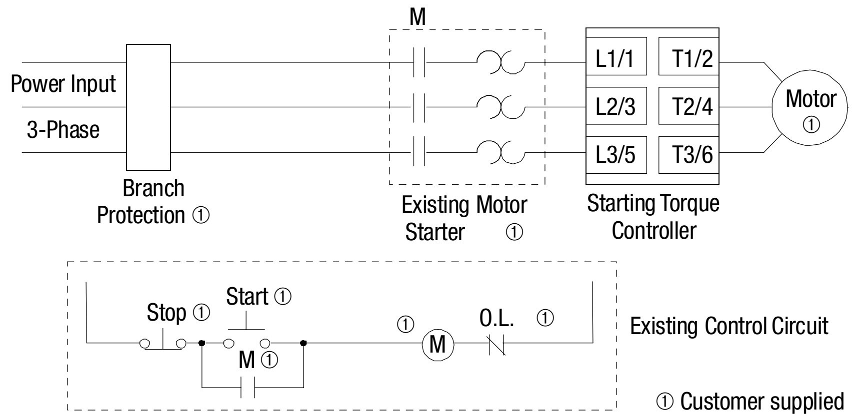


Figure 1.7 Typical Wiring Diagrams for STC Controller in Single-phase Applications

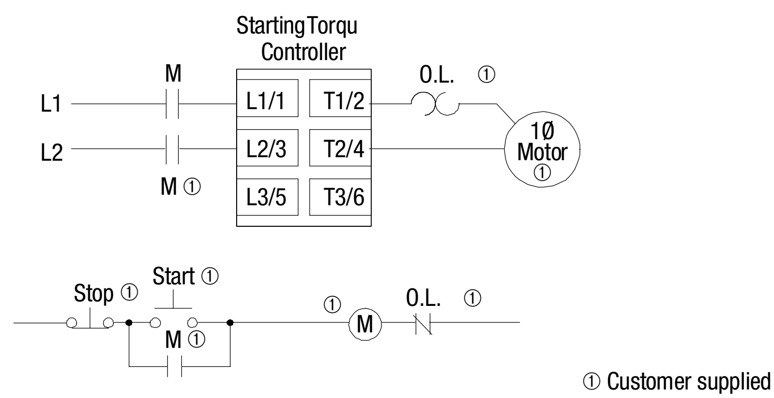
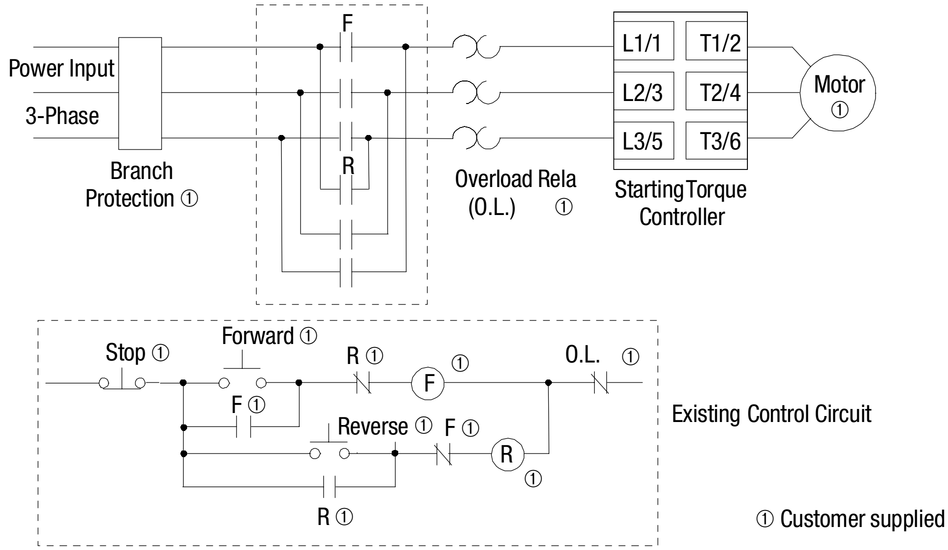


Figure 1.8 Typical Wiring Diagrams for STC Controller – Reversing



Suitable Replacement

The STC controller is a suitable replacement for:

- Wye-delta Starters
- Resistor Ballast Starters
- Line Reactors
- Clutches
- Flywheels
- Fluid Couplings
- Other Mechanical and Electrical Soft Start Devices

Applications

In this section a few of the many STC controller applications are described.

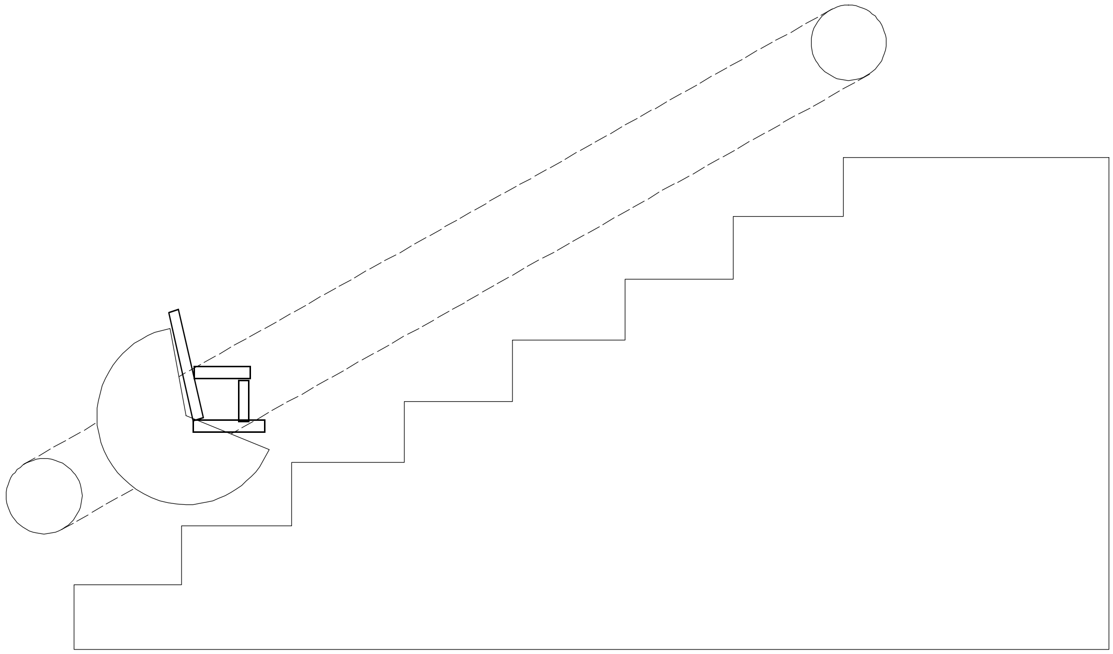
Illustrations are included to help identify the particular application. Motor ratings are specified but this may vary in other typical applications.

Typical applications include:

- Bridge Cranes
- Trolleys
- Monorails
- Shrink Wrap Machines
- Overhead Doors
- Conveyor
- Material Handling Equipment
- Compressors
- Fans and Pumps
- Lifts
- Elevators
- Grinders
- Mixers

Applications (cont.)

Figure 1.9 Chair Elevator

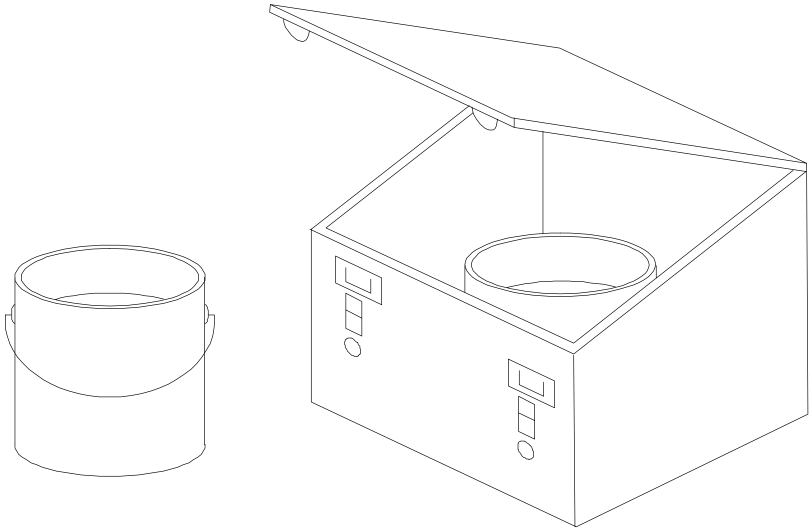


Problem: A single-phase chain driven chair elevator was started across-the-line. The starting torque caused the chair to lurch during the start and occasionally caused chain alignment problems.

Solution: An STC controller was installed to provide controlled acceleration.This minimized the mechanical shock encountered during across-the-line starting and reduced alignment problems. It also allowed for regularly scheduled preventive maintenance inspections, rather than emergency maintenance repair.

Applications (cont.)

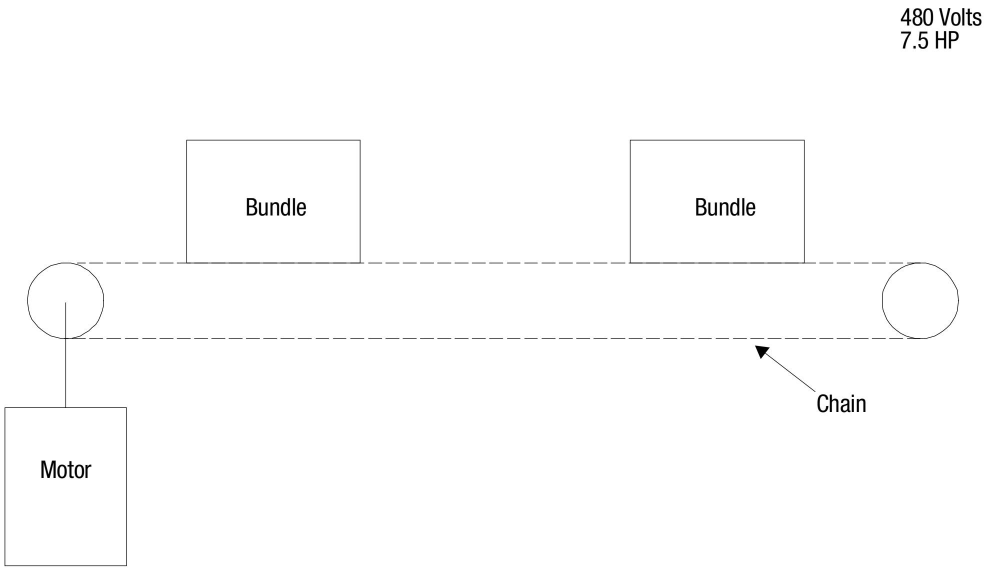
Figure 1.10 Paint Shaker



Problem: The commercial paint shaker was operated with a single phase motor and used across-the-line starting. This method of starting caused the facility's line voltage to dip. The building's fluorescent lighting, with electronic ballasts, was extremely sensitive to line voltage dips and would momentarily shut off when the paint shaker was started.

Solution: A single-phase STC controller was used to provide a soft start to the paint shaker. The ramp time was set to three seconds, thereby eliminating the line voltage dip.

Figure 1.11 Chain Conveyor with Torque Control

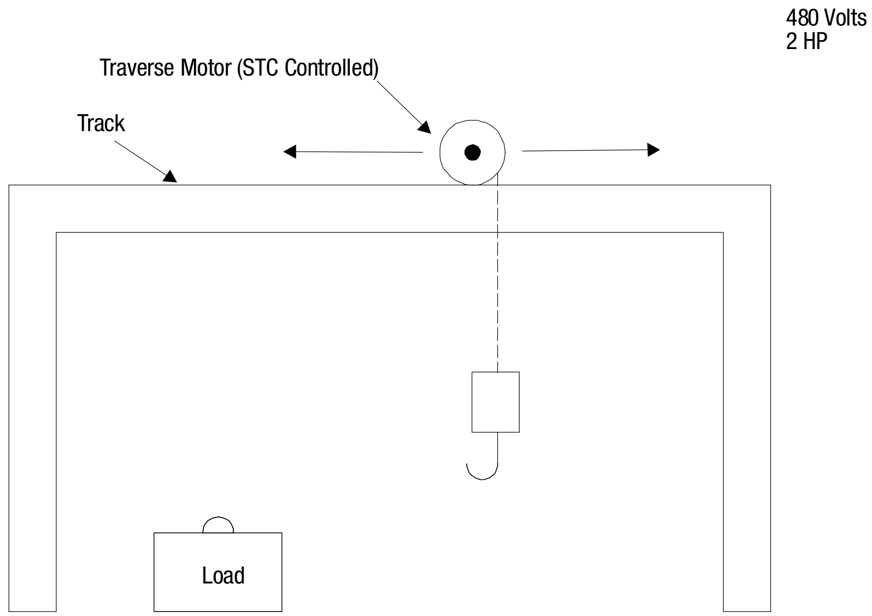


Problem: A chain conveyor is used for transporting bundles of paper. Due to the high starting torque the conveyor motor applies to the chain during startup, the chain was breaking on an average of once per day. Maintenance of the conveyor caused interruptions in the production schedule.

Solution: The STC controller was installed to reduce the starting torque on the motor and mechanical system. This resulted in less downtime and higher productivity. The STC controller was easy to retrofit due to its compact size and feed through wiring.

Applications (cont.)

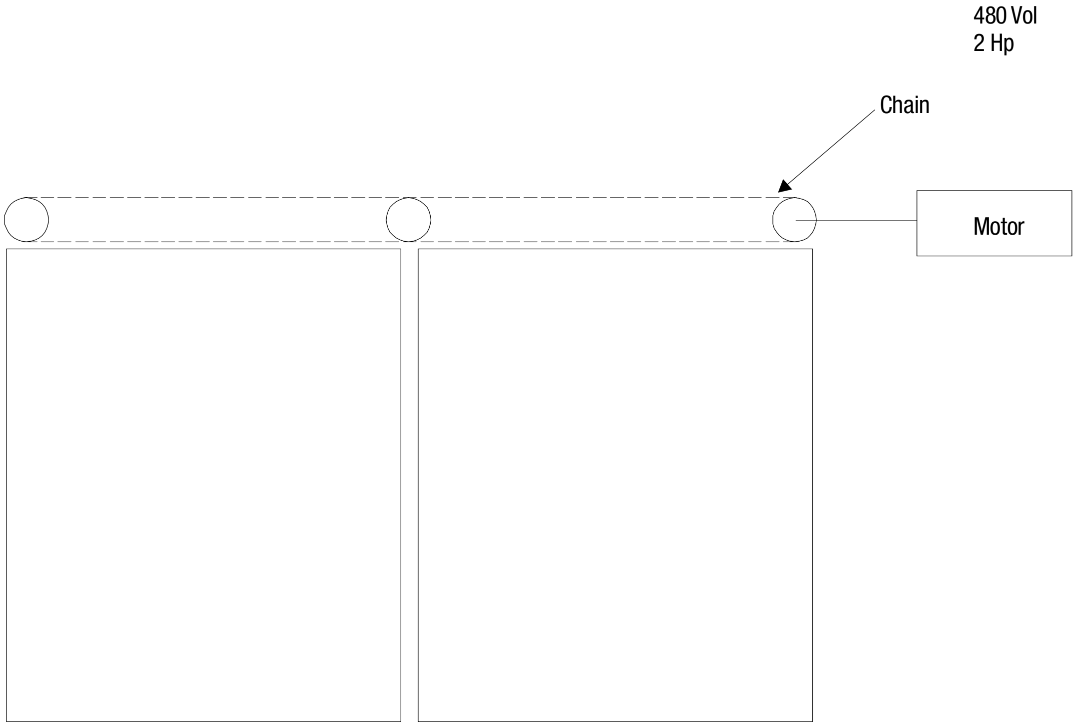
Figure 1.12 Crane with Torque Control



Problem: An overhead crane required frequent jogging due to adjustments in the traverse (horizontal) position. An across-the-line starter was used and this caused overshoot or undershoot when trying to position over a load.

Solution: The STC controller was installed in the application. By reducing the starting torque of the motor, this allowed th crane to be positioned effectively. This meant fewer starts were required to position the crane over the load. This solution reduced the maintenance required as well as improved the productivity of the crane. The STC controller was a cost effective solution.

Figure 1.13 Aircraft Hangar Door



Problem: A chain driven aircraft hangar door was started across-the-line. The starting torque caused chain alignment problems. This required frequent inspection and maintenance.

Solution: An STC controller was installed to provide controlled acceleration. This minimized the mechanical shock encountered during across-the-line starting and reduced maintenance inspection. The digital adjustments of the STC controller were easily set and did not drift with ag or vibration.

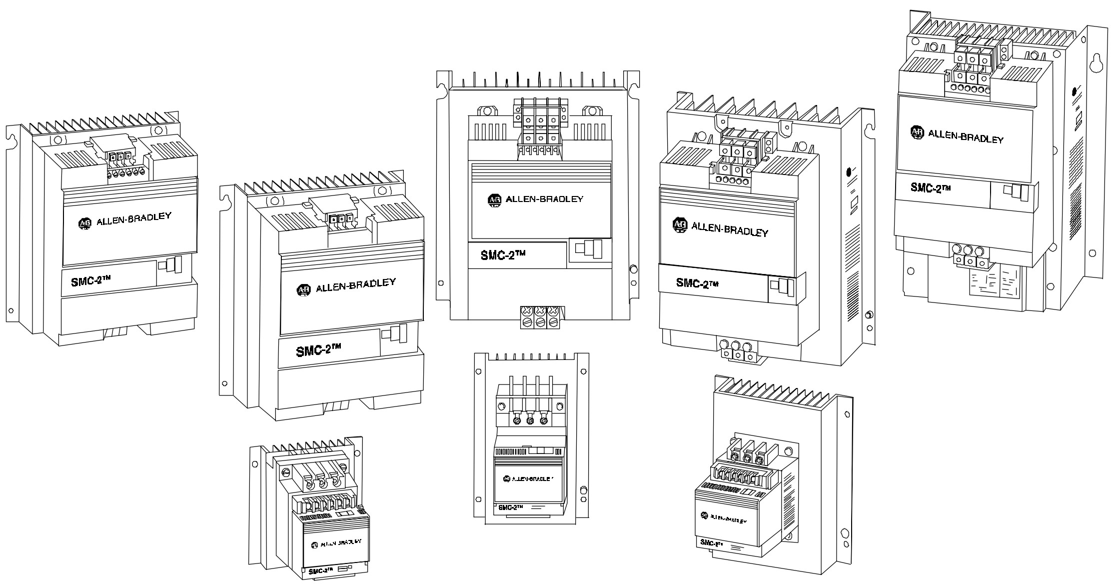
SMC-2 Smart Motor Controller

Description

The SMC-2™ Smart Motor controller is a compact, multi-functional solid state controller used in starting standard three-phase squirrel cage induction motors and controlling resistive loads.

The SMC-2 product line includes current ranges from 5–97 Amps, 200 to 600V, 50/60 Hz., UL Listed, CSA Approved, and CE labeled. This covers applications up to 75 horsepower.

Figure 2.1 SMC-2 Controller (5–97 Amps)



Modes of Operation

The following modes of operation are standard within a single controller:

- Soft Start
- Current Limit Start
- FullVoltage Start

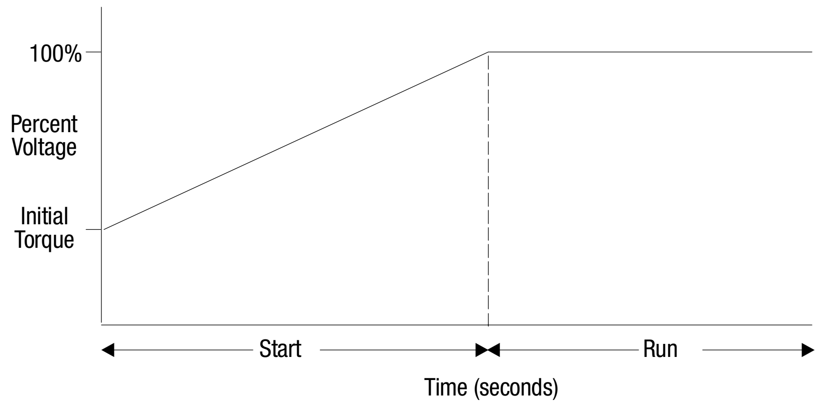
The built-in energy saver feature allows the controller to conserv energy on applications where the motor is lightly loaded or unloaded for long periods of time.

Modes of Operation (cont.)

Soft Start

This is the most common method of starting. The initial torque value is set between 0–70% of locked rotor torque. The motor voltage is steplessly increased during the acceleration ramp period, which is adjustable from 2–30 seconds.

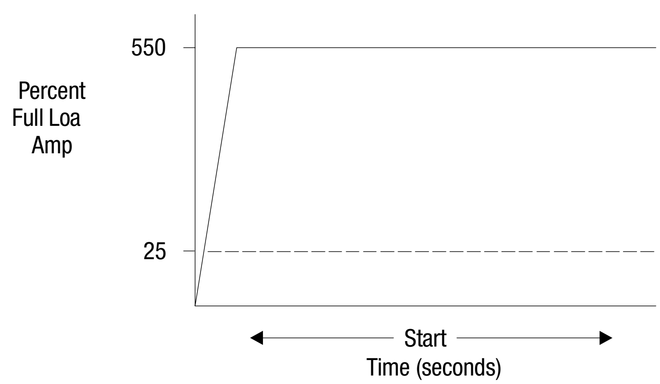
Figure 2.2 Soft Start



Current Limit Start

This starting mode is used when it is necessary to limit the maximum starting current. This can be adjusted from 25 to 550% of full load amperes. The current limit starting time is customer set. If the motor is not up to speed after the selected time, the motor will transition to full voltage

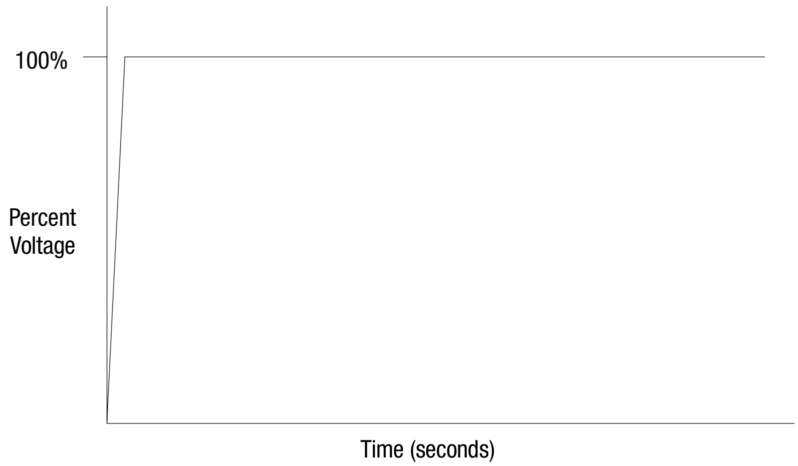
Figure 2.3 Current Limit Start



Full Voltage Start

This mode is used in applications requiring across-the-line starting. The ramp time is less than 1/10 second.

Figure 2.4 Full Voltage Start



Features

Fault Trips

There is a single red LED on the front of the SMC-2 controller for diagnostic indication. When three-phase power is applied to the controller, the LED will be on.

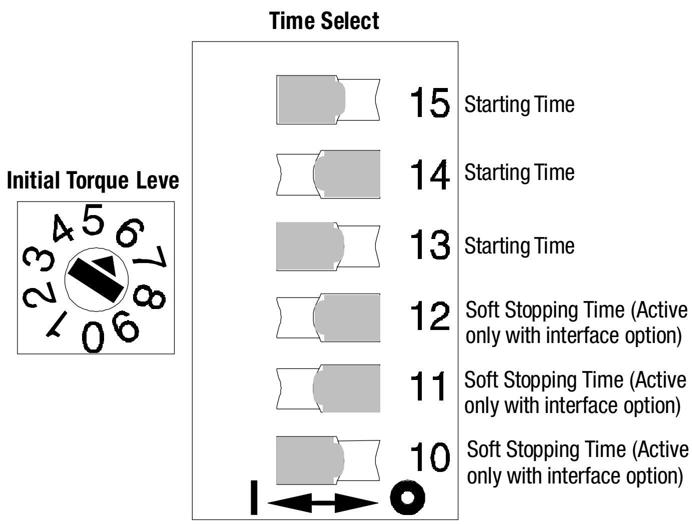
The SMC-2 controller monitors the following fault conditions:

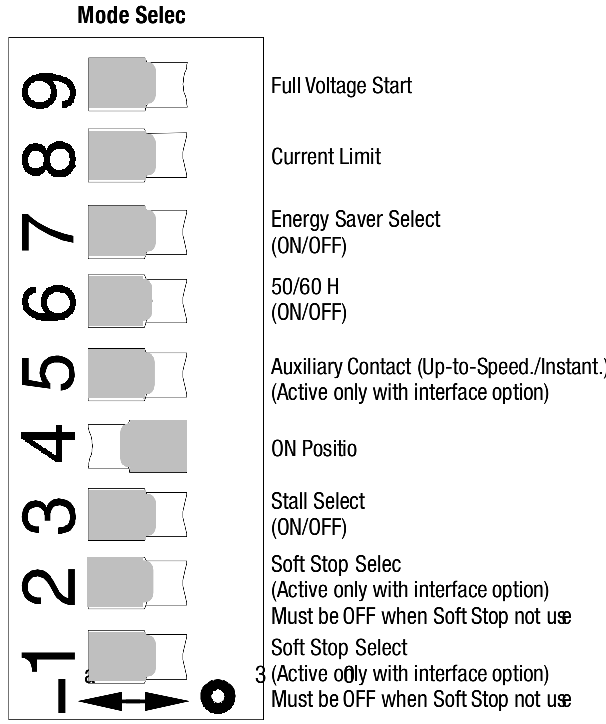
- Shorted SCR (pre-start only)
- Phase Loss (line side and pre-start only
- Stalled Motor (when stall switch is on)

If a shorted SCR or phase loss exists, the SMC-2 controller will not start and the LED will flash. If a stalled motor condition exists, th controller shuts down and flashes the LED. In the event three-phase input power is lost, the LED turns off.

Adjustments

Figure 2.5 SMC-2 Soft Start





NOTE: The switches shown above are for a 10 second Soft Start with initial torque and 25 seconds soft stop.

Table 2.A Rotary Position Initial Torque Level

Position	0	1	2	3	4	5	6	7	8	9
% of Locked Rotor Torque	0	1	2	5	10	20	30	40	50	70

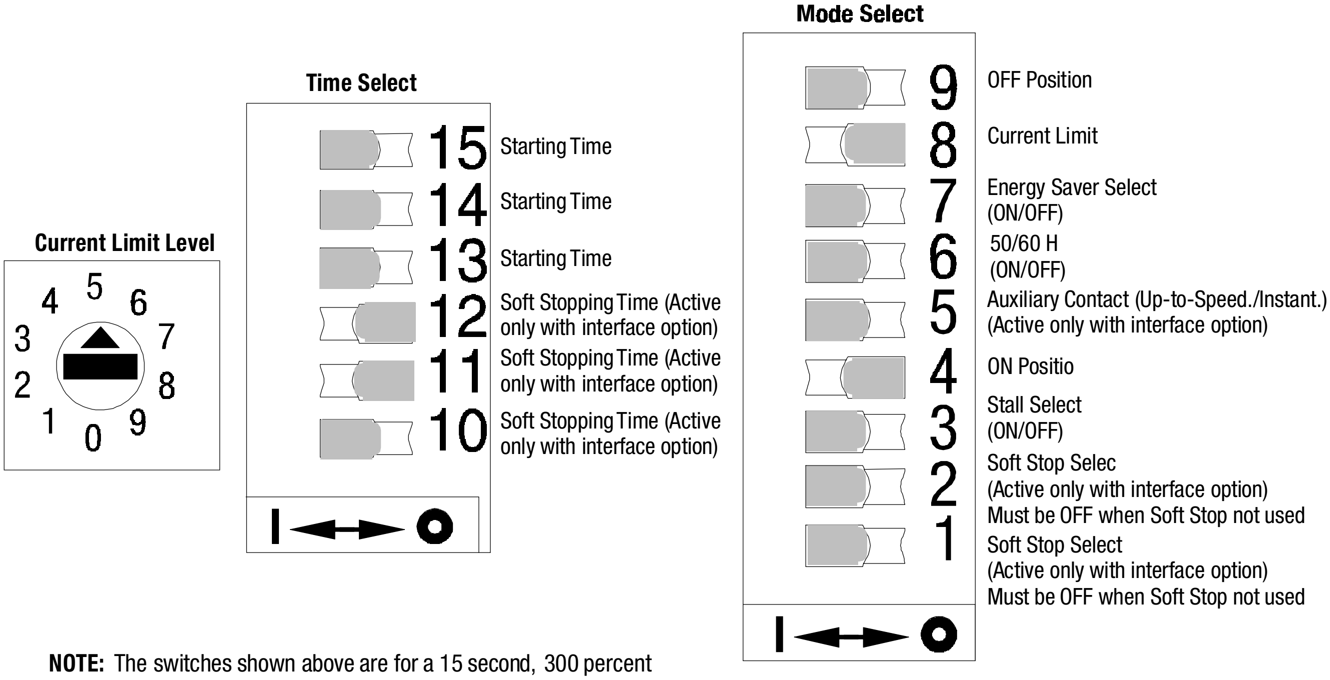
Table 2.B Soft Start Time

Switch Number	Time (seconds)						
	2	5	10	15	20	25	30
15	Off	On	Off	On	Off	On	Off
14	Off	Off	On	On	Off	Off	On
13	Off	Off	Off	Off	On	On	On

Table 2.C Soft Stop (Available only with interface option)

Switch Number	Time (seconds)							
	5	10	15	25	35	45	55	110
12	Off	On	Off	On	Off	On	Off	On
11	Off	Off	On	On	Off	Off	On	On
10	Off	Off	Off	Off	On	On	On	On

Figure 2.6 SMC-2 Current Limit Selection



NOTE: The switches shown above are for a 15 second, 300 percent current limit start with a 25 second soft stop

Table 2.D Rotary Position % Current Limit

Position	0	1	2	3	4	5	6	7	8	9
% of Full Load Amps	25	50	100	200	250	300	350	450	500	550

Table 2.E Current Limit Start Time

Switch Number	Time (seconds)	
	15	30
15	Off	On
14	Off	Off
13	Off	Off

Table 2.F Soft Stop (Available only with interface option)

Switch Number	Time (seconds)							
	5	10	15	25	35	45	55	110
12	Off	On	Off	On	Off	On	Off	On
11	Off	Off	On	On	Off	Off	On	On
10	Off	Off	Off	Off	On	On	On	On

Adjustments (cont.)

Figure 2.7 SMC-2 Full Voltage Selection

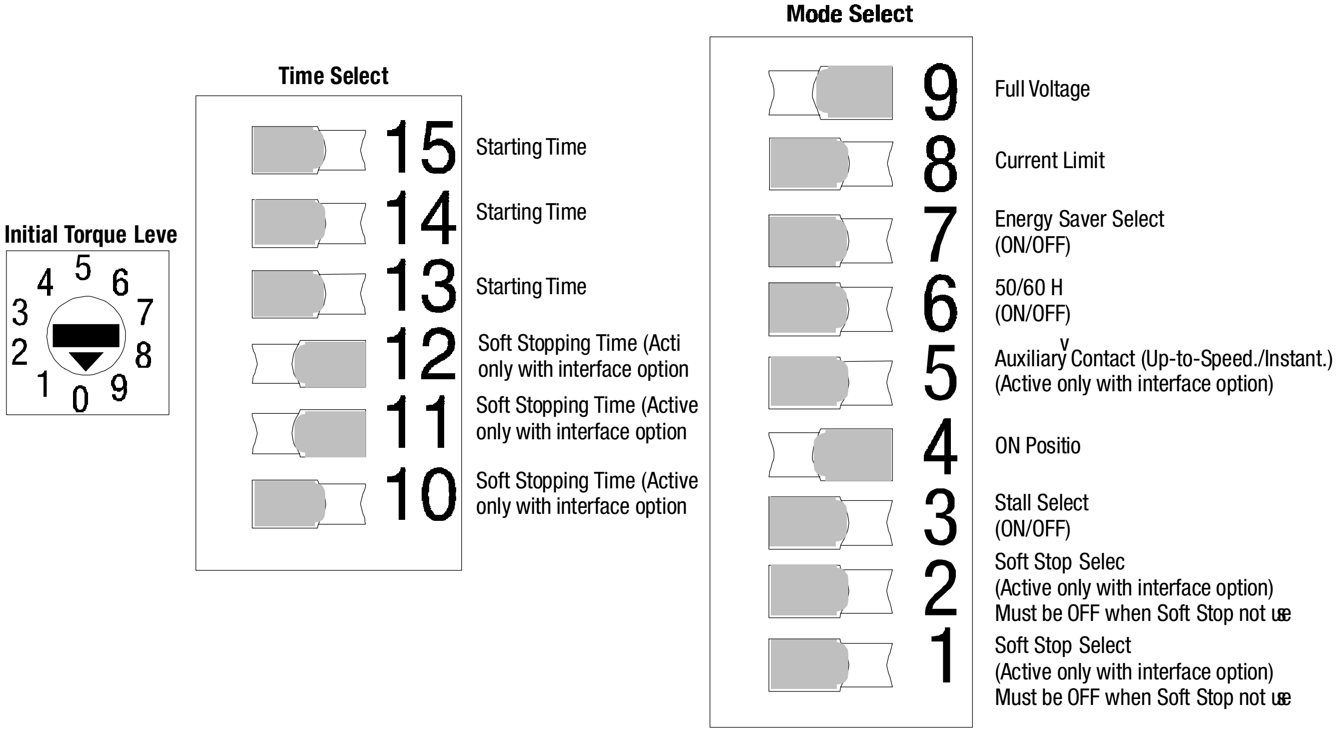


Table 3.G Soft Stop (Available only with interface option)

Switch Number	Time (seconds)							
	5	10	15	25	35	45	55	110
12	Off	On	Off	On	Off	On	Off	On
11	Off	Off	On	On	Off	Off	On	On
10	Off	Off	Off	Off	Off	On	On	On

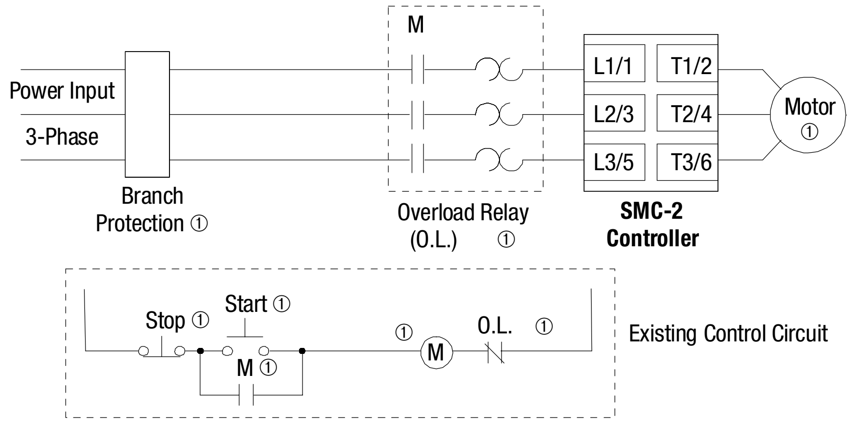
Wiring Diagram

Series Controller

The SMC-2 controller is designed to operate with an electromechanical starter. The series mode has the following features:

- Simplified initial installation – no need for additional wiring
- Easy retrofits – works with existing electromechanical starter

Figure 2.8 Wiring Diagram for Series Controller



① Customer supplied.

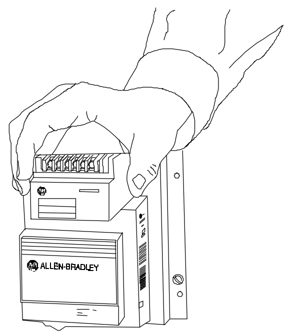
Options

Description of Interface Options

The SMC-2 controller is designed to be operated by an external device. An optional interface is available for the SMC-2 controller. This offers the following features:

- ON/OFF control directly to the controller through an external device. In many applications the interface may eliminate the need for an additional contactor. This reduces the panel space required.
- A configurable auxiliary contact which operates as either an instantaneous or up-to-speed contact.
- Soft Stop. This extends stopping time to minimize load shifting or spillage during stopping.

Figure 2.9 Interface Option (5–16 Amps)

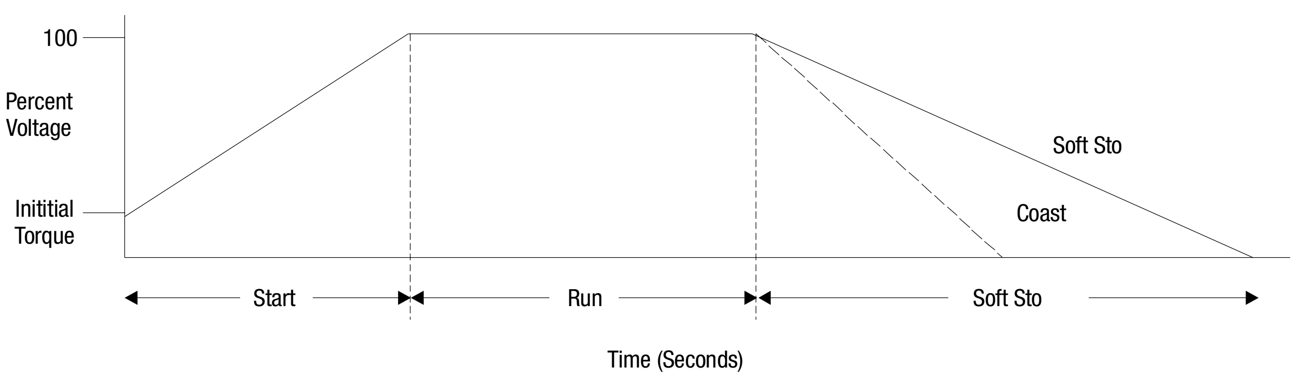


This option is available as a plug-in module for the 5–16 Amp devices. For 24–97 Amp devices, the interface is included as an integral part of the logic design. It is not a plug-in device like th 5–16 Amp interface option.

Soft Stop Option

This function can be used in applications that require an extended coast to rest. The voltage ramp downtime can be set from 5–110 seconds. The starting and stopping times are independently adjusted. The load will stop when the voltage drops to a point where the load torque is greater than the motor torque.

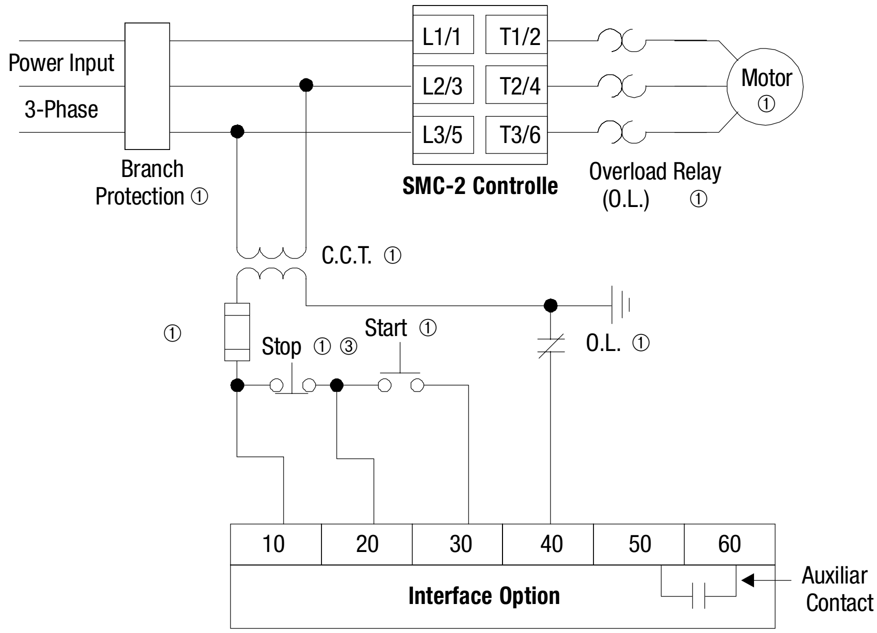
Figure 2.10 Soft Start with Soft Stop



Wiring Diagram with Interface Option

Control power requirement for the interface option is 5VA at 120V and15VA at 240V. Auxiliary contact rating is NEMA C300, 2.5 Amps, 20–250V AC: 1 Amp, 12–30V DC.

Figure 2.11 Wiring Diagram with Interface Option



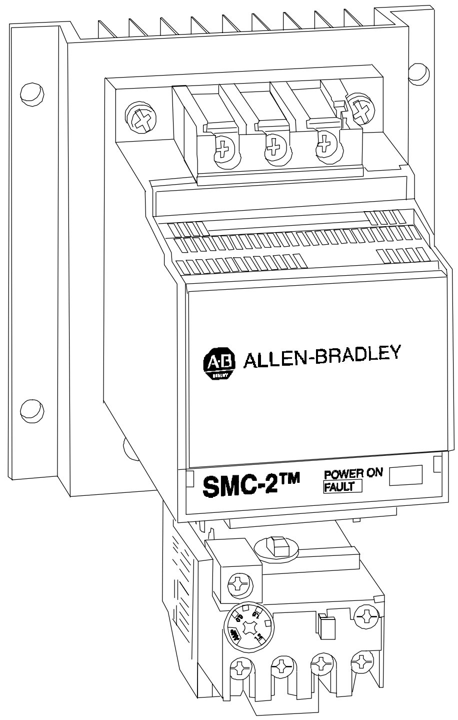
① Customer supplied
② Maximum fuse size 10A, 250V.
③ For two wire control, remove stop/start push buttons and connect two wire device between terminals 10 and 30

Options (cont.)

Overload Relay Option

To save additional panel space, IEC overload relays may be mounted directly to the 5, 9, and 16 Amp SMC-2 controllers.

Figure 2.12 SMC-2 Controller with Bulletin 193 Overload Relay (5–16 Amps)

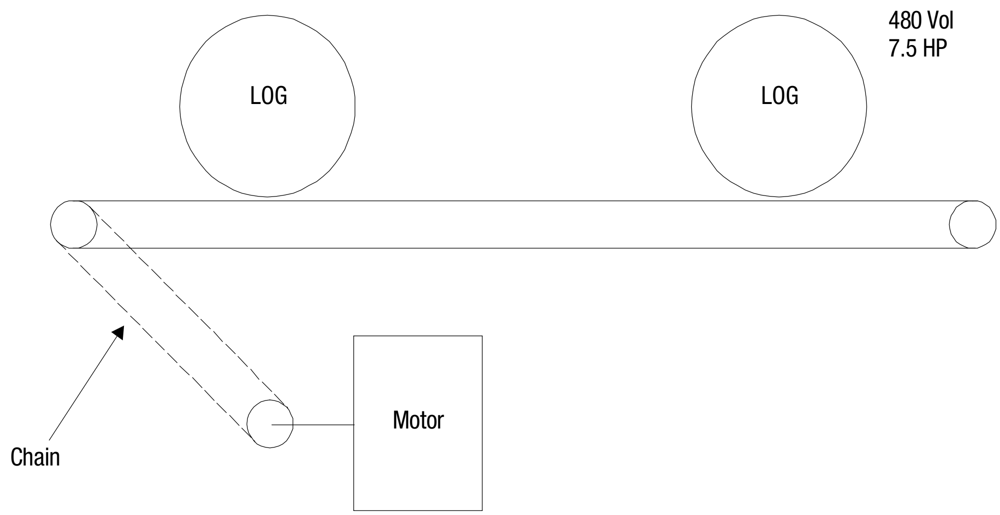


Applications

In this section a few of many applications are described, as well as why the particular control method was selected. For example, tumbler drum is described using a soft start feature. We will then “build” upon this application to describe how the SMC-2 controller options can be used to improve the tumbler drum performance and productivity.

Illustrations are included to help identify the particular application. Motor ratings are specified but this may vary in other typical applications.

Figure 2.13 Conveyor with Soft Start

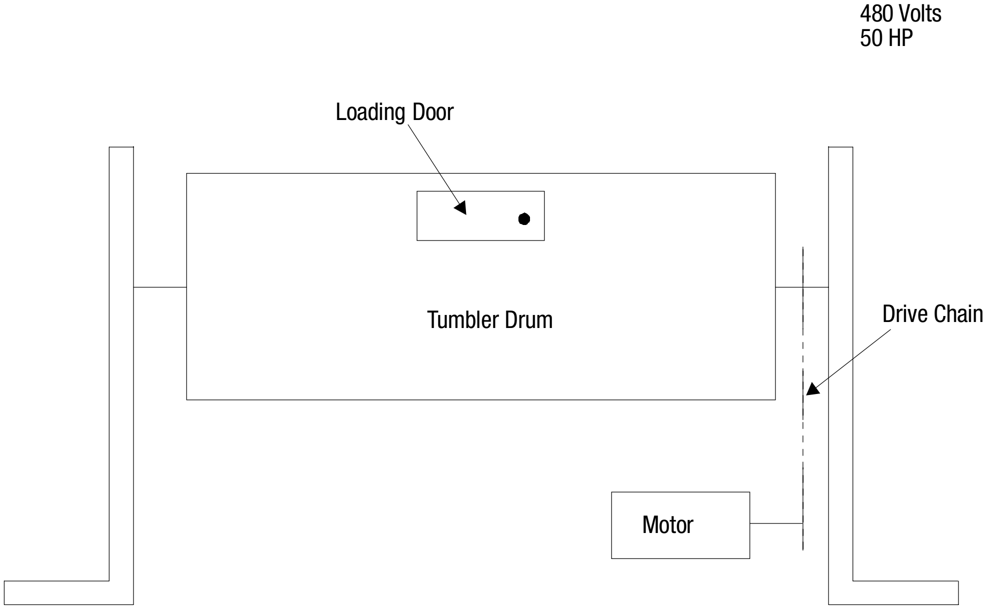


Problem: A conveyor is used to transport logs. The drive chain was breaking due to uncontrolled start-up. This caused interruptions in the production schedule and lost productivity. Panel space was very limited.

Solution: Due to its compact design, the SMC-2 controller was easily installed in the space vacated by the previous starter. A 10-second soft start was selected. This reduced the starting torque and the shock to the mechanical system.

Applications (cont.)

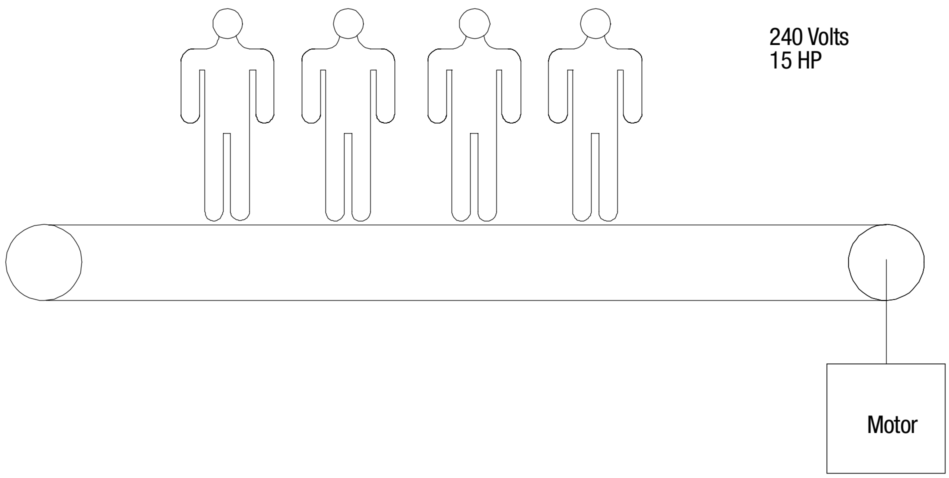
Figure 2.14 Tumbler with Soft Start



Problem: A tumbler used in a nail finishing process was breaking the drive chain due to the uncontrolled acceleration from the across-the-line start. In addition, a reversing starte was needed to position the drum to the top position for loading the product. Due to lack of controlled acceleration, numerous jogs were used to position the drum. The stopping time was not a concern in this application. In addition, single phasing of the motor was a frequent problem, causing premature motor failure.

Solution: The SMC-2 controller was installed after the reversing contactor to control the starting torque of the motor. This prevented the snapping of the drive chain on the start up which increased the life of the chain and reduced th downtime on the tumbler. In addition, the SMC-2 controller made it easier to jog the drum into position for loading and unloading. (The SMC-2 controller slowed the acceleration rate to prevent overshoot.) This helped improve the productivity of the loading and unloading process. In addition, the SMC-2 controller could quickly detect the phase failure during starting. The controller would prevent starting until the line had been corrected. This added additional standard protection to the motor and system.

Figure 2.15 Power Walk with Soft Start and Soft Stop Option

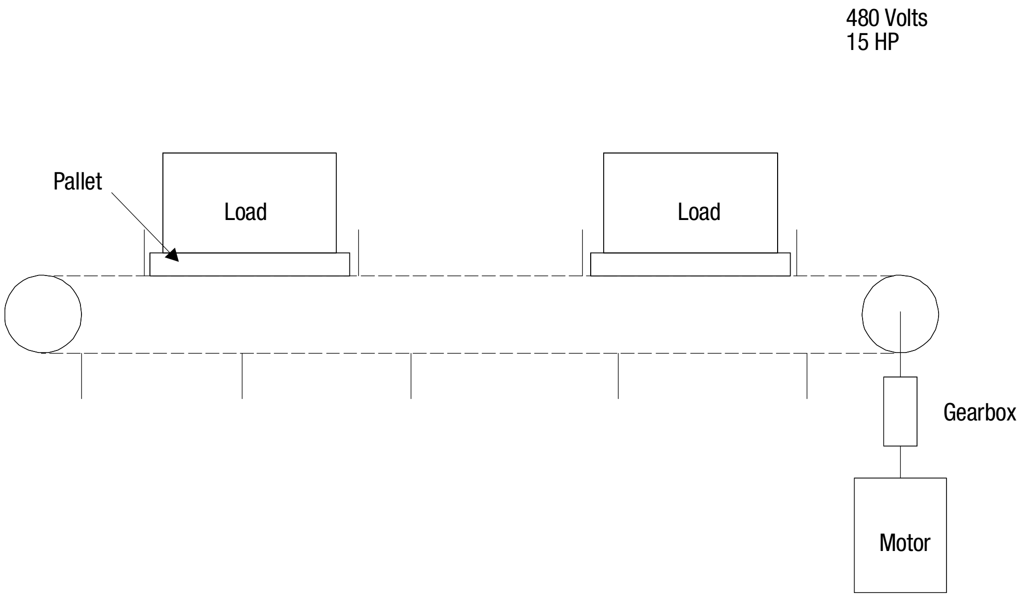


Problem: A power walk at an airport required a soft start to prevent damage to the drive chain gearbox on start-up. A soft stop was also required in case the power walk would b shut off while people were still on the belt. There would be multiple units at the site, and a controller that could be quickly installed and adjusted was required.

Solution: The SMC-2 controller with the Interface option was designed into the system. A 10-second soft start with the Energy Saver enabled was selected. A 10-second soft stop was also selected. This allowed the power walk to have a controlled start and stop. During periods where the walk was unloaded, the SMC-2 controller Energy Saver reduced the voltage to the motor, minimizing the magnetic losses of the motor.

Applications (cont.)

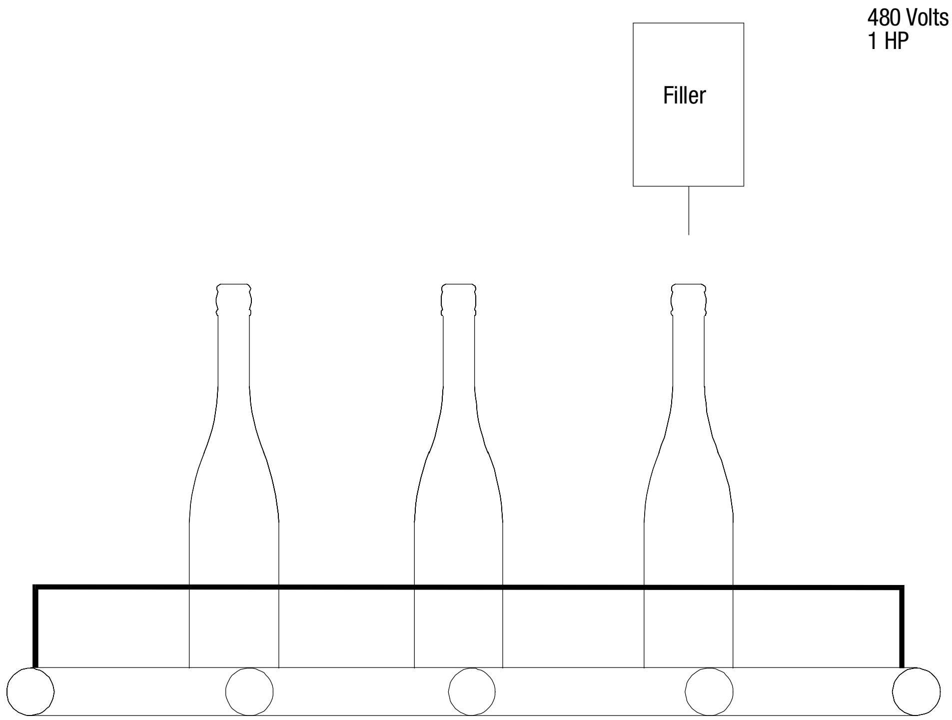
Figure 2.16 Towline Conveyor with Soft Start and Soft Stop Option



Problem: A towline conveyor at the end of a production line had frequent damage to the gearbox due to the starting torque from across-the-line starting of the motor. There were frequent spills on both starting and stopping of the conveyor system.

Solution: The SMC-2 controller with the Interface option was installed. Starting and stopping times of 15 seconds were selected. The reduced torque starting prevented shock to the gearbox and kept the load from shifting on start-up. The soft stop prevented the load shifts while stopping. The SMC-2 controller met the application requirements and was a cost effective solution.

Figure 2.17 Bottle Filler with Soft Start and Soft Stop Option

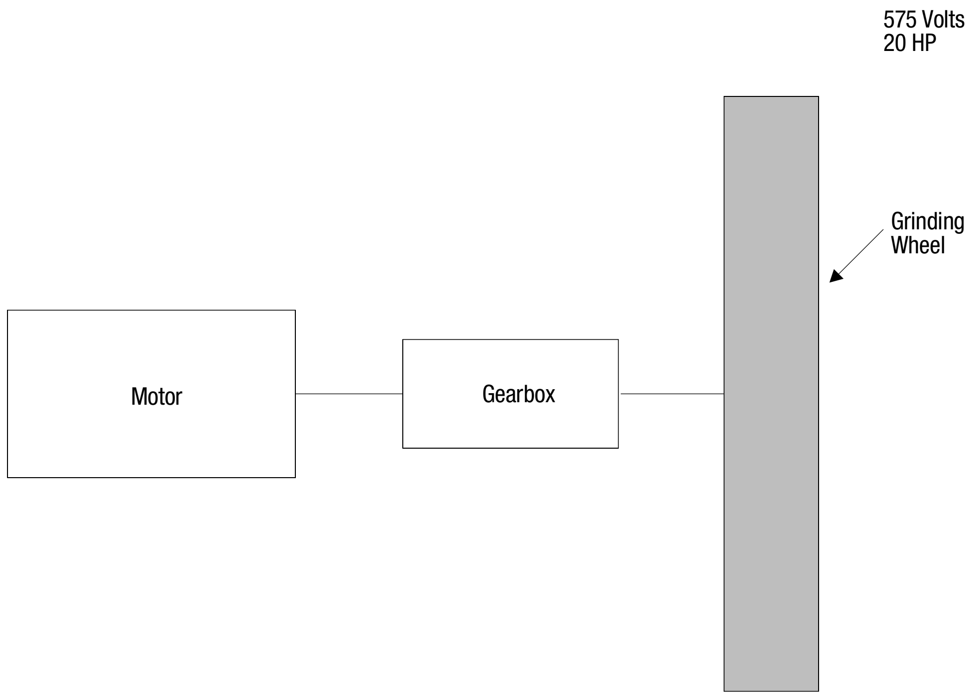


Problem: A bottle filler line had product spillage upon starting and stopping. An across-the-line starter was used to start th motor. In addition, the application required an auxiliary contact that would energize when the motor was up to speed.

Solution: The SMC-2 controller was installed and set for a 10-second soft start with a 20-second soft stop. This controlled the starting torque and prevented the sudden start that would cause the bottles to spill. The soft stop extended the stopping time eliminating load shift while stopping. The auxiliary contact was configured to change state when the motor was up to speed.

Applications (cont.)

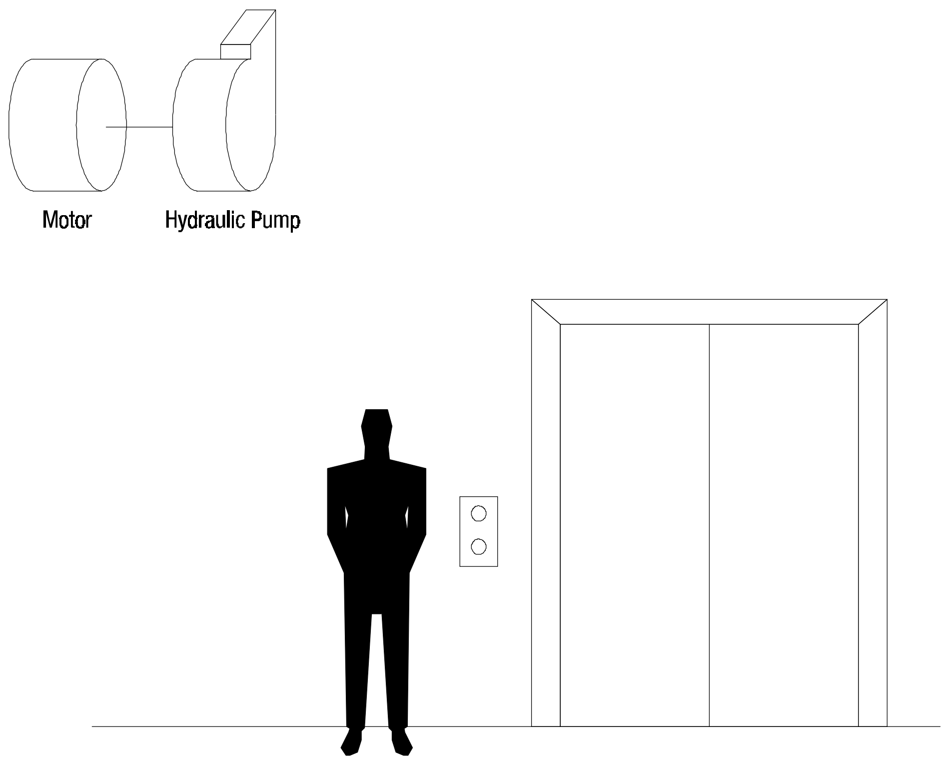
Figure 2.18 Grinder with Soft Start



Problem: Due to the high starting torque developed from starting the motor across-the-line, the gears driving a grinding wheel were frequently damaged. This resulted in unscheduled downtime for repair. This application required a rugged device because vibration at the control panel was a problem.

Solution: The SMC-2 controller was installed and set for a 20-second acceleration time. This reduced the starting torque and the downtime for repairs on the grinder. In addition, the benefit of the Energy Saver was realized when the motor was running lightly loaded. The SMC-2 controller meets the same shock and vibration requirements as electromechanical devices, therefore it met the durability requirements.

Figure 2.19 Passenger Elevator



Problem: A passenger elevator in a parking structure required a soft start to eliminate the jolt which occurred during an across-the-line start. Due to the size of the enclosure, the soft starter must fit in the space vacated by the electromechanical motor starter.

Solution: An SMC-2 controller with the Interface option was installed. The starting time was set for 10 seconds. This reduced the starting torque and eliminated the jolt during the start. The Interface option allowed all control wiring to be connected directly to the SMC-2 controller, thereby eliminating the need for the electromechanical motor starter. The small size of the SMC-2 controller allowed it to fit easily into the space vacated by th electromechanical motor starter.

SMC Dialog Plus Smart Motor Controller

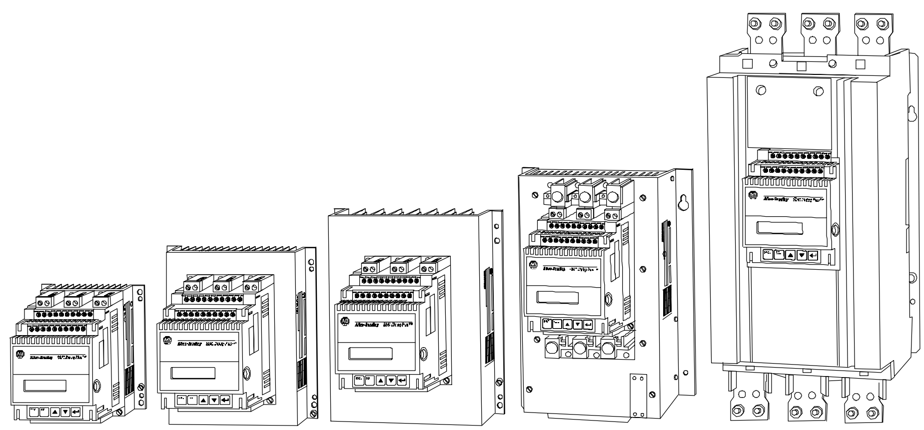
Description

When the Smart Motor Controller (SMC) was first introduced in 1986, its modular design, digital set-up, and microprocessor control set the standard for soft starters. Since its launch in 1989, the SMC PLUS™ controller has been in a class by itself, providing unmatched performance with innovative starting and stopping options. Now, the SMC Dialog Plus™ controller achieves a higher level of sophistication with greatly enhanced protection, expanded **dia**gnostics, and the ability to **log t**he motor's operation (amps, kW, and power factor), as well as the option to **"dialog"** with various network protocols.

While the SMC Dialog Plus controller incorporates many new features into its design, it remains easy to set-up and operate. You can make use of as few or as many of the features as your application requires.

The SMC Dialog Plus controller is a compact, modular, multi-functional solid-state controller used in starting three-phase squirrel cage induction motors and controlling resistive loads. The SMC Dialog Plus product line includes current ratings from 24 to 1000 Amps, 200 to 600V, 50/60Hz. This covers applications up to 1000 horsepower. The SMC Dialog Plus controller meets applicabl standards and requirements.

Figure 3.1 SMC Dialog Plus Controller (24–1000 Amps)



Starting Methods

The following starting methods are standard within the controller:

- Soft Start with Selectable Kickstart
- Current Limit Start
- Dual Ramp Start
- FullVoltage Start

Optional features include:

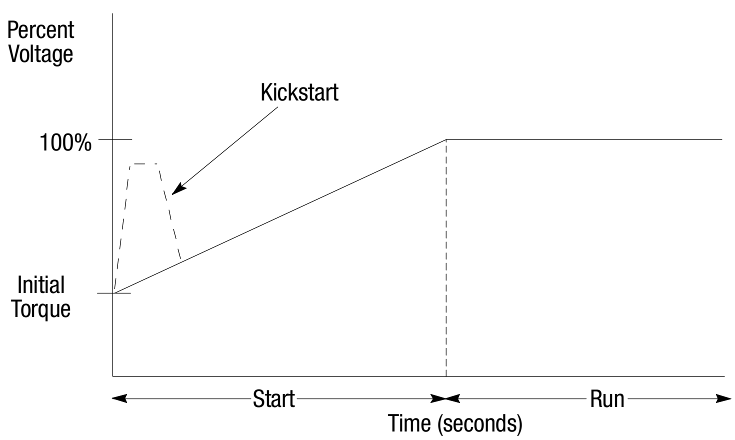
- Soft Stop
- Pump Control
- Preset Slow Speed
- SMB™ Smart Motor Brake
- Accu-Stop™/Slow Speed with Braking

Soft Start with Selectable Kickstart

This method has the most general application. The motor is given an initial torque setting, which is user adjustable from 0 to 90% of locked rotor torque. From the initial torque level, the output voltag to the motor is steplessly increased during the acceleration ramp time, which is user adjustable from 0 to 30 seconds. If, during the voltag ramp operation, the SMC Dialog Plus controller senses that the moto has reached an up-to-speed condition, the output voltage will automatically switch to full voltage.

The kickstart feature provides a boost at start-up to break away loads that may require a pulse of high torque to get started. It is intended to provide a current pulse of 550% of full load current and is user adjustable from 0.0 to 2.0 seconds.

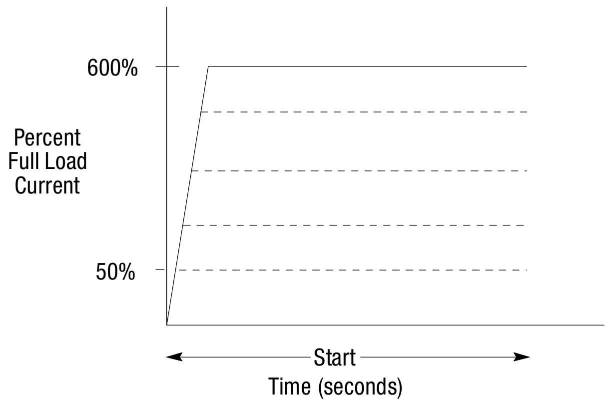
Figure 3.2 Soft Start with Selectable Kickstart



Current Limit Start

This starting method provides a fixed reduced voltage start and is used when it is necessary to limit the maximum starting current. Th starting current is user adjustable from 50 to 600% of full load amperes. The current limit starting time is user adjustable from 0 to 30 seconds.

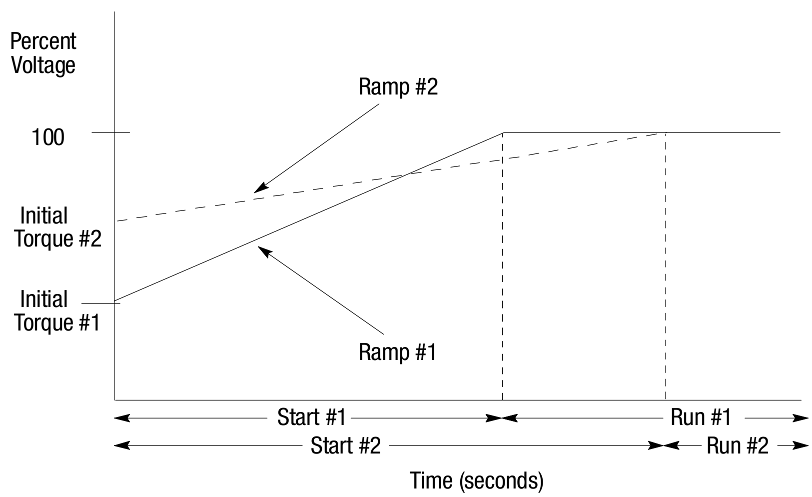
Figure 3.3 Current Limit Start



Dual Ramp Start

This starting method is useful on applications with varying loads and varying starting torque requirements. Dual Ramp Start offers the user the ability to select between two separate Soft Start profiles with separately adjustable ramp times and initial torque settings.

Figure 3.4 Dual Ramp Start



Starting Methods (cont.)

Full Voltage Start

This method is used in applications requiring across-the-line starting. The SMC Dialog Plus controller performs like a solid-state contactor. Full inrush current and locked rotor torque are realized.

Figure 3.5 Full Voltage Start

Features

LCD Display

A two line, sixteen character backlit LCD display provides parameter definition with straightforward text so that controller set-up may be accomplished without a reference manual. Parameters are arranged in an organized four level menu structure for ease of programming and fast access to parameters.

Keypad Programming

Programming of parameters is accomplished through a five button keypad on the front of the SMC Dialog Plus controller. The five buttons include up and down arrows, an Enter button, a Select button, and an Escape button. The user needs only to enter the correct sequence of keystrokes for programming the SMC Dialog Plus controller.

Figure 3.6 LCD Display with Keypa

Electronic Overload

The SMC Dialog Plus controller meets applicable requirements as motor overload protective device. Overload protection is accomplished electronically through an I^2t algorithm.

The overload is programmable, providing the user with flexibility. The overload trip class is selectable for class 10, 15, 20, or 30 protection. The trip current is set by entering the motor's full load current rating and the service factor.

Thermal memory is included to accurately model motor operating temperature. Ambient insensitivity is inherent in the electronic design of the overload.

Note: The current sensing capability of the SMC Dialog Plus controller is disabled during bypass operation. The Bulletin 825 Converter Module is required to provide current feedback in these applications.

Built-in Communication Port

A serial interface port is furnished as standard with the SMC Dialog Plus controller. This communication port allows for connection to a Bulletin 1201 Human Interface Module. It also allows for a variety of other communications, including Allen-Bradley's Remote I/O, DH-485, RS 232/422/485-DF1, and DeviceNet™ network through the connection to the Bulletin 1203 communication modules.

Features (cont.)

Stall Protection and Jam Detection

Motors can experience locked rotor currents and develop maximum torque in the event of a stall (during start) or a jam (after full speed is reached). These conditions can result in winding insulation breakdown or mechanical damage to the connected load.

The SMC Dialog Plus controller provides both stall and jam detection for enhanced motor and system protection. Stall protection allows the user to program a maximum stall time of up to 10 seconds. Jam detection allows the user to determine the jam level as a percentage o the motor's full load current rating, and a trip delay time of up to 10 seconds.

Note: The stall trip delay time is in addition to the programmed start time.

Figure 3.7 Stall Protection

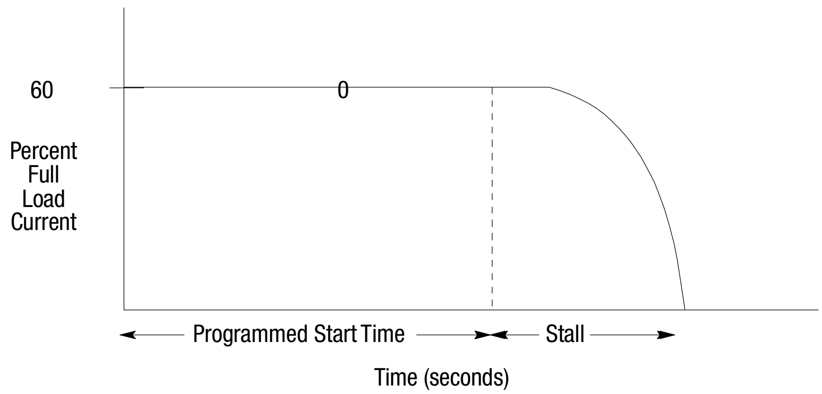
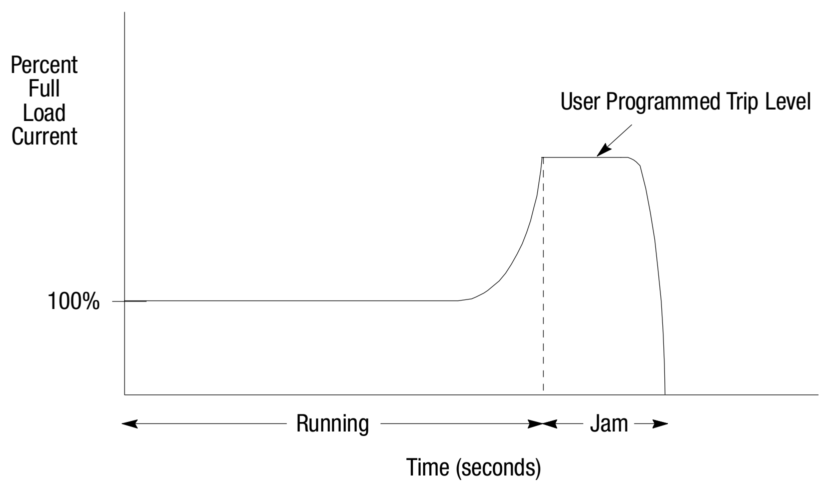


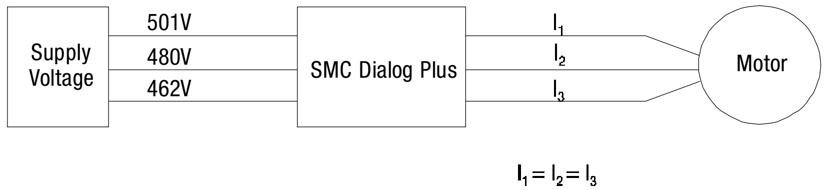
Figure 3.8 Jam Detection



Phase Rebalance

As little as 4% supply voltage unbalance can result in a 20% current unbalance and a 25% increase in motor temperature, possibly triggering a premature failure of the motor. The SMC Dialog Plus controller continuously monitors the incoming three-phase line voltage balance and adjusts the output voltage automatically to balance the three-phase currents drawn by the motor.

Figure 3.9 Phase Rebalance



Notes: (1) Phase Rebalance is not active during bypass operation.
(2) Phase rebalance requires the use of the converter modul (Bulletin 825) and fanning strip (Cat. No. 150-NFS).

Metering

The SMC Dialog Plus controller contains several power monitoring parameters as standard. These parameters include:

- Three-phase Current
- Three-phase Voltage
- Power in kW
- Power Usage in kWH
- Power Factor
- Elapsed Time
- Motor Thermal Capacity Usage

Fault Indication

The SMC Dialog Plus controller monitors both the pre-start and running modes. If the controller senses a fault, the SMC Dialog Plus controller shuts down the motor and displays the appropriate fault condition in the LCD display. The controller monitors the following conditions:

- Open Gate
- Line Fault
- Undervoltage
- Underload
- Overvoltage
- Excessive Starts/Hour
- Voltage Unbalance
- Overtemperature
- Phase Reversal
- Stall
- Power Loss
- Jam
- Overload
- System

Any fault condition will cause the auxiliary contacts to change state and the hold-in circuit to release.

Features (cont.)

Auxiliary Contacts

Three hard contacts are provided as standard with the SMC Dialog Plus controller. The first two contacts are programmable for Normal/ Up-to-speed. The third contact is programmable for Normal/Fault.

Energy Saver

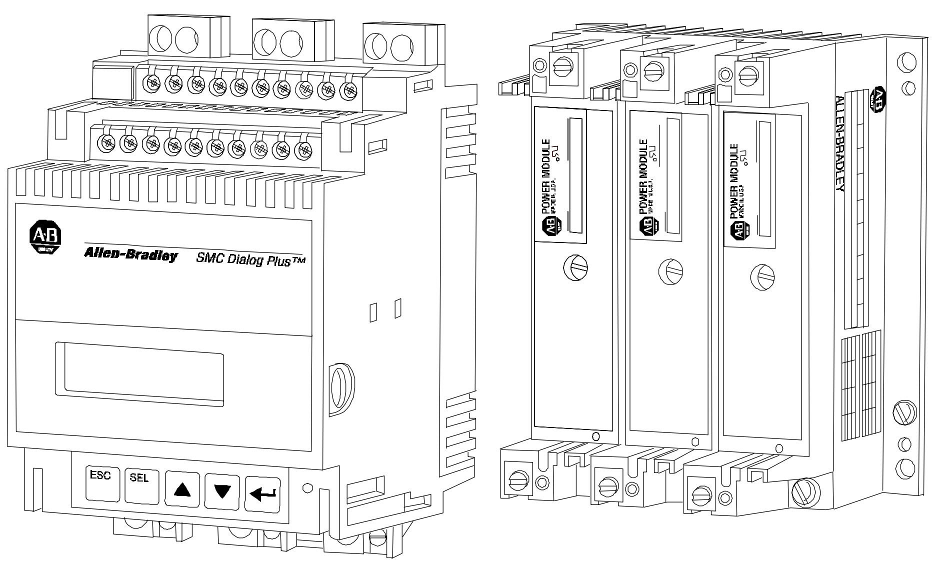
The built-in Energy Saver feature is integral to the SMC Dialog Plus controller and may be applied to applications where the motor is lightly loaded or unloaded for long periods of time. With the Energy Saver feature enabled, the SMC Dialog Plus controller continuously monitors the loading of the motor with its internal feedback circuitry. Because the output voltage is SCR controlled, motor power losses can be reduced by decreasing the motor terminal voltage.

Note: The Energy Saver feature is not available when a bypass contactor is used.

Modular Design

The SMC Dialog Plus controller packaging is designed for industrial environments. The modularity of control and power modules featur plug-in functionality. There are no gate wires to remove and no soldering is required. Common control modules reduce inventory requirements.

Figure 3.10 Exploded View of the 24 Amp SMC Dialog Plus Controller



Control Terminal Description

The SMC Dialog Plus controller contains 20 control terminals on the front of the controller. These control terminals are described below. See Figure 3.11.

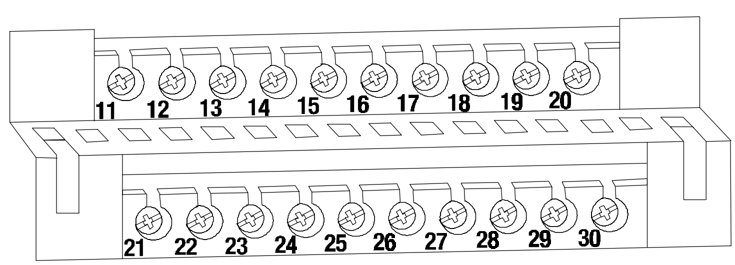
Power Supply Board

Terminal Number	Description
11	Control Power Input
12	Control Power Common
13	Controller Enable Input
14	Logic Ground
15	Dual Ramp/Option Input
16	Start Input
17	Stop Input
18	Auxiliary Relay Common
19	N.O. Auxiliary Contact 1 (Normal/Up-to-speed)
20	N.C. Auxiliary Contact 2 (Normal/Up-to-speed)

Logic Board

Terminal Number	Description
21	Not Used
22	Not Used
23	Not Used
24	Not Used
25	Common (Converter Module)
26	Phase A Input (Converter Module)
27	Phase B Input (Converter Module)
28	Phase C Input (Converter Module)
29	N.O./N.C. Auxiliary Contact 3 (Normal/Fault)
30	N.O./N.C. Auxiliary Contact 3 (Normal/Fault)

Figure 3.11 SMC Dialog Plus Controller Control Terminals



Adjustments

Soft Start without Options

The following parameters are specifically used to provide and adjust the voltage ramp supplied to the motor

Parameter	Range
Starting Mode This must be programmed for "Soft Start."	Soft Start, Current Limit
Ramp Time #1 This sets the time period during which the controller will ramp the output voltage.	0 to 30 seconds
Initial Torque #1 The initial output voltage level for the voltage ramp is established and adjusted with this parameter.	0 to 90% of locked rotor torque
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19, and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminals 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered-up" state of the third auxiliary contact.	N.O., N.C.
Parameter Mgmt The newly programmed parameters values can be saved to memory, or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

Current Limit Start without Options

To apply a fixed reduced voltage output to the motor, the following parameters are provided for user adjustment.

Parameter	Range
Starting Mode This must be programmed for "Current Limit."	Soft Start, Current Limit
Ramp Time #1 This sets the time period during which the controller will hold the fixed reduced voltage output before switching to full voltage.	0 to 30 seconds
Current Limit Level This provides adjustability for the reduce voltage output level to the motor.	50 to 600% of full load current
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19, and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminals 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered-up" state of the third auxiliary contact.	N.O., N.C.
Parameter Mgmt The newly programmed parameters values can be saved to memory, or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

Adjustments (cont.)

Dual Ramp Start without Options

The SMC Dialog Plus controller provides the user with the ability to select between two soft start profiles. To obtain Dual Ramp Start control, the following parameters are available in the "Advanced Setup" programming mode.

Note: The Dual Ramp Start feature is only available with the standard control module.

Parameter	Range
Advanced Setup The user must select the "Advanced Setup" programming mode in order to obtain access to the Dual Ramp Start parameters	—
Starting Mode This must be programmed for "Soft Start."	Soft Start, Current Limit
Dual Ramp This allows the user to choose between two soft start profiles defined by: Ramp Time #1 and Initial Torque #1 Ramp Time #2 and Initial Torque #2 When the Dual Ramp feature is selected, the ramp time/initial torque combination is determined by a hard contact to input terminal 15. A low input signal to terminal 15 signifies that ramp time/initial torque #1 are selected. A high input signal to terminal 15 signifies that ramp time/initial torque #2 are selected.	No, Yes
Ramp Time #1 This determines the time period in which the controller will ramp the output voltage to the motor for the first soft start setup.	0 to 30 seconds
Initial Torque #1 The initial reduced voltage output level for the first soft start setup is established and adjusted with this parameter.	0 to 90 % of locked rotor torque
Ramp Time #2 This determines the time period in which the controller will ramp the output voltage to the motor for the second soft start setup.	0 to 30 seconds
Initial Torque #2 The initial reduced voltage output level for the second soft start setup is established and adjusted with this parameter.	0 to 90 % of locked rotor torque
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.	0.0 to 2.0 seconds

Dual Ramp Start without Options (cont.)

Parameter	Range
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19, and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminals 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the “powered-up” state of the third auxiliary contact.	N.O., N.C.
Parameter Mgmt The newly programmed parameters values can be saved to memory, or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

Adjustments (cont.)

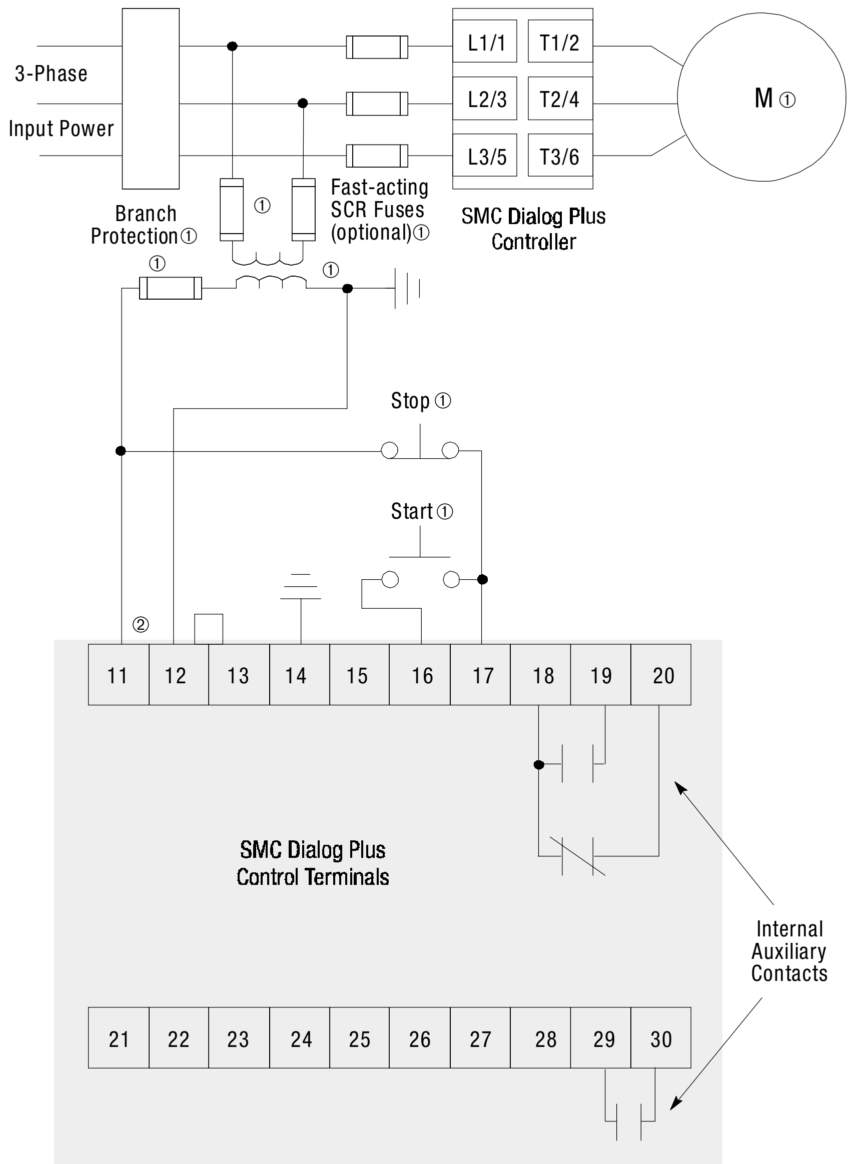
Full Voltage Start without Options

The SMC Dialog Plus controller may be programmed to provid full voltage start in which the output voltage to the motor reaches full voltage in 1/4 second.

Parameter	Range
Start Mode This must be programmed for "Soft Start."	Soft Start, Current Limit
Ramp Time #1 This must be programmed for "0" seconds.	0 to 30 seconds
Initial Torque #1 This must be programmed for 90% of locked rotor torque.	0 to 90% of locked rotor torque
Kickstart Time This must be programmed for "0" seconds.	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19, and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminals 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered-up" state of the third auxiliary contact.	N.O., N.C.
Parameter Mgmt The newly programmed parameters values can be saved to memory, or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

Typical Wiring Diagrams (without options)

Figure 3.12 Typical Wiring Diagram for Standard Controller

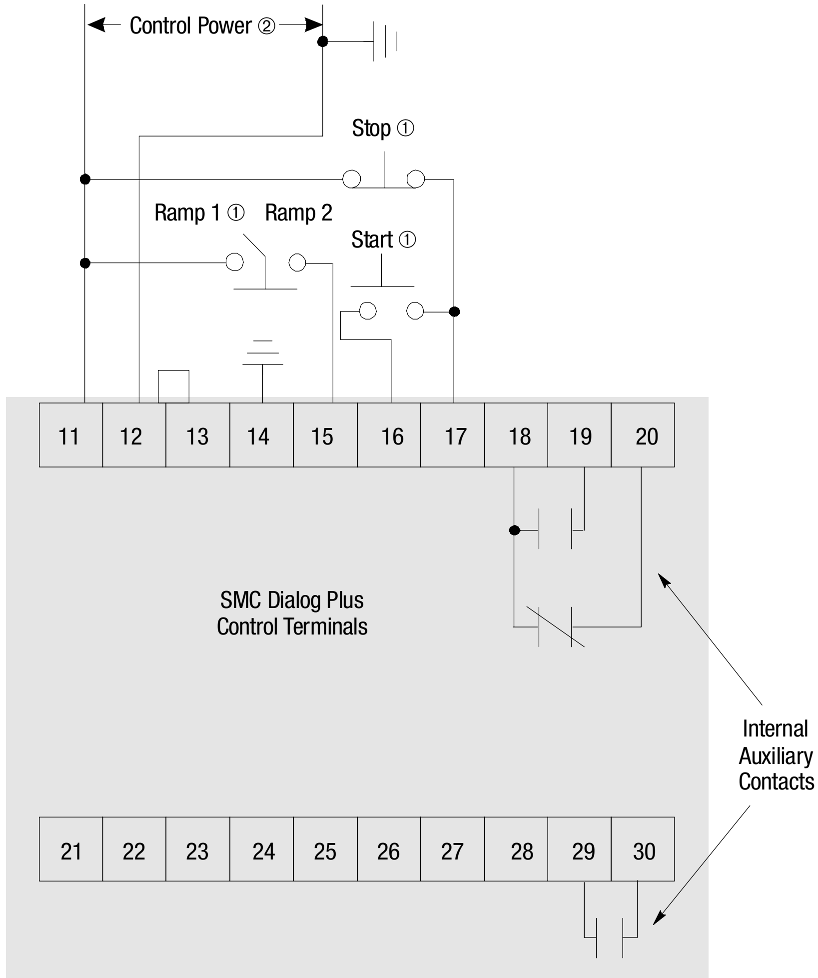


① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Typical Wiring Diagrams (without options)

Figure 3.13 Typical Wiring Diagram for Dual Ramp Applications

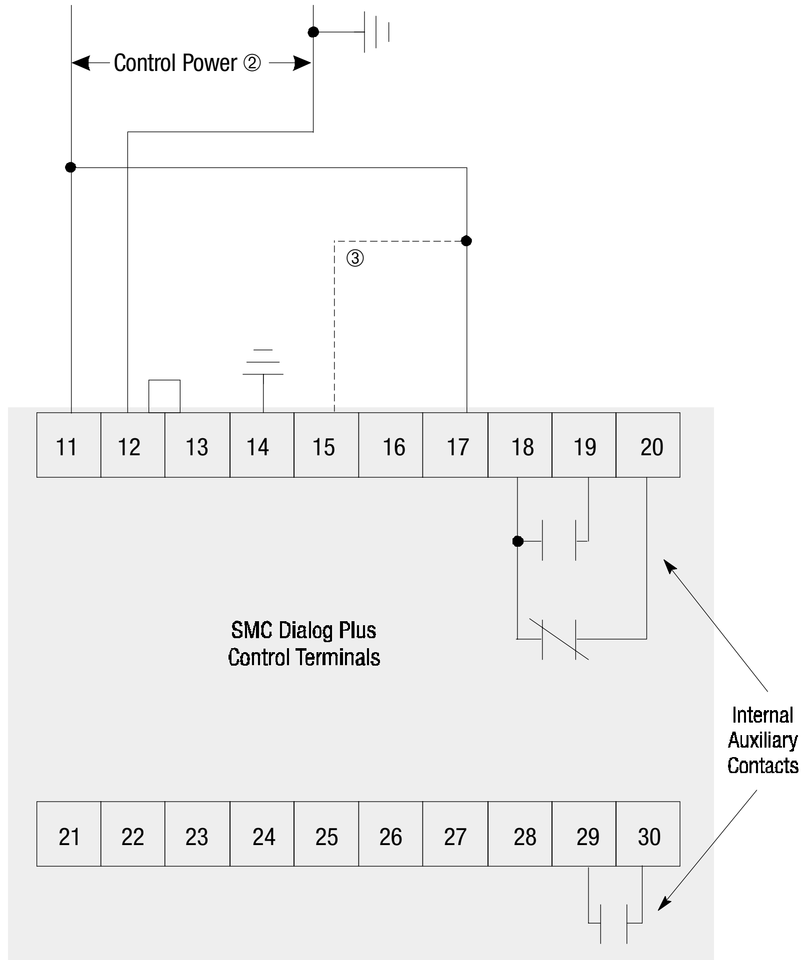


① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Note: The Dual Ramp feature is only available with the standard control module.

Figure 3.14 Typical Wiring Diagram for Start-Stop Control via the SCANport



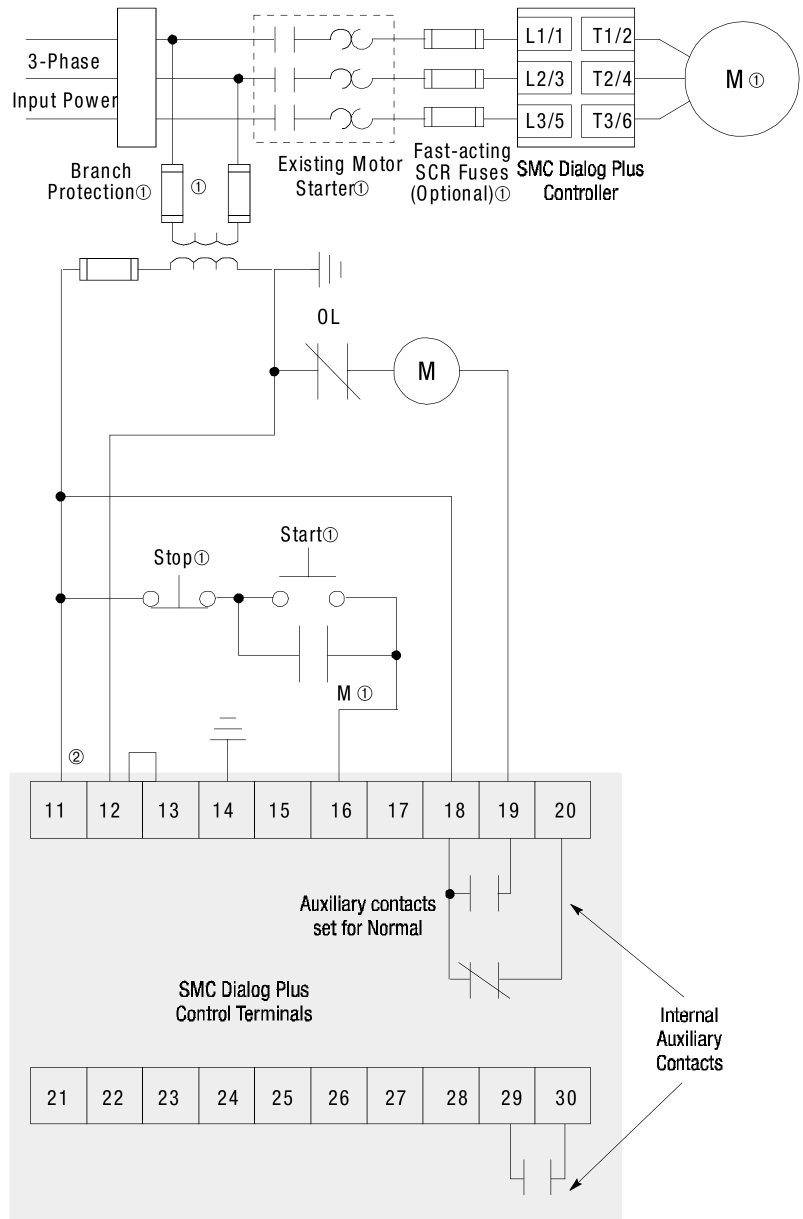
① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

③ If Soft Stop, Pump Control, or SMB Smart Motor option is installed, place additional jumper to terminal 15.

Typical Wiring Diagrams (without options) (cont.)

Figure 3.15 Typical Wiring Diagram for Retrofit Applications



① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Control Options

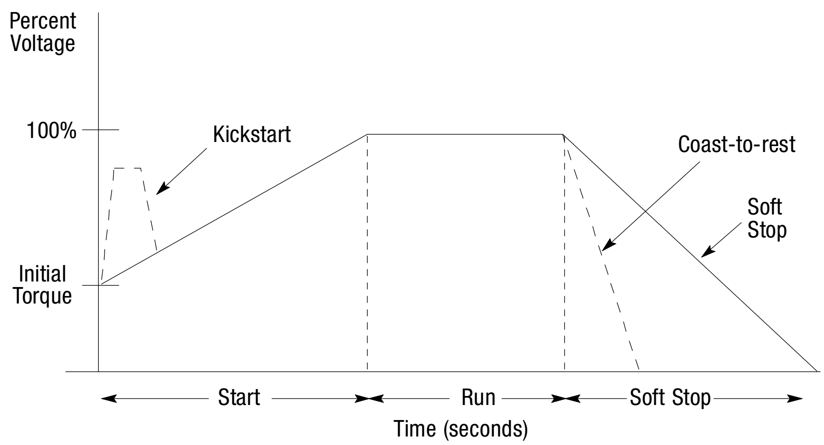
The SMC Dialog Plus controller offers a variety of unique control options that provide enhanced motor starting and stopping capabilities. Please note that the options are mutually exclusive and must be specified at the time of order entry.

- Soft Stop
- Pump Control
- Preset Slow Speed
- SMB™ Smart Motor Braking
- Accu-Stop™/Slow Speed with Braking

Soft Stop Option

The Soft Stop option can be used in applications requiring an extended coast-to-rest. The voltage ramp down time is use adjustable from 0 to 60 seconds. The Soft Stop time is adjusted independently from the start time. The load will stop when the voltage drops to a point where the load torque is greater than th motor torque.

Figure 3.16 Soft Stop Option

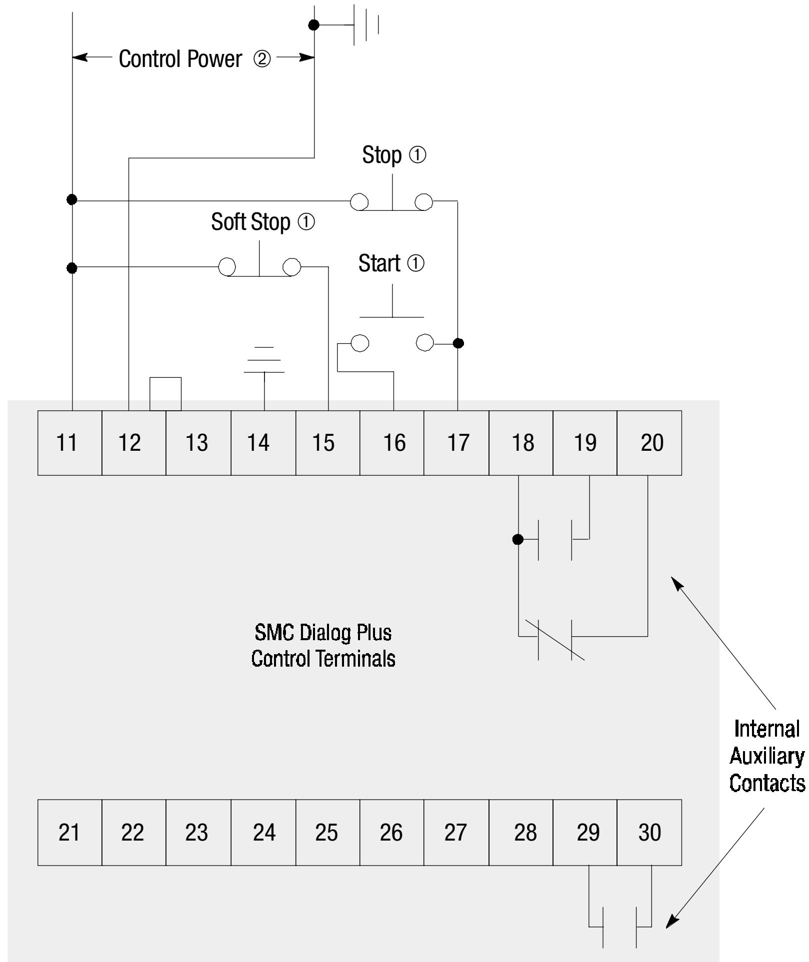


ATTENTION: Soft Stop is not intended to be used as an emergency stop. Refer to the applicable standards for emergency stop requirements

Control Options (cont.)

Soft Stop Option (cont.)

Figure 3.17 Typical Wiring Diagram for Soft Stop Option



① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Programming - Soft Start with Soft Stop Option

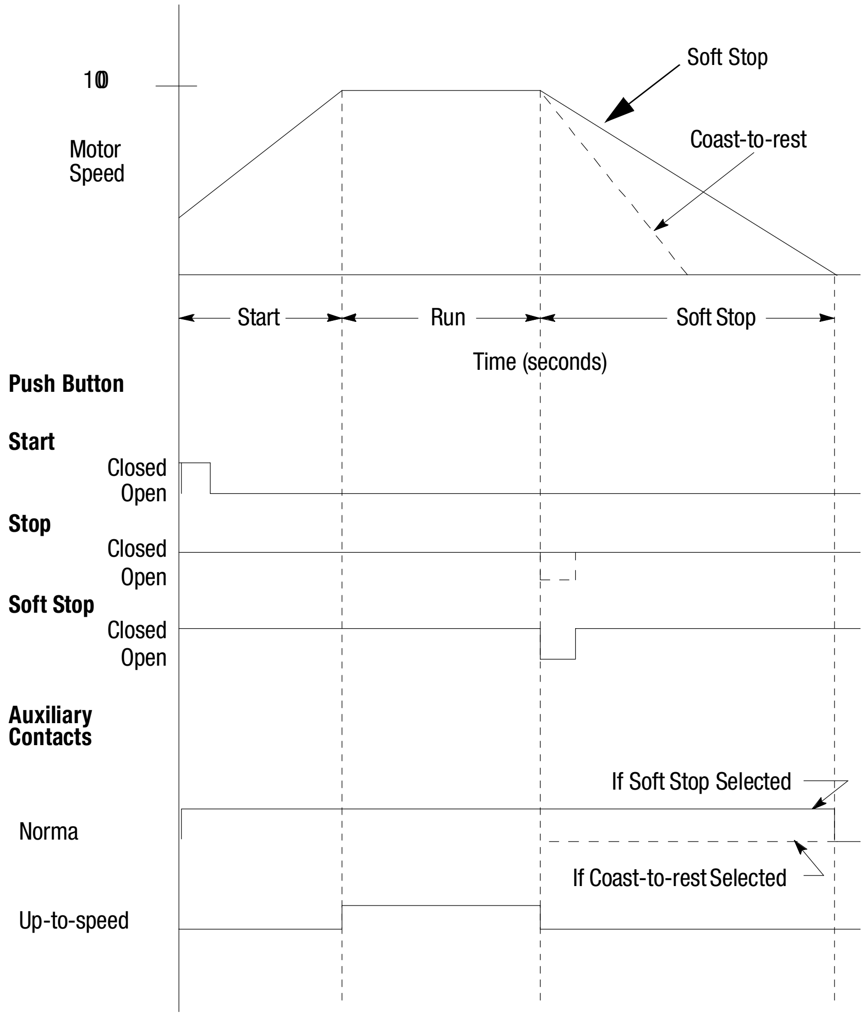
The basic parameter set-up for Soft Start selection with Soft Stop option follows:

Parameter	Range
SMC Option "Soft Start" will be displayed.	—
Starting Mode Allows the user to program the SMC Dialog Plus controller for the type of starting that best fits the application.	Soft Start, Current Limit
Ramp Time This sets the time period during which the controller will ramp the output voltage.	0 to 30 seconds
Initial Torque The initial reduced voltage output level for the voltage ramp is established and adjusted with this parameter.	0 to 90% of locked rotor torque
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19 and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminals 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered up" state of the third auxiliary contact.	N.O., N.C.
Soft Stop Time This parameter allows the user to program the soft stop (voltage ramp down) time that best fits the application.	0 to 60 seconds
Parameter Mgmt The newly programmed parameters values can be saved to memory, or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

Control Options (cont.)

Soft Stop Option (cont.)

Figure 3.18 Soft Stop Option Sequence of Operation

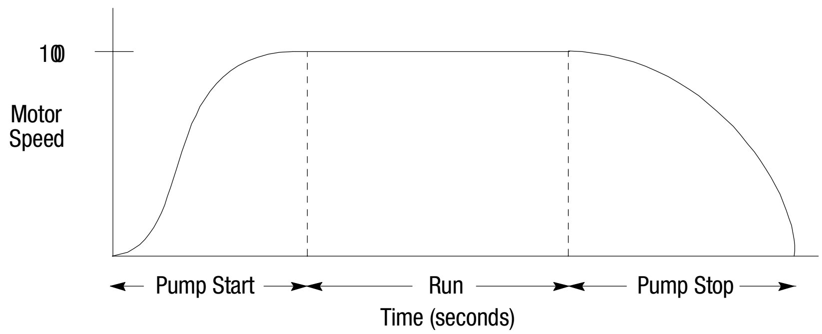


ATTENTION: The user has the ultimat responsibility to determine which stopping mode is best suited to the application and will meet applicable standards for operator safety on a particular machine.

Pump Control Option

The SMC Dialog Plus controller's unique interactive Pump Control is designed to reduce fluid surges in pumping systems. It provides closed loop acceleration and deceleration control of centrifugal pump motors without the need for feedback devices.

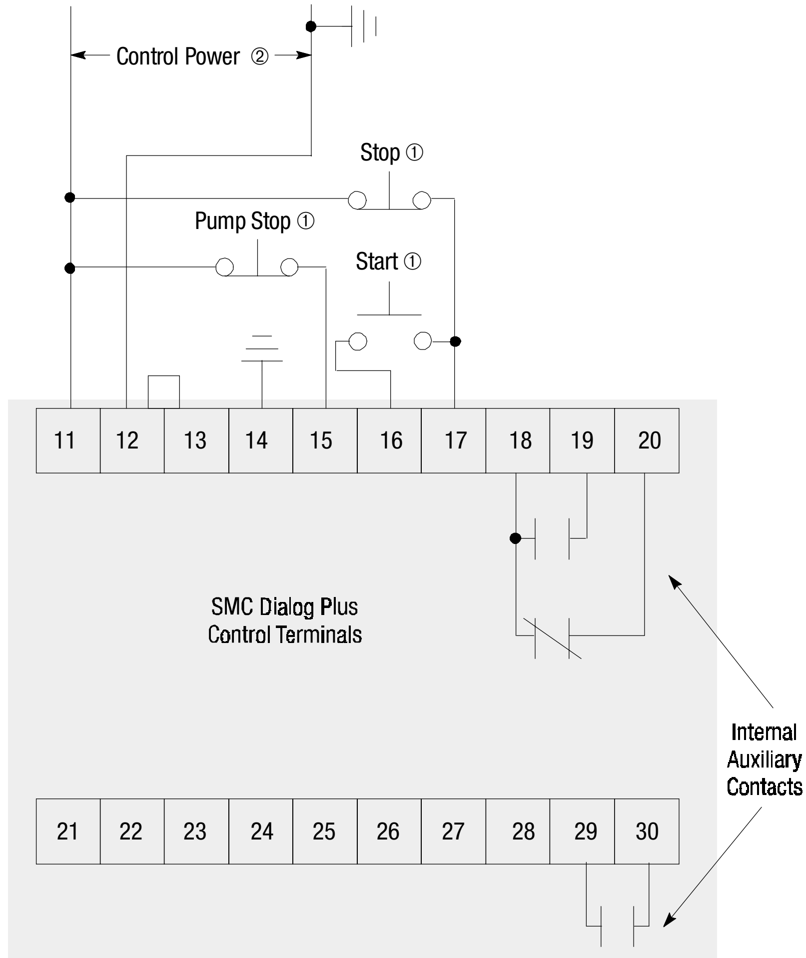
Figure 3.19 Pump Control Option



ATTENTION: Pump Stop is not intended to be used as an emergency stop. Refer to the applicable standards for emergency stop requirements.

Control Options (cont.)

Figure 3.20 Typical Wiring Diagram for Pump Control Option



① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Programming - Pump Control Starting and Stopping

The basic parameter set-up for the Pump Control Starting and Stopping follows:

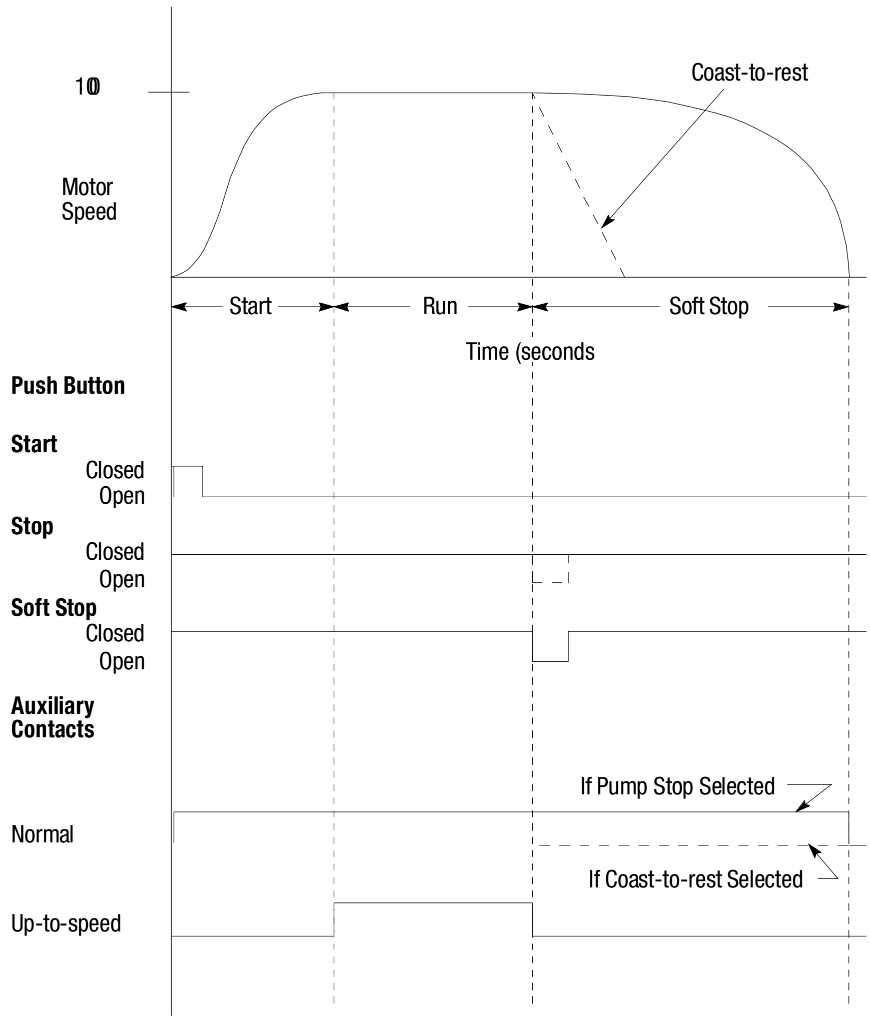
Parameter	Range
SMC Option "Pump Control" will be displayed.	—
Starting Mode Allows the user to program the SMC Dialog Plus controller for the type of starting that best fits the application.	Soft Start, Current Limit, Pump Start
Ramp Time This sets the time period during which the controller will ramp the output voltage.	0 to 30 seconds
Initial Torque The initial reduced voltage output level for the voltage ramp is established and adjusted with this parameter.	0 to 90% of locked rotor torque
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.①	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19 and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminal 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered up" state of the third auxiliary contact.	N.O., N.C.
Pump Stop Time This parameter allows the user to program the Pump Stop time that best fits the application.	0 to 120 seconds
Parameter Mgmt The newly programmed parameters values can be saved to memory, or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

① Kickstart is not available if "Pump Start" is selected.

Control Options (cont.)

Pump Control Option (cont.)

Figure 3.21 Pump Control Option Sequence of Operation

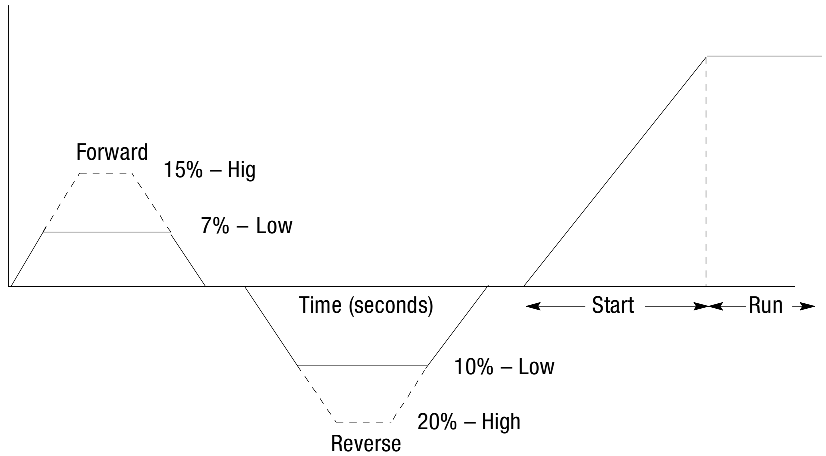


ATTENTION: The user has the ultimat responsibility to determine which stopping mode is best suited to the application and will meet applicable standards for operator safety on a particular machine.

Preset Slow Speed Option

The Preset Slow Speed option can be used on applications that require a slow speed for positioning material. The Preset Slow Speed can be set for either Low, 7% of base speed, or High, 15% of base speed. Reversing is also possible through programming. Speeds provided during reverse operation are Low, 10% of base speed, or High, 20% of base speed.

Figure 3.22 Preset Slow Speed Option

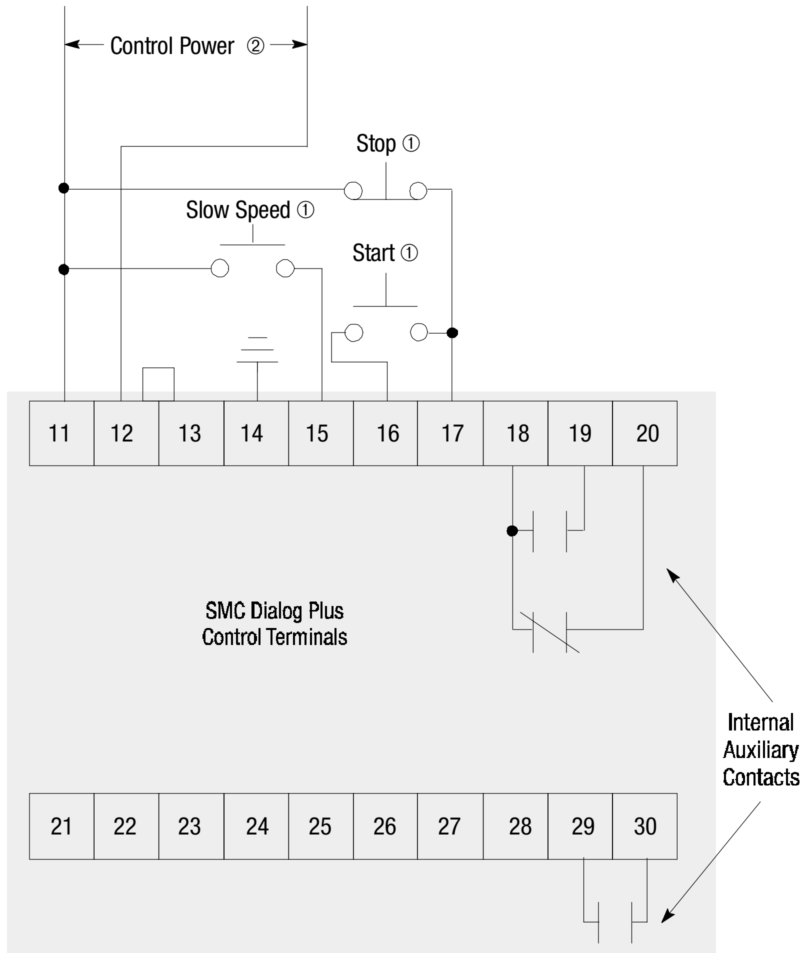


ATTENTION: Slow speed running is not intended fo continuous operation due to reduced motor cooling.

Control Options (cont.)

Preset Slow Speed Option (cont.)

Figure 3.23 Typical Wiring Diagram for Preset Slow Speed Option



① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Programming - Soft Start with Preset Slow Speed Option

The basic parameter set-up for Soft Start selection with Preset Slow Speed Option follows:

Parameter	Range
SMC Option "Preset Slow Speed" will be displayed.	—
Starting Mode Allows the user to program the SMC Dialog Plus controller for the type of starting that best fits the application.	Soft Start, Current Limit
Ramp Time This sets the time period during which the controller will ramp the output voltage.	0 to 30 seconds
Initial Torque The initial reduced voltage output level for the voltage ramp is established and adjusted with this parameter.	0 to 90% of locked rotor torque
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19 and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminal 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered up" state of the third auxiliary contact.	N.O., N.C.
Slow Speed Sel This parameter allows the user to program the Preset Slow Speed that best fits the application.	High, Low
Slow Speed Dir Allows the user to select the Preset Slow Speed direction.	Forward, Reverse

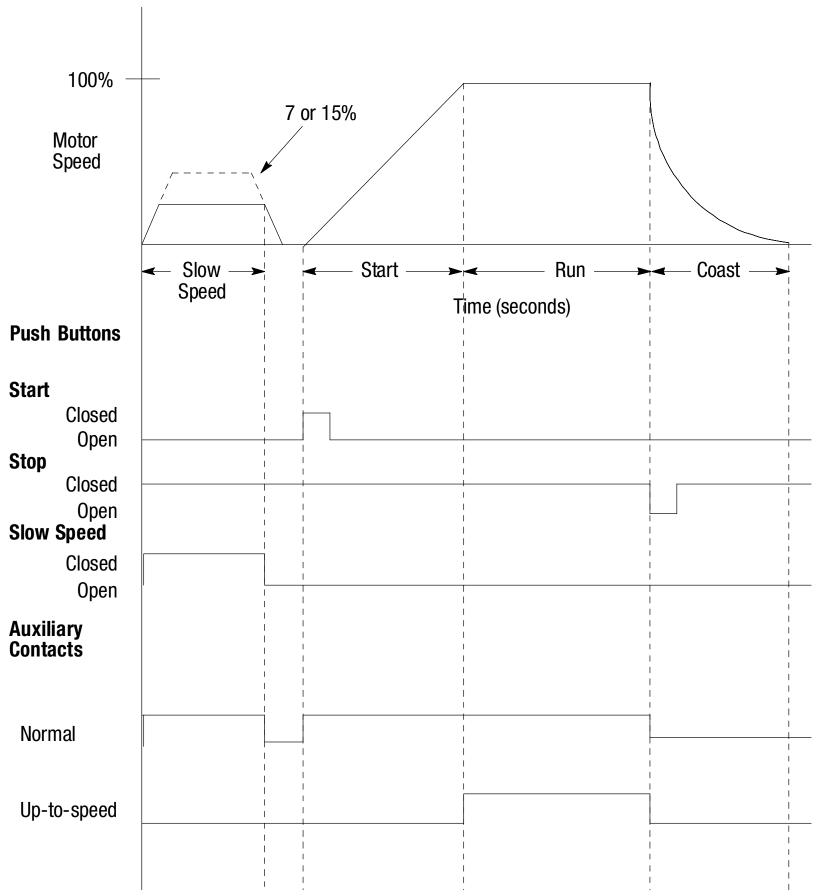
Control Options (cont.)

Programming - Soft Start with Preset Slow Speed Option (cont.)

Parameter	Range
Slow Accel Cur. Allows the user to program the Preset Slow Speed acceleration current.	0 to 450% of full load current
Slow Running Cur. Allows the user to program the Preset Slow Speed running current.	0 to 450% of full load current
Parameter Mgmt The newly programmed parameters values can be saved to memory, or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

Preset Slow Speed Option (cont.)

Figure 3.24 Preset Slow Speed Option Sequence of Operation

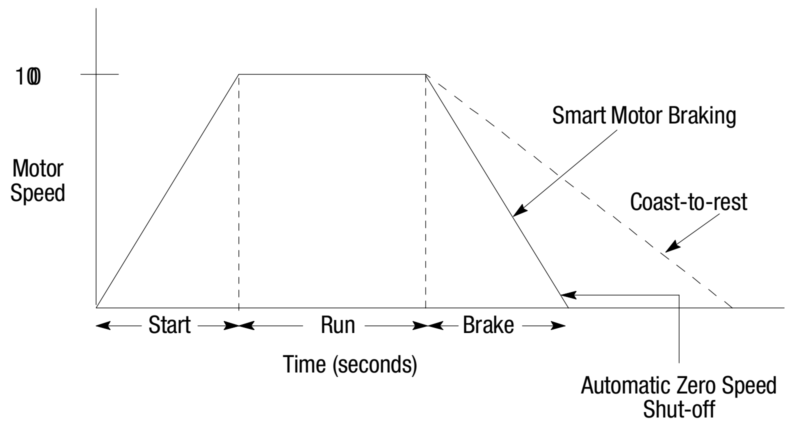


Control Options (cont.)

SMB™ Smart Motor Braking Option

The SMB Smart Motor Braking option provides motor braking for applications which require the motor to stop quickly. It is a microprocessor based braking system which applies braking current to a standard squirrel cage induction motor. The strength of the braking current is adjustable from 150 to 400% of full load current.

Figure 3.25 SMB Smart Motor Braking Option

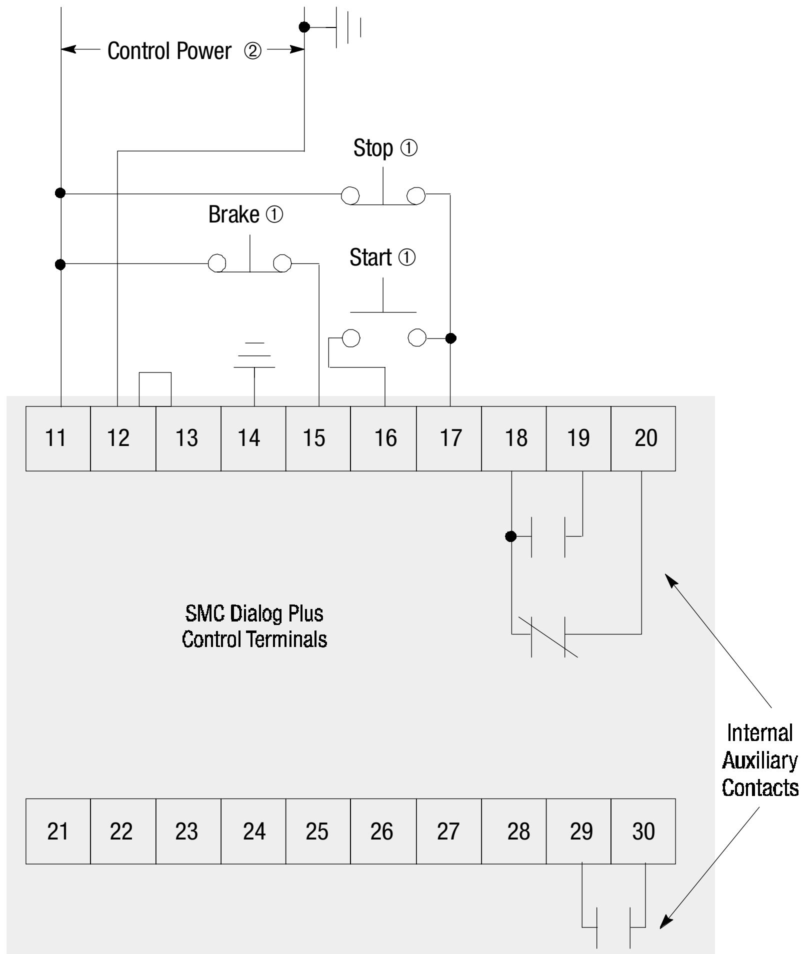


ATTENTION: Braking may cause motor heating and equipment vibration depending on braking current, frequency of braking, and duration of braking cycle. Select the lowest brake current setting that will brake satisfactorily.

ATTENTION: SMB Smart Motor Braking is not intended to be used as an emergency stop. Refer to the applicable standards for emergency stop requirements.

SMB™ Smart Motor Braking Option (cont.)

Figure 3.26 Typical Wiring Diagram for SMB Smart Motor Braking Option



① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Control Options (cont.)

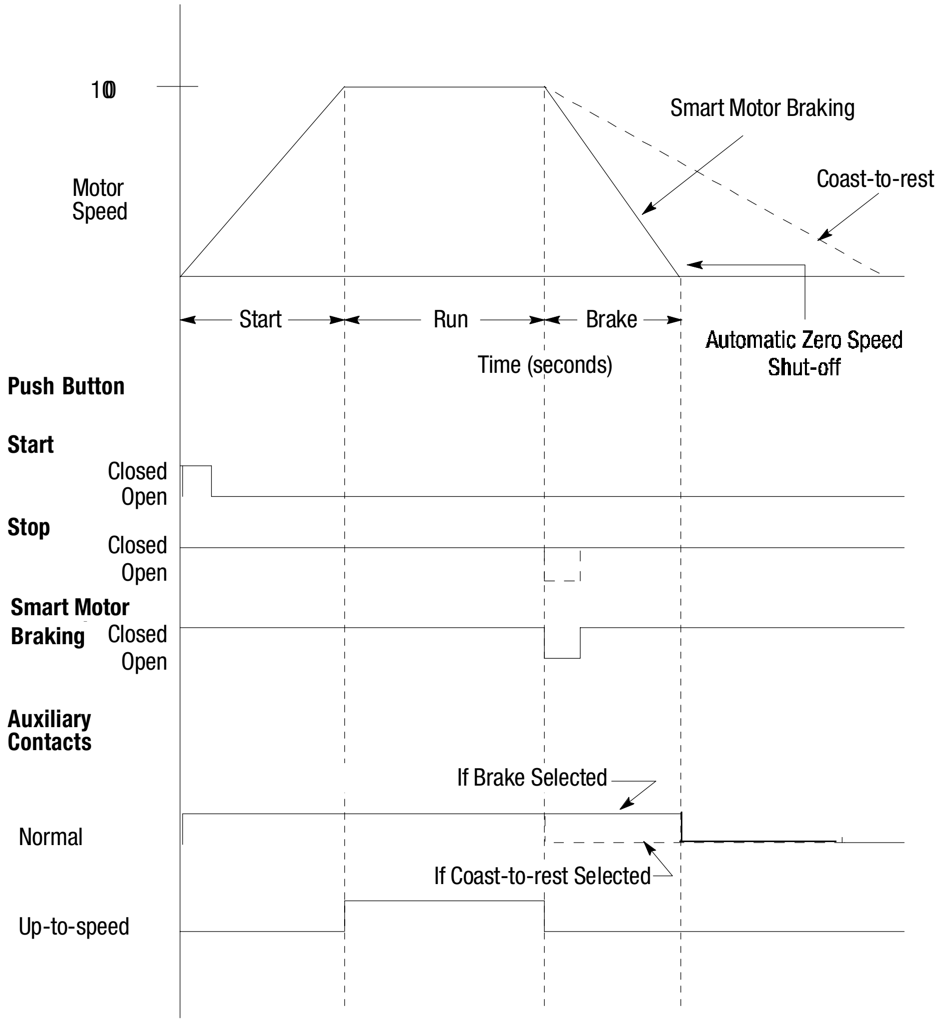
Programming - Soft Start with SMB™ Smart Motor Braking Option

The basic parameter set-up for Soft Start selection with SMB Smart Motor Braking option follows:

Parameter	Range
SMC Option "SMB Smart Motor" Braking will be displayed.	—
Starting Mode Allows the user to program the SMC Dialog Plus controller for the type of starting that best fits the application.	Soft Start, Current Limit
Ramp Time This sets the time period during which the controller will ramp the output voltage.	0 to 30 seconds
Initial Torque The initial reduced voltage output level for the voltage ramp is established and adjusted with this parameter.	0 to 90% of locked rotor torque
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19, and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminal 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered up" state of the third auxiliary contact.	N.O., N.C.
Braking Current Allows the user to program the percentage of braking current applied to the motor during the stop sequence. With the SMB Smart Motor Braking option, this is the current applied to bring the motor to zero speed.	0 to 400% full load current
Parameter Mgmt The newly programmed parameters values can be saved to memory, or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

SMB™ Smart Motor Braking Option (cont.)

Figure 3.27 SMB Smart Motor Braking Option Sequence of Operation



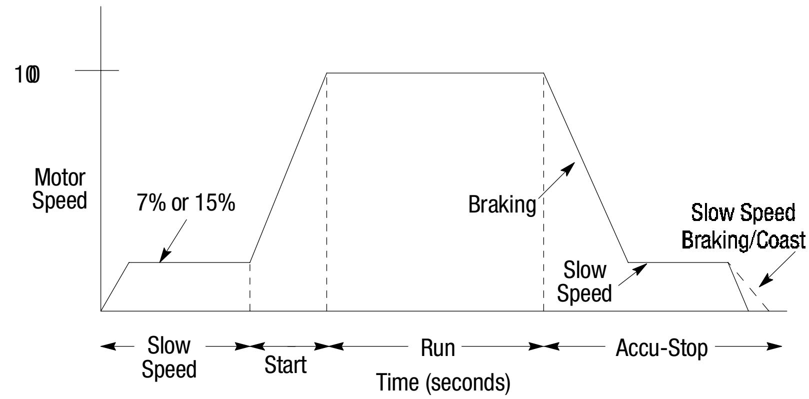
ATTENTION: The user has the ultimate responsibility to determine which stopping mode is best suited to th application and will meet applicable standards for operator safety on a particular machine.

Control Options (cont.)

Accu-Stop/Slow Speed with Braking Option

The Accu-Stop portion of this option provides rapid braking to a slow speed, and then braking to stop, facilitating cost-effective general positioning control.

Figure 3.28 Accu-Stop Option



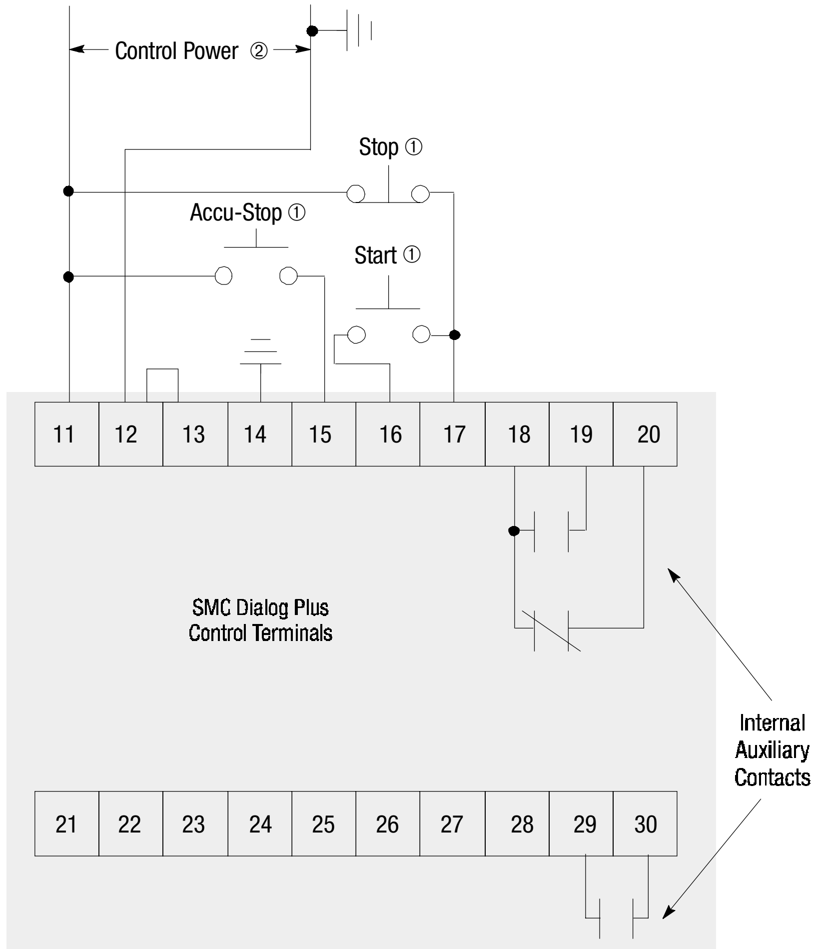
> **ATTENTION:** Slow speed running is not intended for continuous operation due to reduced motor cooling.

> **ATTENTION:** Braking may cause motor heating and equipment vibration depending on braking current, frequency of braking, and duration of braking cycle. Select the lowest brake current setting that will brake satisfactorily.

> **ATTENTION:** Accu-Stop is not intended to be used as an emergency stop. Refer to the applicable standards for emergency stop requirements.

Accu-Stop Option

Figure 3.29 Typical Wiring Diagram for Accu-Stop Option



① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Control Options (cont.)

Programming - Soft Start with Accu-Stop Option

The basic parameter set-up for Soft Start selection with Accu-Stop option follows:

Parameter	Range
SMC Option "Accu-Stop" will be displayed.	—
Starting Mode Allows the user to program the SMC Dialog Plus controller for the type of starting that best fits the application.	Soft Start, Current Limit
Ramp Time This sets the time period during which the controller will ramp the output voltage.	0 to 30 seconds
Initial Torque The initial reduced voltage output level for the voltage ramp is established and adjusted with this parameter.	0 to 90% of locked rotor torque
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19, and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminal 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered up" state of the third auxiliary contact.	N.O., N.C.
Slow Speed Sel This parameter allows the user to program the Preset Slow Speed that best fits the application.	High, Low
Slow at Start This parameter allows the user to activate or deactivate the Preset Slow Speed.	Off, On
Slow Accel Cur. This parameter allows the user to program the Preset Slow Speed acceleration current.	0 to 450% of full load current

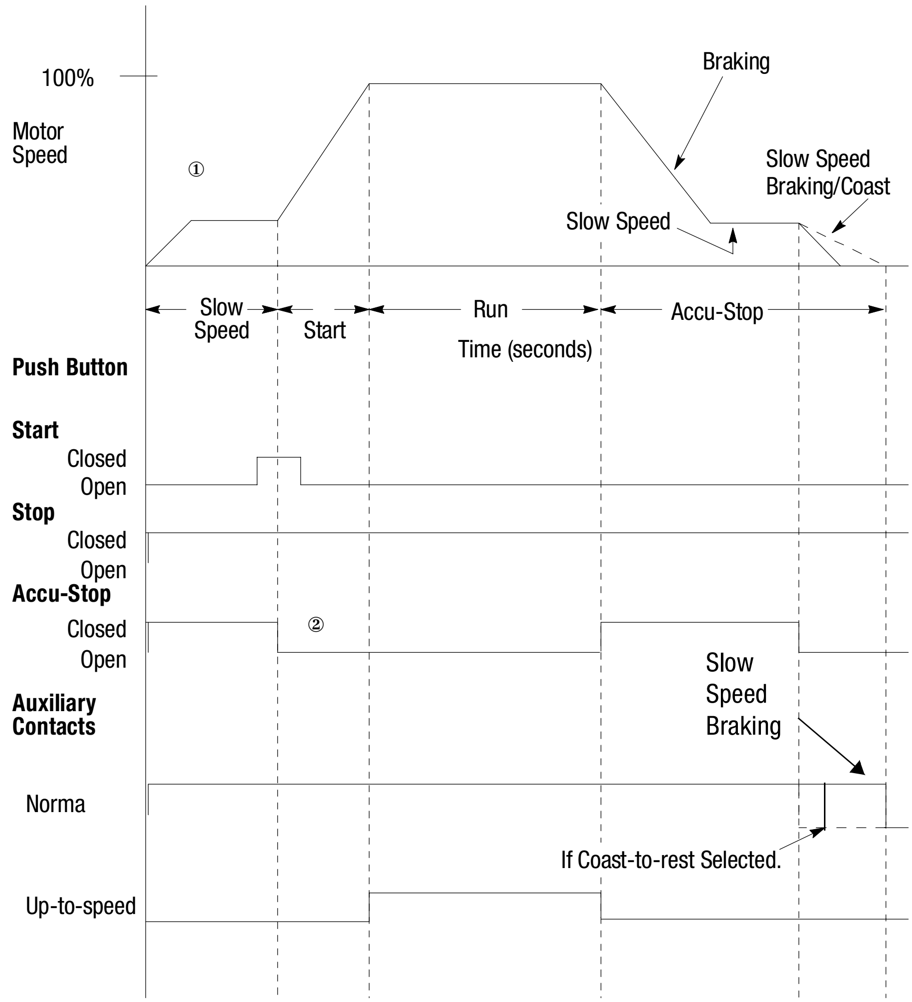
Programming - Soft Start with Accu-Stop (cont.)

Parameter	Range
Slow Running Cur This parameter allows the user to program the Preset Slow Speed running current.	0 to 450% of full load current
Brake to Stop **This parameter allows th**e user to program the controller to brake from full speed to zero speed.	No, Yes
Braking Current Allows the user to program the percentage of braking current applied to the motor during the stop sequence. With the SMC Smart Motor Braking option, this is the current applied to bring the motor to zero speed.	0 to 450% full load current
Stopping Current Allows the user to program the percentage of braking current applied to bring the motor from Preset Slow Speed to zero speed.	0 to 400% of full load current
Parameter Mgmt The newly programmed parameters values can be saved to memory or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

Control Options (cont.)

Accu-Stop Option (cont.)

Figure 3.30 Accu-Stop Option Sequence of Operation



① Slow Speed Start Select "On."

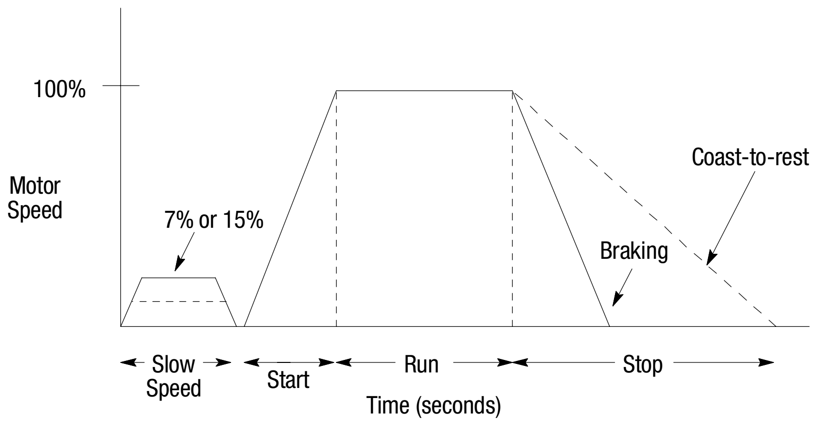
② When Accu-Stop push button is closed, start/stop function is disabled.

ATTENTION: The user has the ultimate responsibility to determine which stopping mode is best suited to th application and will meet applicable standards for operator safety on a particular machine.

Accu-Stop/Slow Speed with Braking Option

The Slow Speed with Braking portion of this option combines the benefits of the SMB Smart Motor Braking and Preset Slow Speed options for applications that require slow set-up speeds and braking to a stop.

Figure 3.31 Slow Speed with Braking Option



ATTENTION: Slow speed running is not intended for continuous operation due to reduced motor cooling.

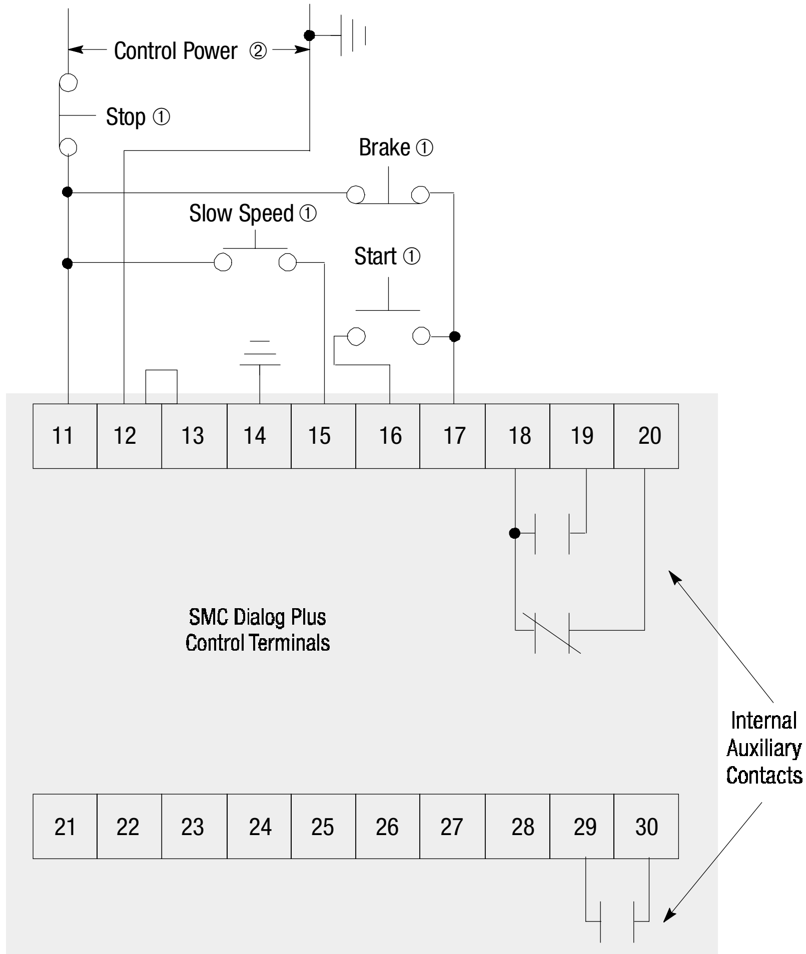
ATTENTION: Braking may cause motor heating and equipment vibration depending on braking current, frequency of braking, and duration of braking cycle. Select the lowest brake current setting that will brake satisfactorily.

ATTENTION: Slow Speed with Braking is not intended to be used as an emergency stop. Refer to th applicable standards for emergency stop requirements.

Control Options (cont.)

Slow Speed with Braking Capability

Figure 3.32 Typical Wiring Diagram for Slow Speed with Braking Capability



① Customer supplied.

② Refer to the controller nameplate to verify the rating of the control power input voltage.

Programming - Soft Start with Slow Speed with Braking Capability

The basic parameter set-up for Soft Start Selection with Slow Speed with Braking capability follows:

Parameter	Range
SMC Option "Accu-Stop" will be displayed.	—
Starting Mode Allows the user to program the SMC Dialog Plus controller for the type of starting that best fits the application.	Soft Start, Current Limit
Ramp Time This sets the time period during which the controller will ramp the output voltage.	0 to 30 seconds
Initial Torque The initial reduced voltage output level for the voltage ramp is established and adjusted with this parameter.	0 to 90% of locked rotor torque
Kickstart Time A boost of 550% of full load current is provided to the motor for the programmed time period.	0.0 to 2.0 seconds
Stall Delay Allows the user to program the stall protection delay time. The delay time begins after the start time has timed out.	0 to 10 seconds
Energy Saver The Energy Saver feature monitors the motor load, phasing back the voltage output to the motor when the motor is lightly loaded or unloaded for an extended period of time.	Off, On
Aux Contacts 1&2 Two form C contacts are provided as standard with the SMC Dialog Plus controller. These contacts are located at terminals 18, 19, and 20. Aux Contacts 1&2 allows the user to configure the operation of the contacts.	Normal, Up-to-speed
Aux Contact 3 A third auxiliary contact is provided between terminal 29 and 30. Aux Contact 3 allows the user to program the operation of the contact.	Normal, Fault
Contact 3 Config This parameter provides the user with the ability to program the "powered up" state of the third auxiliary contact.	N.O., N.C.
Slow Speed Sel This parameter allows the user to program the Preset Slow Speed that best fits the application.	High, Low
Slow at Start This parameter allows the user to activate to deactivate the Preset Slow Speed.	Off, On
Slow Accel Cur. This parameter allows the user to program the Preset Slow Speed acceleration current.	0 to 450% of full load current

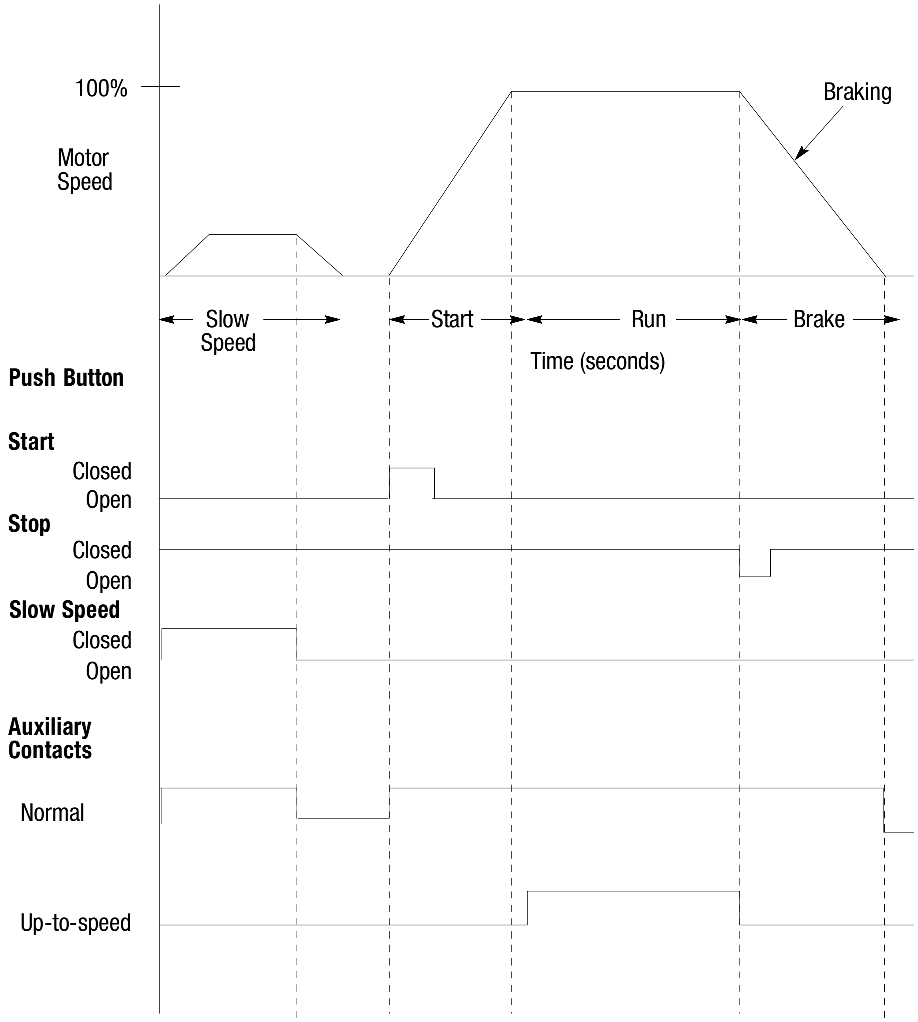
Control Options (cont.)

Programming - Soft Start with Slow Speed with Braking Capability (cont.)

Parameter	Range
Slow Running Cur This parameter allows the user to program the Preset Slow Speed running current.	0 to 450% of full load current
Brake to Stop This parameter allows the user to program the controller to brake from full speed to zero speed.	No, Yes
Braking Current Allows the user to program the percentage of braking current applied to the motor during the stop sequence. With the SMC Smart Motor Braking option, this is the current applied to bring the motor to zero speed.	0 to 400% full load current
Stopping Current Allows the user to program the percentage of braking current applied to bring the motor from Preset Slow Speed to zero speed.	0 to 450% of full load current
Parameter Mgmt The newly programmed parameters values can be saved to memory. or the factory default parameter values can be recalled.	Ready, Default Init., Recll Frm EE, Store In EE

Slow Speed with Braking Capability (cont.)

Figure 3.33 Slow Speed with Braking Capability Sequence of Operation



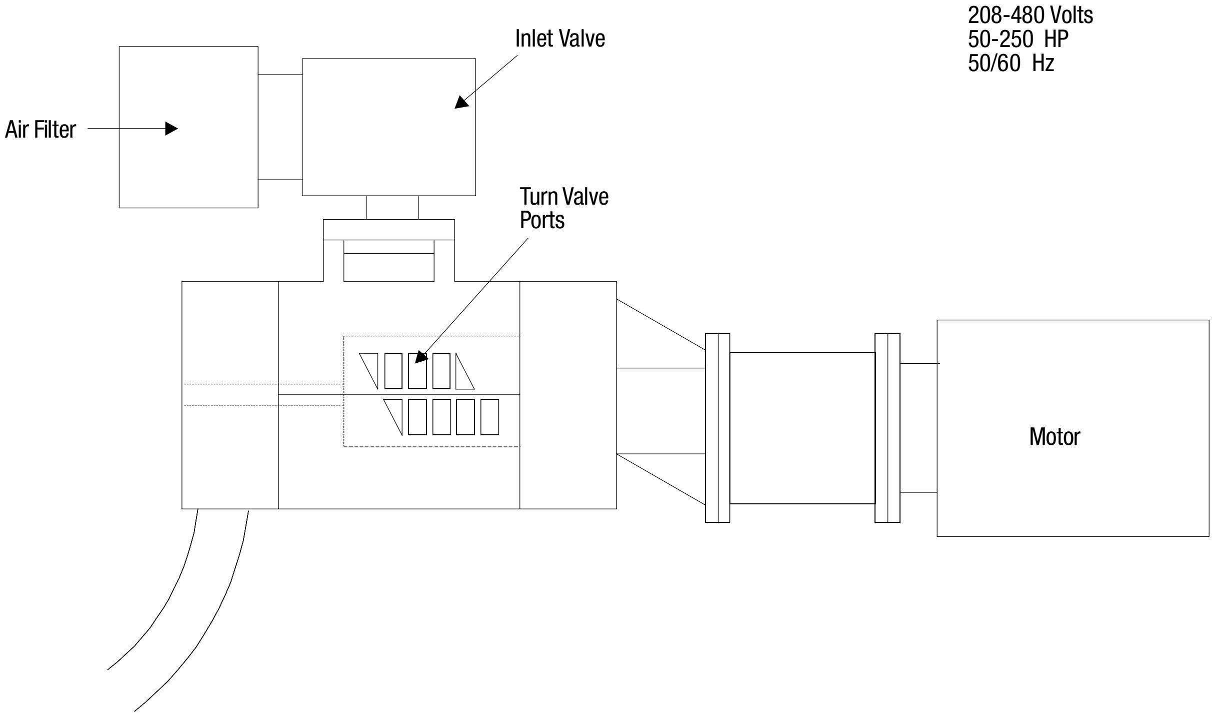
ATTENTION: The user has the ultimate responsibility to determine which stopping mode is best suited to th application and will meet applicable standards for operator safety on a particular machine.

Application Profiles for the SMC Dialog Plus Controller

In this chapter, a few of the many possible applications for the SMC Dialog Plus controller are described. The basis for selecting particular control method is also detailed. Illustrations are included to help identify the particular application. Motor ratings are specified, but the ratings may vary in other typical applications.

For example, a tumbler drum is described as requiring the Soft Start feature. The application is examined further to determine how the SMC Dialog Plus controller options can be used to improve the tumbler drum performance and productivity.

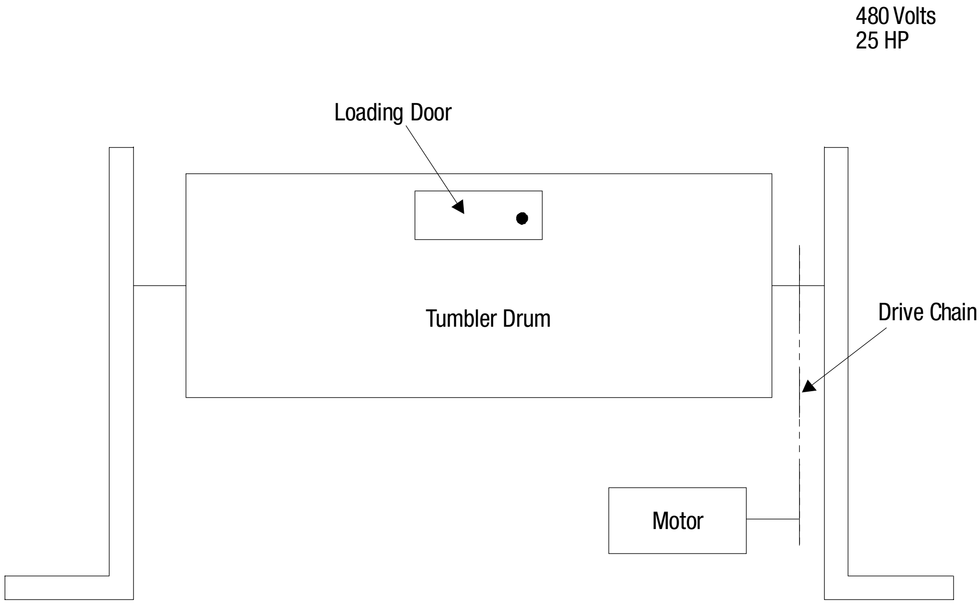
Figure 4.1 Compressor with Soft Start



Problem: A compressor OEM shipped its equipment into overseas markets. There were many different voltage and frequency requirements to meet because of the compressor's final destination. Due to power company requirements and mechanical stress on the compressor, reduced voltage starter was required. This made ordering and stocking spare parts difficult. Energy savings was desired because this is typically one of the larger motors in the plant and it frequently runs lightly loaded. Also, because of the size of the motor, the incoming line voltage unbalance was causing excessive heating in th motor.

Solution: The SMC Dialog Plus controller was installed and set for an 18-second Soft Start, which reduced the voltage to the motor during starting and met the power company requirements. By reducing the voltage, the starting torque was also reduced, minimizing the shock to the compressor. Panel space was saved because the SMC Dialog Plus controller has a built-in overload feature. The Phase Rebalance feature automatically adjusted the voltage output to balance the three-phase currents drawn by the motor. In addition, the Energy Saver feature optimized the voltage to the motor while it was running unloaded.

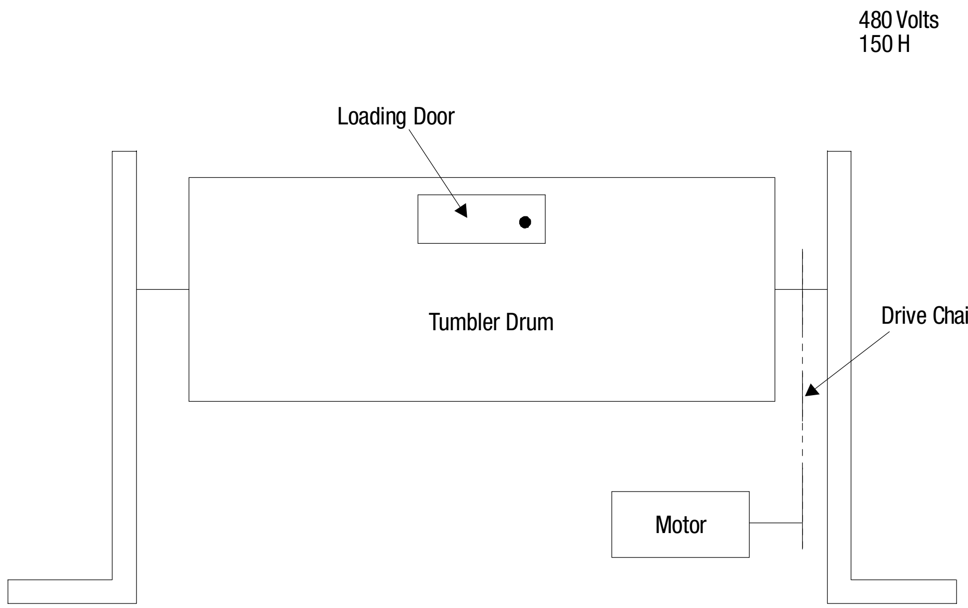
Figure 4.2 Tumbler with Dual Ramp Start



Problem: A tumbler used in a nail finishing process was breaking the drive chain because of uncontrolled acceleration from the across-the-line start. In addition, a reversing starte was needed to position the drum to the top position for loading the product. Because of the lack of controlled acceleration, numerous jogs were used to position the drum. The stopping time was not a concern in this application. When in maintenance mode, the tumble started unloaded, reaching full speed very quickly. A second starting ramp, for unloaded conditions, was desired. Additionally, single phasing of the motor was a frequent problem, causing premature motor failure.

Solution: The SMC Dialog Plus controller was installed after the reversing contactor to control the starting torque of th motor. This decreased the snapping of the drive chain on start up, which in turn increased the life of the chain and reduced the downtime on the tumbler. In addition, the SMC Dialog Plus controller made it easier to jog the drum into position for loading and unloading. (The SMC Dialog Plus controller slowed the acceleration rate to prevent overshoot.) When in maintenance mode, the Dual Ramp Start feature of the SMC Dialog Plus controller was utilized to provide a soft start specifically for no load conditions. This improved the productivity of the loading and unloading process. Further, the SMC Dialog Plus controller quickly detected a phase failure during either the starting or running modes. The controller would shut off with a “line fault” condition and prevent restarting the motor until the line had been corrected. This provided additional protection to the motor and system.

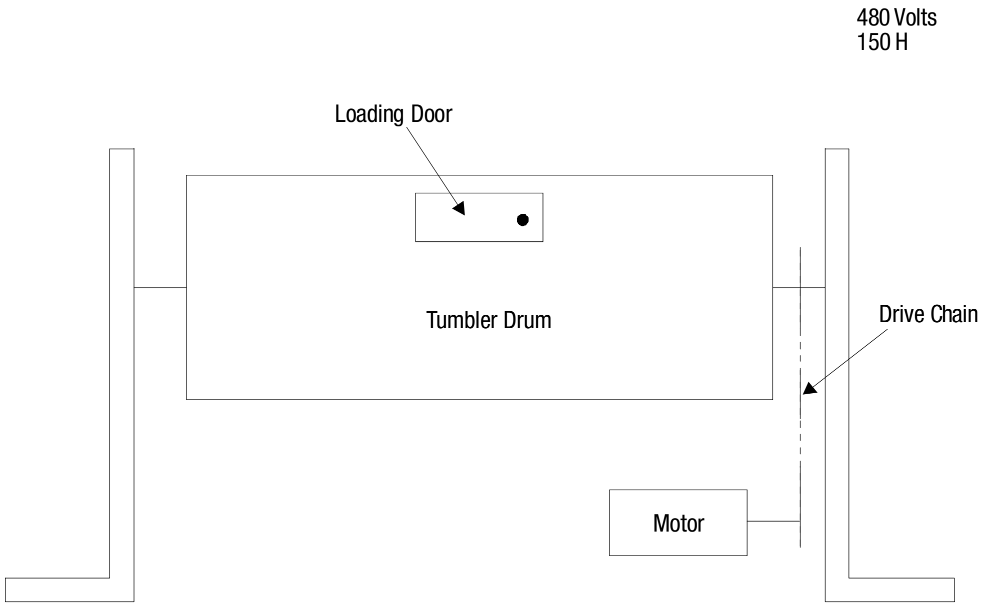
Figure 4.3 Tumbler with Soft Start and SMB Smart Motor Braking Option



Problem: A tumbler drum used in the de-burring process was breaking the drive chain because of the uncontrolled acceleration from the across-the-line starter. To increase production on the drum, the coasting time on stop had to be reduced. Previous solutions were a separate soft start package plus a motor brake, which required additional panel space and power wiring. A small enclosure siz and simplified power wiring were needed to reduce the cost of the controls. Because a PLC was controlling several other processes in the facility, communication capabilities were desired.

Solution: The SMC Dialog Plus controller with the SMB Smart Motor Braking option was installed on the process. The Soft Start provided a smooth acceleration of the drive chain, which reduced downtime. The controlled acceleration made positioning for loading/unloading easier. The SMB Smart Motor Braking option allowed the system to be stopped quickly, improving productivity. Further, the SMB Smart Motor Braking option did not require additional panel space or wiring. The SMC Dialog Plus controller's built-in overload eliminated the need to mount an external overload relay in the enclosure, saving further panel space. The communication feature of the SMC Dialog Plus controller allowed for remote starting and stopping of th process from a PLC.

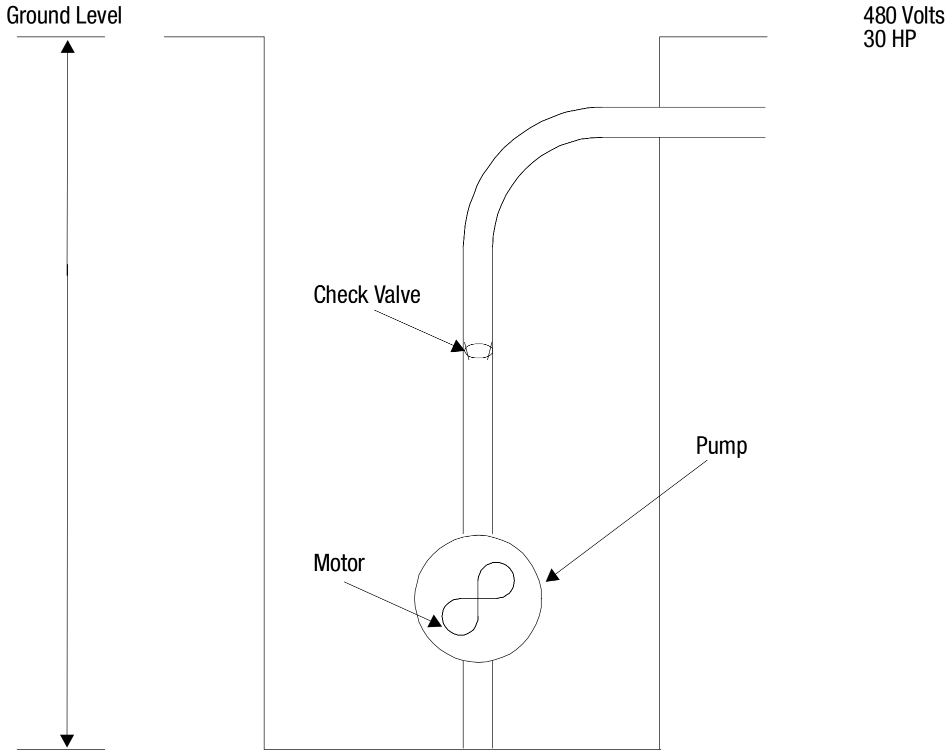
Figure 4.4 Tumbler with Accu-Stop Option



Problem: A tumbler drum used in a hide processing plant required a controlled acceleration to prevent the drive chain from breaking. In addition, it was desirable to minimize the loading and unloading time. The drum would coast for a long period of time before stopping for unloading. Previously, a soft start with electronic brake had been applied. This method still required excessive jogging for loading and unloading, which resulted in extended production times. It also required additional panel space and wiring for the brake. Consequently, higher installation costs were incurred.

Solution: The SMC Dialog Plus controller with the Accu-Stop option was installed. This allowed the drum to b positioned for loading using the Preset Slow Speed. For unloading, the drum was rotated at Preset Slow Speed and then accurately stopped. This increased the productivity of the loading/unloading cycle. The SMC Dialog Plus controller required no additional panel space or power wiring, facilitating a smooth retrofit and reducing the installation costs.

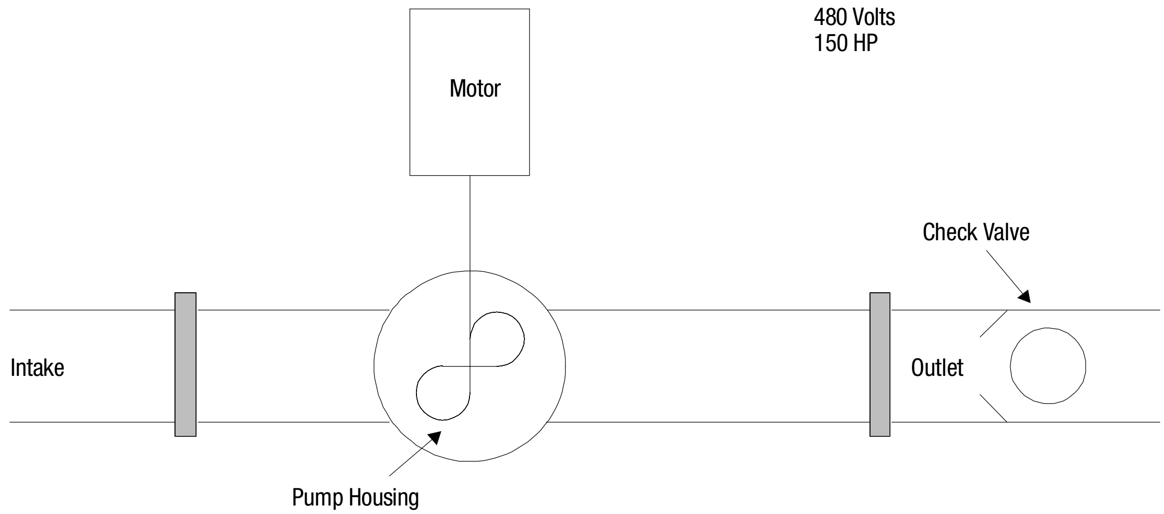
Figure 4.5 Pump with Soft Start



Problem: A municipal water company was experiencing problems with pump impellers being damaged. The damage occurred during an across-the-line start and was caused by the heavy shock to the impeller. The pumping station motor was over 100 feet below ground, making repair costly. For maintenance scheduling purposes, an elapsed time meter measuring motor running time had to b installed in the enclosure. Additional concerns were energy consumption and frequent line failures, which resulted in single phasing the motor.

Solution: The SMC Dialog Plus controller was installed, providing a controlled acceleration of the motor. By decreasing the torque during start-up, the shock to the impeller was reduced. The SMC Dialog Plus controller's built-in Energy Saver feature was automatically activated whenever the pump was lightly loaded for long periods of time. Panel space was saved by employing the built-in elapsed time meter. The SMC Dialog Plus controller's line diagnostics detected the pre-start and running single phase condition and shut off the motor, thereby protecting against motor damage.

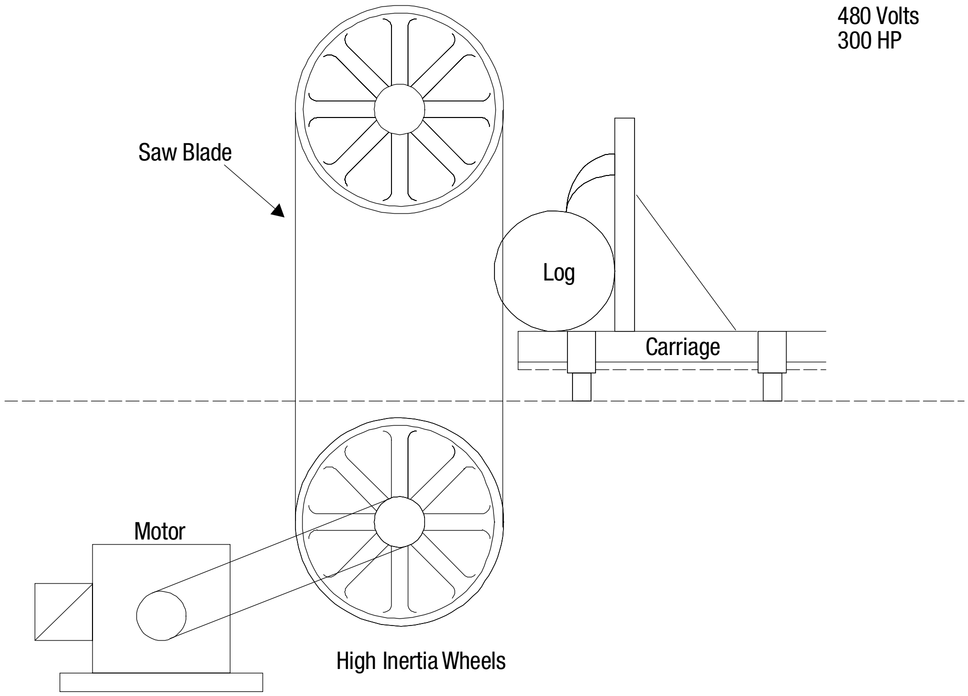
Figure 4.6 Pump with Pump Control Option



Problem: A municipal pump was utilizing a soft start controller with soft stop to control the pump motor. The soft stop was controlling the motor in an open loop fashion by reducing the voltage to the motor. Because there was not enough torque provided to the motor to drive the load, the motor's stall point was quickly reached. During the stop mode, severe surges were causing pipe vibration and breakage.

Solution: The SMC Dialog Plus controller with the Pump Control option was installed. The Pump Control option removed the surges by controlling the speed of the motor during starting and stopping. The microprocessor inside the SMC Dialog Plus controller analyzed the motor variables and generated control commands to reduce the surges in the system.

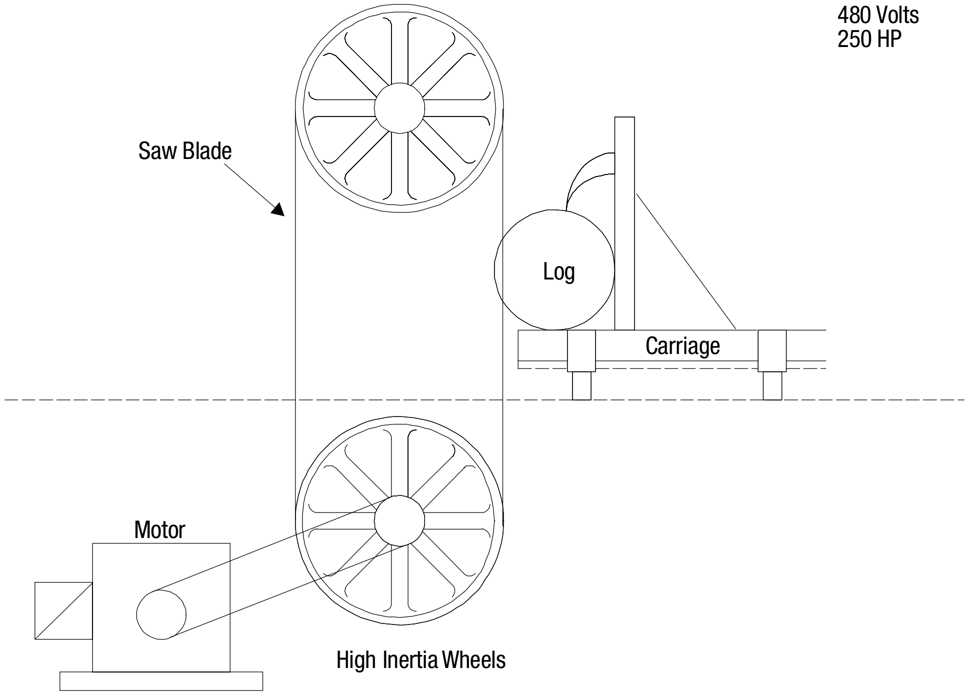
Figure 4.7 Bandsaw with Soft Start



Problem: Because of the remote location of the facility and powe distribution limitations, a reduced voltage starter was needed on a bandsaw application. The saw was turned off only during shift changes. When the saw blade became dull, the current drawn by the motor increased. Therefore, an ammeter was required. Metering th application for jam conditions was a necessity. In addition, single phasing of the motor was a problem because of distribution limitations.

Solution: The SMC Dialog Plus controller was installed to provid a reduced voltage start. This minimized the starting torque shock to the system. The Energy Saver feature was activated whenever the bandsaw was running lightly loaded. The current monitoring and jam detection features of the SMC Dialog Plus controller were implemented, saving valuable panel space and the cost o purchasing dedicated monitoring devices. The controller's built-in programmable overload protection was utilized. The SMC Dialog Plus controller's diagnostic capabilities would detect single phasing and shut the motor off accordingly.

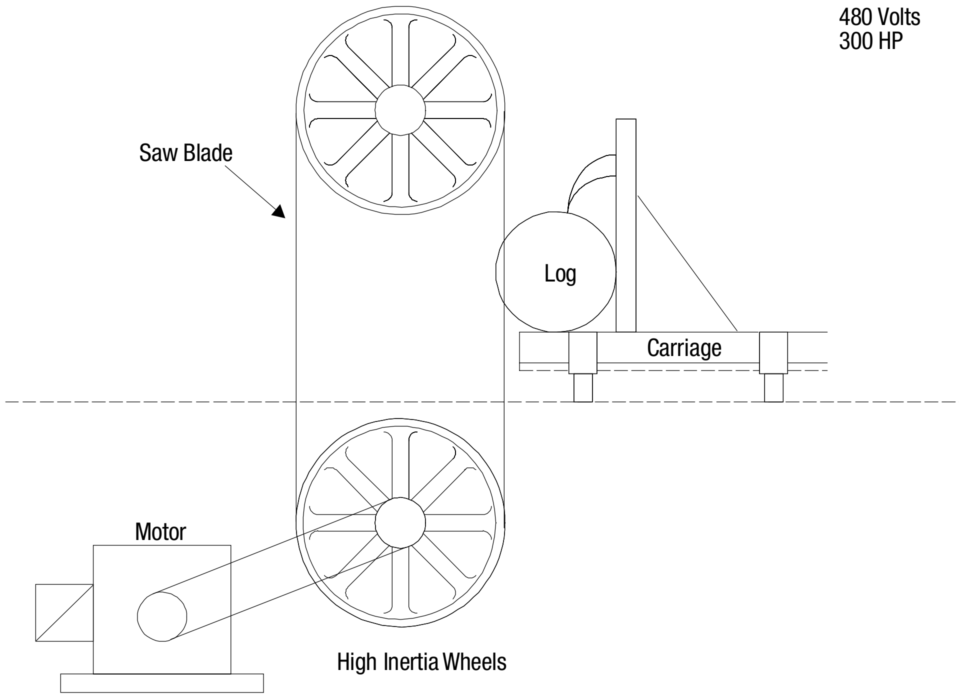
Figure 4.8 Bandsaw with Soft Start and SMB Smart Motor Braking Option



Problem: A bandsaw application required a reduced voltage start because of power company restrictions. A brake package was required to reduce the stopping time of the saw. Previously, an autotransformer had been used to start the saw. The saw was stopped by sawing down. Sawing down is accomplished by running logs through the saw after the motor has been de-energized, which results in large amount of scrap lumber. Other stopping methods using dedicated braking devices were investigated but were unacceptable because of overly complex installation. Additionally, other stopping methods required panel space for the brake module, brak contactors and timers, and they offered no zero speed detection.

Solution: The SMC Dialog Plus controller with the SMB Smart Motor Braking option was installed. It provided the reduced voltage start needed to meet the power company restrictions. The SMB Smart Motor Braking option did not require additional panel space or DC braking contactors. The starting and stopping control was furnished in a single modular design, providing ease of installation.

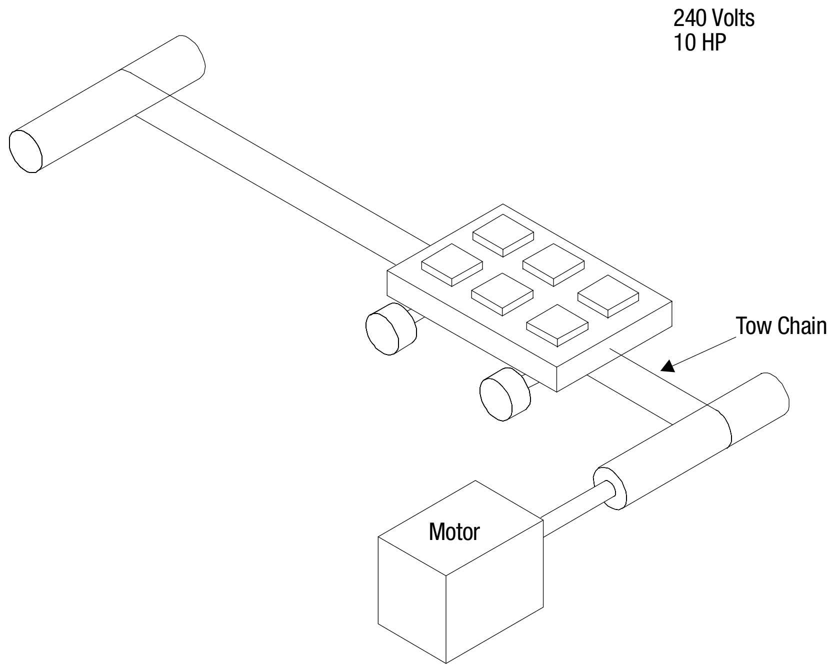
Figure 4.9 Bandsaw with Soft Start and Slow Speed with Braking Option



Problem: A bandsaw required 25 minutes to coast to a stop to routinely change the saw blade. A braking package was required to reduce the stopping time. Other methods using dedicated braking devices were investigated but were unacceptable because of overly complex installation. These methods required additional panel space for the brake module, brake contactors, and timers. Because of potential alignment problems, it was dangerous to bring the saw up to full speed afte installing a new blade.

Solution: The SMC Dialog Plus controller with the Slow Speed with Braking option was installed. It provided a Preset Slow Speed, allowing the saw blade tracking to b inspected before the motor was brought to full speed. The braking option of the SMC Dialog Plus controlle did not require additional panel space or DC braking contactors. Starting and stopping control was furnished in a single modular unit, providing ease of installation.

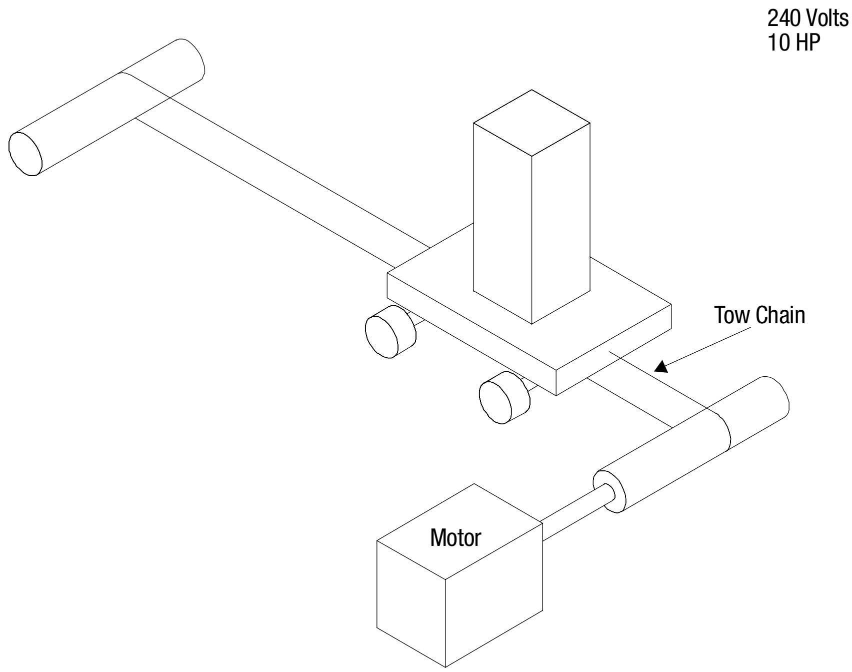
Figure 4.10 Trolley with Dual Ramp Start



Problem: A trolley carrying ceramic tiles entered a kiln for heating. When heated, the trolley exited the kiln and entered th production area. Any abrupt movement caused the tiles to fall over, resulting in damaged product. An across-the-line starter, gearbox, and fluid coupling were used to perform this work, with some lost production expected.

Solution: The SMC Dialog Plus controller was installed to utiliz acceleration control, which resulted in improved productivity and a reduction in damaged product. Th maintenance time for the fluid coupling was also minimized. Further, the Dual Ramp Start feature allowed for two separate acceleration ramps to be programmed; one ramp for a start with a heavy load, and one for a start with the lighter tiles loaded.

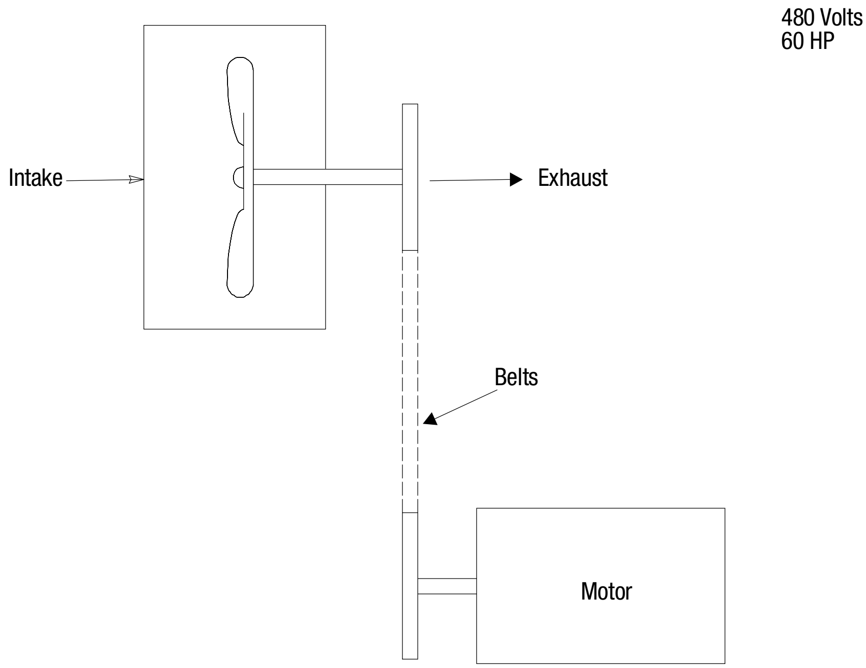
Figure 4.11 Trolley with Soft Start and Preset Slow Speed Option



Problem: A trolley application required a slow speed, as well as soft start, to eliminate product tipping while accelerating from rest. A variable frequency drive was considered. However, variable speed was not required during the run cycle. A cost-effective solution was desired.

Solution: The SMC Dialog Plus controller with the Preset Slow Speed option was installed. The Preset Slow Speed of 15% of rated speed was selected. After running at 15 of full speed for a few seconds, a 25-second ramp start was selected to accelerate the motor to full speed. The SMC Dialog Plus controller with Preset Slow Speed helped protect against product tipping during start-up. In addition, the desired acceleration control was provided at a reasonable cost.

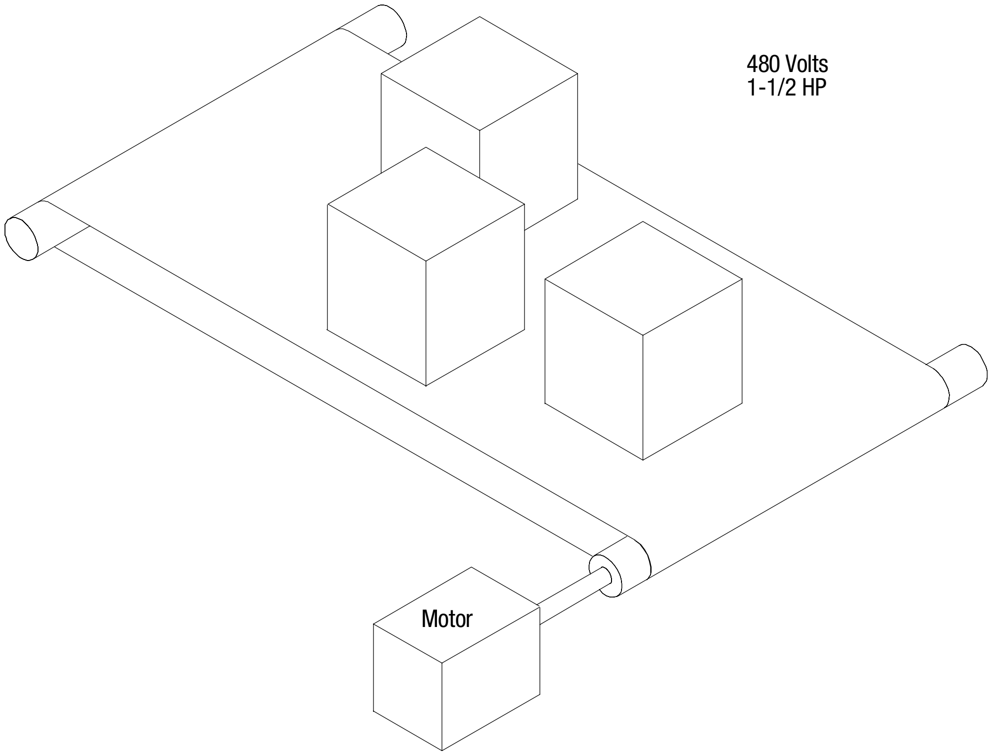
Figure 4.12 Exhaust Fan with Soft Start



Problem: The belts on an exhaust fan were frequently breaking, causing maintenance problems. In addition to the high cost of the belts, the fan belt guard was cumbersome to remove. The high starting torque from the motor was major contributor to the belt wear. Also, remote starting and stopping of the fan from a PLC was desired. Panel space was limited, requiring a compact device.

Solution: The SMC Dialog Plus controller was installed as a retrofit to the existing starter. The ramp time was set for 28 seconds, facilitating a smooth acceleration while reducing the starting torque of the motor and minimizing the mechanical shock to the belts. The SMC Dialog Plus controller has communication capabilities built-in, allowing for remote control via a PLC. It also has built-in overload protection, which saved valuable panel space.

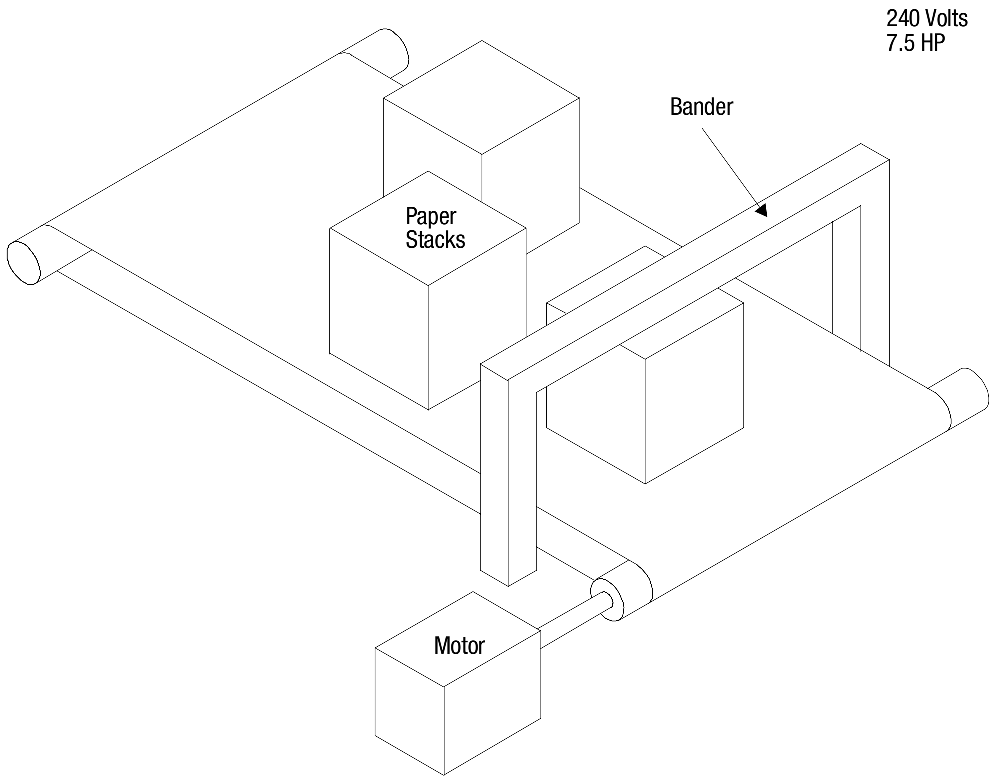
Figure 4.13 Palletizer with Dual Ramp Start



Problem: A palletizer moved cereal boxes through a packaging process to a shrink wrap machine. Across-the-line starting caused unwanted product spillage, as well as an interruption of production due to the uncontrolled torque from the motor on start-up. Since several types of cereals, in different size boxes, were produced on the same line, the ability to match the acceleration ramp to the cereal was desired. The facility was standardized on Allen-Bradley's Motor Control Centers. Therefore, the installation of the soft start in an MCC plug-in bucket was required.

Solution: The SMC Dialog Plus controller was installed, furnishing a controlled acceleration, reducing the shock to the load, and eliminating product spillage. The Dual Ramp Start feature allowed the controller to be programmed with two separate acceleration ramps, more closely matching the motor acceleration with the cereal produced. The SMC Dialog Plus controller was installed in a Motor Control Center plug-in bucket, making the packaging attractive to the customer and eliminating the need for a stand-alone enclosure.

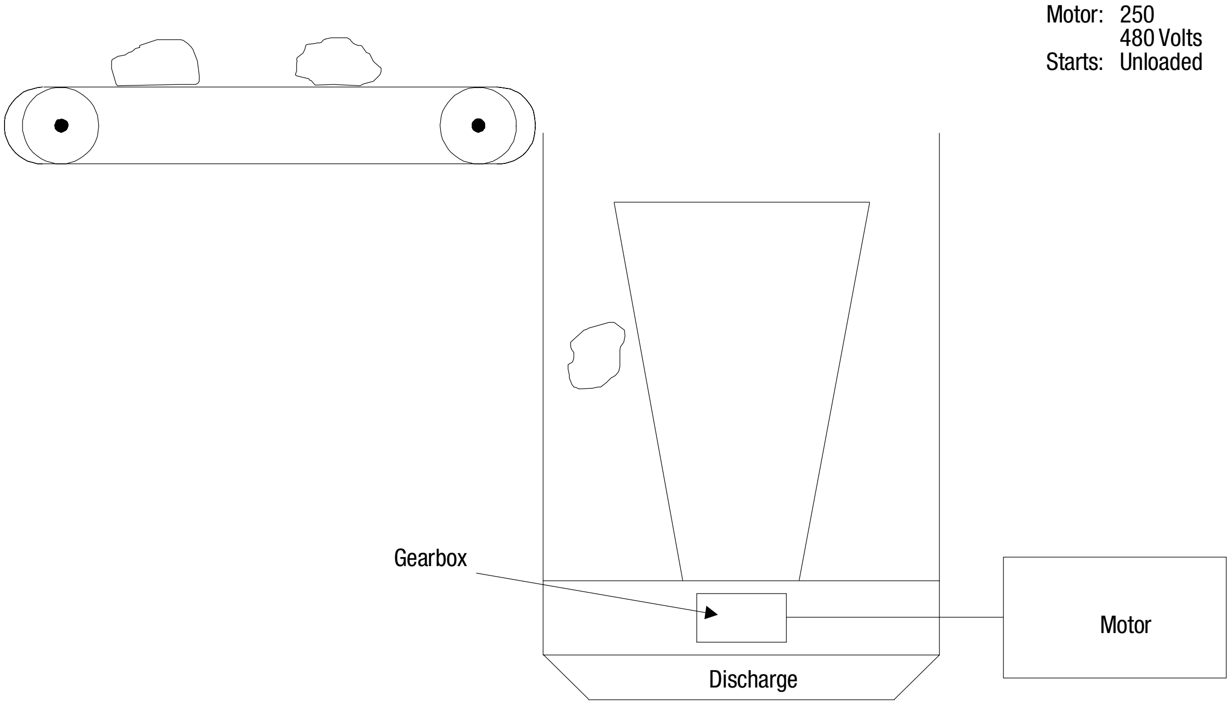
Figure 4.14 Palletizer with Soft Start and Preset Slow Speed Option



Problem: Stacks of paper on a conveyor were moved to a bander and then moved through the bander process onto a skid. When the papers were loose, a controlled low speed acceleration into the bander was required. After the papers were bound, a soft start was needed to keep the bundles from falling off the palletizer. The expense of a variable frequency drive to control the motor speed was not feasible.

Solution: The SMC Dialog Plus controller with the Preset Slow Speed option was installed, eliminating the need for frequent jogging of the conveyor to align the load with the bander. The loose papers were moved into the bander at 15% of full speed. A Soft Start was used to accelerat the motor to full speed, and load the bound stacks on th skid. The SMC Dialog Plus controller was a cost effective method of achieving the results required by the application.

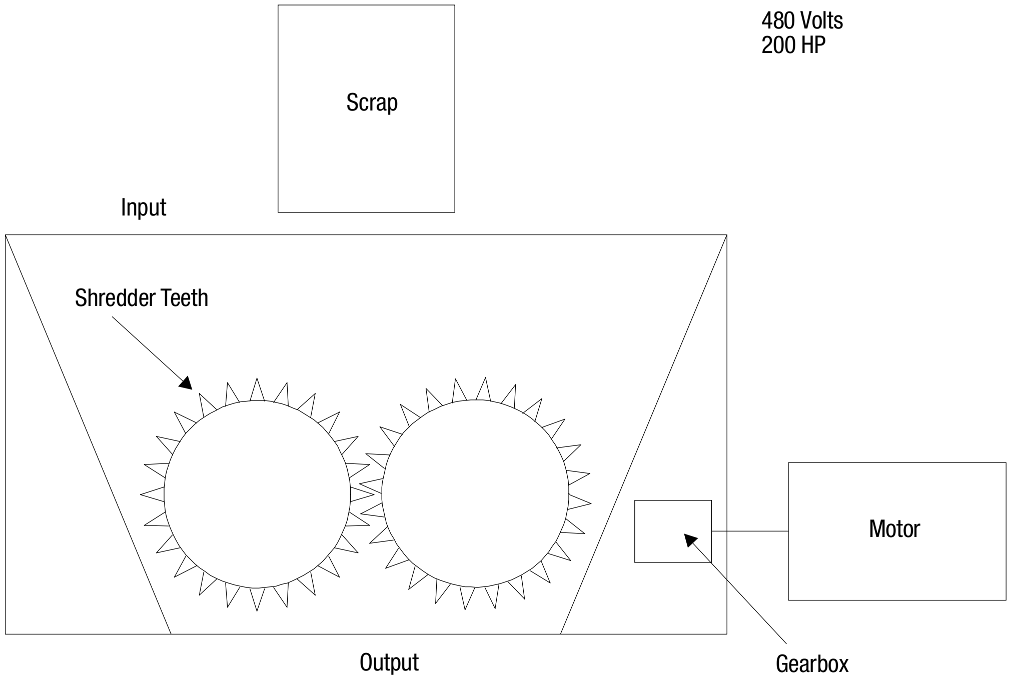
Figure 4.15 Rock Crusher with Soft Start



Problem: Because of the remote location of a rock quarry, the power company required a reduced voltage start on all motors over 150 HP. The starting current on these larg motors strained the capacity of the power system, causing severe voltage dips. When the rock crusher became overloaded, the current drawn by the motor increased. Therefore, current monitoring capabilities within the soft starter were required. Because the conveyor feeding the rock crusher was controlled by a PLC, communications between the soft starter and a PLC was necessary. The rock crusher ran unloaded at times, and occasionally stall or jam would occur.

Solution: The SMC Dialog Plus controller was installed, meeting the power company requirements. The metering capabilities of the SMC Dialog Plus controller allowed the current drawn by the motor to be monitored. With the built-in communications capabilities, the motor current could then be communicated to the PLC. When the motor current reached a specified limit, the conveyor feeding the rock crusher could be slowed. By slowing the conveyor, a jam condition in the rock crusher was avoided. The Energy Saver feature of the controlle reduced the voltage to the motor when the system was running lightly loaded. The stall and jam detection capabilities of the SMC Dialog Plus controller would shut off the motor when a stall or jam condition occurred.

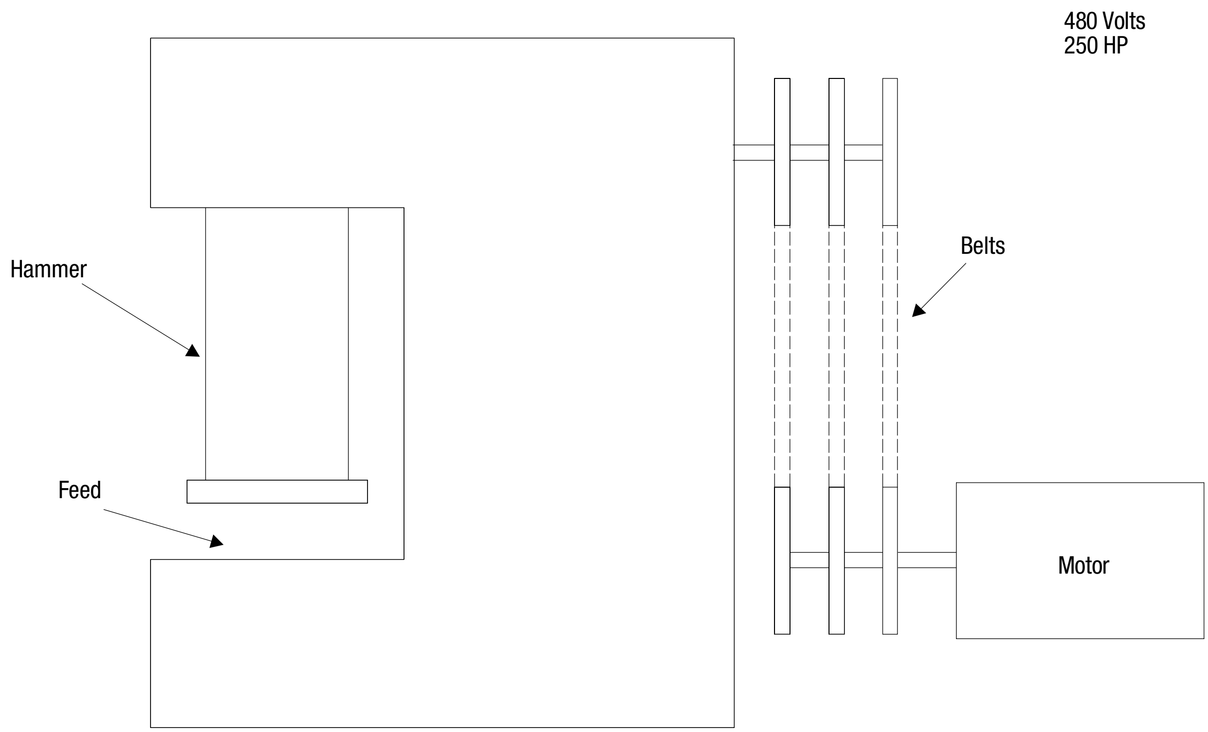
Figure 4.16 Shredder with Soft Start



Problem: Because of power company restrictions, a metal shredder required a reduced voltage start. Occasionally, a jam would occur during the shredding process. Additionally, the equipment ran unloaded for long periods. An autotransformer-type starter had been used in the past.

Solution: The SMC Dialog Plus controller was installed, facilitating a reduced voltage start. The controller also provided jam detection, which helped protect against excessive motor heating when a jam condition was encountered. The Energy Saver feature of the SMC Dialog Plus controller reduced the voltage to the motor when the motor was running lightly loaded. The built-in overload feature of the controller saved valuable panel space.

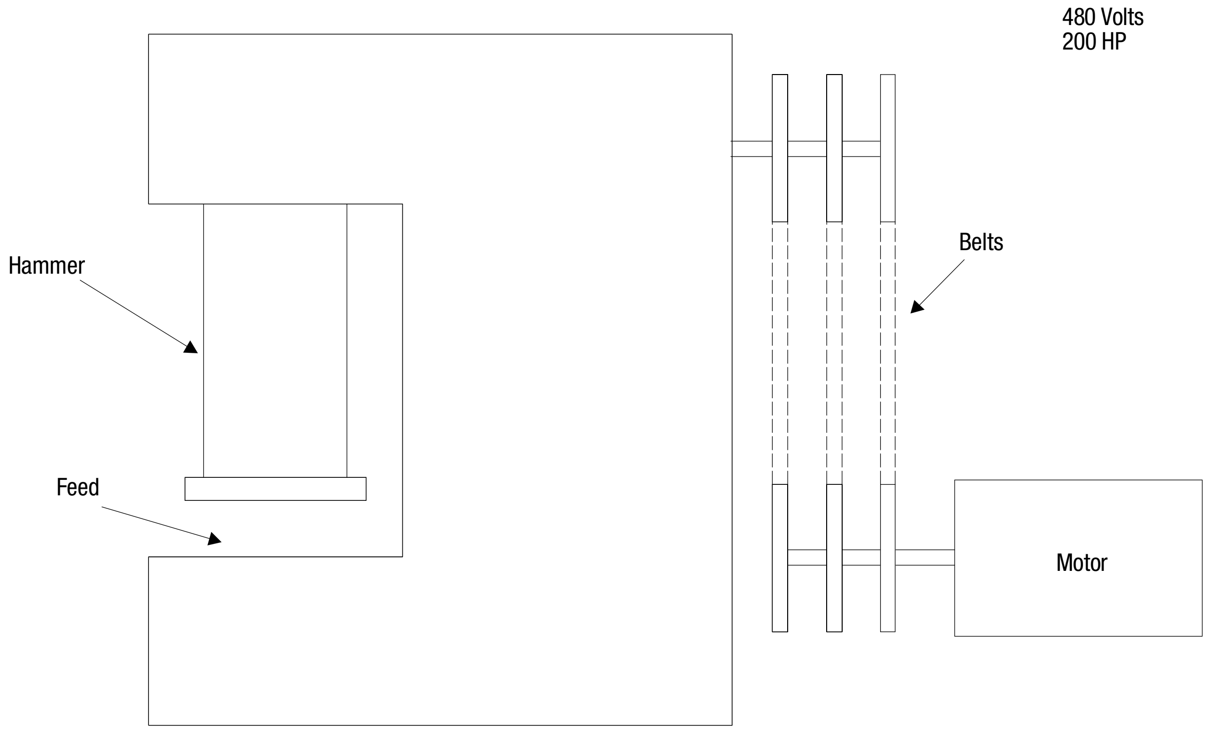
Figure 4.17 Hammermill with Current Limit Start



Problem: A hammermill with a high inertia load required a reduced voltage start because of power company restrictions. High torque on start-up was causing belt wear. Panel space was very limited. Traditional reduced voltage starters would not fit in the available space.

Solution: The SMC Dialog Plus controller was installed and set for a 23-second, 425% current limit start, which met the power company's requirement for the reduced voltage start. The belt life was extended since the starting torque was reduced. A current limit start was selected to quickly break away the high inertia load and still provide a reduced voltage start. The Energy Saver feature was used when the mill was running lightly loaded. The compact size of the SMC Dialog Plus controller, along with th built-in overload feature, enabled the controller to fit into the available panel space.

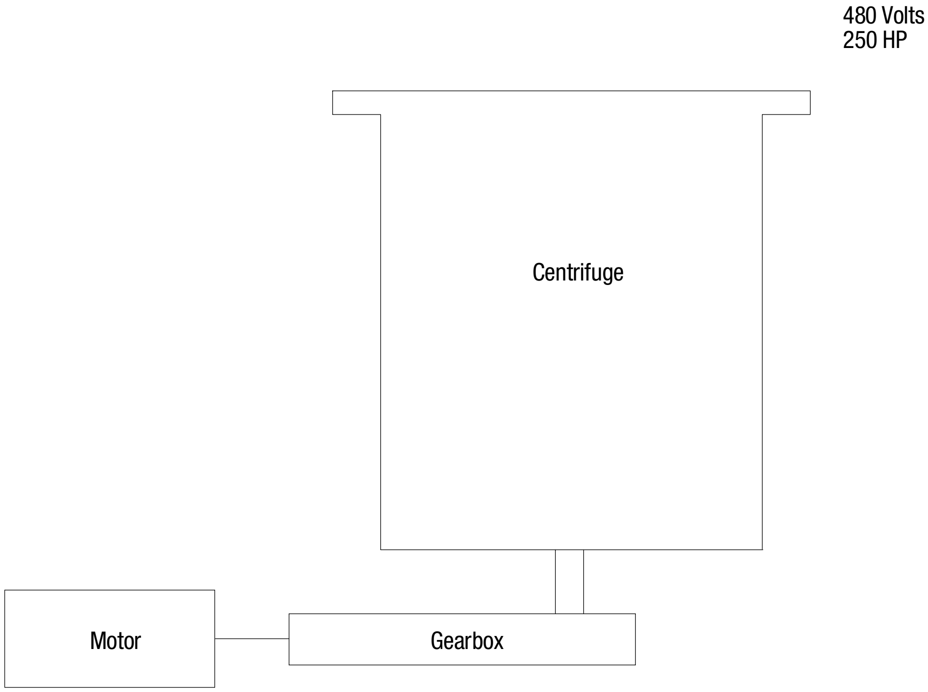
Figure 4.18 Hammermill with Current Limit Start and SMB Smart Motor Braking Option



Problem: A hammermill required a reduced voltage start because of power company restrictions. A stopping time less than the present five minute coast-to-rest was desired. To save panel space, the customer wanted to incorporate both starting and stopping control in the same device.

Solution: The SMC Dialog Plus controller with the SMB Smart Motor Braking option was installed. A 23-second, 450% current limit acceleration was programmed, meeting the power company requirements and reducing the mechanical stress on the belts during start-up. Th braking function was accomplished without additional power wiring, panel space, or contactors. Zero speed was detected without additional sensors or timers. The current limit start, braking, and overload protection were accomplished within the same modular package.

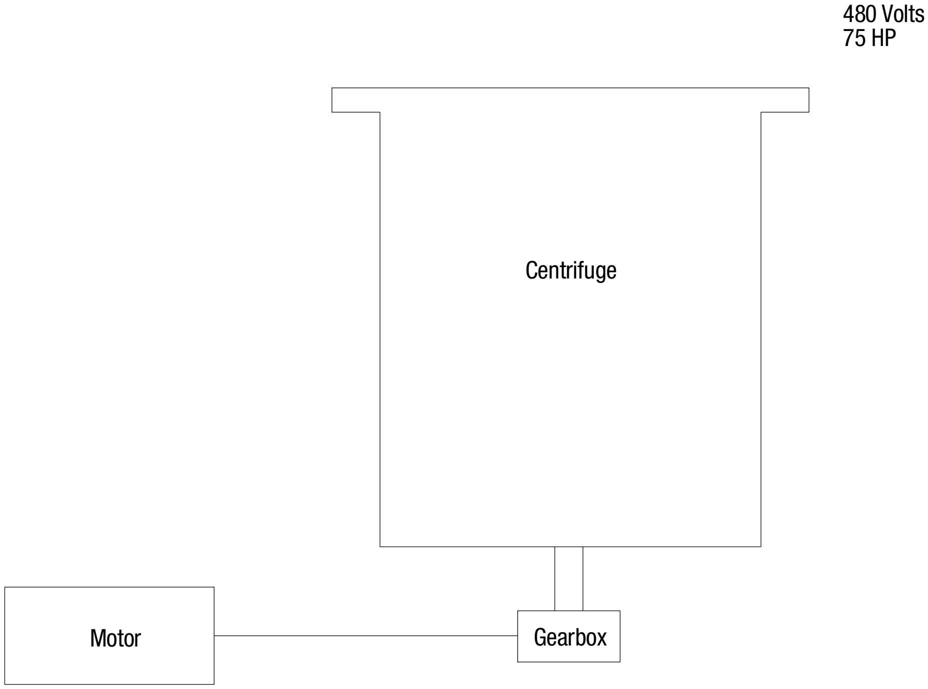
Figure 4.19 Centrifuge with Current Limit Start



Problem: Because of the high starting torque, the gearbox to a centrifuge was being damaged. A reduced voltage starter was desired because this motor was near the end of the distribution line. In addition, the incoming power was unbalanced. A controller with a circuit breaker combination enclosure was needed. When the enclosur door was open, the controller's circuit boards could not be exposed.

Solution: The SMC Dialog Plus controller was installed. It was programmed for a 27-second, 300% current limit start, which limited the starting torque of the motor and the shock to the gearbox on start-up. The Energy Saver feature reduced the voltage to the motor when it was running lightly loaded. The SMC Dialog Plus controller was ordered as a combination controller with a circuit breaker. The SMC Dialog Plus controller has no exposed circuit boards, fulfilling the packaging requirements.

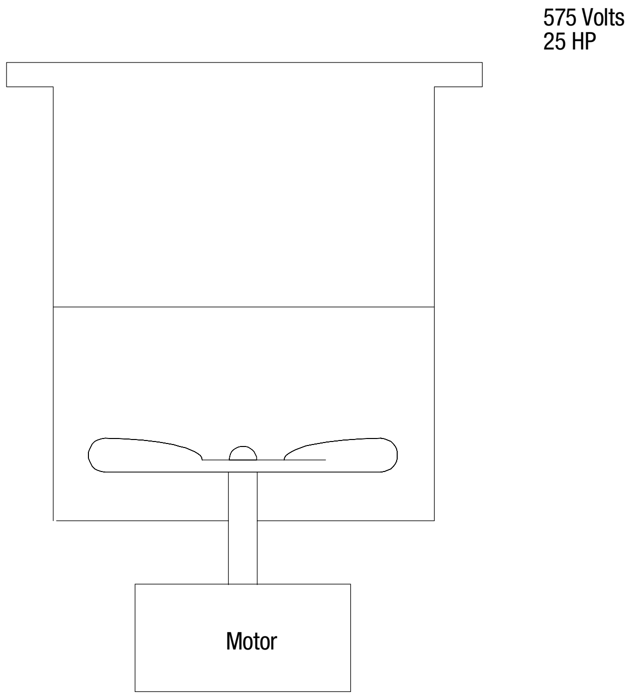
Figure 4.20 Centrifuge with Current Limit Start and SMB Smart Motor Braking Option



Problem: A centrifuge required a reduced voltage start because of power company restrictions. The high torque during starting was causing damage to the gearbox. A shorte stopping time than the present fifteen minute coast-to-rest was desired. The long stop time caused delays in the production process. A Wye-Delta starter with a mechanical brake was currently in use. A zero speed switch was used to release the brake. The mechanical brake required frequent maintenance and replacement, which was costly and time consuming. Both the mechanical brake and zero speed switches were worn out and required replacement.

Solution: The SMC Dialog Plus controller with the SMB Smart Motor Braking option was installed. The controller was set for a 28-second, 340% current limit start, meeting the power company requirements and reducing the starting torque stress to the gearbox. The SMB Smart Moto Braking option allowed the centrifuge to stop in approximately one minute. The SMC Dialog Plus controller with SMB Smart Motor Braking option did not require additional mounting space or panel wiring. Th controller was mounted in a panel that was considerably smaller than the previous controller. Additionally, the controller did not require frequent maintenance and could sense zero speed without a feedback device.

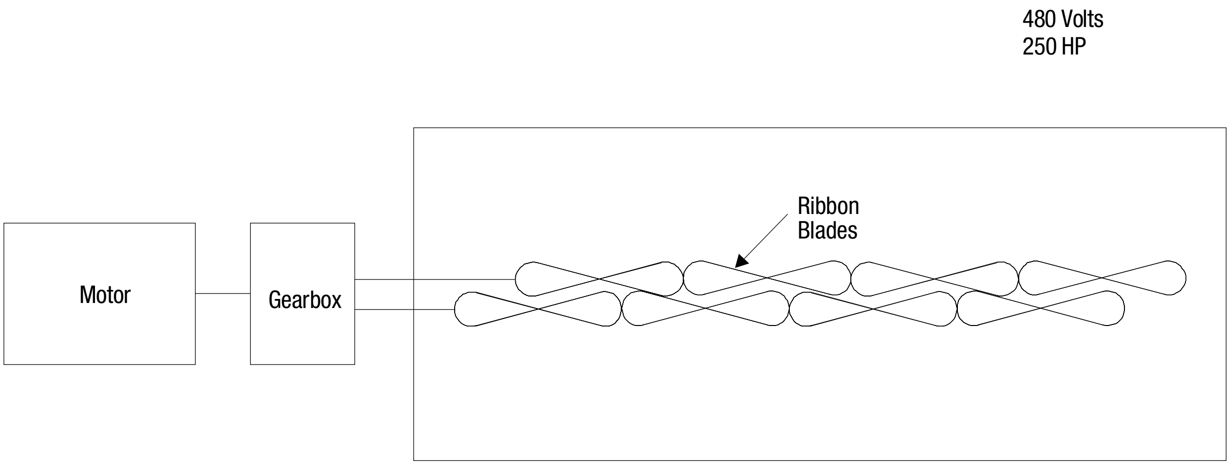
Figure 4.21 Mixer with Dual Ramp Start



Problem: A mixer used an across-the-line starter to control motor starting. The shock from the full voltage start frequently broke the shear pin, causing the batch to be ruined as th material solidified. Further, when the shear pin broke, the vat required cleaning. Occasionally, the material would begin to congeal before the mixer was started. Full starting torque would then be required. Finally, a connection to the PLC controlling many of the applications in the facility was required.

Solution: The SMC Dialog Plus controller was installed and set for a 13-second soft start, which smoothed the shock to the impeller on start-up and kept the shear pin from breaking. The Energy Saver feature reduced the voltage to the motor when it was running lightly loaded. The SMC Dialog Plus controller's Dual Ramp Start feature allowed for two starting ramps: the first for normal starting conditions and the second with a higher starting torque for the occasions when the product had begun to congeal. The Dual Ramp Start feature saved valuable production time, since the vat no longer required unloading once th product started to congeal. The communications capability of the SMC Dialog Plus controller allowed fo connection to the PLC.

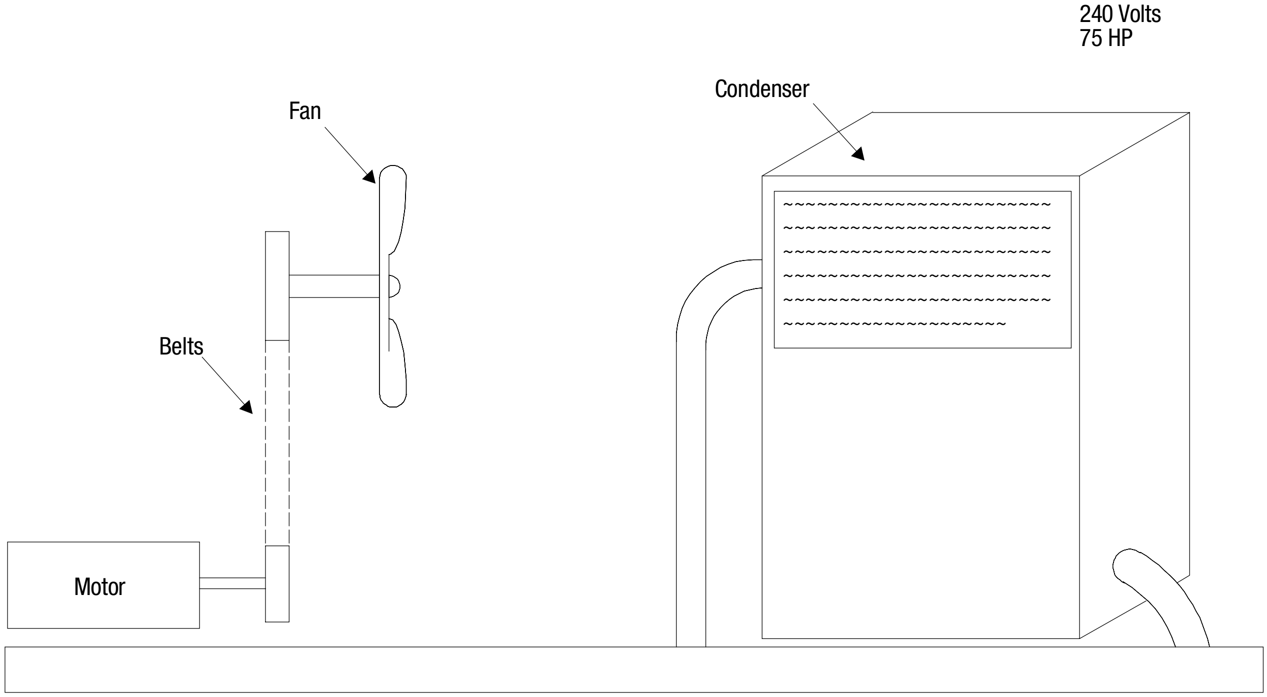
Figure 4.22 Mixer with Preset Slow Speed Option



Problem: A mixing process required a soft start to prevent damage to the mixer, as well as meet the local power requirement for reduced voltage starting. Running the machine at slow speed on start-up to ensure it was not binding was desirable. The mixer would then be run at full speed.

Solution: The SMC Dialog Plus controller with the Preset Slow Speed option was installed, allowing the mixer to be jogged at slow speed to ensure there was no binding. The SMC Dialog Plus controller was then set for a 22-second soft start to meet the local reduced voltage requirement. The Energy Saver was activated for slack production periods. This allowed for greater control of the moto without the expense of a variable frequency drive.

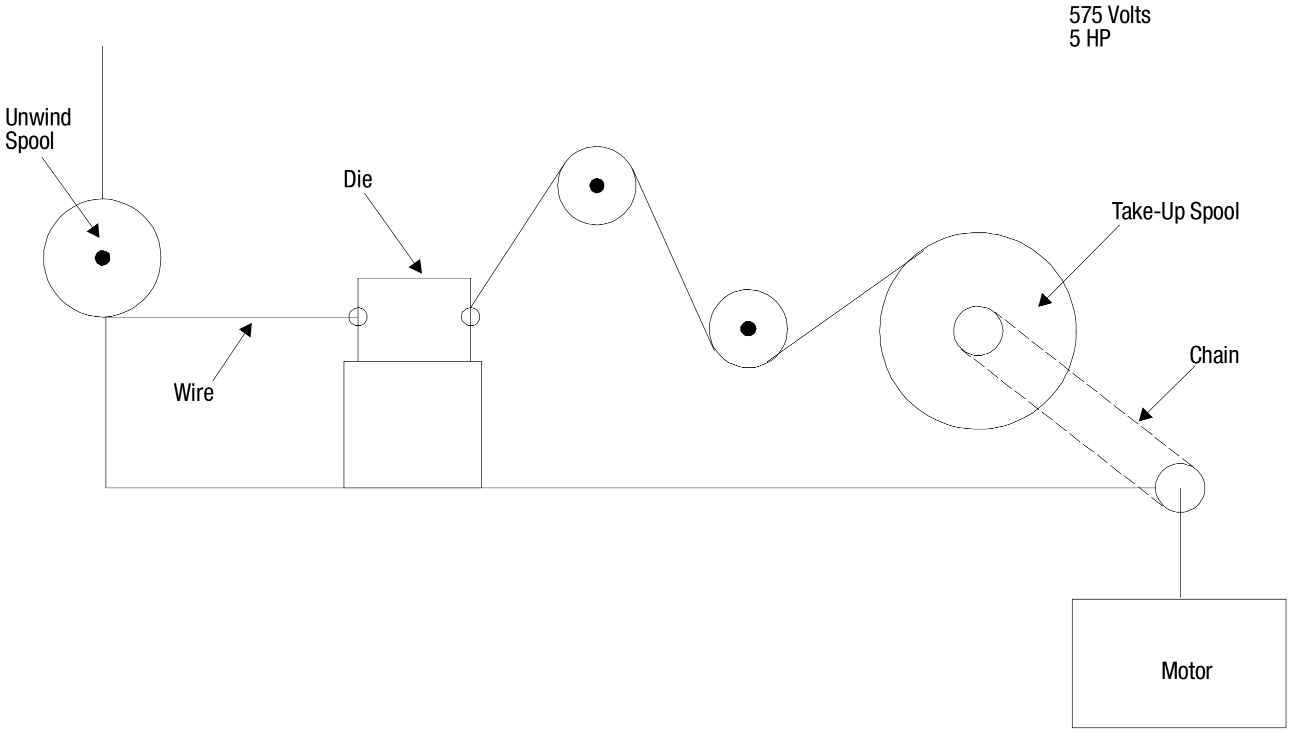
Figure 4.23 Chiller with Soft Start



Problem: A belt-driven fan on a chiller was frequently breaking th belt because of high starting torque. Excessive downtime was incurred because the housing had to be removed to replace the belt. A combination across-the-line starter was being used to control the motor. Control panel spac was limited. A device utilizing the same control voltage and line voltage was required because there was no room in the panel for a control circuit transformer.

Solution: The SMC Dialog Plus controller was installed as a retrofit to the chiller. It was set for an 18-second soft start to reduce the snap to the belts as a result of the high starting torque. It also reduced belt “squealing” previously experienced during start-up. Because the SMC Dialog Plus controller can operate with 240 volt control voltage and line voltage, a control circuit transformer was not required. The built-in overload protection on the SMC Dialog Plus controller further reduced the panel space required. The customer was able to retrofit the controller into the existing panel space.

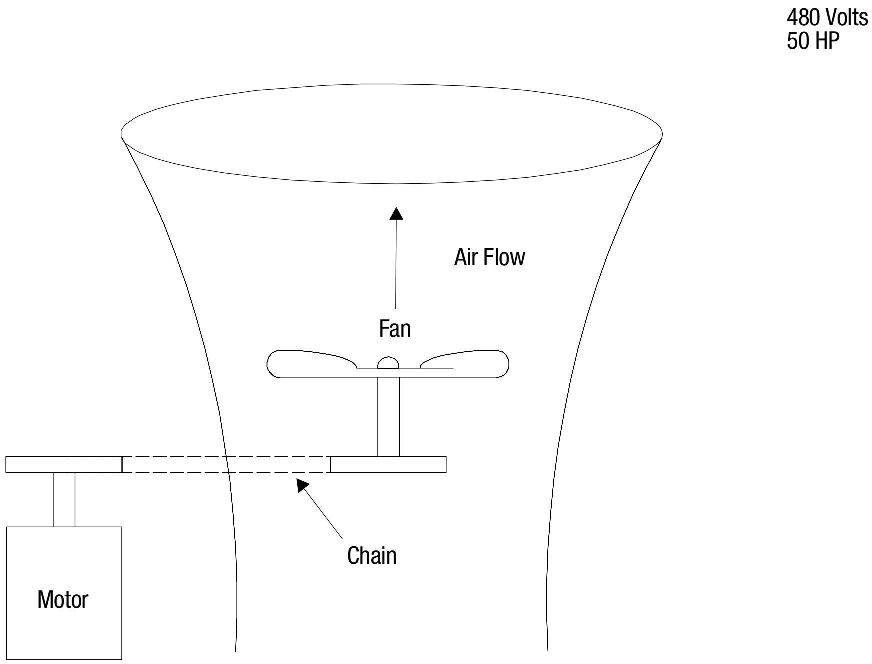
Figure 4.24 Wire Draw Machine with Soft Start



Problem: An across-the-line starter was used on a wire draw machine to pull wire. This rapid cycling application caused mechanical wear on both the chain and th electromechanical starter. Other soft starts had been experimented with, but not enough torque was developed to pull the wire through the die.

Solution: The SMC Dialog Plus controller was installed to accelerate the motor smoothly. The kickstart feature was adjusted to provide enough torque to pull the wire through the die. After the initial kickstart, the controller went back to the soft start acceleration mode, reducing the amount of starting torque on the chain and helping to lower maintenance inspection and repair time. The controller was set for a 9-second ramp time.

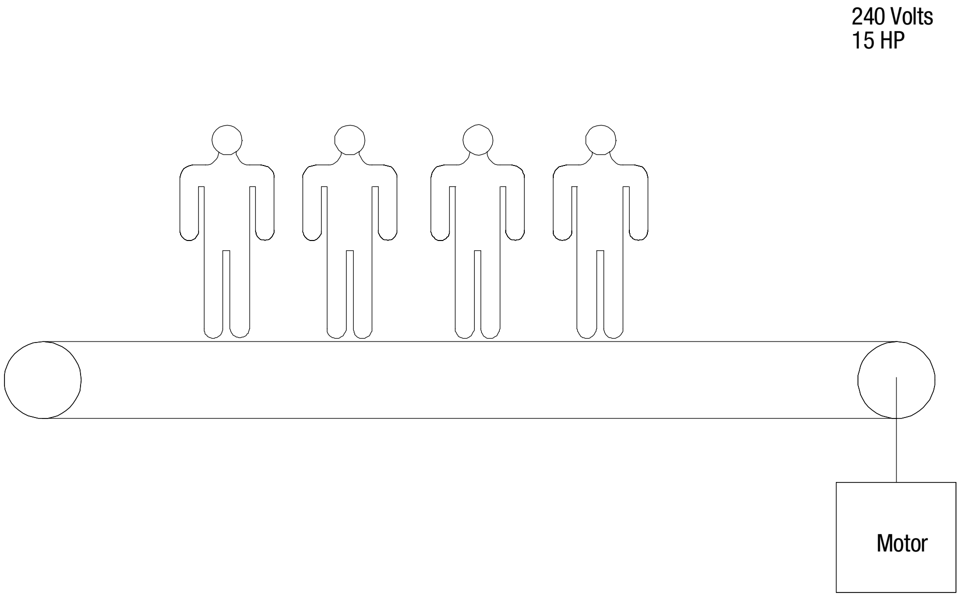
Figure 4.25 Cooling Tower Fan with Dual Ramp Start



Problem: A chain-driven fan that moderates the temperature of water in a chemical process was started across-the-line. The system required frequent inspection and maintenance because of problems with the chain drive. In the winters, ice would form on the blades. Also, the air density varied between winter and summer, which affected the starting time. A controlled start was required.

Solution: The SMC Dialog Plus controller was installed to provid a controlled acceleration, thereby minimizing the mechanical shock encountered during an across-the-line start. Maintenance inspection was also reduced. In th winter, when a longer start was required, the controlle could quickly be switched to the second ramp of the Dual Ramp Start feature.

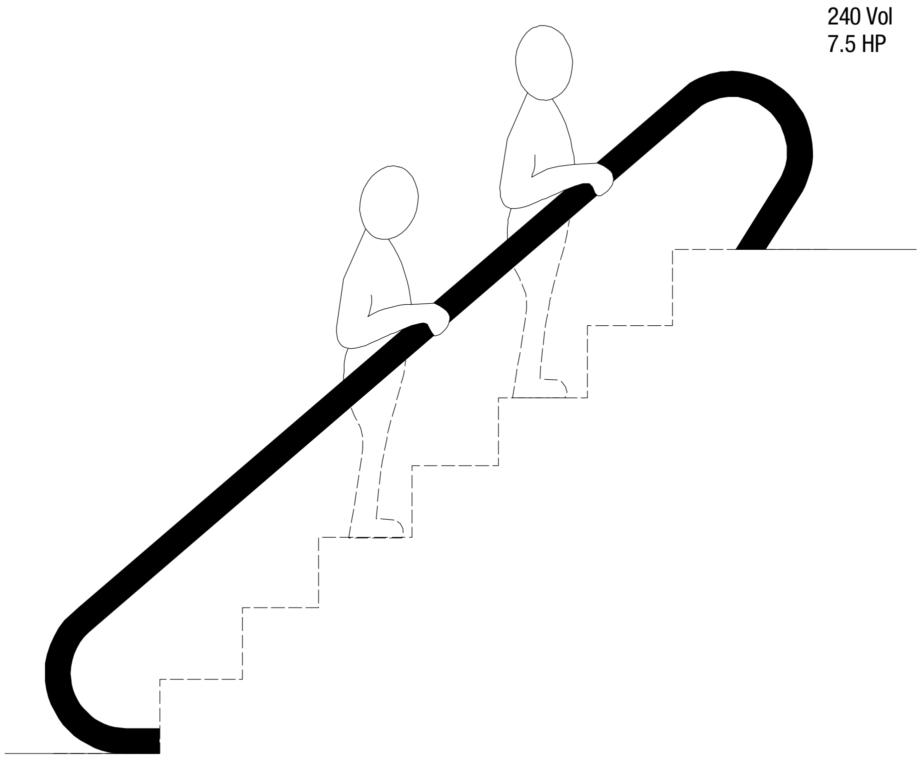
Figure 4.26 Power Walk with Soft Start and Soft Stop Option



Problem: A power walk in an airport required a soft start to prevent damage to the drive chain gearbox on start-up. A soft stop was also required in case the power walk would b shut off while people were on the belt. Several power walks were installed in the airport, and each required its own soft starter. A controller that could be quickly replaced and adjusted was required. Also, panel space was limited.

Solution: The SMC Dialog Plus controller with the Soft Stop option was installed. An 8-second soft start and a 12 second soft stop were programmed into the controller, facilitating a controlled start and stop. During periods when the walk was unloaded, the SMC Dialog Plus controller's built-in Energy Saver feature reduced the voltage to the motor. The built-in overload protection eliminated the need for a separate overload relay, thereby saving panel space. In the event that a control module needed replacement, one could be quickly plugged in. The same control module was used for all applications, minimizing spare parts requirements.

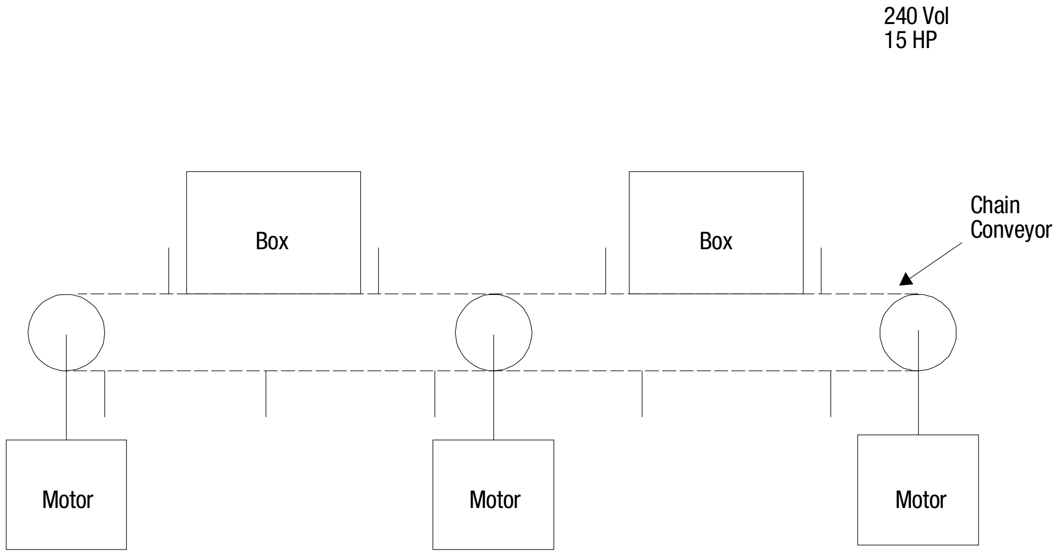
Figure 4.27 Escalator with Preset Slow Speed Option



Problem: An escalator in a shopping mall required a soft start to prevent damage to the drive chain gearbox on start-up. A slow speed capability was also required for inspection and maintenance. Because the stairs were at either end of the mall and the escalator was located in the center of the mall, a controller that could be quickly replaced was required. The control panel, located under the escalator, was by necessity very small.

Solution: The SMC Dialog Plus controller with the Preset Slow Speed option was installed. The controller provided both a soft start, reducing the damage to the drive chain gearbox, and a slow speed, for inspection and maintenance. The built-in overload protection eliminated the need for a separate overload relay, saving valuable panel space.

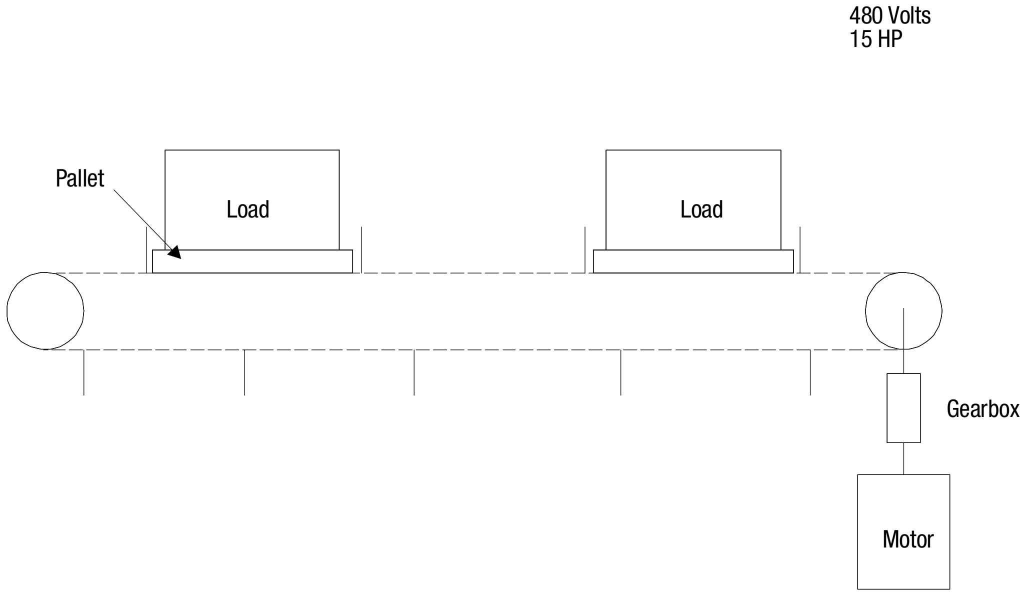
Figure 4.28 Towline Conveyor with Soft Start



Problem: A towline conveyor in a freight house had three motors to drive the conveying system. Across-the-line starts caused damage to the conveyor and spilled freight on the conveyor. Occasionally, the conveyor would stop fully loaded. An across-the-line start would then be needed to provide enough torque to accelerate the load.

Solution: The conveyor OEM installed a single SMC Dialog Plus controller to provide a smooth acceleration to all three motors, reducing the starting torque of the motors and the mechanical shock to the conveyor and load. In addition, the controller could be configured to simulate a full voltage start, allowing the conveyor to accelerate when fully loaded. The OEM liked the SMC Dialog Plus controller because of its ability to control three motors as if they were a single motor, eliminating the need fo multiple soft starters.

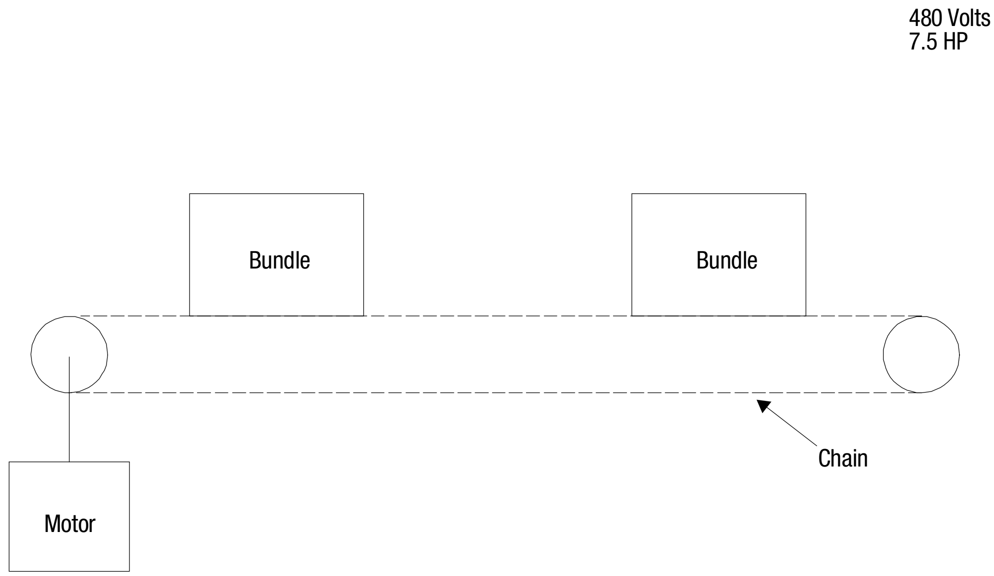
Figure 4.29 Towline Conveyor with Soft Start and Soft Stop Option



Problem: A towline conveyor at the end of a production line had frequent damage to the gearbox caused by the starting torque from across-the-line starting of the motor. There were also frequent spills during starting and stopping. Occasionally, the conveyor needed to be started under heavy load. This towline application had a variety o starting requirements that other soft starters could not satisfy. Investing in a variable speed drive was not cost effective.

Solution: The SMC Dialog Plus controller with the Soft Stop option was installed as a retrofit to the existing across the-line starter. The starting and stopping times wer programmed for 13 seconds. The reduced starting torqu decreased the shock to the gearbox and kept the load from shifting on start-up. The Soft Stop option protected against loads shifting while stopping. The kickstart feature was used to provide a pulse of current to break the load away when higher starting torque was required. The SMC Dialog Plus controller met the starting requirements and was a cost-effective solution.

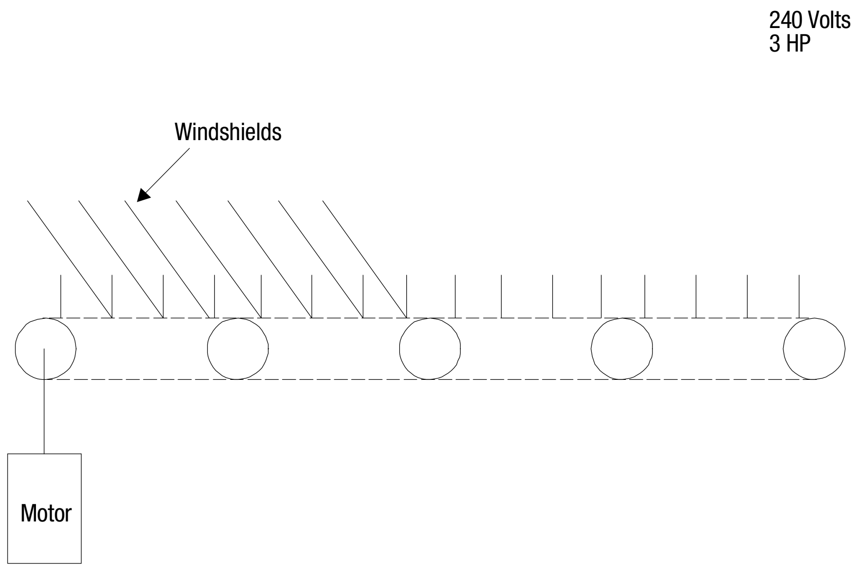
Figure 4.30 Chain Conveyor with Soft Start



Problem: A chain conveyor was used to transport bundles of paper. Because of high starting torque, the chain was breaking once per day. Maintenance of the conveyor caused interruptions in the production schedule and lost productivity. Line surges were also a frequent problem.

Solution: The SMC Dialog Plus controller was installed. A 12-second soft start was programmed, reducing the starting torque and the mechanical shock to the chain. It was estimated that the SMC Dialog Plus controller paid for itself in three months due to the reduced downtime. A line side protective module (MOV) was installed to suppress the voltage transients.

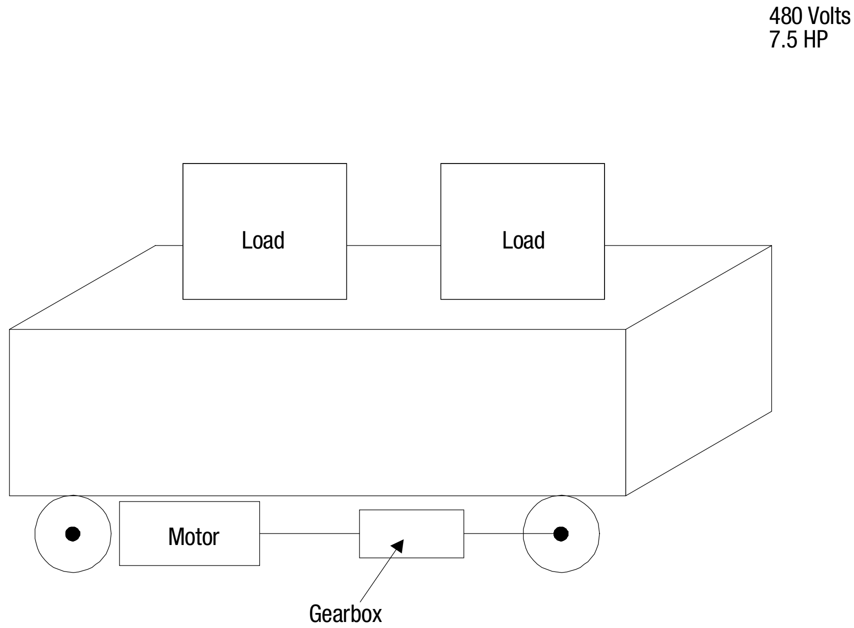
Figure 4.31 Chain Conveyor with Soft Start and Soft Stop Option



Problem: A chain conveyor was used to transport automobile windshields to a packaging area. The high starting torque would cause the load to shift, damaging th windshields. The stopping of the conveyor also caused shifting problems when the load decelerated quickly. An across-the-line starter was used in this application. Because the cost of downtime was high, a modular controller was required for ease of maintenance.

Solution: The SMC Dialog Plus controller with the Soft Stop option was installed, reducing the starting torque and decreasing the product shift on start-up. The Soft Stop option extended the stopping time, bringing the conveyor to a smooth stop. The SMC Dialog Plus controller has a plug-in control module and power poles. Th programming could be bench-adjusted for the desired ramp parameters and quickly replaced.

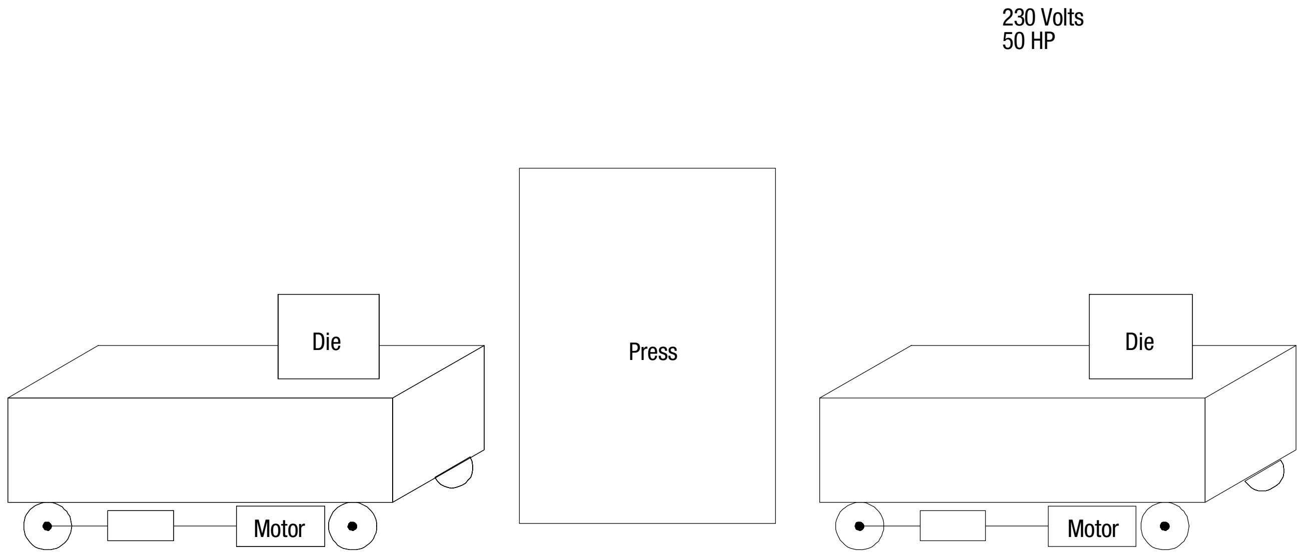
Figure 4.32 Shuttle Car with Soft Start and Accu-Stop Option



Problem: A shuttle car was used to transfer product in a materiel handling application. The shuttle car OEM was using a two-speed motor with a mechanical brake. To prevent load shifts, the low speed was used when the shuttle was started; high speed was used for running. As the car approached the second station, the brake was applied. There was considerable brake wear. Because the brak was built into the motor, it was difficult and costly to replace. Other control devices were not cost effective.

Solution: The SMC Dialog Plus controller with the Accu-Stop option was installed with a single speed motor. The controller was set for a 15% slow speed to start the car, followed by a ramp to full voltage. As the car neared th second station, the speed would be brought down to the 15% slow speed. A braking action would then stop the car completely. The controller required approximately the same panel space as the multi-speed starter. The power wiring was simplified significantly. The new motor was a standard NEMA Design B stocked motor, greatly decreasing the motor cost. The SMC Dialog Plus controller was a cost effective solution for the application requirements.

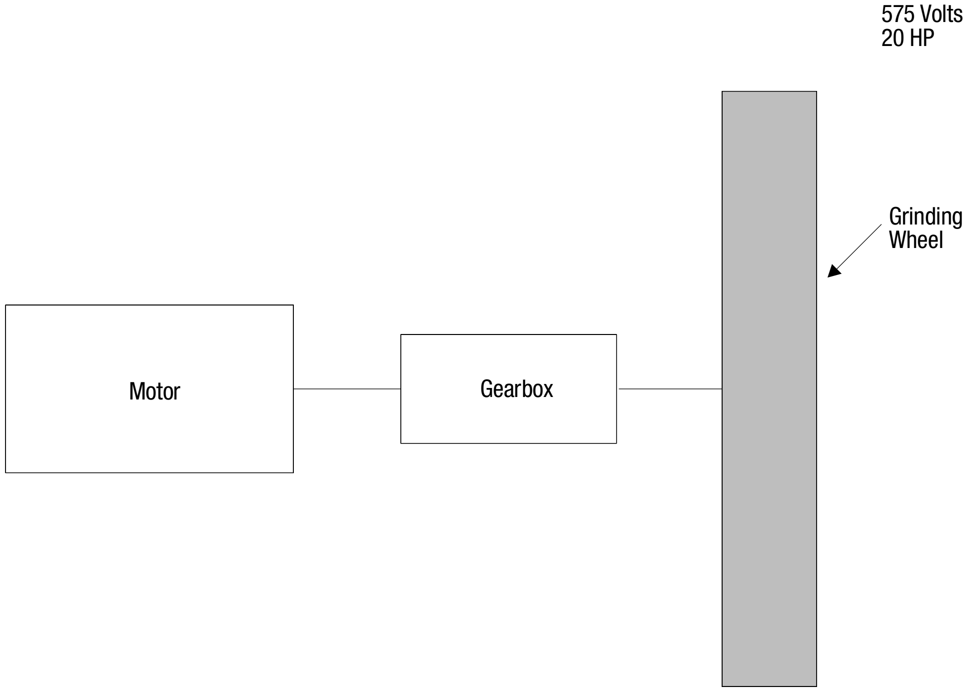
Figure 4.33 Die Changer with Soft Start and Accu-Stop Option



Problem: A die changer on a press required frequent jogging to move the die into position. An across-the-line starter was being used. When new operators controlled the press, the set-up time increased, because more trial and error occurred in positioning. The application required reduced speed as the die neared the press. The company was also looking into automating the die changing process with the use of a PLC. A controller with communications capabilities was a plus.

Solution: The SMC Dialog Plus controller with the Accu-Stop option was installed on both carts. The motor was soft started. As the cart neared the press, it decelerated to th preset slow speed (15%). A braking action would then stop the cart in the proper position. This reduced the time previously required to position the die. The built-in communications capabilities of the SMC Dialog Plus controller made it possible to communicate with many different protocols, leaving several network options available to the company.

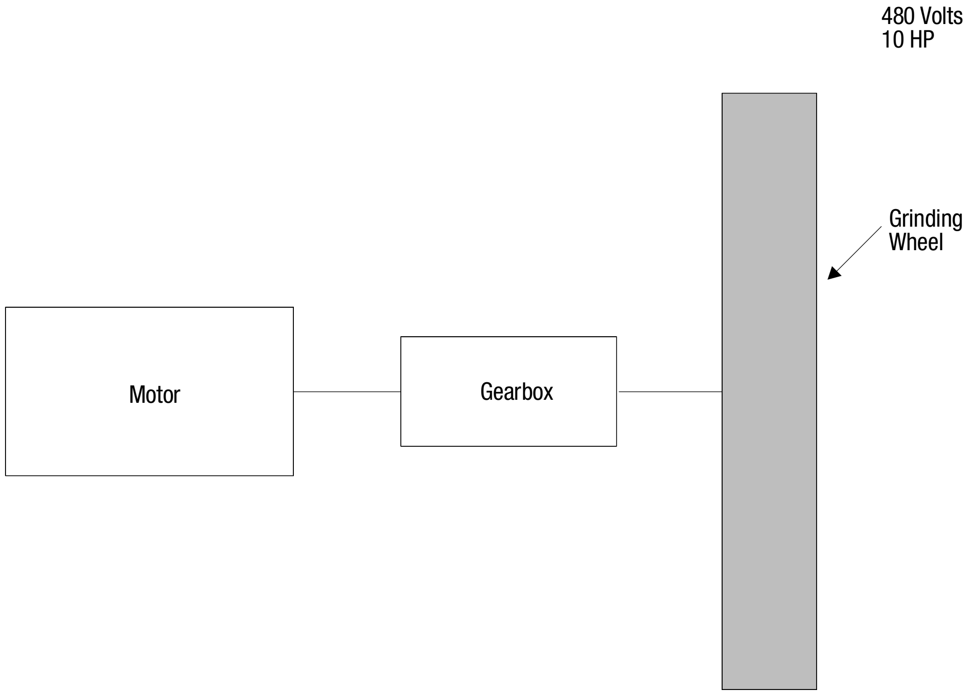
Figure 4.34 Grinder with Soft Start



Problem: Because of the high starting torque developed from starting the motor across-the-line, the gears driving a grinding wheel were frequently damaged, resulting in unscheduled downtime for repair. This application required a rugged device because vibration at the control panel was a problem.

Solution: The SMC Dialog Plus controller was installed and programmed for a 23-second acceleration, reducing the starting torque and the downtime required for repairs. The built-in Energy Saver feature reduced the voltage to the motor when the motor was running lightly loaded. The SMC Dialog Plus controller meets the same shock and vibration requirements as electromechanical devices, and therefore met the applications' durability requirements.

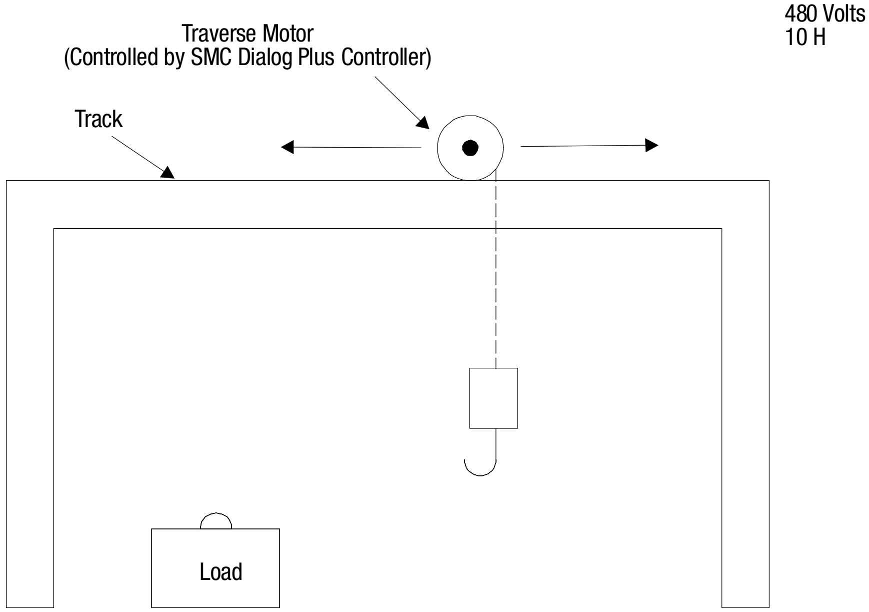
Figure 4.35 Grinder with Soft Start and SMB Smart Motor Braking Option



Problem: A grinder application used a soft start and a separat braking package to start and stop the motor. This method was functionally acceptable, but required extra power wiring and contactors. Additional panel space and adjustments were required to interlock the soft start and brake, which meant a larger control panel and added cost to the package.

Solution: The SMC Dialog Plus controller with the SMB Smart Motor Braking option was installed. The soft start reduced the starting torque, protecting against damage to the gearbox. The SMB Smart Motor Braking option stopped the grinder quickly. This option required no additional panel space or power wiring. The power wiring, installation and programming of the SMC Dialog Plus controller were easier to use than previous methods, and the cost of the control package was significantly reduced.

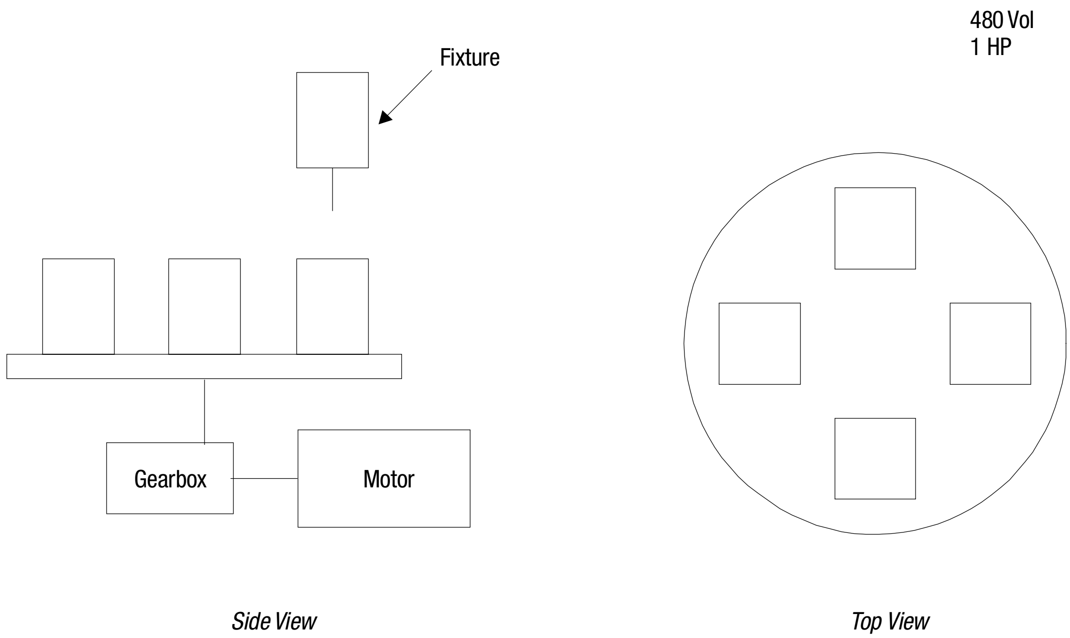
Figure 4.36 Crane with Dual Ramp Start



Problem: An overhead crane required frequent jogging due to adjustments in the traverse (horizontal) position. An across-the-line starter was used, causing overshoot or undershoot when trying to position the hook over a load. When starting loaded, the crane required much more starting torque. Contactors were frequently wearing out, requiring replacement or repair. The application required a device that could be programmed quickly, but whose programming would not be readily accessible to the operators.

Solution: The SMC Dialog Plus controller was installed. Reducing the starting torque of the motor allowed the crane to be positioned effectively, which resulted in fewer starts. The SMC Dialog Plus controller helped reduce th maintenance required and improve the productivity of the crane. The ramp time was programmed through th built-in programming keys on the front of the controller. The built-in Dual Ramp Start feature allowed two ramp times to be programmed, one for standard starting and one for starting with an attached load. Password protection prevented the operators from changing th set up.

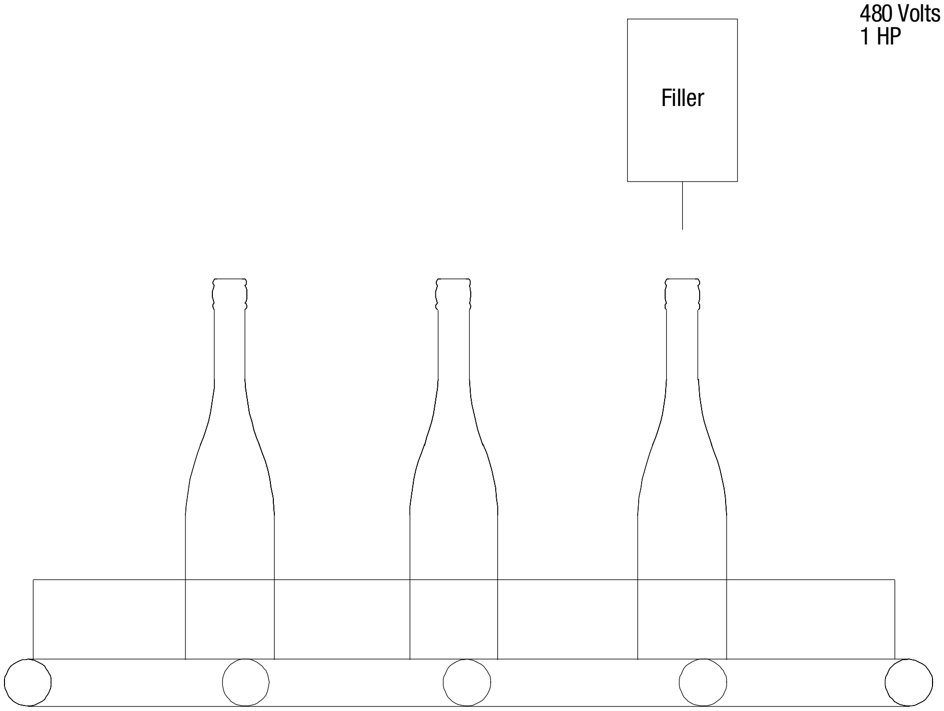
Figure 4.37 Rotary Table with Soft Start and Accu-Stop Option



Problem: A machining process required a station change to attach a different tool. The part had to be jogged into position before the tool could be changed. The tool was replaced approximately three times per hour. Since the majority of the operation was controlled through a PLC, communications capability was required. The customer did not need the functionality of more costly motor-positioning methods.

Solution: The SMC Dialog Plus controller with the Accu-Stop option was installed, allowing the part to be positioned into the station at a slow speed. The controller was set to brake the rotary table to a preset slow speed and then to stop the table in the proper location. The Accu-Stop option provided the position control required without jogging the motor, thereby increasing the productivity of the rotary table station. The built-in communications feature of the SMC Dialog Plus controller provided communication to the PLC controlling the rest of th operation.

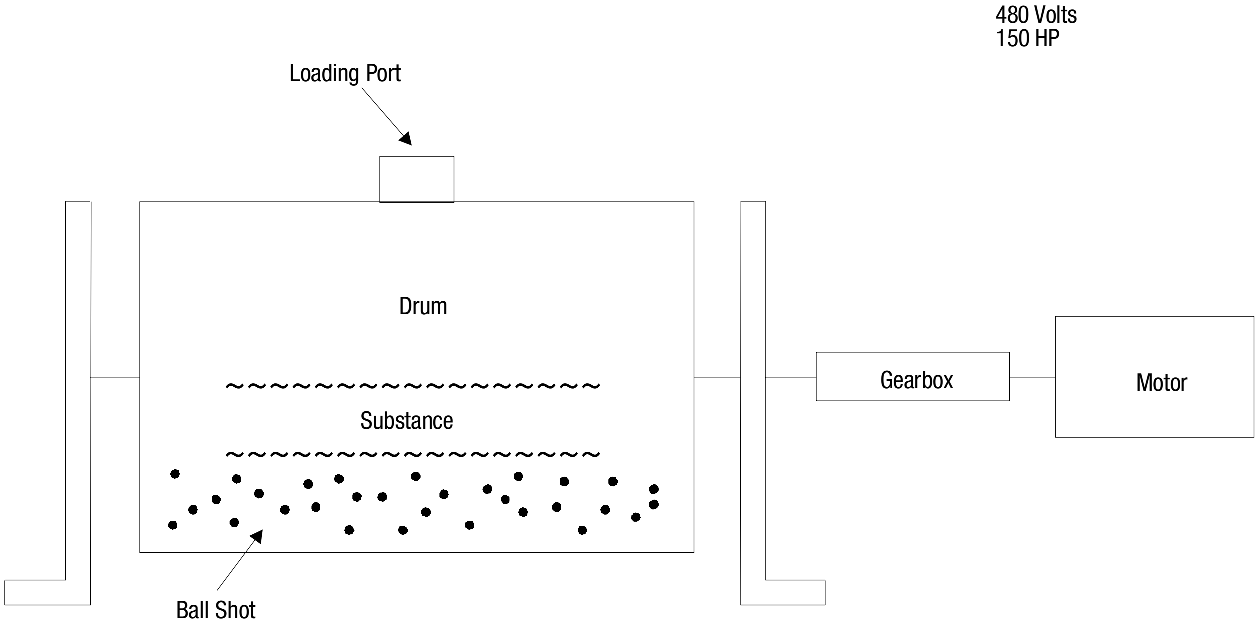
Figure 4.38 Bottle Filler with Soft Start and Soft Stop Option



Problem: A bottle filler line had product spillage during starting and stopping. An across-the-line starter was used to start the motor. In addition, the application required an auxiliary contact that would energize when the motor was up to speed.

Solution: The SMC Dialog Plus controller was installed and programmed for a 13-second soft start with an 18-second soft stop. The controlled start reduced the starting torqu and, consequently, the product spillage. The Soft Stop option extended the stopping time, smoothing load shift while stopping. The auxiliary contacts were configured to change state when the motor was up to speed.

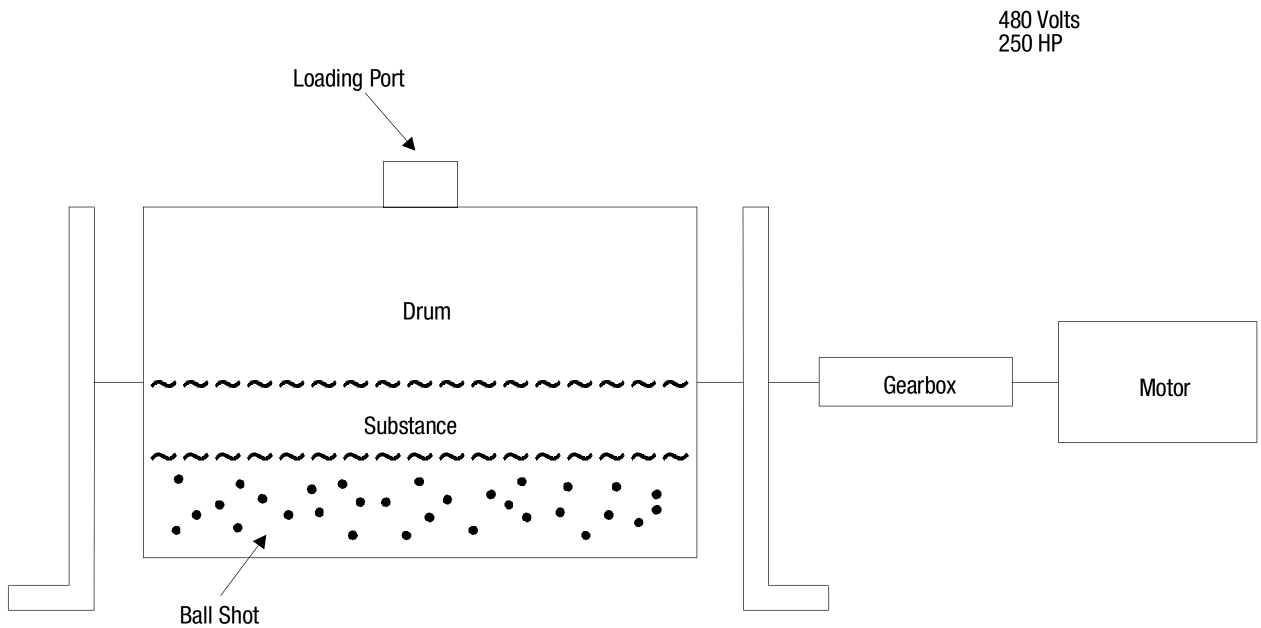
Figure 4.39 Ball Mill with Current Limit Start



Problem: An across-the-line starter was used to start the motor in a ball mill application. The uncontrolled start was causing damage to the gearbox, resulting in maintenance downtime, as well as the potential for the loss of the product (paint) being mixed. Line failures were a frequent problem. The application required prestart and running protection, as well as an elapsed time meter to monitor the process time. Communication capability was desired, and panel space was limited.

Solution: The SMC Dialog Plus controller was installed. It was programmed for a 26-second current limit start, thereby reducing the starting torque and the damage to th gearbox. The metering feature of the SMC Dialog Plus controller contained an elapsed time meter, which could monitor the process time of the ball mill. Th communications capabilities of the controller allowed the process time to be communicated to the PLC, which could remotely stop the ball mill. The line diagnostics required in the application are standard in the SMC Dialog Plus controller, and the built-in overload protection saved panel space.

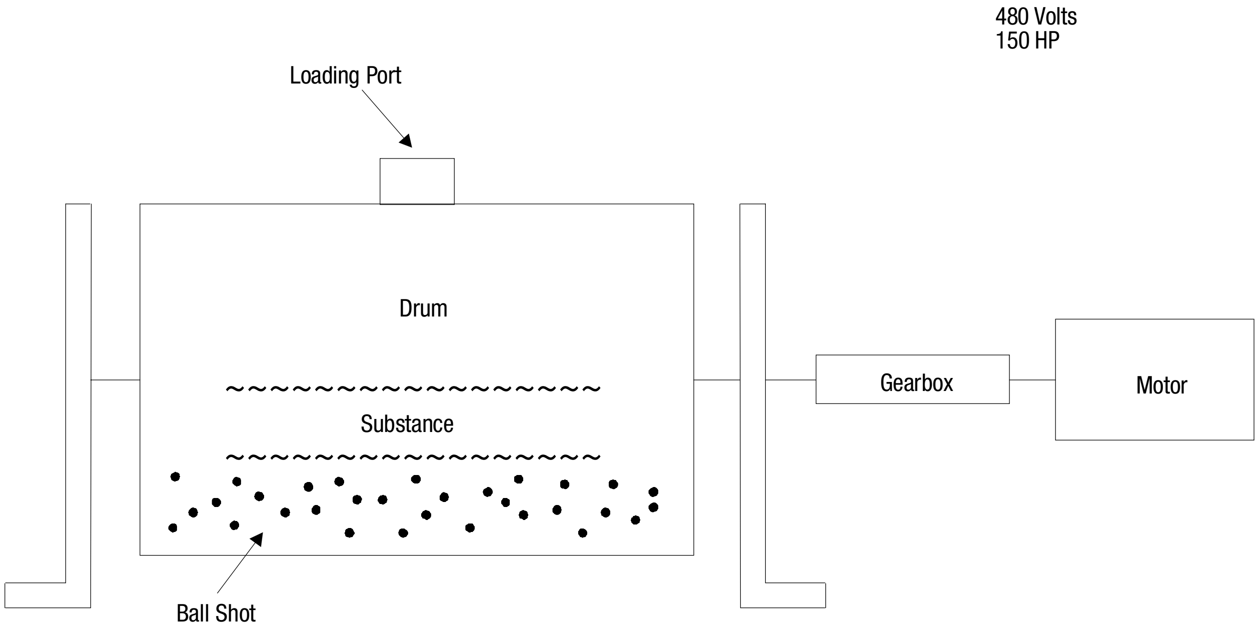
Figure 4.40 Ball Mill with Soft Start and SMB Smart Motor Braking Option



Problem: The gearbox on a ball mill was being damaged by across-the-line starts. The result was extra maintenance time to keep the mill operating. Due to the high inertia of the load, the coast-to-stop time was approximately five minutes. The application required a soft start and braking package in a single controller since panel space was at a premium.

Solution: The SMC Dialog Plus controller with the SMB Smart Motor Braking option was installed on the ball mill. The soft start reduced the shock to the gearbox on start-up. The SMB Smart Motor Braking option reduced the stopping time and increased the productivity of the mill. The SMC Dialog Plus controller with the SMB Smart Motor Braking option was installed in the same space in which the previous contactor had been mounted. No additional power wiring was required.

Figure 4.41 Ball Mill Soft Start and with Accu-Stop Option



Problem: An across-the-line starter was used in a ball mill application. An electronic braking package was used to stop the mill. The mill had to be jogged excessively to position the port for loading. Gearbox problems wer caused by the starting torque surges. The application required a cost-effective method to position the mill and control the stopping.

Solution: The SMC Dialog Plus controller with the Accu-Stop option was installed on the mill. The Accu-Stop option allowed the drum to brake down to 15% slow speed and rotate the loading port into position before stopping. Th SMC Dialog Plus controller required less space and power wiring than the across-the-line starter and braking package.

SMC Dialog Plus Controller Special Application Considerations

SMC Dialog Plus Controllers in Drive Applications

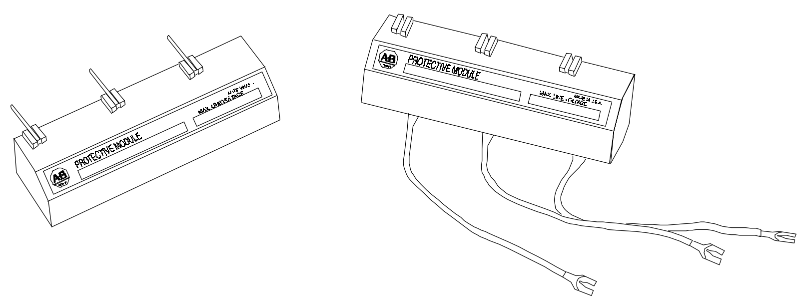
The SMC Dialog Plus controller can be installed in starting and stopping control applications. A variable frequency drive must b installed when speed variation is required during run.

Use of Protective Modules

A protective module (see Figure 5.1) containing metal oxide varistors (MOVs) and capacitors can be installed to protect the powe components from electrical transients and/or electrical noise. The protective modules clip transients generated on the lines and prevent such surges from damaging the SCRs. The capacitors in th protective modules are used to shunt noise energy away from the SMC Dialog Plus controller electronics.

Note: On SMC Dialog Plus controllers rated 500 Amps and above, the MOV protection is incorporated as standard.

Figure 5.1 Protective Modules



Use of Protective Modules (cont.)

There are two general situations that may occur which would indicate the need for utilizing the protective modules.

1. Transient spikes may occur on the lines feeding the SMC Dialog Plus controller (or feeding the load from the SMC Dialog Plus controller). Lightning can cause spikes. Spikes are also created on the line when devices are attached with current-carrying inductances that are open-circuited. The energy stored in the magnetic field is released when the contacts open the circuit. Examples of these are lightly loaded motors, transformers, solenoids, and electromechanical brakes.

2. The second situation arises when the SMC Dialog Plus controller is installed on a system which has fast-rising wavefronts present, although not necessarily high peak voltages. Lightning strikes can cause this type of response. Additionally, if the SMC Dialog Plus controller is on the same bus as other SCR devices, (AC/DC drives, induction heating equipment, or welding equipment) th firing of the SCRs in those devices can cause noise. This high frequency noise can penetrate the SMC Dialog Plus controlle through stray capacitance.

ATTENTION: When installing or inspecting the protective module, disconnect the controller from th power source. The protective module should be checked periodically. Inspect for damage or discoloration. Replace if necessary.

Current Limit Fuses (Overcurrent Protection of SCRs)

The heat energy of high-level fault currents can quickly damage an SCR. As illustrated in Figure 5.2, a current limit fuse limits peak let through current (Ip) to a level which is a fraction of the potential available short circuit peak current.

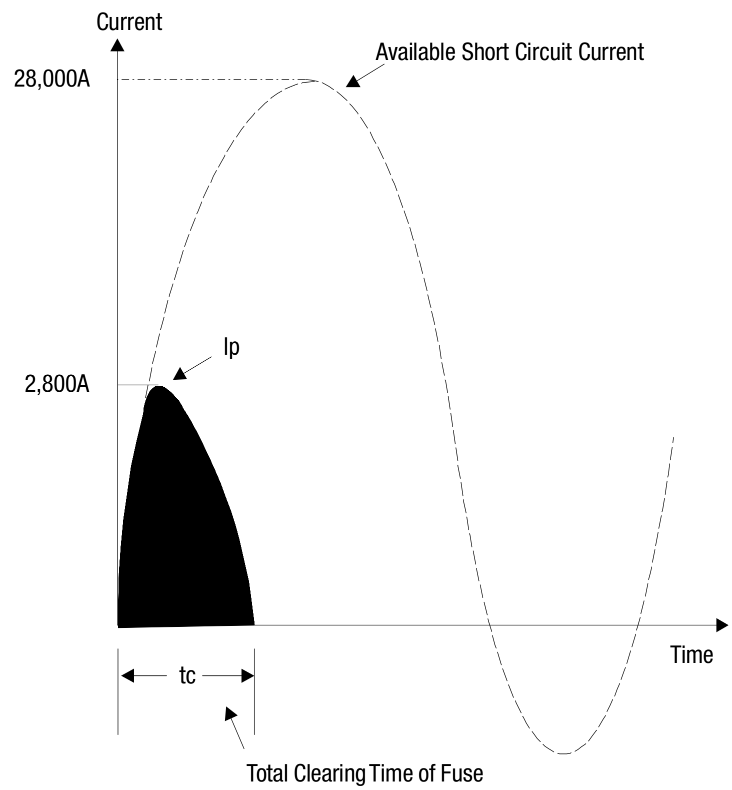
The fast response to the buildup of short circuit current and the quickly decaying short circuit current as the fuse suppresses internal arcing together can limit the I^2t let through values substantially lower than the I^2t withstand of the semiconductor device. The fuse clearing time decreases with the higher available short circuit currents.

The SCR fuses are coordinated with the SCRs used in the SMC Dialog Plus controller. They are sized to clear a short circuit fault in approximately three milliseconds or less.

These SCR fuses are sized to operate the controller at 60-70% of the fuse rating to avoid deterioration of the fuse. The suggested fuse fo the particular current rated device should be used to allow prope protection of the SCRs. Fuses which are undersized will cause nuisance trips and incur fuse replacement costs.

Fast acting SCR fuses may not provide branch circuit protection. Branch circuit protection in accordance with applicable electrical codes may require additional branch fusing (or a circuit breaker) even though fast acting current limiting fuses are used.

Figure 5.2 Clearing Time of Fuse



Motor Overload Protection

When coordinated with the proper short circuit protection, overload protection is intended to protect the motor, motor controller, and power wiring against overheating caused by excessive overcurrent. The SMC Dialog Plus controller meets applicable requirements as motor overload protective device.

The SMC Dialog Plus controller incorporates, as standard, electronic motor overload protection. This overload protection is accomplished electronically with an I^2t algorithm.

The controller's overload protection is programmable, providing th user with flexibility. The overload trip class can be selected for class 10, 15, 20, or 30 protection. The trip current can be programmed to the motor full load current rating.

Thermal memory is included to accurately model motor operating temperature. Ambient insensitivity is inherent in the electronic design of the overload.

Note: The current sensing capability of the SMC Dialog Plus controller is disabled during bypass operation. The Bulletin 825 Converter Module is required for providing current feedback in these applications

Phase Rebalance

As little as 4% supply voltage unbalance can result in a 20% current unbalance and a 25% increase in motor temperature, possibly triggering a premature failure of the motor. The SMC Dialog Plus controller incorporates, as standard, a dynamic phase rebalance feature. The controller continuously monitors the incoming three-phase line voltage balance. It compensates for voltage unbalance by automatically adjusting the output voltage to balance the three-phas currents drawn by the motor. When phase rebalance is achieved, motor life may be extended, and production can continue without interruption.

Note: The performance of the Phase Rebalance feature is dependent upon motor characteristics and loading. Severe unbalances cannot be corrected.

Stall Protection and Jam Detection

Motors can experience locked rotor currents and develop high torque levels in the event of a stall or a jam. These conditions can result in winding insulation breakdown or mechanical damage to the connected load.

The SMC Dialog Plus controller provides both stall and jam detection for enhanced motor and system protection. Stall protection allows the user to program a maximum stall protection delay time from 0 to 10 seconds. The stall protection delay time is in addition to th programmed start time and begins only after the start time has timed out.

Jam detection allows the user to determine the motor jam detection level as a percentage of the motor's full load current rating. To prevent nuisance tripping, a jam detection delay time, from 0.0 to 10.0 seconds, can be programmed. This allows the user to select the time delay required before the SMC Dialog Plus controller will trip on a motor jam condition. The motor current must remain above th jam detection level during the delay time. Jam detection is active only after the motor has reached full speed.

Built-in SCANport Communications

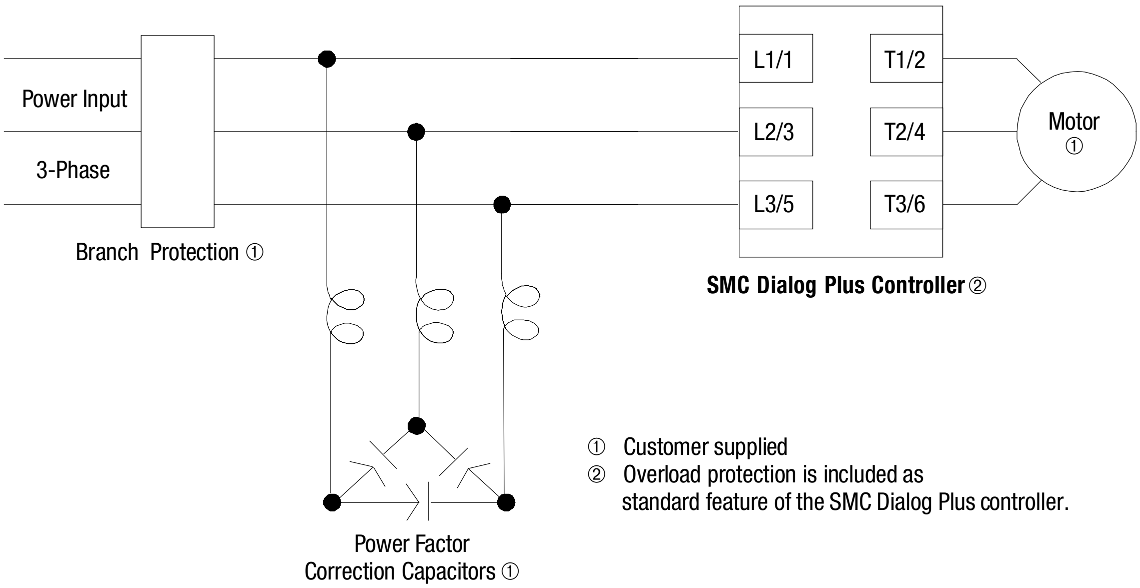
A serial interface port, the SCANport, is furnished as standard on the SMC Dialog Plus controller. The SCANport allows for connection to a Bulletin 1201 Human Interface Module or a variety of Bulletin 1203 communication modules. Utilizing the built-in communication capabilities, the user can remotely access parameter settings, fault diagnostics, and metering. Remote start-stop control can also b performed.

When used with the Bulletin 1203 communication modules, the SMC Dialog Plus controller offers true networking capabilities with several network protocols, including Allen-Bradley's Remote I/O, DeviceNet network, DH-485, and RS 232/422/485-DF1.

Power Factor Capacitors

The controller may be installed on a system with power facto correction capacitors. These capacitors must be installed on the lin side to prevent damage to the SCRs in the SMC Dialog Plus controller (Se Figure 5.3).

Figure 5.3 Power Factor Capacitors



High values of inrush current and oscillating voltages are common when capacitors are switched. Therefore, additional impedance should be connected in series with the capacitor bank to limit th inrush current and dampen oscillations. The preferred practice is to insert air-core inductors as shown in Figure 5.4.

The inductors can be simply constructed:

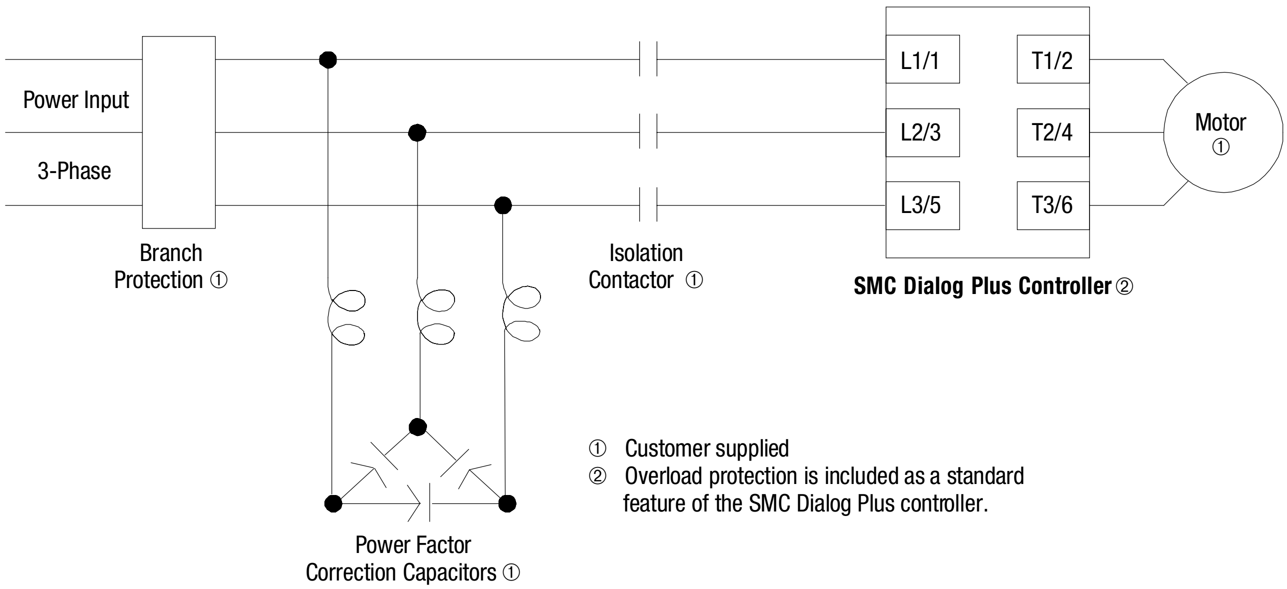
- for volts greater than or equal to 460V: use a six inch diameter coil with eight loops
- for volts less than 460V: use a six inch diameter coil with six loops

The wire should be sized to carry the steady-state current that will flow through the capacitor bank during normal operations.

The coils should be mounted on insulated supports away from metal parts. This will minimize the possibility of producing heating effects. Do not mount the coils to be stacked directly on top of each other. This will increase the chances of canceling the effectiveness of the inductors.

If an isolation contactor is used, it is preferable that the power factor capacitors be installed ahead of the isolation contactor if at all possible (see Figure 5.4). In some installations, this may not be physically possible and the capacitor bank will have to be connected to the downstream terminals of the contactor. In this case, th installer must exercise caution and ensure that the air-core inductance is sufficient to prevent oscillating voltages from interfering with th proper performance of the SMC Dialog Plus controller. It may be necessary to add more loops to the coil.

Figure 5.4 Power Factor Capacitors with Isolation Contactor

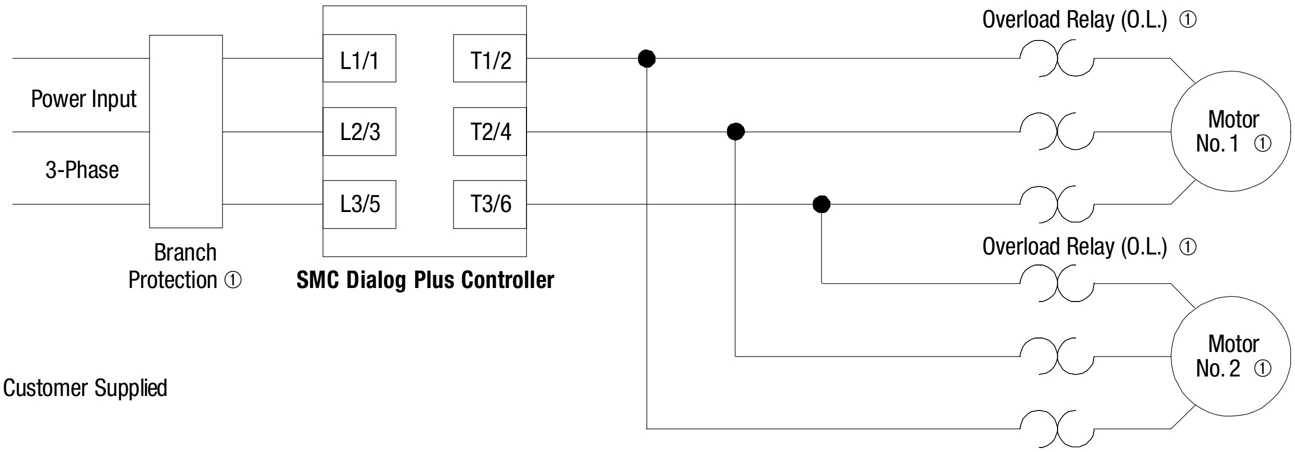


Multi-motor Applications

The SMC Dialog Plus controller will operate with more than one motor connected. To size the controller, add the total nameplat amperes of all of the connected loads. The stall, jam, Phas Rebalance, and Energy Saver features should be turned off. (If th separate motor loads are not mechanically coupled, it is possible fo one motor to be lightly loaded, and if the Energy Saver is activated, this may cause the heavily loaded motor to stall.) Separate overloads would still be required to meet the National Electric Code (NEC).

Note: The SMC Dialog Plus controller's built-in overload protection cannot be used in multi-motor applications.

Figure 5.5 Multi-motor Application



① Customer Supplied

Special Motors

The SMC Dialog Plus controller may be applied or retrofitted to special motors (wye-delta, part winding, synchronous, and wound rotor) as described below.

Wye-Delta

Wye-Delta is a traditional electro-mechanical method of reduced voltage starting. It requires a delta-wound motor with all its leads brought out to facilitate a wye connection. At the start command, approximately 58% of full line voltage is applied, generating about 33% of the motor's full voltage starting torque capability. After an adjustable time interval, the motor is automatically connected in delta.

To apply an SMC Dialog Plus controller to a wye-delta motor, th power wiring from the SMC Dialog Plus controller is simply wired in a delta configuration to the motor. Because the SMC Dialog Plus controller applies a reduced voltage start electronically, the wye connection is no longer necessary. Additionally, the starting torqu can be adjusted with parameter programming.

Part Winding

Part Winding motors incorporate two separate, parallel windings in their design. With the traditional part winding starter, one set of windings is given full line voltage, and the motor draws about 400% of the motor's full load current rating. Additionally, about 45% of locked rotor torque is generated. After a preset interval, the second winding is brought online in parallel with the first and the moto develops normal torque.

The part winding motor may be wired to an SMC Dialog Plus controller by connecting both windings in parallel. Again, the starting torque can be adjusted to match the load with paramete programming.

Wound Rotor

Wound Rotor motors require careful consideration when implementing SMC Dialog Plus controllers. A wound rotor motor depends on external resistors to develop high starting torque. It may be possible to develop enough starting torque using the SMC Dialog Plus controller and a single step of resistors. The resistors are placed in the rotor circuit until the motor reaches approximately 70% of synchronous speed. At this point, the resistors are removed from the secondary by a shorting contactor. Resistor sizing will depend on the characteristics of the motor used.

Please note that it is not recommended to short the rotor slip rings during start-up, as starting torque will be greatly reduced, even with full voltage applied to the motor. The starting torque will be even further reduced with the SMC Dialog Plus controller since the output voltage to the motor is reduced on start-up.

Synchronous

Synchronous, brush-type motors differ from standard squirrel cag motors in the construction of the rotor. The rotor of a synchronous motor is comprised of two separate windings, a starting winding and a DC magnetic field winding.

The starting winding is used to accelerate the motor to about 95% of synchronous speed. Once there, the DC magnetic field winding is energized to pull the motor up to synchronous speed.

The SMC Dialog Plus controller can be retrofitted to a synchronous controller by replacing the stator contactor with the SMC Dialog Plus controller and maintaining the DC field application package.

For technical support in applying the Bulletin 150 SMC Dialog Plus controller to these special motors, contact your local Allen-Bradley representative. In the United States and Canada, you can also call 1-800-765-SMCS (765-7627) for assistance during the hours of 8:00 am to 12:00 noon and 1:00 pm to 4:30 pm (Central Time Zone), Monday through Friday.

Altitude De-rating

Because of the decreased efficiency of fans and heatsinks, it is necessary to de-rate the SMC Dialog Plus controller above 6,500 feet (approximately 2,000 meters). When using the controller above 6,500 feet, use the next size device to guard against potential over temperature trips.

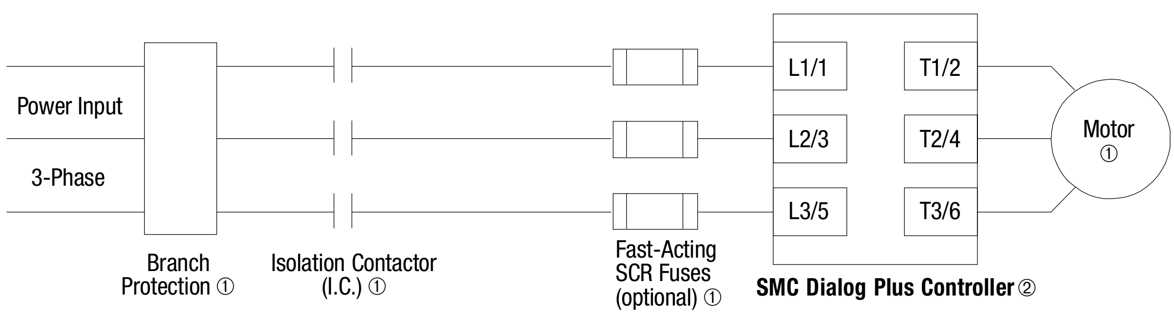
Isolation Contactor

When installed with branch circuit protection and an overcurrent device, SMC Dialog Plus controllers are compatible with the National Electric Code (NEC). When an isolation contactor is not used, hazardous voltages are present at the load terminals of the power module even when the controller is turned off. Warning labels must be attached to the motor terminal box, the controller enclosure, and the control station to indicate this hazard.

The isolation contactor is used to provide automatic electrical isolation of the controller and motor circuit when the controller is shut down. Shut down can occur in either of two ways: either manually, by pressing the stop button, or automatically, by the presence of abnormal conditions (such as a motor overload relay trip).

Under normal conditions the isolation contactor carries only the load current. During start, the isolation contactor is energized before th SCRs are gated "on." While stopping, the SCRs are gated "off" before the isolation contactor is de-energized. The isolation contactor is not making or breaking the load current.

Figure 5.6 Typical Connection Diagram with Isolation Contactor

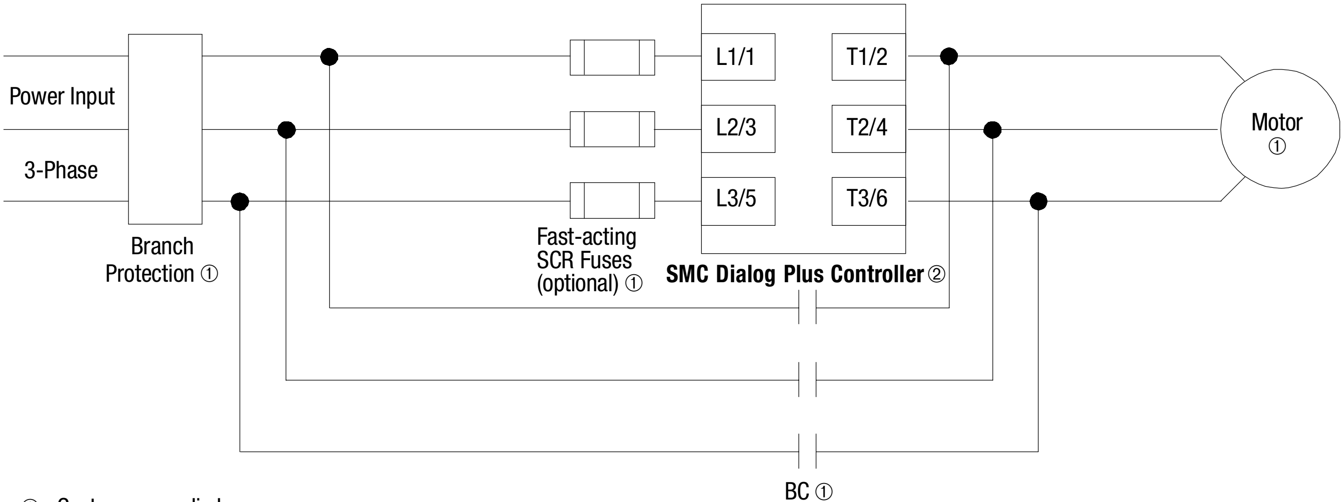


① Customer supplied
② Overload protection is included as a standard feature of the SMC Dialog Plus controller.

SMC Dialog Plus Controller with Bypass Contactor (BC)

Controlled start and stop are provided by wiring the controller as shown in Figure 5.7. When the motor is up to speed, the bypass contactor is "pulled in" for run. The bypass mode reduces the amount of heat produced by the SCRs.

Figure 5.7 Typical Application Diagram of a Bypass Contactor



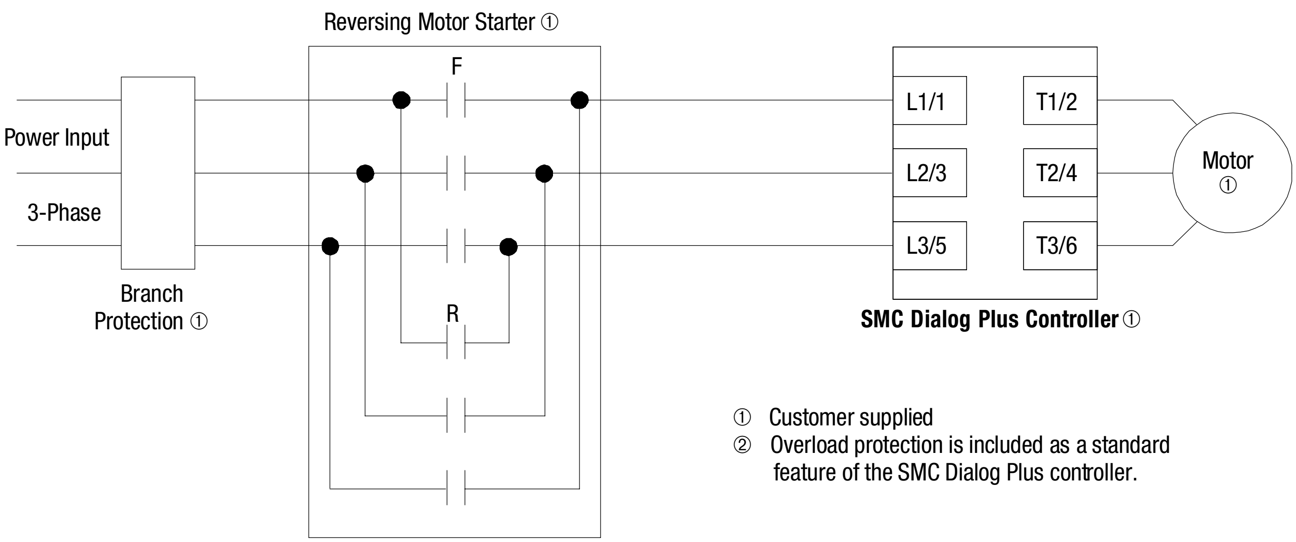
① Customer supplied
② Overload protection is included as a standard feature of the SMC Dialog Plus controller.

SMC Dialog Plus Controller with Reversing Contactor

By using the controller as shown in Figure 5.8, the motor accelerates under a controlled start mode in either forward or reverse.

Notes: (1) Minimum transition time for reversing is 1/2 second.
(2) Phase Reversal must be OFF.

Figure 5.8 Typical Application with a Single-speed Reversing Starter



① Customer supplied
② Overload protection is included as a standard feature of the SMC Dialog Plus controller.

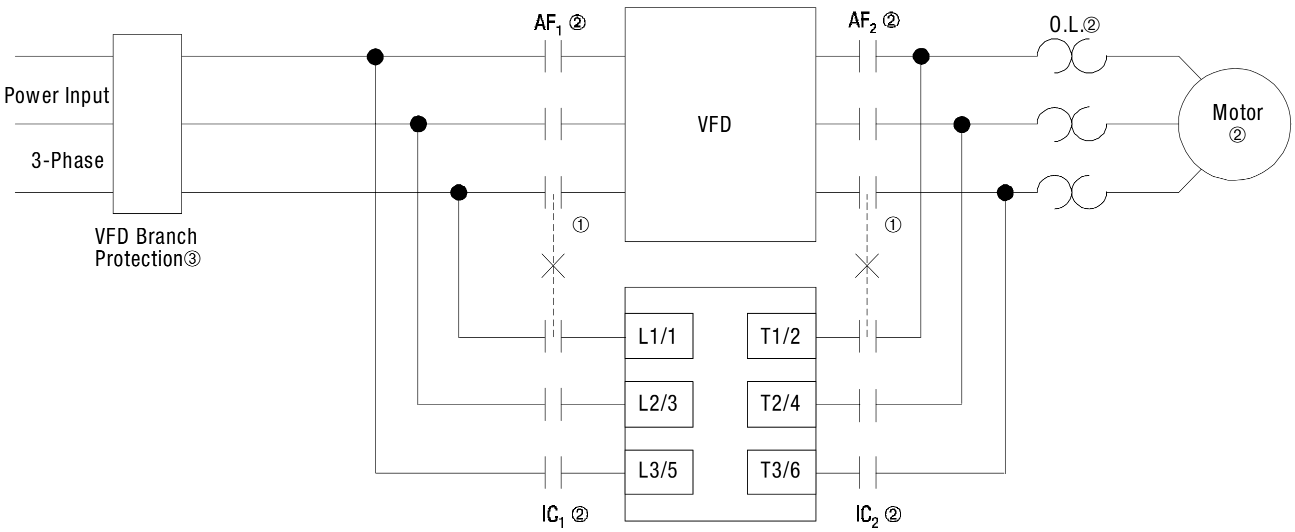
SMC Dialog Plus Controller as a Bypass to an AC Drive

By using the controller as shown in Figure 5.9, a soft star characteristic can be provided in the event that an AC drive is non-operational.

Note: A controlled acceleration can be achieved with this scheme, but speed control is not available in the bypass mode.

ATTENTION: Proper care must be taken to isolate th AC drive from line and load potential when the controller is energized.

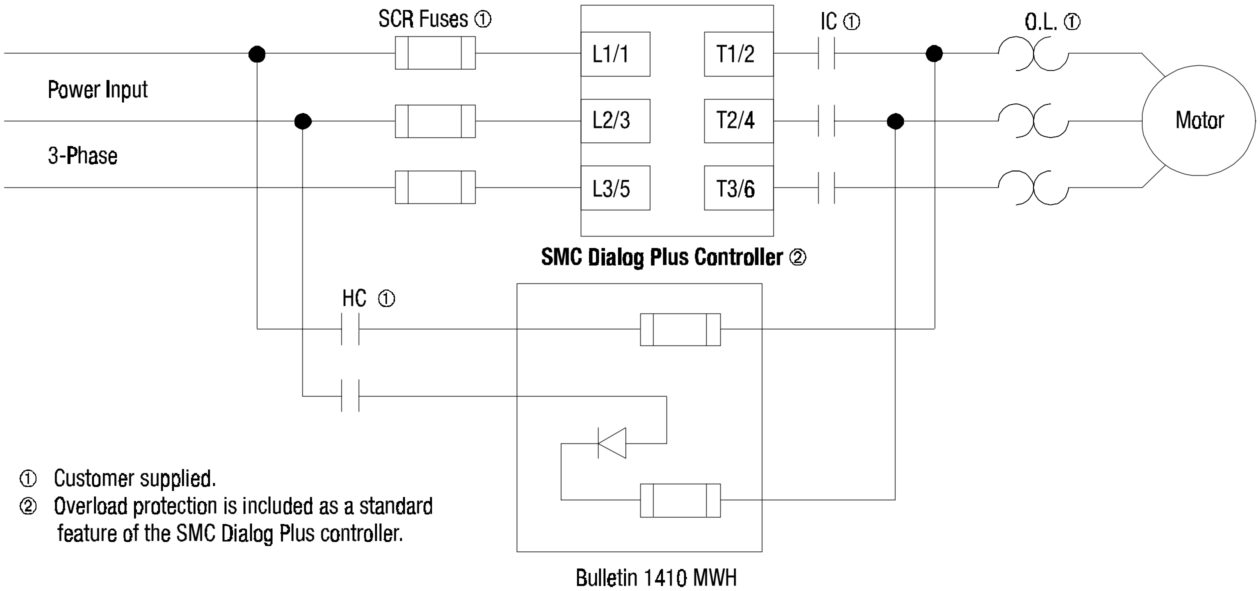
Figure 5.9 Typical Application Diagram of a Bypass Contactor for an AC Drive



① Mechanical interlock required.
② Customer supplied.
③ Many VF drives are rated 150% FLA. Because the SMC Dialog Plus controller can be used for 600% FLA starting, separate branch circuit protection may be required.
④ Overload protection is included as a standard feature of the SMC Dialog Plus controller.

SMC Dialog Plus Controller with a Bulletin 1410 Motor Winding Heater

Figure 5.10 Typical Application Diagram of SMC Dialog Plus Controller with a Bulletin 1410 Motor Winding Heater



① Customer supplied.
② Overload protection is included as a standard feature of the SMC Dialog Plus controller.

Motor Torque Capabilities with SMC Dialog Plus Controller Options

SMB™ Smart Motor Braking

The stopping torque output of the SMC Dialog Plus controller will vary depending on the braking current setting and motor characteristics. Typically the maximum stopping torque will b between 80–100% of the full load torque of the motor when set at 400% braking current.

Preset Slow Speed

Two torque characteristics of the Preset Slow Speed option must be considered. The first is the starting torque. The second is th available running torque at low speed (see Figure 5.11). These torqu characteristics will also vary, depending on the speed selected. Refe to Table 5.J for the approximate maximum available starting and running full load torque at maximum current settings. On adjustment (Slow Speed Current) will control the starting and running torque values.

Figure 5.11 Starting and Running Torque

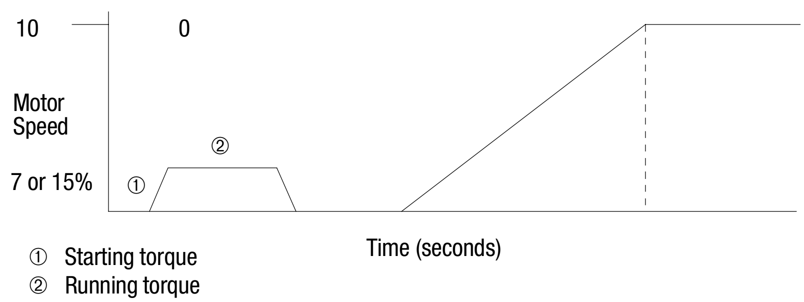


Table 5.J Maximum Torque at Maximum Current Settings

Preset Slow Speed	Maximum Starting Torque as a Percentage of Full Load Torque	Maximum Running Torque as a Percentage of Full Load Torque
7%	90–100%	110–120%
15%	50%	100%

③ Values may vary based on motor types.

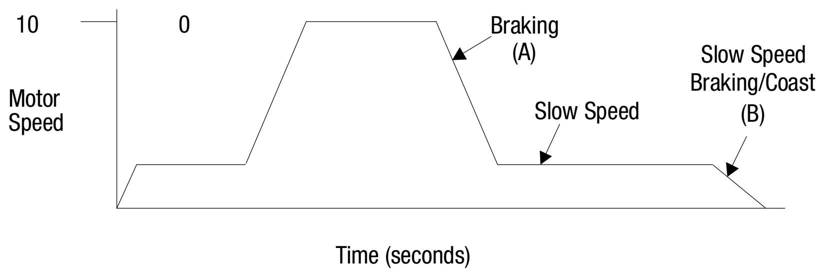
Accu-Stop™

Two levels of braking torque are applied with the Accu-Stop option. There is the braking portion that brakes to slow speed, and the slow speed braking/coast (see Figure 5.12). The level of these braking currents are adjusted using one rotary digital switch.

The maximum braking torque available from braking to slow speed and from slow speed to stop is approximately 80–100% of full load torque of the motor

Using the slow speed starting portion of the Accu-Stop option will result in the same starting and running torque characteristics as described in the Preset Slow Speed option.

Figure 5.12 Accu-Stop Option



Energy Saver

The Energy Saver is an integral feature of the SMC Dialog Plus controller. It can be used in applications such as conveyors, material handling equipment, variable volume air handling units, pumps, compressors, and various other applications where the motor is lightly loaded or unloaded for extended periods of time.

Energy Saver Operation

Since the SMC Dialog Plus controller output voltage is under SCR control at all times, the Energy Saver can automatically decreas motor power losses by controlling the motor terminal voltage.

The Energy Saving mode is operational when turned on and the motor is operating at less than full load. As the motor is unloaded, the motor terminal voltage is reduced. The motor then operates at the optimum level required to drive a given load without severely affecting speed.

When the load is reapplied, the motor voltage increases. The controller provides only enough voltage to keep the motor running. Typical response time from no load to full load is 50 milliseconds. Full to no load response time to optimum level is typically less than five seconds.

Energy Saver (cont.)

Background

Losses within a motor are divided into a number of different components. There are friction and winding losses, ^2R losses, core losses, and magnetic losses. The friction and winding losses remain constant at both full load and no load. However, at no load, I^2R losses, core losses and magnetic losses can be reduced by deceasing the applied voltage.

For example, a 30 kW (40 HP) motor draws 30 kW from the line to produce work. An additional amount of energy is drawn from the line because of the internal losses to the motor. If the motor is 90 efficient, an additional 3 kW, or a total of approximately 33 kW, is drawn from the power line when the motor is operating at full load.

If an energy saver could be designed to eliminate all the losses in th motor, the maximum amount of energy this theoretical device could save would be the 3kW in losses. The motor would still draw the 30 kW from the line, which it would convert to power from its output shaft.

The motor industry indicates that one-half of the losses could, theoretically, be saved. The other one-half could not be saved because of such variables as friction, windage, etc. Using this approximation with the 30 kW (40 HP) motor, one-half of the 3 kW losses could be saved, The maximum theoretical savings would b equal to 1.5 kW. Actual applications would probably have less than the theoretical 1.5 kW.

Application Requirements

Savings in energy costs are possible in certain applications. Figure 5.13 shows test results of actual motors. Figure 5.13 was developed using 10, 50, and 125 HP motors.

Based on these test results and other data, there is very little savings possible above 50% load. A curve of maximum theoretical savings can be drawn using the theoretical savings of 50% of the losses and the data which indicates little or no savings above 50% load. This is illustrated by the upper curve in.

In reviewing the test data for lower limits, it could be estimated that 20% losses are saved at no load, and no losses are saved at 20% load. This is illustrated by the lower curve in Figure 5.14.

Figure 5.13 % kW Saved vs. % Rated Load

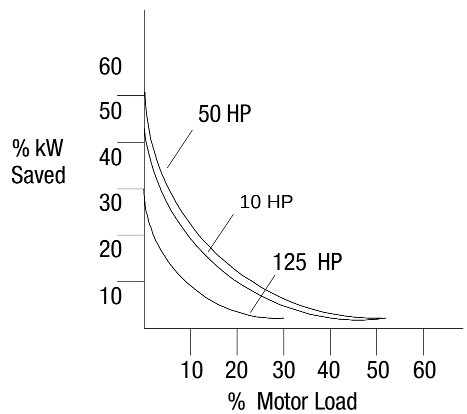
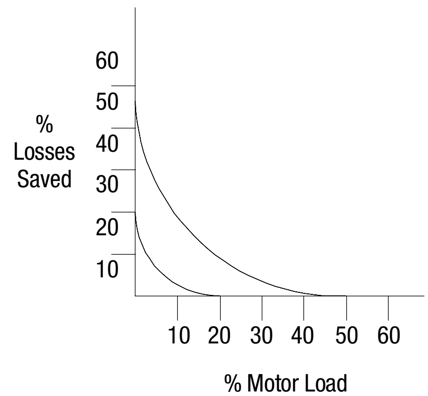


Figure 5.14 Estimated Energy Savings



Preliminary Estimates

A simple “full load-no load” preliminary estimate for the application of an energy saver can be made by using the following procedure:

1. Convert horsepower to kilowatts.
2. Determine the total kilowatts used by the motor by dividing the horsepower kilowatts by motor efficiency.
3. Determine the motor losses by subtracting converted horsepower kilowatts from total kilowatts.
4. Calculate the maximum theoretical savings in kilowatts by multiplying motor losses by 0.50.
5. Determine kilowatt-hours saved by multiplying the maximum theoretical savings in kW times the number of hours per year the motor is operated at no load.
6. Maximum theoretical savings dollars can then be determined by multiplying kilowatt-hours saved times the cost of electricity per kilowatt hours.

Energy Saver (cont.)

Figure 5.14 Sample Calculation

Motor efficiency: 90%
Motor loading duty cycle: 50% (On 15 min., Off 15 min.).
Motor horsepower and run time: 50 HP, 8 hours perday, 2,080 hours per year
Use the above data and the following procedure for theoretical maximum energy savings

1. kW = 0.746(50)
   kW = 37.3
2. kW_{total} = (37.3) ³ 0.90
   kW_{total} = 41.4 kW
3. Losses = 41.4 - 37.3
   Losses = 4.1 kW
4. Maximum theoretical savings - (4.1 kW) ¥ (0.50)
   Maximum theoretical savings = 2.05 kW
5. (2.05) ¥ (0.5) ¥ (2,080) = 2,132 kWh per year

Finally at a typical cost of $0.08 per kWh, the estimated savings is:

6. (0.08) ¥ (2,132), for $170.56 per yea

Note: Calculations assume that the normal load is equal to the full load rating of the motor, and that the loading level is a no-load condition

If this calculation looks favorable, then additional detailed calculations must be made to get a more exact figure on the dollars saved. Precise duty cycle and loading cycles must be more accurately estimated. Points can then be selected from the theoretical maximum savings curve. Savings for each increment of loading must then be calculated.

Note that a motor running unloaded and not connected to equipment is not the same as when the motor is connected to the equipment. Motor manufacturers should be contacted to determine the actual no load characteristics.

These calculations have been done on the basis that a solid-stat controller was required for reasons other than energy savings. I energy savings is the main reason for purchasing this type of device, the savings would decrease, because there is approximately a 1 to 1-1/2 volt drop across each solid-state power pole. There ar additional losses associated with solid-state devices.

For example, a solid-state controller for a three-phase motor drawing 50 amperes will have a loss ranging from 150 to 225 watts above an equivalent electromechanical device. Therefore, if the energy saver were replacing an electromechanical device, these losses are deducted from the total energy savings.

SMC Product Line Applications Matrix

Description

Use this chapter to identify possible STC, SMC-2, SMC PLUS, and SMC Dialog Plus controller applications. This chapter contains an application matrix which will identify starting characteristics, as well as typical stopping features that may be used in various applications.

Mining and Metals

Applications	STC	SMC-2		SMC PLUS and SMC Dialog Plus = X								
		Soft Start	Current Limit	Soft Start	Current Limit	Kick Start	Soft Stop	Pump Control	Accu-Stop	Smart Motor Brake	Preset Slow Speed	Slow Speed with Brake
Roller Mills		X	X	X	X					X		X
Hammermills		X	X	X	X					X		X
Roller Conveyors	X	X		X			X					
Centrifugal Pumps	X	X	X	X	X			X				
Fans		X	X	X	X	X						
Tumbler		X	X	X	X				X	X	X	X
Rock Crusher		X	X	X	X							
Dust Collecto		X	X	X	X							
Chillers		X	X	X	X							
Compressor		X	X	X	X							
Wire Draw Machine		X	X	X	X	X						
Belt Conveyors	X	X	X	X	X	X	X		X		X	
Shredder		X	X	X	X							
Grinder		X	X	X	X					X		X
Slicer		X	X	X	X	X						

Food Processing

Applications	STC	SMC-2		SMC PLUS and SMC Dialog Plus = X								
		Soft Start	Current Limit	Soft Start	Current Limit	Kick Start	Soft Stop	Pump Control	Accu-Stop	Smart Motor Brake	Preset Slow Speed	Slow Speed with Brake
Centrifugal Pumps	X	X	X	X	X			X				
Pallitizers	X	X		X			X					
Mixers	X	X	X	X	X	X					X	
Agitators		X		X								
Centrifuges			X		X					X		X
Conveyors	X	X		X		X	X		X			
Fans	X	X	X	X	X							
Bottle Washers	X	X		X			X					
Compressors		X	X	X	X							
Hammermill		X	X	X	X							
Separators		X	X	X	X							
Dryers	X	X	X	X	X							
Slicers		X	X	X	X	X						

Pulp and Paper

Applications	STC	SMC-2		SMC PLUS and SMC Dialog Plus = X								
		Soft Start	Current Limit	Soft Start	Current Limit	Kick Start	Soft Stop	Pump Control	Accu-Stop	Smart Motor Brake	Preset Slow Speed	Slow Speed with Brake
Compressors		X	X	X	X							
Conveyors	X	X	X	X	X	X	X		X		X	
Trolleys	X	X		X			X		X		X	
Dryers	X	X	X	X	X							
Agitators		X	X	X	X							
Centrifugal Pumps	X	X	X	X	X			X				
Mixers	X	X	X	X	X							
Fans	X	X	X	X	X							
Re-Pulper		X	X	X	X	X						
Shredder		X	X	X	X							

Petrochemical

Applications	STC	SMC-2		SMC PLUS and SMC Dialog Plus = X								
		Soft Start	Current Limit	Soft Start	Current Limit	Kick Start	Soft Stop	Pump Control	Accu-Stop	Smart Motor Brake	Preset Slow Speed	Slow Speed with Brake
Centrifugal Pumps	X	X	X	X	X			X				
Extruders		X	X	X	X							
Screw Conveyors	X	X	X	X	X	X						
Mixers		X	X	X	X						X	
Agitators		X	X	X	X							
Compressors		X	X	X	X							
Fans	X	X	X	X	X							
Ball Mills		X	X	X	X				X	X		X
Centrifuge		X	X	X	X					X		X

Transportation and Machine Tool

Applications	STC	SMC-2		SMC PLUS and SMC Dialog Plus = X								
		Soft Start	Current Limit	Soft Start	Current Limit	Kick Start	Soft Stop	Pump Control	Accu-Stop	Smart Motor Brake	Preset Slow Speed	Slow Speed with Brake
Material Handling Conveyors	X	X	X	X	X	X	X		X		X	
Ball Mills		X	X	X	X				X	X	X	X
Grinders		X	X	X	X					X		X
Centrifugal Pumps	X	X	X	X	X			X				
Trolleys	X	X		X			X		X		X	
Presses		X	X	X	X					X		X
Fans	X	X	X	X	X							
Palletizers	X	X	X	X	X		X		X		X	
Compressors		X	X	X	X							
Roller Mill	X	X	X	X	X					X		X
Die Charger		X		X					X			
Rotary Table		X		X					X		X	

OEM Specialty Machine

Applications	STC	SMC-2		SMC PLUS and SMC Dialog Plus = X								
		Soft Start	Current Limit	Soft Start	Current Limit	Kick Start	Soft Stop	Pump Control	Accu-Stop	Smart Motor Brake	Preset Slow Speed	Slow Speed with Brake
Centrifugal Pumps	X	X	X	X	X			X				
Washers	X	X	X	X	X				X	X	X	X
Conveyors	X	X	X	X	X	X	X		X	X	X	X
Power Walks	X	X	X	X	X		X					
Fans	X	X	X	X	X							
Twisting/ Spinning Machine	X	X	X	X	X							

Lumber and Wood Products

Applications	STC	SMC-2		SMC PLUS and SMC Dialog Plus = X								
		Soft Start	Current Limit	Soft Start	Current Limit	Kick Start	Soft Stop	Pump Control	Accu-Stop	Smart Motor Brake	Preset Slow Speed	Slow Speed with Brake
Chipper		X	X	X	X					X		X
Circular Saw		X	X	X	X					X		X
Bandsaw		X	X	X	X					X	X	X
Edger		X	X	X	X							
Conveyors	X	X	X	X	X	X	X		X		X	
Centrifugal Pumps	X	X	X	X	X			X				
Compressors		X	X	X	X							
Fans	X	X	X	X	X							
Planers		X	X	X	X							
Sander		X	X	X	X				X	X	X	X
Debarker		X	X	X	X					X		X

Water/Wastewater Treatment and Municipalities

Applications	STC	SMC-2		SMC PLUS and SMC Dialog Plus = X								
		Soft Start	Current Limit	Soft Start	Current Limit	Kick Start	Soft Stop	Pump Control	Accu-Stop	Smart Motor Brake	Preset Slow Speed	Slow Speed with Brake
Centrifugal Pumps	X	X	X	X	X			X				
Centrifuge		X	X	X	X					X		X
Fans	X	X	X	X	X							
Compressors		X	X	X	X							

Design Philosophy

Philosophy

Allen-Bradley's SMC controllers are designed to operate in today' industrial environments. These controllers are manufactured to provide consistent and reliable operation.

Line Voltage Conditions

Voltage transients, disturbances, harmonics and noise exist in any industrial supply. A solid-state controller must be able to withstand these noises and should not be an unnecessary source of generating noise back into the line.

- Ease of selection for the required line voltage is achieved with a design that provides operation over a wide voltage range, at 50/60 Hz, within a given controller rating.
- The controller can withstand 3000V surges at a rate of 100 bursts per second for 10 seconds (IEEE Std. 472). Further, the controller can withstand the showering arc test of 350–1500V (NEMA Std. ICS2-230) for higher resistance to malfunction in a noisy environment.
- An optional MOV module is available to protect SCRs from voltage transients.

Current and Thermal Ratings

Solid-state controller ratings must ensure reliability under the wid range of current levels and starting times needed in various applications.

- SCR packaging keeps junction temperatures below 12 °C (25 °F) when running at full-rated current to reduce thermal stress and provide longer, more reliable operation.
- The thermal capacity of the SMC Dialog Plus controllers meet NEMA standards MG-1 and IEC34 (S1).

Mechanical Shock and Vibration

Solid-state controllers must withstand the shock and vibration generated by the machinery that they control.

- SMC Dialog Plus controllers meet the same shock and vibration specifications as electromechanical starters. They can withstand a 30G shock for 11 ms in any plane and one hour of vibration of 2.5G without malfunction.

Set-up

Simple, easily understood settings provide identifiable, consistent results.

- For ease of installation, the controllers include compact design and feed-through wiring.
- SMC Dialog Plus controllers are global products rated at 50/60 Hz.
- All parameter adjustments are programmed into the controller through the built-in keypad.
- A full line of enclosures is available.

Reduced Voltage Starting

Introduction to Reduced Voltage Starting

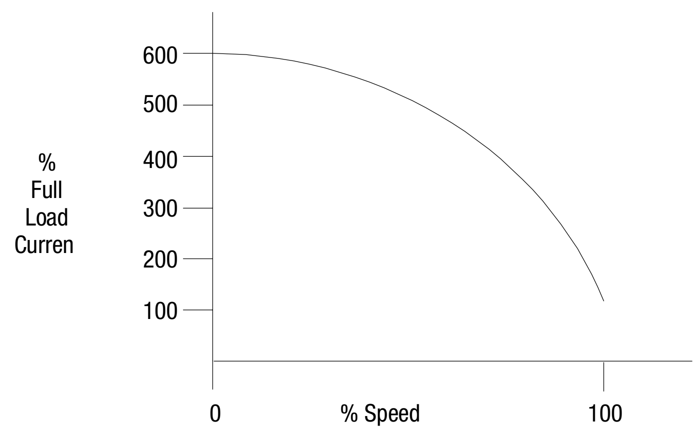
There are two primary reasons for using reduced voltage when starting a motor:

- Limit line disturbances
- Reduce excessive torque to the driven equipment

The reasons for avoiding these problems will not be described. However, different methods of reduced voltage starting of motors will be explored.

When starting a motor at full voltage, the current drawn from the power line is typically 600% of normal full load current. This high current flows until the motor is almost up to speed and then decreases, as shown in Figure 8.1. This could cause line voltage dips and brown-outs.

Figure 8.1 Full Load Current vs. Speed



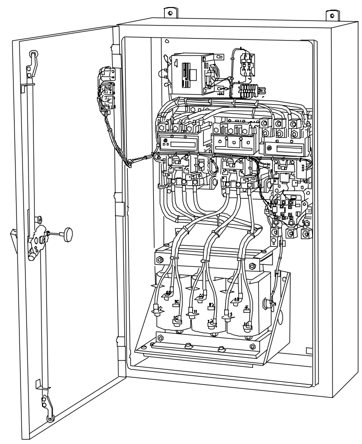
In addition to high starting currents, the motor also produces starting torques that are higher than full load torque. The magnitude of th starting torque depends on the motor design. NEMA publishes standards for torques and currents for motor manufacturers to follow. Typically, a NEMA Design B motor will have a locked rotor or starting torque in the area of 180% of full load torque.

In many applications, this starting torque can cause excessive mechanical damage such as belt, chain, or coupling breakage.

Reduced Voltage

The most widely used method of electromechanical reduced voltage starting is the autotransformer. Wye-Delta (Y-D), also referred to as Star-Delta, is the next most popular method

Figure 8.2 Bulletin 570 Autotransformer



All forms of reduced voltage starting affect the motor current and torque characteristics. When a reduced voltage is applied to a motor at rest, the current drawn by the motor is reduced. In addition, the torque produced by the motor is a factor of approximately the square of the percentage of voltage applied.

For example, if 50% voltage is applied to the motor, a starting torque of approximately 25% of the normal starting torque would b produced. In the previous full voltage example, the NEMA Design B motor had a starting torque of 180% of full load torque. With only 50% voltage applied, this would equate to approximately 45% of full load torque. Table 5.A shows the typical relationship of voltage, current, and torque for a NEMA Design B motor.

Table 8.K Typical Voltage, Current and Torque Characteristics for NEMA Design B Motors

Starting Method	% Voltage at Motor Terminals	Motor Starting Current as a % of:		Line Current as a % of:		Motor Starting Torque as a % of:	
		Locked Rotor Current	Full Load Current	Locked Rotor Current	Full Load Current	Locked Rotor Torque	Full Load Torque
Full Voltage	100	100	600	100	600	100	180
Autotrans.							
80% tap	80	80	480	64	384	64	115
65% tap	65	65	390	42	252	42	76
50% tap	50	50	300	25	150	25	45
Part Winding	100	65	390	65	390	50	90
Wye-Delta	100	33	198	33	198	33	60
Solid-state	0–100	0–100	0–600	0–100	0–600	0–100	0–180

With the wide range of torque characteristics for the various starting methods, selecting an electromechanical reduced voltage starter becomes more application dependent. In many instances, available torque becomes the factor in the selection processes.

Limiting line current has been a prime reason in the past for using electromechanical reduced voltage starting. Utility current restrictions, as well as in-plant bus capacity, may require motors above a certain horsepower to be started with reduced voltage. Som areas of the world require that any motor above 7-1/2 HP be started with reduced voltage.

Using reduced voltage motor starting also enables torque control. High inertia loads are a good example of an application in which electromechanical reduced voltage starting has been used to control the acceleration of the motor and load.

Electromechanical reduced voltage starters must make a transition from reduced voltage to full voltage at some point in the starting cycle. At this point, there is normally a line current surge. The amount of surge depends upon the type of transition being used and the speed of the motor at the transition point.

Reduced Voltage (cont.)

There are two methods of transition: Open Circuit Transition and Closed Circuit Transition. Open circuit transition means that th motor is actually disconnected from the line for a brief period of time when the transition takes place. With closed transition, the motor remains connected to the line during transition. Open circuit transition will produce a higher surge of current because the motor is momentarily disconnected from the line. Examples of open and closed circuit transition currents are shown in Figure 8.3 and Figure 8.4.

Figure 8.3 Open Circuit Transition

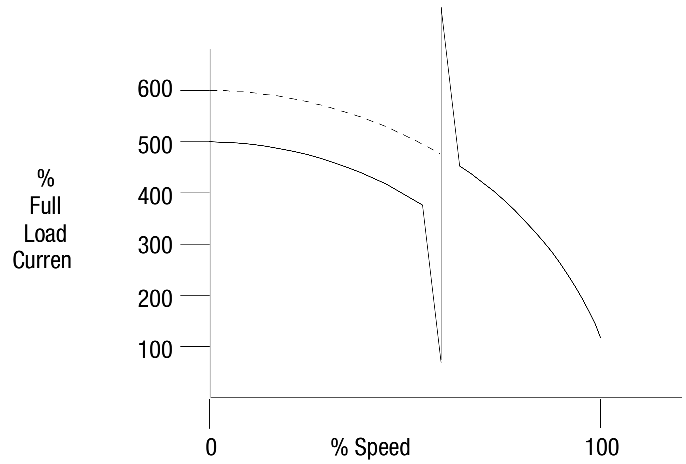
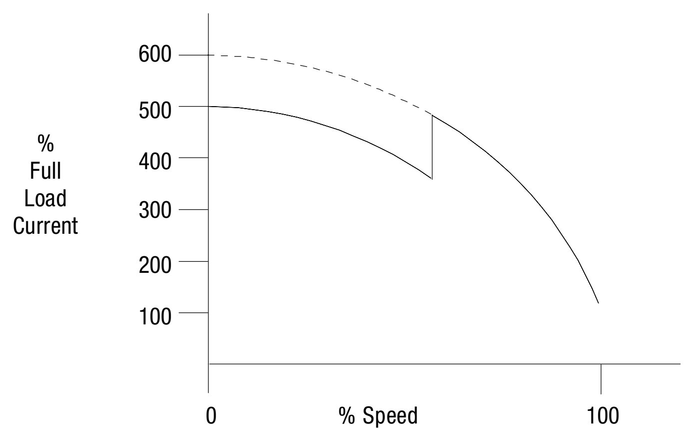


Figure 8.4 Closed Circuit Transition



The motor speed can determine the amount of current surge that occurs at transition. Transfer from reduced voltage to full voltage should occur at as close to full speed as possible. This also minimizes the amount of surge on the line.

The following figures illustrate transition at low motor speed and near full speed. The transition at low speed shows the current surge as transition occurs at 550%, which is greater than the starting current o 400%. The transition near full speed shows that the current surge is 300%, which is below the starting current.

Figure 8.5 Transition at Low Speed

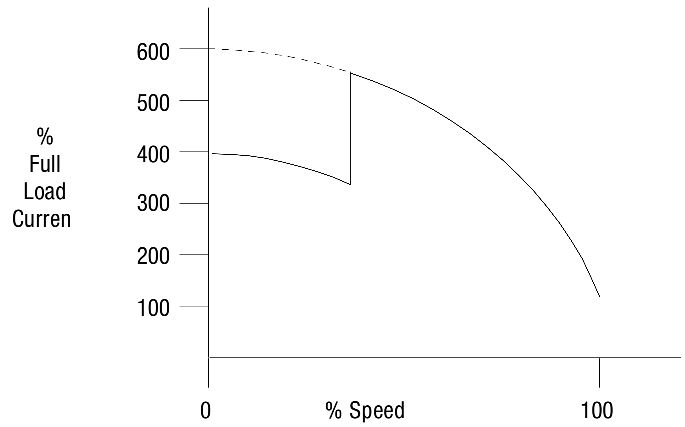
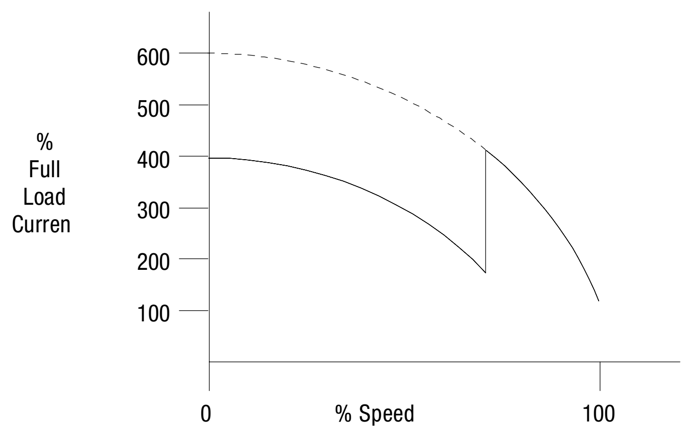


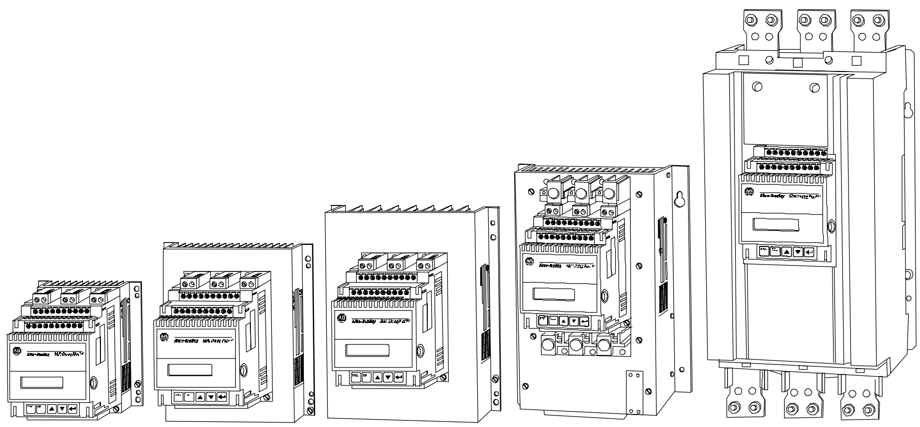
Figure 8.6 Transition near Full Speed



Solid-state

The main function of solid-state controllers is their ability to provid a soft start or stepless reduced voltage start of AC motors. The same principles of current and torque apply to both electromechanical reduced voltage starters and solid-state controllers. Many solid-state controllers offer the choice of four starting modes: soft start, current limit start, dual ramp start, or full voltage start in the same device.

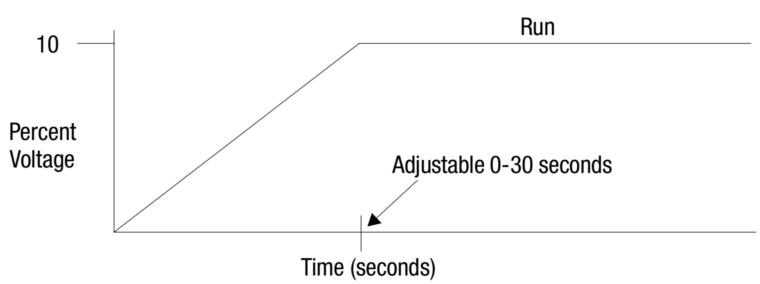
Figure 8.7 Solid-state Controllers



In addition to selecting the starting modes, the solid-state controlle allows adjustment of the time for the soft start ramp, or the current limit maximum value, which enables selection of the starting characteristic to meet the application. The most widely used version is the soft start. This method provides a smooth start for most applications.

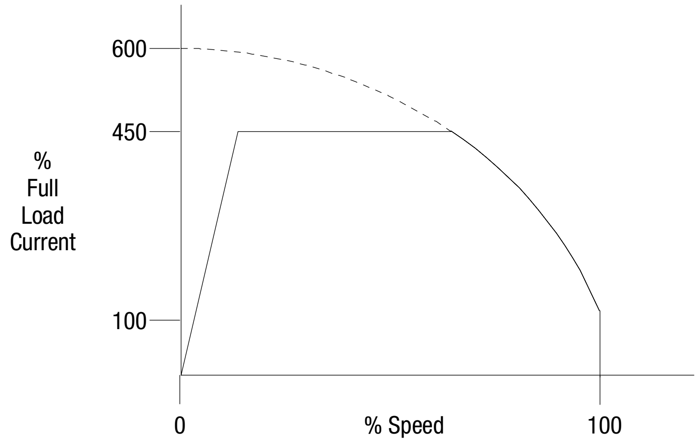
The major advantages of solid-state controllers are the elimination of the current transition point and the capability of adjusting the time to reach full voltage. The result is no large current surge when the solid-state controller is set up and correctly matched to the load, as illustrated in Figure 8.8.

Figure 8.8 Soft Start



Current limit starting can be used in situations where power line limitations or restrictions require a specific current load. The next illustration shows a 450% current limit curve. Other values may be selected, such as 200%, 300%, or 400%, depending on the particular application. Current limit starting is also used in applications wher higher starting torque is required compared to a soft start, which typically starts at less than 300% current. Current limit starting is typically used on high inertia loads, such as ball mills.

Figure 8.9 Current Limit Start



Solid-state controllers control the voltage applied to the motor, even when the motor is up to speed, because of the semiconductors used in the power circuit. This allows solid-state reduced voltage to provide an energy saving function for motors that run unloaded or lightly loaded for long periods of time. Intelligence within the solid-state controller determines when the motor is lightly loaded. The voltage to the motor can then be reduced by properly controlling th semiconductors until the motor is operating at an optimum point. This same intelligence detects when a load is reapplied and increases the voltage to prevent stalling.

Other features available with solid-state controllers include additional protection to the motor and controller, and diagnostics to aid in set-up and troubleshooting. Protection typically provided includes shorted SCR, phase loss, open load lead, SCR overtemperature, and stalled motor. Appropriate fault messages are displayed to aid in troubleshooting when one of these faults trip out the solid-state reduced voltage controller.

Solid-state Starters Using SCRs

Solid-state Starters Using SCRs

In solid-state starters, silicon controlled rectifiers (SCRs) (se Figure 9.1) are used to control the voltage output to the motor. An SCR allows current to flow in one direction only. The amount of conduction of an SCR is controlled by the pulses received at the gate of the SCR. When two SCRs are connected back to back (se Figure 9.2), the AC power to a load can be controlled by changing the firing angle of the line voltage (see Figure 9.3) during each half cycle. By changing the angle, it is possible to increase or decrease th voltage and current to the motor. The SMC Dialog Plus controller incorporates a microprocessor to control the firing of the SCRs. Six SCRs are used in the power section to provide full cycle control of the voltage and current. The voltage and current can be slowly and steplessly increased to the motor.

Figure 9.1 Silicon Controlled Rectifier (SCR)

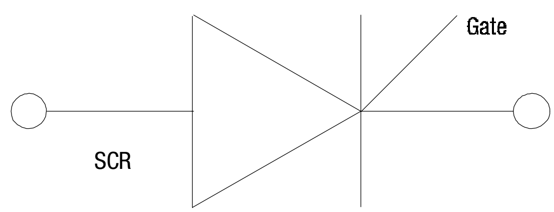
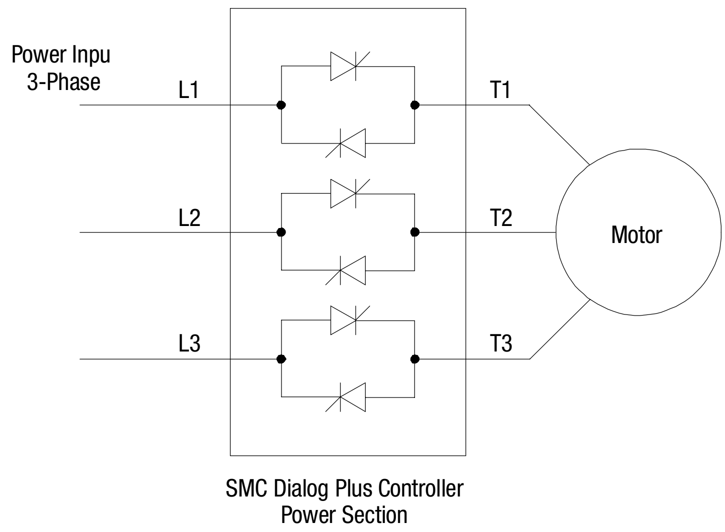
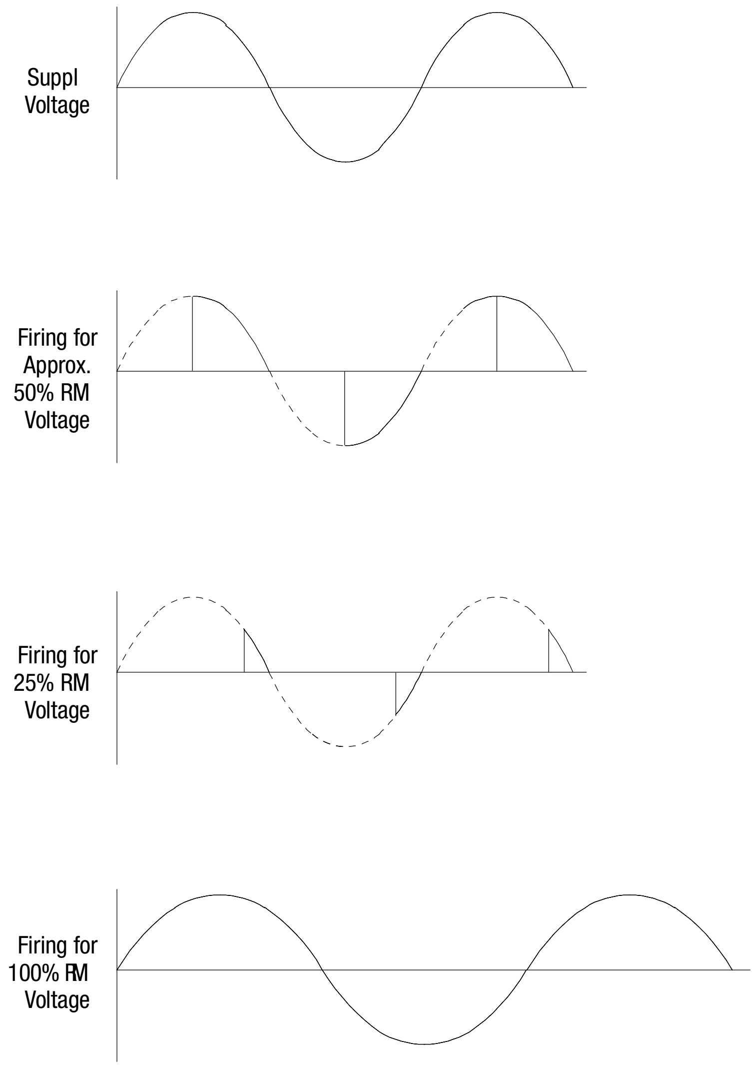


Figure 9.2 Typical Wiring Diagram of SCRs



Solid-state Starters Using SCRs (cont.)

Figure 9.3 Different Firing Angles (Single-phase Simplification)



Reference

Introduction

Certain mechanical parameters must be taken into consideration when applying motor controllers. The following section explains thes parameters and how to calculate or measure them.

Motor Output Speed/Torque/Horsepower

The speed at which an induction motor operates depends on the input power frequency and the number of poles for which the motor is wound. The higher the frequency, the faster the motor runs. The more poles the motor has, the slower it runs. To determine the synchronous speed of an induction motor, use the following equation:

$$\text{Synchronous Spee} = \frac{60 \times 2 \times \text{Frequenc}}{\text{Number of Poles}}$$

Actual full-load speed (the speed at which the motor will operate at nameplate rated load) will be less than synchronous speed. This difference between synchronous speed and full-load speed is called slip. Percent slip is defined as follows:

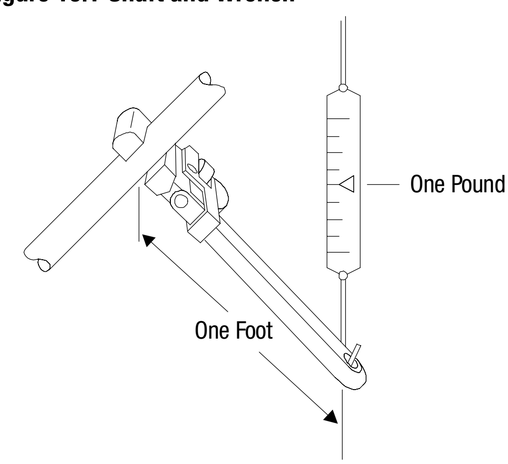
$$\text{Percent Sli} = \frac{\text{Synchronous Speed} - \text{Full Load String}}{\text{Synchronous Speed}} \times 100$$

Induction motors are built with slip ranging from less than 5% to as much as 20%. A motor with a slip of less than 5% is called a normal slip motor. Motors with a slip of 5% or more are used for applications requiring high starting torque.

Torque and Horsepower

Torque and horsepower, two important motor characteristics, determine the size of the motor required for a given application. Th difference between the two can be explained using a simple illustration of a shaft and wrench.

Figure 10.1 Shaft and Wrench



Torque and Horsepower (cont.)

Torque is merely a turning effort. In the previous illustration, it takes one pound at the end of the one foot wrench to turn the shaft at a steady rate. Therefore, the torque required is one pound × one foot, or one foot-lb. If the wrench were turned twice as fast, the torque required would remain the same, provided it is turned at a steady rate.

Horsepower, on the other hand, takes into account how fast the shaft is turned. Turning the shaft rapidly requires more horsepower than turning it slowly. Thus, horsepower is a measure of the rate at which work is done. By definition, the relationship between torque and horsepower is as follows:

$$1 \text{ Horsepower} = 33{,}000 \text{ ft.-lbs./Min.}$$

In the above example, the one pound of force moves a distance of:

$$2 \text{ Ft.} \times \pi \times 1 \text{ Lb.} \quad \text{or} \quad 6.28 \text{ Ft.-Lb}$$

To produce one horsepower, the shaft would have to be turned at rate of:

$$\frac{1 \text{ HP} \times 33{,}000 \text{ ft.-lbs./Min.}}{6.28 \text{ ft.-lbs./Revolutio}} = 5{,}250 \text{ R}$$

For this relationship, an equation can be derived for determining horsepower output from speed and torque.

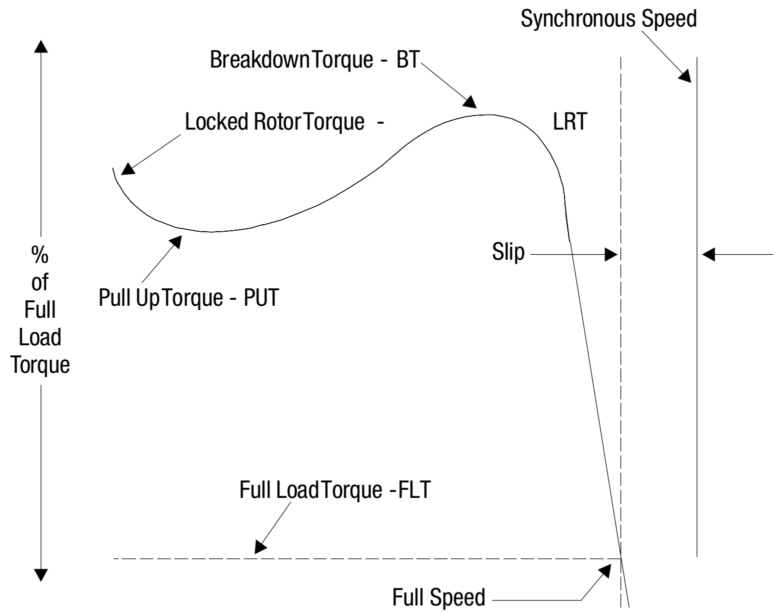
$$\text{HP} = \frac{\text{RPM} \times \quad \times \text{Torqu}}{30{,}00} \quad \text{or} \quad \frac{\text{RPM} \times \text{Torqu}}{5{,}25}$$

For this relationship, full-load torque is:

$$\text{Full-load Torque in ft.-lb} = \frac{\text{HP} \times 5{,}25}{\text{Full-load RPM}}$$

The following graph illustrates a typical speed-torque curve for a NEMA Design B induction motor. An understanding of several points on this curve will aid in properly applying motors.

Figure 10.2 Speed Torque Curv



Locked-Rotor Torque (LRT)

Locked-rotor torque is the torque which the motor will develop at rest for all angular positions of the rotor, with rated voltage at rated frequency applied. It is sometimes known as “starting torque” and is usually measured as a percentage of full-load torque.

Pull-Up Torque (PUT)

Pull-up torque of an induction motor is the minimum torqu developed during the period of acceleration from locked rotor to the speed at which breakdown torque occurs. For motors that do not have definite breakdown torque (such as NEMA Design D), pull-up torque is the minimum torque developed, up to rated full-load speed, and is usually expressed as a percentage of full-load torque.

Breakdown Torque (BT)

The breakdown torque of an induction motor is the maximum torque the motor will develop with rated voltage applied, at rated frequency, without an abrupt drop in speed. Breakdown torque is usually expressed as a percentage of full-load torque.

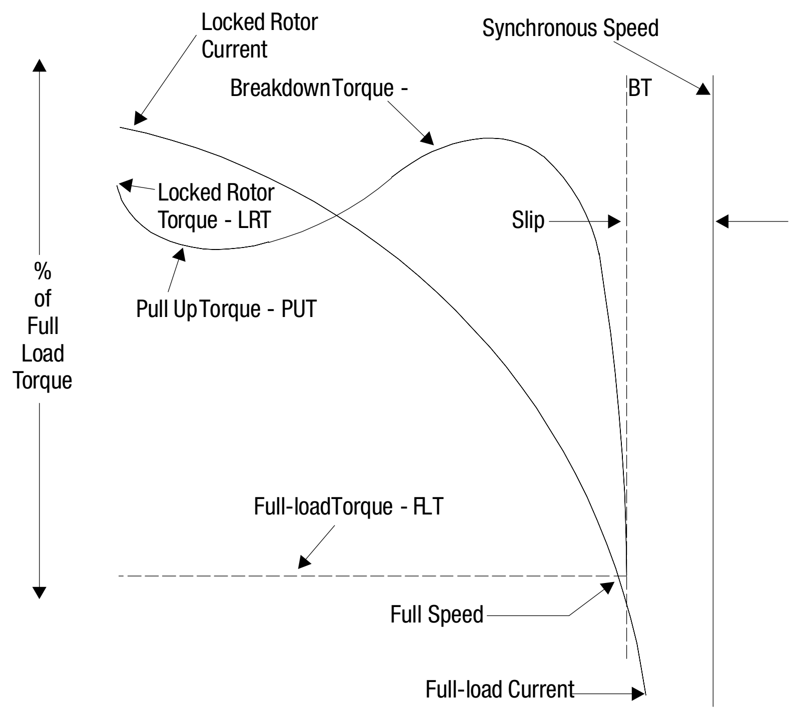
Torque and Horsepower (cont.)

Full-load Torque (FLT)

The full-load torque of a motor is the torque necessary to produce its rated horsepower at full-load speed. In foot-lbs, it is equal to the rated horsepower, multiplied by 5250, divided by the full-load speed in RPM.

In addition to the relationship between speed and torque, the relationship of current draw to these two values is an important application consideration. The speed/torque curve is repeated below, with the current curve added, to demonstrate a typical relationship.

Figure 10.3 Speed Torque Curve with Current Curve



Two important points on this current curve require explanation.

Full-load Current

The full-load current of an induction motor is the steady-state current taken from the power line when the motor is operating at full-load torque with rated voltage and rated frequency applied.

Locked-rotor Current

Locked-rotor current is the steady state current of a motor with th rotor locked and with rated voltage applied at rated frequency. NEMA has designed a set of code letters to define locked-rotor: Kilovolt-amperes-per-horsepower (kVA/HP). This code letter appears on the nameplate of all AC squirrel cage induction motors.

kVA per Horsepower is Calculated as Follows:

For three-phase motors:

$$\text{kVA/HP} = \frac{1.73 \times \text{Current (in Amperes)} \times \text{Volts}}{1{,}00\ \times 0\text{H}}$$

For single phase motors:

$$\text{kVA/HP} = \frac{\text{Current (in Amperes)} \times \text{Volts}}{1{,}00\ \times 0\text{H}}$$

Table 10. NEMA Locked-Rotor Current Code Letters

Letter Designation	kVA per HP ①
A	0–3.15
B	3.15–3.55
C	3.55–4.0
D	4.0–4.5
E	4.5–5.0
F	5.0–5.6
G	5.6–6.3
H	6.3–7.1
J	7.1–8.0
K	8.0–9.0
L	9.0–10.0
M	10.0–11.2
N	11.2–12.5
P	12.5–14.0
R	14.0-–6.0
S	16.0–18.0
T	18.0–20.0
U	20.0–22.4
V	22.4 and up

❶ Locked-rotor kilovolt -amperes-per-horsepower range includes the lower figure up to, but not including, the higher figure (i.e., 3.14 is letter “A” and 3.15 is letter “B”).

Torque and Horsepower (cont.)

By manipulating the preceding equation for kVA/HP for three-phas motors, the following equation can be used for calculating locked-rotor current:

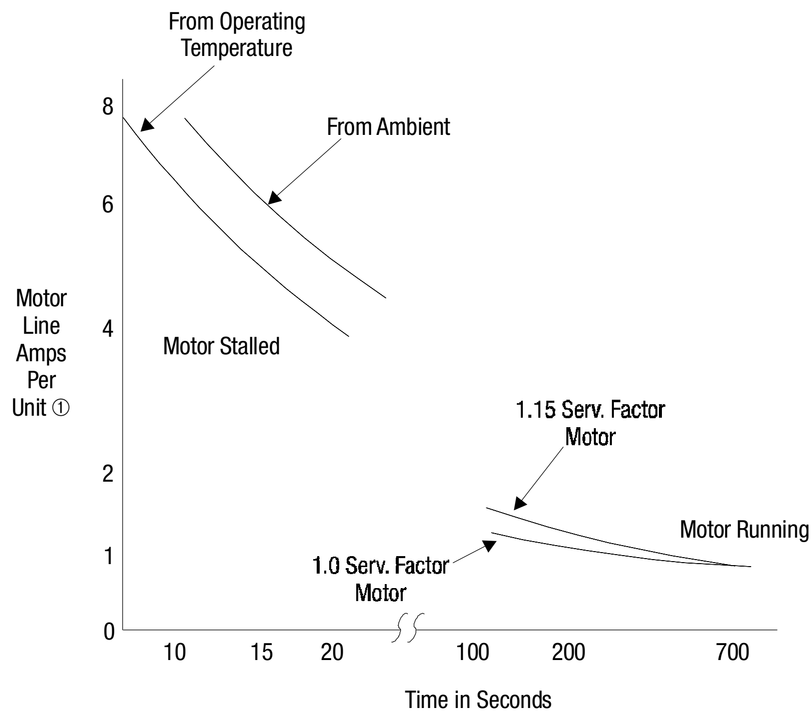
$$LRA = \frac{1,00 \times 0H \times kVA/HP}{1.73 \times Volts}$$

This equation can then be used to determine the approximate starting current of any particular motor. For instance, the approximate starting current for 7-1/2HP, 230 volt motor with a locked-rotor kVA code letter of G would be:

$$LRA = \frac{1,00 \times 07. \times 6.0}{1.73 \times 230} = 113\ Amp$$

Operating a motor in a locked-rotor condition for an extended period of time will result in insulation failure because of the excessive heat generated in the stator. The following graph illustrates the maximum time a motor may be operated at locked-rotor without incurring damage caused by heating. This graph assumes a NEMA Design B motor with Class B temperature rise.

Figure 10.4 Motor Safe Time vs. Line Current - Standard Induction Motors



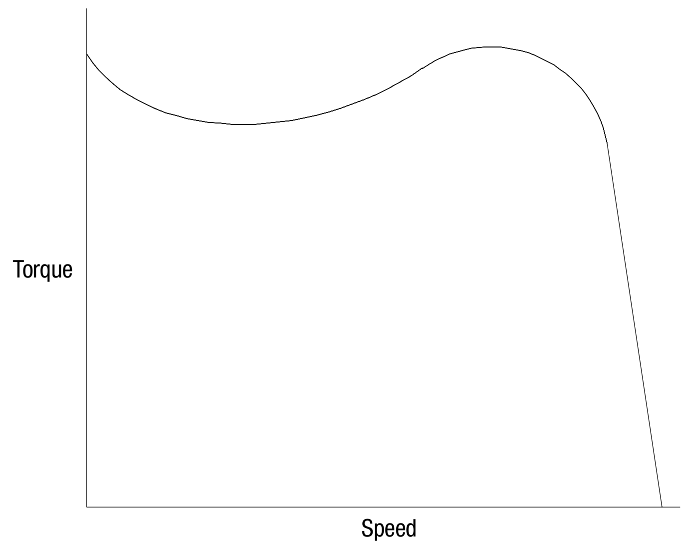
❶ Base Amps and Nameplate Amps.

Motor protection, either inherent or in the motor control, should be selected to limit the stall time of the motor.

Motor Output for NEMA Design Designations Polyphase 1–500 HP

NEMA has designated several specific types of motors, each having unique speed/torque relationships. These designs, along with some typical applications for each type, are described below. Following these descriptions are summaries of performance characteristics.

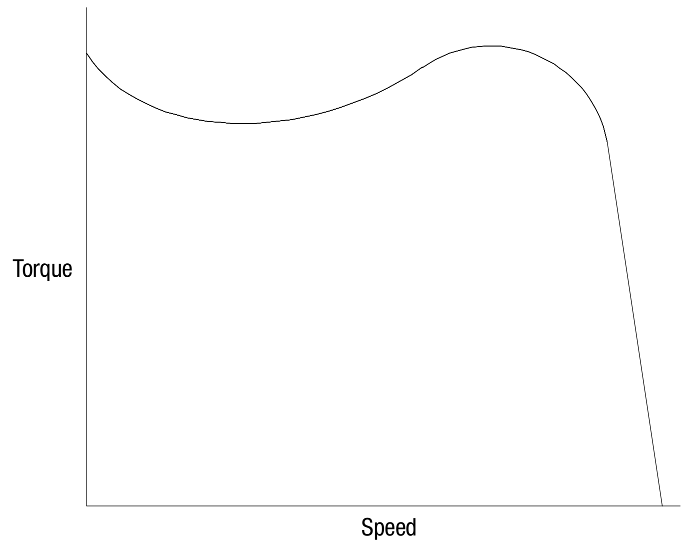
Figure 10.5 Typical NEMA Design A Speed/Torque Curv



Starting Current:	High
Starting Torque:	High
Breakdown Torque:	High
Full-load Slip:	Low
Applications:	Fans, blowers, pumps, machine tools, or other applications with high starting torque requirements and an essentially constant load.

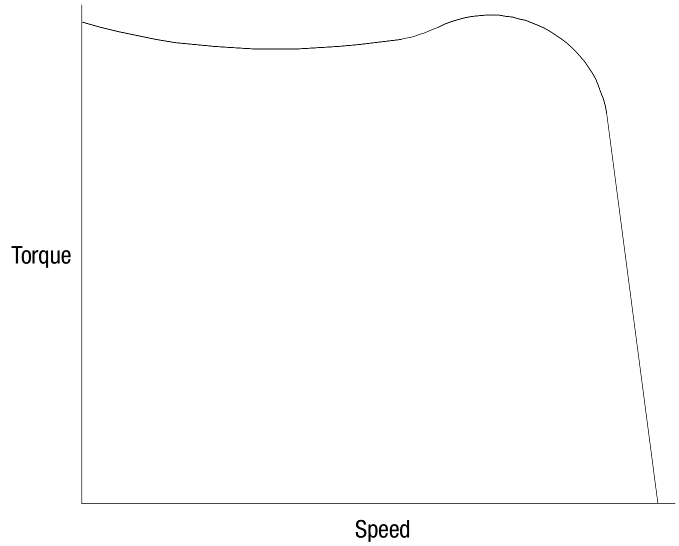
Motor Output for NEMA Design Designations Polyphase 1–500 HP (cont.)

Figure 10.6 Typical NEMA Design B Speed/Torque Curv



Starting Current:	Normal
Starting Torque:	Normal
Breakdown Torque:	Normal
Full-load Slip:	Normal
Applications:	Fans, blowers, pumps, machine tools, or other applications with normal starting torque requirements and an essentially constant load.

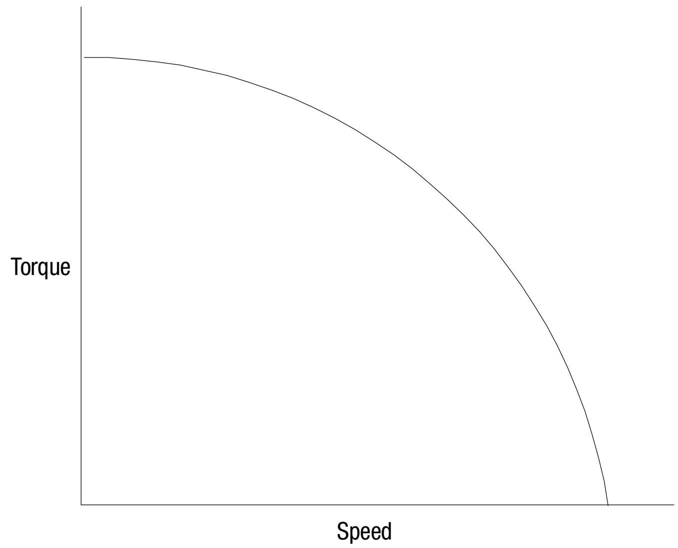
Figure 10.7 Typical NEMA Design C Speed/Torque Curve



Starting Current:	Low
Starting Torque:	High
Breakdown Torque:	Low
Full-load Slip:	Low
Applications:	The higher starting torque of NEMA Design C motors makes them advantageous for use on hard-to-start loads such as plunger pumps, conveyors, and compressors.

Motor Output for NEMA Design Designations Polyphase 1–500 HP (cont.)

Figure 10.8 Typical NEMA Design D Speed/Torque Curve



Starting Current:	Normal
Starting Torque:	High
Breakdown Torque:	None
Full-load Slip:	High (5-13%)
Applications:	The combination of high starting torque and high slip make NEMA Design D motors ideal for use on very high inertia loads and/or in applications where a considerable variation in load exists. These motors are commonly used on punch presses, shears, cranes, hoists, and elevators.

Table 10.M Motor Output - Comparison of NEMA Polyphase Designs

NEMA Design	Starting Torque	Locked Rotor Torque	Breakdown Torque	% Slip	Applications
A	High	High	High	< 5%	Broad applications including fans, blowers, pumps, and machine tools.
B	Normal	Normal	Normal	< 5%	Normal starting torque for fans, blowers, rotary pumps, unloaded compressors, conveyors, metal cutting, machine tools, miscellaneous machinery.
C	Low	High	Low	Low	High inertia starts such as large centrifugal blowers, fly wheels and crusher drums. Loaded starts such as piston pumps, compressors and conveyors.
D	Normal	High	None	High	Very high inertia and loaded starts. Choice of slip range to match application.
				5–8%	Punch press, sheers and forming machine tools.
				8–13%	Cranes, hoists, elevators and oil well pumping jacks.

Calculating Torque (Acceleration Torque Required for Rotating Motion)

Some machines must be accelerated to a given speed in a certain period of time. The torque rating of the drive may have to be increased to accomplish this objective. The following equation may be used to calculate the average torque required to accelerate a known inertia (WK^2). This torque must be added to all the other torque requirements of the machine when determining the drive and motor's required peak torque output.

$$T = \frac{WK^2 \times (\Delta N)}{30 \times 8t}$$

Where:

T = Acceleration Torque (ft.-lb.)

WK^2 = total system inertia (ft.-lb.^{2}) that the motor must accelerate. This value includes motor armature, reducer, and load.

ΔN = Change in speed required (RPM

t = time to accelerate total system load (seconds).

Note: The number substituted for (WK^2) in this equation must be in units of ft.-lb.^{2}. Consult the conversion tables for the proper conversion factor.

Calculating Torque (Acceleration Torque Required for Rotating Motion) (cont.)

The same formula can be used to determine the minimum acceleration time of a given drive, or it can be used to establish whether a drive can accomplish the desired change in speed within the required time period.

Transposed formula:

$$T = \frac{WK^2 \times (\Delta N)}{30 \times 8t}$$

General Rule:
If the running torque is greater than the accelerating torque, use the running torque as the full-load torque required to determine the motor horsepower.

Calculating Horsepower

Note: The following equations for calculating horsepower are meant to be used for estimating purposes only. These equations do not include any allowance for machine friction, winding or other factors that must be considered when selecting a device for a machine application.

After the machine torque is determined, the required horsepower is calculated using the formula:

$$HP = \frac{T \times N}{5,25}$$

Where:
HP = Horsepower
T = Torque (ft.-lb.)
N = Speed of motor at rated load (RPM)

If the calculated horsepower falls between standard available motor ratings, select the higher available horsepower rating. It is good practice to allow some margin when selecting the motor horsepower.

Inertia

Inertia is a measure of the body's resistance to changes in velocity, whether the body is at rest or moving at a constant velocity. The velocity can be either linear or rotational.

The moment of inertia (WK^2) is the product of the weight (W) of an object and the square of the radius of gyration (K^2). The radius of gyration is a measure of how the mass of the object is distributed about the axis of rotation. Because of this distribution of mass, a small diameter cylindrical part has a much lower inertia than a large diameter part.

WK² or WR²

Where:

WR^2 refers to the inertia of a rotating member that was calculated by assuming the weight of the object was concentrated around its rim at a distance R (radius) from the center (e.g., flywheel).

WK^2 refers to the inertia of a rotating member that was calculated by assuming the weight of the object was concentrated at some smaller radius, K (termed the radius of gyration). To determine the WK^2 of a part, the weight is normally required (e.g., cylinder, pully, gear).

Torque Formulas

$$T = \frac{HP \times 525}{N}$$

Where:

T = Torque (ft.-lb.)

HP = Horsepower

N = Speed of motor at rated load (RPM)

$$T = F \times R$$

Where:

T = Torque (ft.-lb.)

F = Force (lbs.)

R = Radius (ft.)

$$T\ (\text{Accelerating} = \frac{WK^2 \times (\Delta RPM)}{30 \times 8t}$$

Where:

T = Torque (ft.-lb.)

WK^2 = Inertia reflected to the Motor Shaft (ft.-lb.^{2})

DRPM = Change in speed

t = Time to accelerate (sec.)

Note: To change ft.-lb.^{2} to in-lb-sec.^{2}: Divide by 2.68
To change in-lb-sec.^{2} to ft.-lb.^{2}: Multiply by 2.68

AC Motor Formulas

$$\text{Sync Speed} = \frac{\text{Freq} \times 12}{\text{Number of Poles}}$$

Where:

Sync Speed = Synchronous Speed (RPM)

Freq = Frequency (Hz)

$$\%\ \text{Sli} = \frac{\text{Sync Spee} - \text{dFL Spee}}{\text{Sync Spee}} \times 10$$

Where:

FL Speed = Full Load Speed (RPM)

Sync Speed = Synchronous Speed (RPM)

$$\text{Reflected WK}^2 = \frac{(\text{WK}^2 \text{of Loa})}{(\text{Reduction Rati})^2}$$

Where:

WK^2 = Inertia (ft.-lb.^{2})

Torque Characteristics on Common Applications

This chart offers a quick guideline on the torque required to breakaway, start and run many common applications.

Table 10.N Torque Characteristics

Application	Load Torque as Percent of Full Load Drive Torque		
	Breakaway	Accelerating	Peak Running
Agitators:			
Liquid	100	100	100
Slurry	150	100	100
Blowers, centrifugal:			
Valve closed	30	50	40
Valve open	40	110	100
Blowers, positive-displacement, rotary, bypassed	40	40	100
Card machines, textile	100	110	100
Centrifuges (extractors)	40	60	125
Chippers, wood, starting empty	50	40	200
Compressors, axial-vane, loaded	40	100	100
Compressors, reciprocating, start unloaded	100	50	100
Conveyors, belt (loaded)	150	130	100
Conveyors, drag (or apron)	175	150	100
Conveyors, screw (loaded)	175	100	100
Conveyors, shaker-type (vibrating)	150	150	75
Draw presses (flywheel)	50	50	200
Drill presses	25	50	150
Escalators, stairways (starting unloaded)	50	75	100
Fans, centrifugal, ambient:			
Valve closed	25	60	50
Valve open	25	110	100
Fans, centrifugal, hot:			
Valve closed	25	60	100
Valve open	25	200	175
Fans, propeller, axial-flow	40	110	100
Feeders, (belt) loaded	100	120	100
Feeders, distributing, oscillating drive	150	150	100
Feeders, screw, compacting rolls	150	100	100
Feeders, screw, filter-cake	150	100	100
Feeders, screw, dry	175	100	100
Feeders, vibrating, motor-driven	150	150	100
Frames, spinning, textile	50	125	100
Grinders, metal	25	50	100
Ironers, laundry (mangles)	50	50	125
Jointers, woodworking	50	125	125

Torque Characteristics on Common Applications (cont.)

Table 10.N (cont.) Torque Characteristics

Application	Load Torque as Percent of Full Load Drive Torque		
	Breakaway	Accelerating	Peak Running
Machines, bottling	150	50	100
Machines, buffing, automatic	50	75	100
Machines, cinder-block, vibrating	150	150	70
Machines, keyseating	25	50	100
Machines, polishing	50	75	100
Mills, flour, grinding	50	75	100
Mills, saw, band	50	75	200
Mixers, chemical	175	75	100
Mixers, concrete	40	50	100
Mixers, dough	175	125	100
Mixers, liquid	100	100	100
Mixers, sand, centrifugal	50	100	100
Mixers, sand, screw	175	100	100
Mixers, slurry	150	125	100
Mixers, solids	175	125	175
Planers, woodworking	50	125	150
Presses, pellet (flywheel)	150	75	150
Presses, punch (flywheel	150	75	100
Pumps, adjustable-blade, vertical	50	40	125
Pumps, centrifugal, discharge open	40	100	100
Pumps, oil-field, flywheel	150	200	200
Pumps, oil, lubricating	40	150	150
Pumps, oil fuel	40	150	150
Pumps, propeller	40	100	100
Pumps, reciprocating, positive displacement	175	30	175
Pumps, screw-type, primed, discharge open	150	100	100
Pumps, Slurry-handling, discharge open	150	100	100
Pumps, turbine, centrifugal, deep-well	50	100	100
Pumps, vacuum (paper mill service)	60	100	150
Pumps, vacuum (other applications)	40	60	100
Pumps, vane-type, positive displacement	150	150	175
Rolls, crushing (sugar cane)	30	50	100
Rolls, flaking	30	50	100
Sanders, woodworking, disk or belt	30	50	100
Saws, band, metalworking	30	50	100
Saws, circular, metal, cutoff	25	50	150

Table 10.N (cont.)Torque Characteristics

Application	Load Torque as Percent of Full Load Drive Torque		
	Breakaway	Accelerating	Peak Running
Saws, circular, wood, production	50	30	150
Saws, edger (see edgers)			
Saws, gang	60	30	150
Screens, centrifugal (centrifuges)	40	60	125
Screens, vibrating	50	150	70
Separators, air (fan-type)	40	100	100
Shears, flywheel-type	50	50	120
Textile machinery	150	100	90
Walkways, mechanized	50	50	100
Washers, laundry	25	75	100

Electrical Formulas

Ohm's Law:

$$I = \frac{E}{R} \qquad R = \frac{E}{I} \qquad E = I \times R$$

Where:
I = Current (Amperes)
E = EMF or Voltage (Volts)
R = Resistance (Ohms)

Power in DC Circuits:

$$P = I \times E \qquad HP = \frac{I \times E}{74}$$

$$kW = \frac{I \times E}{1,00} \qquad kWH = \frac{I \times E \times Hour}{1,00}$$

Where:
P = Power (Watts)
I = Current (Amperes)
E = EMF or Voltage (Volts)
kW = Kilowatts
kWH = Kilowatt-Hours

Electrical Formulas (cont.)

$$\text{kVA (1-phase)} = \frac{I \times E}{1{,}00} \qquad \text{kVA (3-phase} = \frac{I \times E \times 1.73}{1{,}00}$$

Where:
kVA = Kilovolt-Amperes
I = Current (Amperes)
E = EMF or Voltage (Volts)

$$\text{kW (1-phase)} = \frac{I \times E \times PF}{1{,}00}$$

$$\text{kW (2-phase)} = \frac{I \times E \times PF \times 1.42}{1{,}00}$$

$$\text{kW (3-phase)} = \frac{I \times E \times PF \times 1.73}{1{,}00}$$

$$PF = \frac{W}{V \times I} = \frac{kW}{kVA}$$

Where:
kW = Kilowatts
I = Current (Amperes)
E = EMF or Voltage (Volts)
PF = Power Factor
W = Watts
V = Volts
kVA = Kilovolt-Amperes

Calculating Motor Amperes

$$\text{Motor Amperes} = \frac{HP \times 74}{E \times 1.73 \quad \times Eff \times PF}$$

$$\text{Motor Amperes} = \frac{kVA \times 1{,}00}{1.73 \times E}$$

$$\text{Motor Amperes} = \frac{kW \times 1{,}00}{1.73 \times E \times PF}$$

Where:
HP = Horsepower
E = EMF or Voltage (Volts)
Eff = Efficiency of Motor (%/100)
kVA = Kilovolt-Amperes
kW = Kilowatts
PF = Power Factor

Other Formulas

Calculating Accelerating Force for Linear Motion:

$$\text{F (Acceleration)} = \frac{W \times \Delta V}{1{,}93 \times 3t}$$

Where:
F = Force (lbs.)
W = Weight (lb.)
DV = Change in Velocity (FPM)
t = Time to accelerate weight (seconds)

$$\text{LRA} = \frac{\text{HP} \times \left(\frac{\text{Start kVA}}{\text{HP}}\right) \times 1{,}00}{E \times 1.73}$$

Where:
LRA = Locked Rotor Amperes
HP = Horsepower
kVA = Kilovolt-Amperes
E = EMF or Voltage (Volts)

$$\text{LRA @ Freq. X} = \frac{\text{60 Hz LR}}{\sqrt{\frac{60}{\text{Freq. X}}}}$$

Where:
60 Hz LRA = Locked Rotor Amperes
Freq. X = Desired frequency (Hz)

Engineering Constants

Temperature

0° C = Freezing point of wate
32° F = Freezing point of water = ° C
10 ° C = Boiling point of water at atmospheric pressure
21 ° F = Boiling point of water at atmospheric pressure
1.8° WF = 1° WC
0.252 Calories = 1 BTU
–270° C = Absolute zero
–459.6° F = Absolute zero

Length

1,760 Yards = 1 Mile
25.4 mm = 2.54 cm = 1 in.
3 ft. = 1 Yard
3.2808 ft. = 1 m
39.37 in. = 1 m = 100 cm = 1000 mm
5,280 ft. = 1 Mile
0.62137 Miles = 1 km

Engineering Constants (cont.)

Weight

16 oz. = 1 lb.
2.2046 lb. = 1 kg.
2.309 ft. water at 6 ° F = 1 PSI
28.35 gm = 1 oz.
59.76 lbs. = Weight of 1 Cu. ft. of water at 21 ° F
0.062428 lb. per cu. ft. = 1 kg/cu. m
62.355 lbs = Weight of 1 cu. ft. water at 6° F
8 (8.32675) lbs. = Weight 1 gal. water at 62° F

Power

1.3410 HP = 1 kW
2.545 BTU per hr. = 1 HP
33,000 ft.-lb. per min. = 1 HP
550 ft.-lb. per sec. = 1 HP
745.7 W = 1 HP

Area

10.764 sq. ft. = 1 sq. m
1,273,239 circular mils = 1 sq. in.
144 sq. in. = 1 sq. ft.
645 mm^2 = 1 sq. in.
9 sq. ft. = 1 sq. yd.
.0929 sq. m = 1 sq. ft.

Mathematic

1.4142 = square root of 2
1.7321 = square root of 3
3.1416 = p ratio of circumference of circle to diamete
= ratio of area of a circle to square of radius
57.296 degrees = 1 rad. (angle)
0.7854 X diameter squared = area of a circle

Pressure

14.223 PSI = 1 kg per sq. cm = 1 “metric atmosphere”
2.0355 in. Hg at 3 ° F = 1 PS
2.0416 in. Hg at 6 ° F = 1 PS
2,116.3 PSF = 1 in. water at 6 ° F
760 mm Hg = atmospheric pressure at 0° C
.07608 lb. = weight 1 cu. ft. air at 6° F and 14.7 PSI

Volume

1,728 cu. in. = 1 cu. ft.
231 cu. in. = 1 gal. (U.S.
277.274 cu. in. = 1 gal. (British)
27 cu. ft. = 1 cu. yd.
31 gal. (31.5 U.S. gal.) = 1 barrel
35.314 cu. ft. = 1 cu. m
3.785 liters = 1 gal.
61.023 cu. in. = 1 liter
7.4805 gal. = 1 cu. ft.

Temperature

° = degrees
C = Celsius (Centigrade
F = Fahrenheit
BTU = British Thermal Unit

Length

yd. = yard
m = meter
mm = millimeter (1/1000 of a meter
cm = centimeter (1/100 of a meter)
in. = inch
ft. = feet
km = kilometer

Weight

oz. = ounce
lb. = pound
kg. = kilogram
g = gram

Electrical

W = Ohms
ý = Phase
V = Volts
A = Amperes
mA = milliamperes
mA = microamperes
mV = millivolts
kV = kilovolts

Power/Energy

HP = horsepower
W = watt
kW = kilowatt
kWH = kilowatt-hours

Engineering Constants (cont.)

Work/Inertia

ft.-lb. = foot pounds
WK^2 = moment of inertia
$N\text{-}m^2$ = Newton meters^2

Area

sq. ft. = square feet
sq. m = square meters
mil = unit of length or angular measurement
mm^2 = square millimeters
sq. in. = square inch

Rotation/Rate

FPM = feet per minute
FPS = feet per second
m/s = meters per second
mph = miles per hour
cfm = cubic feet per minute

Mathematic

p = “pi”
rad. = radians
p = Density
E = Summation
D = Chang

Pressure

kg. per sq. cm = kilograms per square centimeter
Hg = Mercury symbol
PSI = pounds per square inch
PSF = pounds per square foot

Volume

cu. = cubic
cu. in. = cubic inch
cu. ft. = cubic feet
gal. = gallon
ml = milliliter
fl. oz. = fluid ounce (U.S.

Conversion Factors

Table 10.0 Length

To Convert:	To:	Multiply by:
Meters	Feet	3.281
Meters	Inches	39.37
Inches	Meters	.0254
Feet	Meters	.3048
Millimeters	Inches	.0394
Inches	Millimeters	25.4
Threads/Inch	Millimeter Pitch	Divide into 25.4
Yards	Meters	0.914
Example: 10 Meters x 3.281 = 32.81 Feet		

Table 10.P Area

To Convert:	To:	Multiply by:
Circular mil	$Meter^2$	0.50×10^{-9}
$Yard^2$	$Meter^2$	0.8361
Example: (0.5×10^{-7} Circular mils = .00000005 m^2)		

Table 10.Q Power

To Convert:	To:	Multiply by:
Watts	HP	.00134
ft.-lb./min.	HP	.0000303
HP	kW	0.746
Example: 1500W x .00134 = 2.01 HP		

Conversion Factors (cont.)

Table 10.R Rotational/Rate

To Convert:	To:	Multiply by:
RPM	deg./sec.	6.00
RPM	Rad./sec.	0.1047
deg./sec.	RPM	0.1667
Rad./sec.	RPM	9.549
FPM	m/s	.00508
FPS	m/s	0.3048
gal./min.	cm3/sec.	63.09
in./sec.	m/sec.	.0254
km/hr	m/sec.	0.2778
mph	m/sec.	0.447
mph	km/hr	1.609
yd. ^{3}/min.	m^3/sec.	0.1274
Example: 1800 RPM x 6.00 = 10800 deg./sec.		

Table 10.S Moment of Inertia

To Convert:	To:	Multiply by:
Newton-Meters^2	ft.-lb.^{2}	2.42
oz.-in.^{2}	ft.-lb.^{2}	.000434
lb.-in.^{2}	ft.-lb.^{2}	.00694
Slug-ft.2	ft.-lb.^{2}	32.17
oz.-in.-sec.^{2}	ft.-lb.^{2}	0.1675
in.-lb.-sec.^{2}	ft.-lb.^{2}	2.68
Example: 25 Newton-Meters^2 x 2.42 = 60.5 ft.-lb.^{2}		

Table 10.T Mass/Weight

To Convert:	To:	Multiply by:
oz.	g	31.1
kg	lbs.	2.205
lb.	kg	0.4536
Newtons	lbs.	0.2248
Example: 50 oz. x 31.1 = 1555 g		

Table 10.U Torque

To Convert:	To:	Multiply by:
Newton-Meters	ft.-lb.	0.7376
ft.-lb.	Newton-Meters	1.3558
ft.-lb.	ft.-lb.	.0833
ft.-lb.	ft.-lb.	12.00

Example: 30 Newton-Meters x 0.7376 = 22.13 lb-ft.

Table 10.V Volume

To Convert:	To:	Multiply by:
cm^3	m^3	.000001
fl. oz.	cm3	29.57
$ft.^3$ of water (39. °F)	kg (or liter)	28.32
cfm	m^3/sec.	.000472
liter	m^3	.001
$yd.^3$	m^3	0.7646

Example: 250 cm^3 x .000001 = .00025 m^3

Table 10.W Temperature

To Convert:	To:	Multiply by:
°F	°C	$°C = \frac{(°F - 32)}{1.8}$
°C	°F	°F = (°C x 1.8) + 32

Example: 20°C = (20 x 1.8) + 32 = 6 °F

AC	Alternating current.
AC Contacto	An alternating current (AC) contactor is designed for the specific purpose of establishing or interrupting an AC power circuit.
Alphanumeric Display	A device capable of displaying characters (letters, numbers, and symbols) but not graphics.
Ambient Temperature	Ambient temperature is the temperature of air, water, or a surrounding medium where equipment is operated or stored.
American Wire Gauge (AWG)	A standard system used for designing the size of electrical conductors. Gaug numbers have an inverse relationship to size; larger numbers have a smaller cross-sectional area. However, a single-strand conductor has a larger cross-sectional area than a multi-strand conductor of the same gauge so that they have the same current-carrying specification.
Axis	A principal direction along which movement of the tool or workpiece occurs. The term axis also refers to one of the reference lines of a coordinate system.
Back of a Motor	The back of a motor is the end which carries the coupling or driving pulley (NEMA). This is sometimes called the drive end (D.E.) or pulley end (P.E.).
Base Speed	Base speed is the manufacturer's nameplate rating where the motor will develop rated HP at rated load and voltage.
Bearing (Ball)	A "ball" shaped component that is used to reduce friction and wear while supporting rotating elements. For a motor, this type of bearing provides a relatively rigid support for the output shaft.
Bearing (Roller)	A special bearing system with cylindrical rollers capable of handling belted load applications too large for standard ball bearings.
Braking	Braking provides a means of stopping an AC or DC motor and can b accomplished in several ways:

- **DC-injection (AC Drives)** – A method which produces electromagnetic braking forces in the motor by removing two AC motor (stator) phases and injecting the DC current. The result is a linear braking characteristic (ramp) that does not diminish with motor speed. Application is normally limited to 10-20% of rated motor speed due to increased heating in the rotor.
- **Dynamic Braking (AC Drives** – Since AC motors do not have separate excitation, dynamic braking is accomplished by continuing to excite the moto from the drive. This causes a regenerative current to the drive's DC intermediated Bus Circuit. The Dynamic Brake resistors are then placed across the DC bus to dissipate the power returned. The brake resistor is usually switched by a transistor or other power switch controlled by the drive.

- **Dynamic Braking (DC Drives)** – Slows the motor by applying a resistive load across the armature leads after disconnection from the DC supply. This must be done while the motor field is energized. The motor then acts as a generator until the energy of the rotating armature is dissipated. This is not a holding brake.

- **Motor Mounted or Separately Mounted Brake** is a positive action, mechanical, friction device. Normal configuration is such that when the power is removed, the brake is set. This can be used as a holding brake. (Note: A *Separately Mounted Brak*e is not one which is located on some part of the mechanical drive train other than the motor.)

- **Regenerative Braking** is similar to Dynamic Braking, but is accomplished electrically. The generated power is returned to the line through the powe converter. It may also be dissipated as losses in the converter (within its limitations).

- **SMB™ Smart Motor Braking** – An Allen-Bradley smart motor braking feature of an SMC™ smart motor controller.

Breakaway Torque
The torque required to start a machine from standstill. Breakaway torque is always greater than the torque needed to maintain motion.

Breakdown Torque
The breakdown torque of an AC motor is the maximum torque that the motor will develop with rated voltage applied at rated frequency.

Buffer
1. In software terms, a register or group of registers used for temporary storage of data to compensate for transmission rate differences between the transmitter and receiving device.

2. In hardware terms, an isolating circuit used to avoid the reaction of one circuit with another.

C.E.M.F.
Abbreviation for counter electromotive force, which is the product of a motor armature rotating in a magnetic field. This generating action takes place wheneve a motor is rotating. Under stable motoring conditions, the generated voltag (C.E.M.F.) is equal to the voltage supplied to the motor minus small losses. However, the polarity of the C.E.M.F. is opposite to that of the power being supplied to the armature.

Closed Loop
Closed loop refers to a regulator circuit in which the actual value of the controlled variable (e.g., speed) is sensed and a signal proportional to this value (feedback signal) is compared with a signal proportional to the desired value (reference signal). The difference between these signals (error signal) causes the actual valu to change in the direction that will reduce the difference in signals to zero.

Cogging
A condition in which a motor does not rotate smoothly but “steps” or “jerks” from one position to another during shaft revolution. Cogging is most pronounced at low motor speeds and can cause objectionable vibrations in the driven machine.

Constant Horsepower Range — A range of motor operation where motor speed is controlled by field weakening. Motor torque decreases as speed increases. Since horsepower is speed multiplied by torque (divided by a constant), the value of horsepower developed by the motor in this range is constant.

Constant Torque Range — A speed range in which the motor is capable of delivering a constant torque, subject to cooling limitations of the motor.

Contact Reversing — A method of reversing motor rotation by the use of two separate contactors, one of which produces rotation in one direction and the other produces rotation in the opposite direction. The contactors are electrically (and mechanically) interlocked so that both cannot be energized at the same time.

Continuous Duty (CONT) — A motor that can continue to operate within the insulation temperature limits after it has reached normal operating (equilibrium) temperature.

Controller — A unit, such as a programmable controller or relay panel, that controls machine or process elements.

CSA — Canadian Standard Association.

Current Limiting — An electronic method of limiting the maximum current available to the motor. This is adjustable so that the motor's maximum current can be controlled. It can also b preset as a protective device to protect both the motor and control from extended overloads.

Cursor — The intensified or blinking element in a video display. A means for indication where data entry or editing occurs.

Cycle

1. A sequence of operations that is repeated regularly.
2. The time it takes for one sequence of operations to occur.

DC — Direct current.

Definite Purpose Motor — A definite purpose motor is any motor design, listed and offered in standard ratings with standard operating characteristics from a mechanical construction for us under service conditions other than usual or for use on a particular type of application (NEMA).

"D" Flange (Motor Mounting) — This type of motor mounting is used when the motor is to be built as part of the machine. The mounting holes of the flange are not threaded. The bolts protrude through the flange from the motor side. Normally "D" flange motors are supplied without feet since the motor is mounted directly to the driven machine.

DH-485 Link — Data Highway 485 link. An Allen-Bradley token-passing baseband link for a local area network based on the RS-485 standard.

Diagnostic — Pertains to the detection and isolation of an error or malfunction.

Diode — A device that passes current in one direction, but blocks current in the revers direction.

Disable To inhibit logic from being activated.

Display That image that appears on a CRT screen or on other image projection systems.

Display Menu The list of displays from which you select specific information for viewing.

Duty Cycle The relationship between the operating and rest times or repeatable operation at different loads.

Dynamic Braking See *Braking*.

Efficienc Ratio of mechanical output to electrical input indicated by a percentage. In motors, it is the effectiveness with which a motor converts electrical energy into mechanical energy.

EMF The initials of *electromotive forc* , which is another term for voltage or potential difference. In DC adjustable speed drives, voltage applied to the motor armature from a power supply is the EMF and the voltage generated by the motor is the counter-EMF or CEMF.

Enable To allow an action or acceptance of data by applying an appropriate signal to th appropriate input.

Enclosures Enclosure refers the housing in which the controller is mounted. Enclosures ar available in designs for various environmental conditions.

- **NEMA Type 1** – A general purpose enclosure of either a ventilated or a non ventilated variety. It is used for most indoor applications and is intended to protect against dust, light, indirect splashing and accidental human contact with the electrical circuit.

- **NEMA Type 3R** – Intended for outdoor use, primarily to provide a degree of protection against falling rain, and to be undamaged by the formation of ice on the enclosure. It is not intended to provide protection against conditions such as dust, internal condensation, or internal icing.

- **NEMA Type 4** – A watertight enclosure is required whenever the unit is subjected to a great amount of water from any angle. It is normally used in areas that are repeatedly hosed down. These enclosures are not designed to be submerged.

- **NEMA Type 7** – An enclosure designed for a hazardous location, Class 1 (air) Group D per the National Electrical Code. This hazardous environment is one in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. This enclosur shall be of such substantial construction that it will withstand the internal pressure resulting from explosions without bursting, permanently distorting o loosening its joints.

- **NEMA Type 9** – An enclosure designed for a hazardous location, Class 2 Groups F and G per the National Electrical Code. The atmosphere in which this control must operate will contain carbon black, coal or coke dust, flour, starch, or grain dust.

- **NEMA Type 12** – Designed for industrial use. The enclosure is intended fo use in applications where it is desirable to exclude such materials as cooling oil, seepage, dust, lint, fibers and filings. This is normally a non-ventilated enclosure with an oil-resistant synthetic gasket between the case and the cover. The cover is hinged to swing horizontally and is held in place with suitable fasteners which require the use of a tool.

- **JIC** – Joint Industry Conference enclosures are similar in specifications to th NEMA Type 4 and Type 12 enclosures. The most obvious difference is the way the seal is obtained. They are suitable for the abuse of the standard NEM Type 4 and NEMA Type 12 enclosures.

- **Hazardous Location–-** Enclosures normally meet some or all of the following specifications: Class I, Group D; Class II, Groups E, F, and G; NEMA Type 7 and NEMA Type 9.

  1. **Class I, Group D** – is designed to meet the application requirements of the NEC and is in accordance with the latest specifications of Underwriters Laboratories, Inc., for locations having atmospheres containing gasoline, hexane, naptha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors or natural gas.

  2. **Class II, Group E, F, and G** – is designed to meet the application requirements of the NEC and is in accordance with the UL requirements for atmospheres containing metal dust, including: aluminum, magnesium, and their commercial alloys; and other metals of similar hazardous characteristics: carbon black, coal or coke dust, flour, starch, or grain dusts.

Factory Wiring

1. Wiring completed before the product was shipped from the factory in which it was built.

2. Contrasted with *Field Wiring.*

Fault

Any malfunction that interferes with normal system operation.

Floating Ground

A circuit whose electrical common point is not at earth ground potential or the same ground potential as circuitry it is associated with. A voltage difference can exist between the floating ground and earth ground.

Forc

The tendency to change the motion or position of an object with a push or pull. Force is measured in ounces or pounds.

Frame Size

The physical size of a motor, usually consisting of NEMA designed “D” and “F” dimensions at a minimum. The “D” dimension is the distance in quarter inches from the center of the motor shaft to the bottom of the mounting feet. The “F” dimension relates to the distance between the centers of the mounting feet holes.

Frequency The number of periodic cycles per unit of time.

Front of a Motor The end opposite the coupling or driving pulley (NEMA). This is sometimes called the opposite pulley end (O.P.E.) or commutator end (C.E.).

Full-load Torque The full-load torque of a motor is the torque necessary to produce rated horsepower at full-load speed.

Gate The control element of an SCR (silicon controlled rectifier) commonly referred to as a thyristor. When a small positive voltage is applied to the gate momentarily, the SCR will conduct current (when the anode is positive with respect to th cathode of the SCR). Current conduction will continue even after the gate signal is removed.

General-purpose Motor This motor has a continuous Class "B" rating and design, listed and offered in standard ratings with standard operating characteristics and mechanical construction for use under unusual service conditions without restriction to a particular application or type of application (NEMA).

Hard Contacts Any type of physical switching contacts.

Hardware Mechanical, electrical, and electronic components and assemblies.

Horsepower A measure of the amount of work that a motor can perform in a given period of time.

Induction Moto An alternating current motor in which the primary winding on one member (usually the stator) is connected to the power source. A secondary winding on the other member (usually the rotor) carries the induced current. There is no physical electrical connection to the secondary winding, its current is induced.

Inertia A measure of a body's resistance to changes in velocity, whether the body is at rest or moving at a constant velocity. The velocity can be either linear or rotational. The moment of inertia (WK^2) is the product of the weight (W) of an object and the square of the radius of gyration (K^2). The radius of gyration is a measure of how the mass of the object is distributed about the axis of ration. WK^2 is usually expressed in units of ft.-lb.^{2}.

Input Device A digital or analog device such as a limit switch, pushbutton, pressure sensor, or temperature sensor, that supplies input data through an input circuit to a programmable controller.

Interlock

1. A switch or other device that prevents activation of a piece of equipment when a protective door is open or some other hazardous condition exists.

2. Software that inhibits execution of other software logic unless certain defined conditions exist.

Intermittent Duty (INT) A motor that never reaches equilibrium temperature (equilibrium), but is permitted to cool down between operations. For example, a crane, hoist or machine tool motor is often rated for 15 or 30 intermittent duty.

International Standards Organization (ISO)
An organization established to promote development of international standards.

Isolation Transformer
A transformer that electrically separates the drive from the AC power line. An isolation transformer provides the following advantages:

1. In DC motor applications, it guards against inadvertent grounding of plant power lines through grounds in the DC motor armature circuit.
2. Enhances protection of semiconductors from line voltage transients.
3. Reduces disturbances from other solid state control equipment such as drives without isolation transformers, time clock systems, electronic counters, etc.

Jogging
Jogging is a means of accomplishing momentary motor movement by repetitive closure of a circuit using a single pushbutton or contact element.

Joule
1. The work done by the force of one newton acting through a distance of one meter.
2. The energy required to transport one coulomb between two points having potential difference of one volt.

Jumper
A short conductor with which you connect two points.

K
$1K = 2^{10} = 1024$. A prefix used as a multiple for bits, bytes, or words in denoting size of a block of data or memory. Example: 2K bytes = 2048 bytes.

Latching Relay
A relay that maintains a given position by mechanical or electrical means until released mechanically or electrically.

LCD
Liquid crystal display, which is a reflective visual readout device commonly used in digital watches and laptop computers.

Leakage Current
In a switching device, the current that continues despite the fact that the device is turned off. This occurs with solid-state switching devices and filters for hard contact switching devices.

LED
Light-emitting diode.

Limit Switch
An electrical switch actuated by some part and/or motion of a machine or equipment contacting the switch.

Line
Conductor or set of conductors for carrying signals or power.

Locked Rotor Current
Steady state current taken from the line with a rotor at standstill (at rated voltag and frequency). This is the current when starting the motor and load.

Locked Rotor Torque
The minimum torque that a motor will develop at rest for all angular positions of the rotor (with rated voltage applied at rated frequency).

Logic — General term for digital circuits and programmed instructions to perform required decision-making and computational functions.

M

1. Mega. A prefix used with units of measurement to designate a multiple of 1,000,000.
2. 1M = 2^{20} = 1,048,576. A prefix used as a multiple for bits, bytes, or words in denoting size of a block of data or memory. Example: 2M bytes = 2,097,152 bytes.

Megger Test — A test used to measure an insulation system's resistance. This is usually measured in megohms and tested by passing a high voltage at low current through the moto windings and measuring the resistance of the various insulation systems.

Menu — A list of options, on a screen, from which a user can select.

Message

1. A meaningful combination of alphanumeric characters that establishes th content and format of a report.
2. In a communication network, the unit of exchange at the application layer.

Microprocessor — A central processing unit that is manufactured on a single integrated circuit (or on only a few integrated circuits) by utilizing large scale integration technology.

Mode — A selected method of operation. Example: run, test, or program.

Module — An interchangeable plug-in item within a larger (modular) assembly.

Motor

- **AC Motor** – is a device that converts (single or multiple phase) alternating electrical current into mechanical energy. It requires no commutation devices such as brushes.
- **DC Brushless Moto** – is a type of DC motor that uses electronic commutation rather than brushes (as standard) to transfer current.
- **DC Motor** – is a device that converts direct electrical current into mechanical energy. It requires a commutation device, either brushes or electronic.
- **DC Permanent Magnet Motor** – is a type of DC motor that uses permanent magnets to produce a magnetic field. It has linear torque-speed characteristics.
- **Stepper Motor** – is a specialized DC motor that allows discrete positioning without feedback.

Motor Controller, Motor Starter — A device or group of devices that serve to govern, in a predetermined manner, the electrical power delivered to a motor.

Multispeed Motor — An induction motor that can obtain two, three or four discrete (fixed) speeds by th selection of various stator winding configurations.

NEC The National Electrical Code are recommendations of the National Fire Protection Association and is revised every three years. City or state regulations may diffe from code regulations and take precedence over NEC rules.

NEMA The National Electrical Manufacturers Association is a non-profit organization organized and supported by manufacturers of electrical equipment and supplies. Some of the standards NEMA specifies are: HP ratings, speeds, frame sizes and dimensions, torques and enclosures.

NEMA Standards Consensus standards in the United States for electrical equipment approved by the members of the National Electrical Manufacturers Association.

Network A series of stations (nodes) connected by some type of communication medium. A network may be made up of a single link or multiple links.

Noise Unwanted disturbances imposed upon a signal that tend to obscure its data content.

Normally Closed Contacts A set of contacts on a relay or switch that are closed when the relay is de-energized or the switch is de-activated. They are open when the relay is energized or the switch is activated.

Normally Open Contacts A set of contacts on a relay or switch that are open when the relay is de-energized or the switch is de-activated. They are closed when the relay is energized or the switch is activated.

Off

1. A term used to designate the 0 state of a bit; the inoperative state of a device; the state of a switch or circuit that is open. Designated by the symbol 0.
2. The opposite of *On*.

Offline Describes equipment or devices not under direct control and not directly controlling. When equipment is either idle, undergoing repair, or performing a task under its own direction, it is said to be "off line."

On

1. A term used to designate the 1 state of a bit; the operative state of a device; the state of a switch or circuit that is closed. Designated by the symbol 1.
2. The opposite of *Off*.

Online Refers to equipment or devices that are in direct interactive communication.

Open-loop System A control system that has no means of comparing the output with the input for control purposes.

Open Machine (Motors) A machine having ventilating openings which permit passage of external cooling air over and around the winds of the machine.

- **Drip-proof Machine** – is an open type machine in which the ventilating openings are so constructed that successful operation is not interfered with when drops of liquid or solid particles strike or enter the enclosure at any angl from one to fifteen degrees downward from vertical.

- **Guarded Machine** – (NEMA Standard) is an open machine in which all openings giving direct access to live metal or rotating parts (except smooth rotating surfaces) are limited in size by the structural parts or by the screens, baffles, grills, expanded metal or other means to prevent accidental contact with hazardous parts. Openings giving direct access to such live or rotating parts shall not permit the passage of a cylindrical rod 0.75 inch in diameter.

- **Open Externally Ventilated Machine** – is one which is ventilated by means of a separate motor driven blower mounted on the machine enclosure. This machine is sometimes known as a blower-ventilated or a force-ventilated machine.

- **Open Pipe Ventilated Machine** – is basically an open machine except that openings for admission of ventilating air are so arranged that inlet ducts or pipes can be connected to them. Air may be circulated by means integral with the machine or by means external to the machine (separately forced ventilated).

- **Semiguarde** – is an open machine in which part of the ventilating openings in the machine, normally in the top half, are guarded as in the case of a"guarded machine" but the others are left open.

- **Splashproof** – is an open machine in which the ventilating openings are so constructed that successful operation is not interfered with when drops of liquid or solid particles strike or enter the enclosure at any angle not greater than 100 degrees downward from vertical.

- **Weather-protected Machine** – is an open enclosure divided into two types:

  1. **Type 1 –** enclosures have ventilating passages constructed to minimize the entrance of rain, snow, airborne particles and prevent passage of a 0.75 inch diameter cylindrical rod.

  2. **Type 2** – enclosures provide additional protection through the design of their intake and exhaust ventilating passages. The passages are so arranged that wind and airborne particles blown into the machine can be discharged without entering directly into the electrical parts of the machine. Additional baffling is provided to minimize the possibility of moisture or dirt being carried inside the machine.

Operator Interface Device
A terminal from which an operator can monitor and possibly affect aspects of the machine or process control.

Output Device

1. For a programmable controller, any machine/process load device (such as solenoid or motor starter) of a controller output circuit.

2. For a computer, a CRT terminal or printer.

Overload Capacity
The ability of the drive to withstand currents beyond the systems continuous rating. It is normally specified as a percentage of full load current for a specified time period. Overload capacity is defined by NEMA as 150% of rated full load current for one minute for *Standard Industrial DC Motors*.

PLC® Controller

1. An Allen-Bradley programmable controller.
2. An Allen-Bradley programmable controller with a name that includes th letters PLC. Se *Programmable Controlle*r.

Plugging

Plugging refers to a type of motor braking provided by reversing either line voltage polarity or phase sequence so that the motor develops a counter-torque which exerts a retarding force to brake the motor.

Port

On a communication link, the logic circuitry or software at a station that determines its communication parameters for a particular communication channel.

Power

Work done per unit of time. Measured in horsepower or watts: 1 HP = 33,000 ft.-lb./min. = 746 watts.

Power Factor

A measurement of the time phase difference between the voltage and current in an AC circuit. It is represented by the cosine of the angle of this phase difference. Power factor is the ratio of Real Power (kW) to total kVA or the ratio of actual power (W) to apparent power (volt-amperes).

Power Supply

A device that converts available power to a form that a system can use ó usually converts AC power to DC power.

Preset Speed

Preset speed refers to one or more fixed speeds at which the drive will operate.

Programmable Controller

A solid-state system that has a user-programmable memory for storage of instructions to implement specific functions such as I/O control, logic, timing, counting, report generation, communication, arithmetic, and data file manipulation. A controller consists of a central processor, input/output interface, and memory. A controller is designed as an industrial control system.

Protocol

A set of conventions governing the format and timing of data between communication devices.

Pulse

A momentary sharp change in voltage, current, or light from its quiescent condition.

Remote I/O

I/O connected to a processor across a serial link. With a serial link, remote I/O can be located long distances from the processor.

Reversing

Changing the direction of rotation of the motor armature or rotor. A DC motor is reversed by changing the polarity of the field or the armature, but not both. An AC motor is reversed by reversing the connections of one leg on the three phase power line or by reversing the leads on a single phase power line.

RS-232-C

An EIA standard that specifies electrical, mechanical, and functional characteristics for serial binary communication circuits in a point-to-point link.

RS-422

An EIA standard that specifies electrical characteristics of balanced-voltage digital interface circuits in a point-to-point link.

RS-485 An EIA standard that specifies electrical characteristics of balanced-voltage digital interface circuits in a multi-point link.

SCR Silicon Controlled Rectifier. A solid-state uni-directional latching switch.

Scrolling The vertical movement of data on a display screen caused by the dropping of one line of displayed data for each new line added at the opposite end.

Self-diagnostic A description of hardware and firmware that monitors its own operation and indicates any fault it can detect.

Serial Pertaining to time-sequential transmission of, storage of, or logic operations on data, using the same facilities for successive parts.

Service Factor (S-F) When used on a motor nameplate, a number which indicates how much above the nameplate rating a motor can be loaded without causing serious degradation (i.e., a motor with 1.15 S-F can produce 15% greater torque than one with 1.0 S-F) to adjust measured loads in an attempt to compensate for conditions which are difficult to measure or define.

Set Spee The desired operating speed.

Signal The event or electrical quantity that conveys information from one point to another.

Silicon Controlled Rectifier (SCR) A solid-state switch, sometimes referred to as a thyristor. The SCR has an anode, cathode and control element called the gate. The device provides controlled rectification since it can be turned on at will. The SCR can rapidly switch large currents at high voltages. They are small in size and low in weight.

SLC™ Controller An Allen-Bradley programmable controller with a name that includes the letters SLC. See *Programmable Controll* r.

Slip The difference between rotating magnetic field speed (synchronous speed) and rotor speed of AC induction motors. Usually expressed as a percentage of synchronous speed.

SMC Controller An Allen-Bradley Smart Motor Controller.

Special-purpose Moto A motor with special operating characteristics or special mechanical construction or both, designed for a particular application and not failing within the definition of a general purpose or definite purpose motor (NEMA).

Speed Rang The speed minimum and maximum at which a motor must operate under constant or variable torque load conditions. A 50:1 speed range for a motor with a top speed of 1800 RPM means the motor must operate as low as 36 RPM and still remain within regulation specification. Controllers are capable of wider controllabl speed ranges than motors because there is no thermal limitation, only electrical. The controllable speed range of a motor is limited by the ability to deliver 100% torque below base speed without additional cooling.

Star Connection

1. The arrangement of phase windings, in a polyphase circuit, in which one end of each phase winding is connected to a common junction. In a three-phase circuit, it is sometimes called a Y connection.

2. Contrasted with *Delta Connection*.

Status

The condition at a particular time of any numerous entities within a system. These conditions may be represented by values in a status line.

Surge Protection

The process of absorbing and clipping voltage transients on an incoming AC line or control circuit. MOVs (Metal Oxide Varistors) and specially designed R-C networks are usually used to accomplish this.

Surge Suppression

The process of absorbing and clipping voltage transients on an incoming AC line or control circuit. MOVs (Metal Oxide Varistors) and specifically designed R-C networks are usually used to accomplish this.

Surge Suppressor

A device that attenuates the magnitude of electrical noise.

Synchronous

A type of serial transmission that maintains a constant time interval between successive events.

Synchronous Speed

The speed on an AC induction motor's rotating magnetic field. It is determined by the frequency applied to the stator and the number of magnetic poles present in each phase of the stator windings. Mathematically, it is expressed as: Sync Speed (RPM) = 120 x Applied Freq. (Hz)/Number of poles per phase.

Thread Speed

A fixed low speed, usually adjustable, supplied to provide a convenient method for loading and threading machines. May also be called a preset speed.

Toggle

To switch alternately between two possible selections.

Torqu

A turning force applied to a shaft, tending to cause rotation. Torque is normally measured in ounce-inches or pound-feet and is equal to the force applied, times th radius through which it acts.

Torque Constant

(in-lbs.) This motor parameter, abbreviated as "in.-lbs." provides a relationship between input current and output torque. For each ampere of current applied to th rotor, a fixed amount of torque will result.

Torque Control

A method of using current limit circuitry to regulate torque instead of speed.

Totally Enclosed Machine (Motor)

A totally enclosed machine is one so enclosed as to prevent the free exchange of air between the inside and the outside of the case but not sufficiently enclosed to be termed airtight.

- **Dust-ignition-proof Machine** – is a totally enclosed machine whos enclosure is designed and constructed in a manner which will exclude ignitabl amounts of dust or amounts which might affect performance or rating, and which will not permit arcs, sparks or heat otherwise generated or liberated inside of the enclosure to cause ignition or exterior accumulations or atmospheric suspensions of a specific dust on or in the vicinity of the enclosure.

- **Explosion Proof Machine** – is a totally enclosed machine whose enclosure is designed and constructed to withstand an explosion of a specified gas or vapor which may occur within it and to prevent the ignition of the specified gas or vapor surrounding the machine by sparks, flashes or explosions of the specified gas or vapor which may occur within the machine casing.

- **Totally Enclosed Air-over Machin** – is a totally enclosed machine intended for exterior cooling by a ventilating means external to the machine.

- **Totally Enclosed Fan-cooled** – is a totally enclosed machine equipped for exterior cooling by means of a fan or fans integral with the machine but external to the enclosing parts.

- **Totally Enclosed Fan-cooled Guarded Machine** – is a totally enclosed fan-cooled machine in which all openings giving direct access to the fan are limited in size by the design of the structural parts or by screens, grills, expanded metal, etc., to prevent accidental contact with the fan. Such openings shall not permit the passage of a cylindrical rod 0.75 inch in diameter, and a probe shall not contact the blades, spokes or other irregular surfaces of the fan.

- **Totally Enclosed Water-air-cooled Machine** – is a totally enclosed machine which is cooled by circulating air which, in turn, is cooled by circulating water. It is provided with a water-cooled heat exchanger for cooling the internal air and a fan or fans, integral with the rotor shaft or separate, for circulating th internal air.

- **Totally Enclosed Water-cooled Machine** – is a totally enclosed machine which is cooled by circulating water, the water or water conductors coming in direct contact with the machine parts.

- **Waterproof Machine** – is a totally enclosed machine so constructed that it will exclude water applied in the form of a stream from a hose, except that leakag may occur around the shaft provided it is prevented from entering the oil reservoir and provision is made for automatically draining the machine. The means for automatic draining may be a check valve or a tapped hole at the lowest part of the frame which will serve for application of a drain pipe.

Transient A momentary deviation in an electrical or mechanical system.

UL Underwriters Laboratories (an approval agency).

Work A force moving an object over a distance. Measured in inch-ounces (in.-oz.) o foot-pounds (ft.-lbs.) . Work = force times distance.

Y Connection See *Star Connection.*

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