

# Wye-delta and Solid-state Starters

## Explanation and Assistance for Applying Solid-state Soft Starters in Traditional Reduced-voltage Applications

Bulletin 150

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## Summary of Changes

This publication removes references to the SMC™ Delta soft starter and replaces it with the SMC-50 soft starter.

## Introduction

The theory of applying reduced voltage to a motor to alter the motor torque and power consumption characteristics has existed for many years. These concepts have flourished due to the need to limit torque and limited generator/power distribution capabilities. Energy conservation initiatives have forced local governments to place mandatory reduced-voltage starting requirements on motors rated at 7.5 Hp (5.5 kW) and larger.

You can accomplish reduced-voltage starting through various methods, including part winding, wound rotor, auto-transformer, wye-delta, or solid-state. While many of these techniques require specialty motors or special system components, the wye-delta and solid-state methods are the simplest to apply. Applications that are used in the United States differ, but over the years the dominant method worldwide has been the wye-delta or star-delta starting technique.

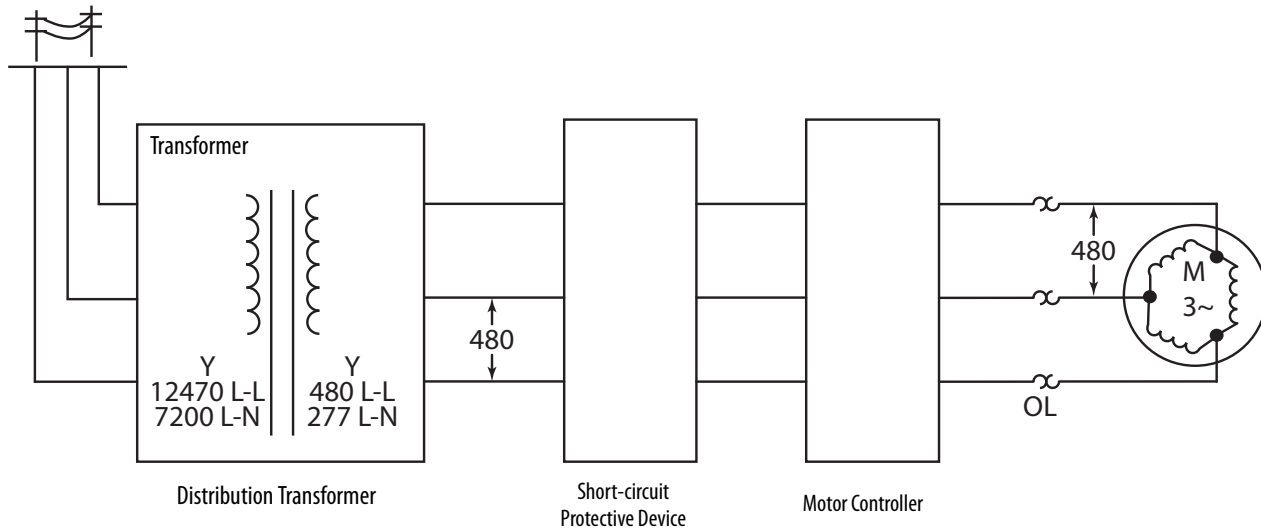
The latest generation of soft starters and Smart Motor Controllers (SMCs) offers significant advantages over its predecessors when it comes to using it in wye-delta applications. In most cases, you can use these solid-state products to replace or retrofit any of the traditional reduced-voltage methods. We have designed the SMC product line to take full advantage of solid-state technology and advanced features. This design allows the controller to provide a cost-effective modular solution to both new and existing reduced-voltage applications.

## Power Distribution Terminology

Approximately 75% of global power systems are supplied as wye power from the transformer. Whether the power is supplied as wye or delta makes little difference to the system starter components, provided there is an appropriate voltage potential and phase relationship present. [Figure 1](#) illustrates a simple connection scheme of the incoming utility power through the motor. Remember that there are many different configurations throughout the world, but a wye-configured system operating at 380 ...415V is the most common. In the United States, both wye and delta power systems are used, and range from 240... 480V AC.

When we use the term “wye-delta motor configuration” in this document, we are referencing how the motor windings are connected to the power system. As we discuss, the physical connection of these windings has an effect on the actual applied voltage to the windings, regardless of the power configuration from the transformer.

**Figure 1 - Simple System Line Diagram—Wye-connected Power Transformer and Delta-connected Motor**



### Traditional Design Theory

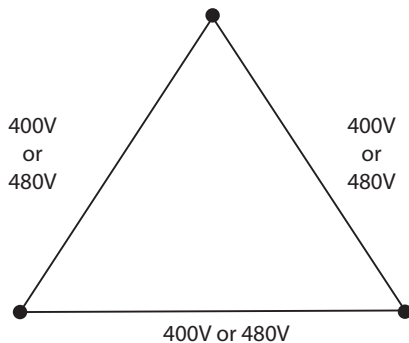
By definition, wye-delta is a traditional electromechanical method of reducing the voltage applied to the motor during starting. This method has significant advantages over conventional full-voltage starting; the disadvantage is that it requires more panel space, more components, and, most importantly, a motor that has all its winding terminations available to the outside so that you can create the wye connection.

While we use the term “reduced-voltage starter” for the wye-delta starting method, the full line voltage is still being applied to the motor leads. The reduced voltage occurs because of the electrical characteristic of the wye vs. delta relationship.

### Delta Connection

The delta configuration shown in [Figure 2](#) shows the resulting applied voltage on a delta connection. The delta connection is the most common way a motor is connected for direct-on-line, full-voltage starting. The motor windings are designed to operate at the nominal full-voltage rating, which is 400V outside the United States or 480V within the U.S.

**Figure 2 - Voltage on Delta Connection**



As an example let's examine the electrical characteristics of a 15 kW/20 Hp 1800 RPM motor. The full load current is approximately 30 A at 400V or 26 A at 480V. If we assume that the nominal starting current is 600% of full load current, then the resulting inrush current during starting is about 180 A/156 A respectively. The resulting starting torque would be 100% of the motor nominal full-load torque.

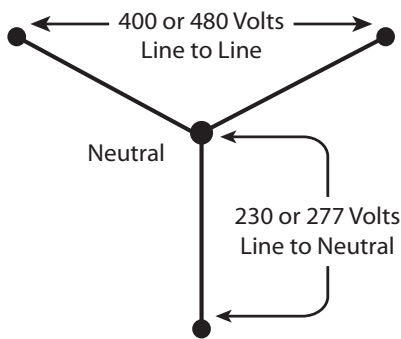
### Wye Connection

With the windings in a wye connection, the full voltage applied line to line is the same as a delta configuration, but the voltage across the individual motor windings is reduced as shown in [Figure 3](#). The voltage is reduced by the inverse of the square root of 3 or 57.7% of full voltage.

$$\text{Starting Voltage Reduction} = \frac{480V}{\sqrt{3}} = \frac{480}{1.73} = \left(\frac{1}{1.73}\right) \times 480 = (0.577) \times 480 = 277V$$

For power systems with a Line to Line (L to L) voltage of 400V or 480V, the actual voltage across the motor windings is the Line to Neutral (L to N) voltage of 230V or 277V, respectively.

**Figure 3 - Voltage on Wye Connection**



The effect of applying reduced voltage across the windings during starting can be explained by our example. With the wye connection, the starting current is proportional to the voltage reduction, therefore:

$$\text{Starting Current Reduction} = \left(\frac{\text{LRA}}{1.73}\right) \times 57.7\% = \left(\frac{156}{1.73}\right) \times 57.7\% = 51 \text{ A}$$

Using the information (LRA = 180 A/156 A), the wye connection current would be approximately 60 A for 400V or 51 A for 480V. It is easy to notice the large reduction in current. However, the result of the reduced voltage also means that some starting torque is sacrificed. The reduction in torque would be approximately equal to the square of the reduction of voltage across the motor windings, or:

$$\text{Starting Torque Reduction} \propto (\%V^2) = (.577^2) \times 100\% = 33\% \text{ of full load torque}$$

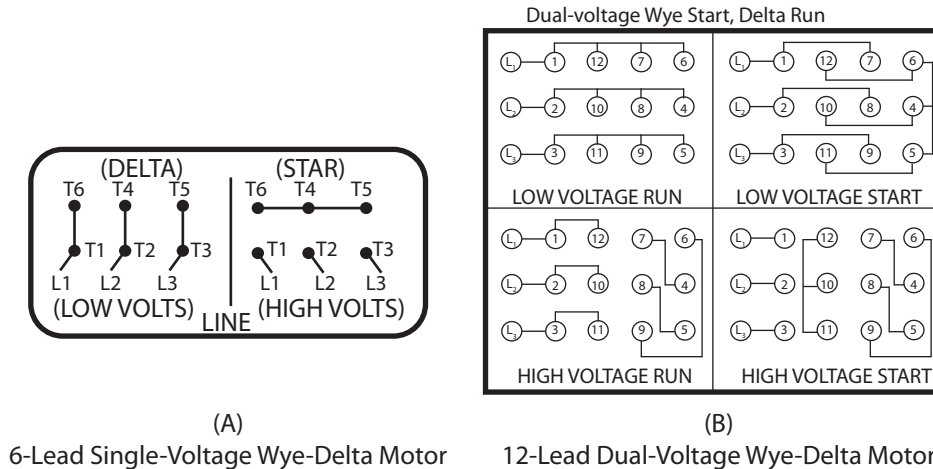
### Motor Identification

Whether the application is new or existing, it can be easy to identify wye-delta connected motors. The motor nameplate and connection diagram typically indicate wye-delta or star-delta, but there may also be references to low volts and high volts. The most common voltage combinations are 220/380V AC and 277/480V AC.

A single-voltage wye-delta motor typically has six leads that are marked T-1 through T-6. In comparison, a standard single-voltage delta motor has three leads that are marked T-1 through T-3. For dual-voltage motors, the wye-delta motor

has 12 leads marked T-1 through T-12; the standard delta motor has nine leads that are marked T-1 through T-9. [Figure 4](#) shows two common connection diagrams for both a six-lead, single-voltage wye-delta motor and a 12-lead, dual-voltage wye-delta motor.

**Figure 4 - Sample Motor Nameplate Diagrams**

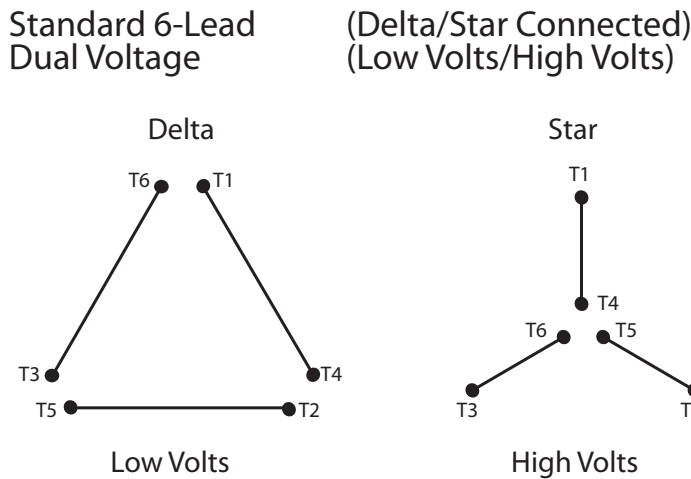


While investigating existing applications, examine the installed starter and take special note of the number of contactors and overload relays. Most traditional wye-delta starters have three contactors (two typically the same size and one slightly smaller) along with one overload. Remember that there are other possible six-lead motor configurations such as two-speed motors, which have two overload relays. In these cases, you can compare the system components to the schematics shown starting with [Wiring Diagrams on page 14](#) and look for other key indicators, like operating voltage, nameplate information, and available connection diagrams.

Though these are the most common configurations, there is no limit to the number of variations or special motors that could exist. Therefore, in addition to the physical information, it is important to realize that 80% of standard IEC-style 50 Hz motors have six or 12 leads and are designed for wye-delta starting. Less than 1% of standard 60 Hz NEMA-style motors are wired wye-delta and most are custom order items, unless they are than the 200 Hp frame size. At that size, many manufactures make the connections standard.

The diagram shown in [Figure 5](#) represents a common connection diagram taken from an actual six-lead motor. In this case all of the wires would be available at the terminal or conduit box. The first phase leads are numbered T1 and T4. The second phase T2 and T5, and the last is numbered T3 and T6.

**Figure 5 - Sample Wye-Delta Connection Diagram**



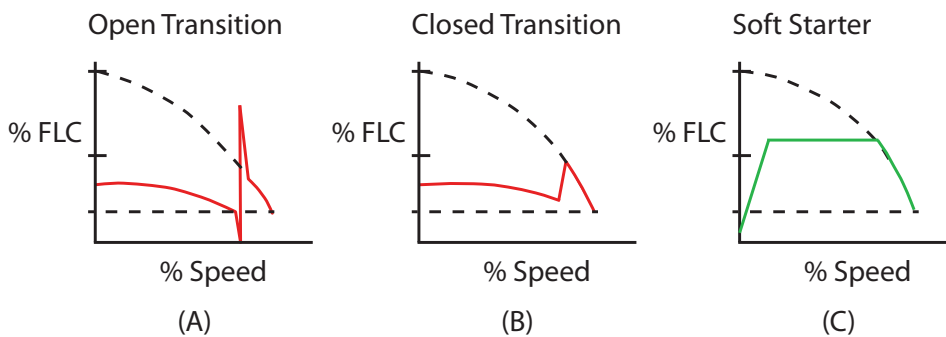
As noted in [Figure 4](#) (A) for connecting the motor for full voltage, leads 1 and 6 are connected together, forming T1 and are connected to L1. Correspondingly leads 3-5 and 2-4 are connected together, forming T3 and T2, respectively. When you connect the motor for reduced voltage and starting current, you must connect the leads in the wye or star configuration. By connecting the motor in the star connection, leads 4, 5, and 6 are tied together and leads T1, T2, and T3 are connected to L1, L2, and L3. While these are common connections, always check with the motor manufacturer or the user manual to confirm the connections are the same before you apply power.

### Electromechanical Wye-Delta vs. Solid-State Starters

The most widely used configuration of the electromechanical wye-delta starter is referred to as open transition. The typical circuit includes three separate contactors, an overload relay, a timer, and an interlock. A sample wiring diagram is included as [Figure 9 on page 14](#).

The term open transition is used to describe this method because the motor is momentarily disconnected from the line when changing from the wye to the delta configuration. This method has one important disadvantage. Depending on the loading of the motor and the timing of this transition, the resulting surge in current and torque could produce electrical and mechanical shocks on the system. In some cases the instantaneous current peaks can exceed even the locked rotor current for short durations. [Figure 6](#) (A) shows this effect graphically. Electrically the consequence of the instantaneous peaks could be power fluctuations or losses. Mechanically the increased torque resulting from the current spike could be enough to damage system components (for example, snap a drive shaft).

**Figure 6 - Current and Speed Relationship for Various Reduced-voltage Methods**



An alternate method to open transition wye-delta starting is called closed transition. The theory of operation is identical with the addition of a few components that are required to help eliminate or reduce the surge associated with the open transition. The additional components include a contactor and few power resistors. The advantage of this method can be seen in [Figure 6 \(B\)](#) as the transition surge is virtually gone, while the disadvantage is that it needs additional components, panel space, and power consumption. A sample diagram of this circuit is provided as [Figure 10 on page 14](#).

The solid-state starters offer another technique of reduced-voltage starting. The use of solid-state electronics to control the voltage, and then provide transitionless starting has been employed throughout industry since the 1980s, as shown in [Figure 6 \(C\)](#). Solid-state starters, often referred to as soft starters, have primarily been used on three-lead, delta-connected motors. However, you have always been able to apply these devices to six-lead motors. Wye-delta starters reduce the voltage to the motor through an electrical relationship and physical connection, while solid-state starters reduce the voltage electrically. By offering this connection option, all six motor leads are brought back to the control just like they are with an electromechanical wye-delta starter. However, the motor is actually always connected in a delta configuration, and that means the starting line current-to-torque ratio is different than that of a traditional wye-delta starter.

For a soft starter to replace a wye-delta starter, the soft starter must reduce torque or limit current during the wye or start mode and then switch to full voltage after a fixed time. You can meet these requirements by using the “current limit” mode of soft starting for a specified period of time. In addition, the electromechanical wye-delta starter has one fixed output (57.7% voltage), but the soft starter current limit mode allows several output levels that you can adjust to match the load requirement. The starting torque to current ratio for a soft starter that is wired to a six-lead motor varies as the square of the ratio of soft start starting current level ( $I_{cl}$ ) divided by the full-voltage starting current ( $I_{LRA}$ ).

$$\text{Starting Torque Reduction} \propto \left( \frac{I_{cl}}{I_{LRA}} \right)^2 \times 100\%$$

[Table 1](#) shows the torque output of a motor with a full-voltage starter, traditional wye-delta starter, and a soft starter at various current limit settings.

**Table 1 - Starting Torque and Currents**

Starting Type	% Voltage Applied During Start	% Full Load Starting Torque	% Full Load Rated Current
Full Voltage	100	100	600
Wye-delta Starting	58	33	200
Soft Start with various <b>current limit</b> settings			
150%	25	6	150
200%	33	11	200
250%	42	18	250
300%	50	25	300
350%	58	34	350
400%	67	49	400
450%	75	56	450

## Solid-State Starting Advantages

The latest extensions of the Rockwell Automation line of solid-state starters are the SMC-3, SMC Flex, and SMC-50. These products are designed to offer the basic functions of an electromechanical wye-delta starter, the reliability of solid-state starting, advanced motor protection, closed transition starting, and significantly smaller mounting panel space than both electromechanical and previous solid-state starters.

One perceived disadvantage is the fact that the current to torque ratio is less with a solid-state starter than with a traditional electromechanical starter. If we look again at [Table 1](#), the soft start must be set up for 350% current limit to provide the equivalent starting torque produced in the traditional wye-delta arrangement. The reason for this is the motor has a slightly different torque characteristic while connected in the wye for starting, as compared to being connected in the delta. The electromechanical starter connected in the wye configuration draws 1/3 the line current which results in 33% of the starting torque. Referring to the example used earlier for a 15 kW/20 Hp motor, the wye connection current would be 60/51 A at 400/480V and 33% of the full load torque at starting. With the SMC controller, a 350% current limit is required to obtain the same torque output (34% FLT) from the motor, which results in current of 105/90 A at 400/480V.

$$T\% \propto \left(\frac{350\%}{600\%}\right)^2 \times 100\% = 34\%$$

The electromechanical wye-delta starter actually provides more torque per line ampere than the solid-state starter; however, the torque is fixed at 33% of the normal starting torque. The adjustability of the SMC controller lets you more closely match the torque requirements of the system to the motor, providing better control and longer life of the mechanical components.

The solid-state soft starter is inherently a closed transition device and provides “transitionless” starting because the motor connection is never removed. The advantages of this starting method include the reduction in components, space requirements, and the cost required to minimize the torque and current surges that occur when you switch from start to run mode.

Some solid-state starters come standard with a built-in bypass contactor. This contactor maximizes power-handling capabilities of the product by using the silicon-controlled rectifiers (SCRs) to handle the currents that are required for starting and using the bypass contacts to minimize power losses during running. Heating during running is the same as with an electromechanical starter, so using this feature helps to minimize the enclosure size because it requires no extra panel space.

Another significant advantage of using a solid-state starter is the additional functionality and built-in diagnostic capabilities. Protection features such as overload, underload, jam/stall, ground fault detection, phase loss, open load, phase unbalance and shorted SCR are just a few of the available features. The device can also protect itself from excessive duty cycles or long starting times with internal over-temperature protection. Some products offer communications capabilities that allow them to share real-time status and telemetry information with various SCADA and information systems.

The most influential driver is the cost associated with applying a starter to a motor. While breaking down the costs it is important to remember that the traditional wye-delta starter still requires a motor with a six-lead motor connection. Most European style motors have no additional costs for this feature, but NEMA style motors carry a cost adder of about 20% on 180T frame (5 Hp) to 1% on a 449T frame (300 Hp). In comparison, a soft starter solution is 5...20% more than a standard full-voltage or wye-delta starter depending on the size. The cost differences become less as the motor size increases; however, the functionality and features increase dramatically. A standard full-voltage starter offers zero features, while a solid-state solution provides advanced motor control, maximum adjustability, diagnostics, and built-in protective features.

Though cost savings can be difficult to quantify, the installation alone can produce savings. A common thought is that it is more expensive to run six leads to a motor than three. While there is an additional cost to run more leads, the costs associated with the installation are negligible when you compare them to the savings that you can achieve using the smaller SMC controller in the inside-the-delta configuration.



While the advantages and enhanced features of the SMC product line are impressive, it is equally important to remember that it still has all of the traditional advantages of reduced-voltage starting, such as the mechanical torque and electrical reduction benefits. These alone can yield additional savings in terms of system maintenance and proactive detection of problems.

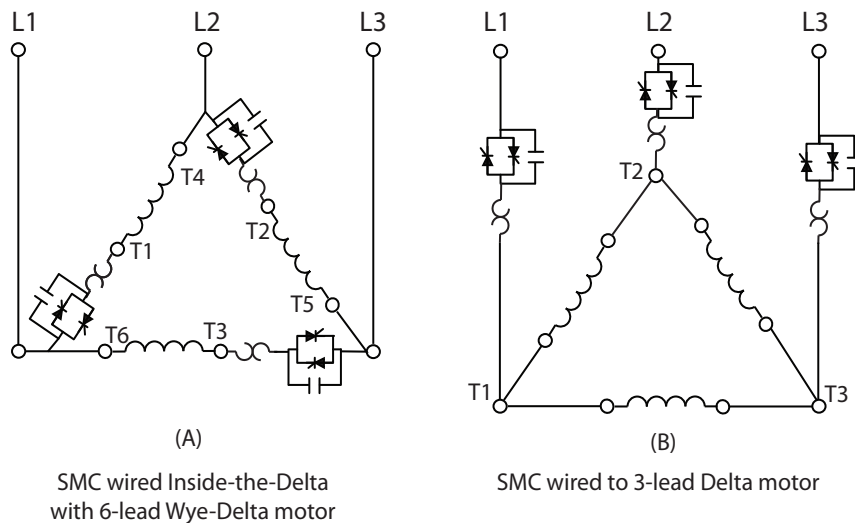
## Solid-State Starters for Wiring Inside-the-Delta

By designing solid-state products such as the SMC-3, SMC Flex, and SMC-50 to be wired inside-the-delta, increased Hp (kW) capacity can be achieved through the standard product offering. Remember that the actual current handling capacity of the device and physical connection does not change, but is due to the physical and electrical relationships of a six-lead motor.

### Sizing

[Figure 7](#) depicts the differences between inside-the-delta and outside the delta wiring. In [Figure 7\(B\)](#) each SCR and bypass is exposed to a portion of the total current draw of both motor windings attached at each corner of the delta. The inside-the-delta wiring shown as [Figure 7 \(A\)](#) shows how each SCR and bypass contactor is only subjected to the current of one winding. This value, as explained earlier, is equal to the full load current divided by 1.73.

**Figure 7 - Inside-the-Delta vs. Delta**



As an example, the 480 A SMC Flex is capable of handling a motor connected wye-delta with a FLA of up to 831 A ( $480 \times 1.73$ ). This increase in current-carrying capacity translates directly into an increase in Hp. [Table 2](#) shows the maximum Hp and kW supported for several SMC controller current ranges based on the connection configuration.

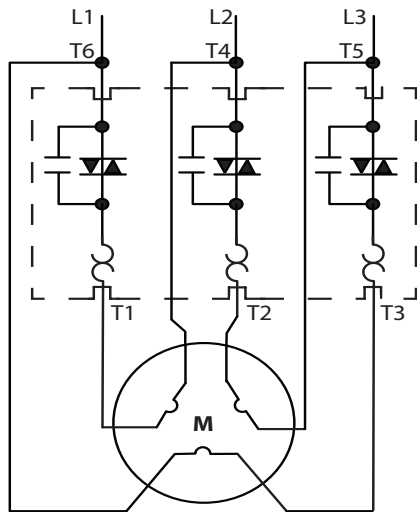
**Table 2 - Horsepower Capacity of Soft Starters**

	Current Capacity		Max Hp @ 460V AC		Max. kW @ 380V AC	
	Standard	Wye-Delta	Standard	Wye-Delta	Standard	Wye-Delta
Connection	3	3	1.5	1.5	1.1	1.1
	9	9	5	5	4	4
	16	16	10	10	7.5	7.5
	—	20	—	10	—	7.5
	—	25	—	15	—	11
	19	32	15	20	7.5	15
	30	51	20	30	15	22
	37	64	25	40	18.5	30
	43	74	30	50	22	37
	60	104	40	75	30	55
	85	147	60	100	45	75
SMC Flex	108	197	75	125	55	90
	135	234	100	150	75	132
	201	348	150	250	110	160
	251	435	200	350	132	250
	317	549	250	450	160	315
	361	625	300	500	200	355
	480	831	400	600	250	450

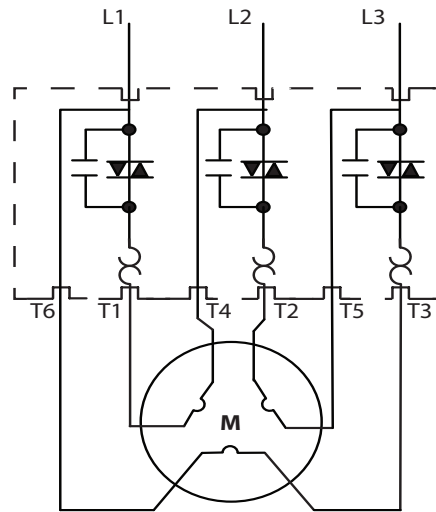
Most increases in power capacity occur at the higher current range offering of each product. This is primarily due to the integration of the overload into the product. The overload current adjustment for a particular product must match the nominal FLA currents of the supported Hp (kW) range. Whether the application is being retrofitted or new, it is important to follow the selection tables for open delta connected controllers.

**Connections and Setup**

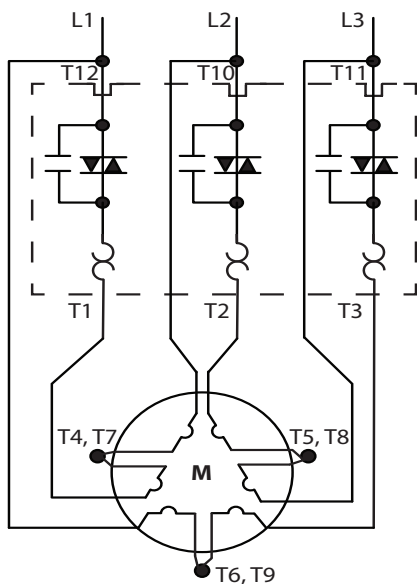
Wiring of the SMC-3 and SMC Flex is simple due to several product enhancements that aid the connection process. You can wire connections almost the same as a conventional wye-delta starter. [Figure 8](#) provides simple power wiring diagrams for both six-lead and 12-lead motors. There is a slight difference between the wiring of the two devices, with the SMC Flex having an internal connection to the line side located on the load side. The leads T4 - T6 and T10 - T12 of the SMC-3 and SMC-50 controllers are connected on the line side of the controller. Additional wiring diagrams with sample control wiring begin on [page 14](#).

**Figure 8 - Sample Power Wiring Diagrams**

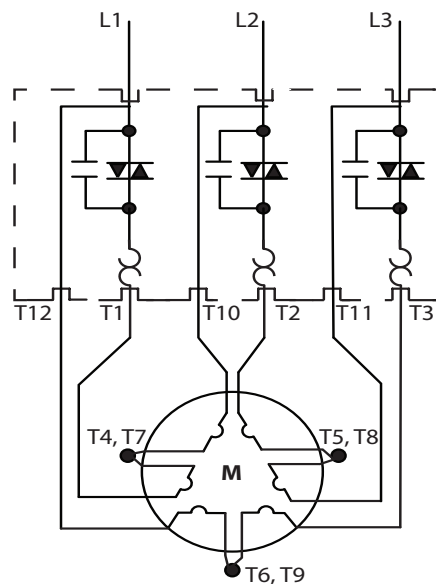
SMC-3 and SMC-50 with 6-lead motor



SMC Flex with 6-lead motor



SMC-3 and SMC-50 with 12-lead motor



SMC Flex with 12-lead motor

Connecting the three incoming power lines, the six or 12 motor leads, and as few as two control wires for two-wire control or three control wires for three-wire control can complete the wiring. Enhancements such as locating the power terminals conveniently on the unit and the elimination of costly inter-wiring helps to reduce panel space requirements and provides saving significant time in wiring.

Since these starters are designed to replace standard wye-delta starters once the connections have been made, simple operation can be accomplished by setting the following starting mode characteristics.

- Start Mode — Current Limit (For typical wye-delta application this may be 350%)
- Start Time — Desired Start Time (Consult the factory for extended start time capabilities)
- Overload — Desired Overload class (Class 10 common for IEC motors, Class 20 for NEMA)
- FLA Setting — Set the motor's full load current (Found on motor nameplate)

With these minimal settings and connections, the product can provide all the functions required to replace a traditional wye-delta starter, as well as provide all the proper motor protection. Additional functionality and advanced features can be configured by referencing the specific product user manual, but are not required for the basic setup.

## Application Examples

Since the SMC-50 soft starter was designed to be used in the same type of applications as electromechanical wye-delta starters, let's review the ideal reduced-voltage starting applications.

Controlling the motor torque is a prime application consideration when you apply solid-state starters. When motor torque exceeds the system requirements, it can cause extreme wear and reduced life of mechanical components. Failure of components, such as couplings, gears, chains, sprockets, and belts, leads to unscheduled shut downs and lost production. The SMC-50 soft starter provides fully adjustable starting current levels from 50 to 600%. Applications that require controlling the starting torque are in many industries, including material handling; heating, ventilation, and air conditioning (HVAC); mining; and wastewater treatment, where the main applications are fans, pumps, conveyors, and compressors.

The HVAC industry is a prime environment for the application of solid-state starters due to the history of using the wye-delta motor starting method. Air handling and centrifugal loads make up the majority of system components and most consist of large Hp motors. A solid-state starter serves as an ideal replacement for legacy applications while offering contractors and original equipment manufacturers savings in terms of wiring and installation time and space.

Every industry has applications where the advantages of solid-state starters can be realized. Even simple fan applications have low starting torque requirements. Fans can be either directly connected to the motor or belted. The fans that are belted usually require torque control during starting to help eliminate or reduce excessive belt wear as a result of slippage during across the line starting. Pumps also have low starting torque profiles. The initial torque and acceleration torque can be critical in some pumping applications and is usually determined by the design of the pump. Some pumps, such as those with long shafts connecting the motor to the pump, may be damaged if the starting torque is too high. The need to control the acceleration torque is evident where shock and vibration are created in the pumping system when the pump starts at full voltage. In some cases, the Pump Control or Linear Acceleration option in the SMC-50 controller helps to significantly reduce the "water hammering" effect found in large systems.

Like fans and pumps, some types of compressors need low torque to accelerate to full speed. Reciprocation compressors require high starting torque especially when starting under load. Other types such as centrifugal and axial vane type require low starting torque because of the design characteristics. These are typically started unloaded and are perfect candidates for reduced-voltage starting.

For other types of applications, reduced-voltage starting may be necessary to limit inrush currents instead of controlling torque. The need to limit the inrush current may be due to government mandates, power company restrictions or distribution system limitations. Operation in areas that are adjacent to or within a residential area may need to limit current during starting to help eliminate voltage drops that cause light flicker. A good example of this is on pumps for hydraulic elevators in an apartment complex. These pumps have low starting torque requirements, so limiting current during starting minimizes any line sags that would have occurred if the pump was started direct on line.

In instances where limiting the current is more critical than torque, the electromechanical wye-delta starter has only one setting — 200% current limit. The SMC-50 controller is fully adjustable. With this adjustment, it is possible to select a level that meets the specific needs of each application while still allowing sufficient torque available at the reduced level to accelerate the load.

## Important Application Considerations

The latest SMC products have built-in overload protection, and most products also have an integral bypass contactor. Select them according to the motor to which they are being applied. Because the bypass is built in, the increased thermal capacity requirement of some applications does not require the SMC controller to be oversized. One exception is due to the decreased efficiency of fans and heat sinks, it may be necessary to de-rate the SMC products for applications above 6,500 feet (2000 m). In most cases, choosing the next size product provides enough thermal capacity to guard against the potential of over-temperature trips. However, it is important to make sure that the motor full load current (FLA) still falls into the devices acceptable FLA adjustment range.

Soft starters can be successfully applied on a wide range of applications which require the controlling (limiting) of torque or the reduction of inrush current. A common and more costly alternative to a soft starter is a Variable Frequency Drive (VFD), which differs in both the theory of operation and functionality. Drives can completely manage the motor torque at any speed. Soft starters only provide control in the form of reduced torque and reduced current during starting. As identified earlier, applications that have low initial torque demands are ideal for using these products.

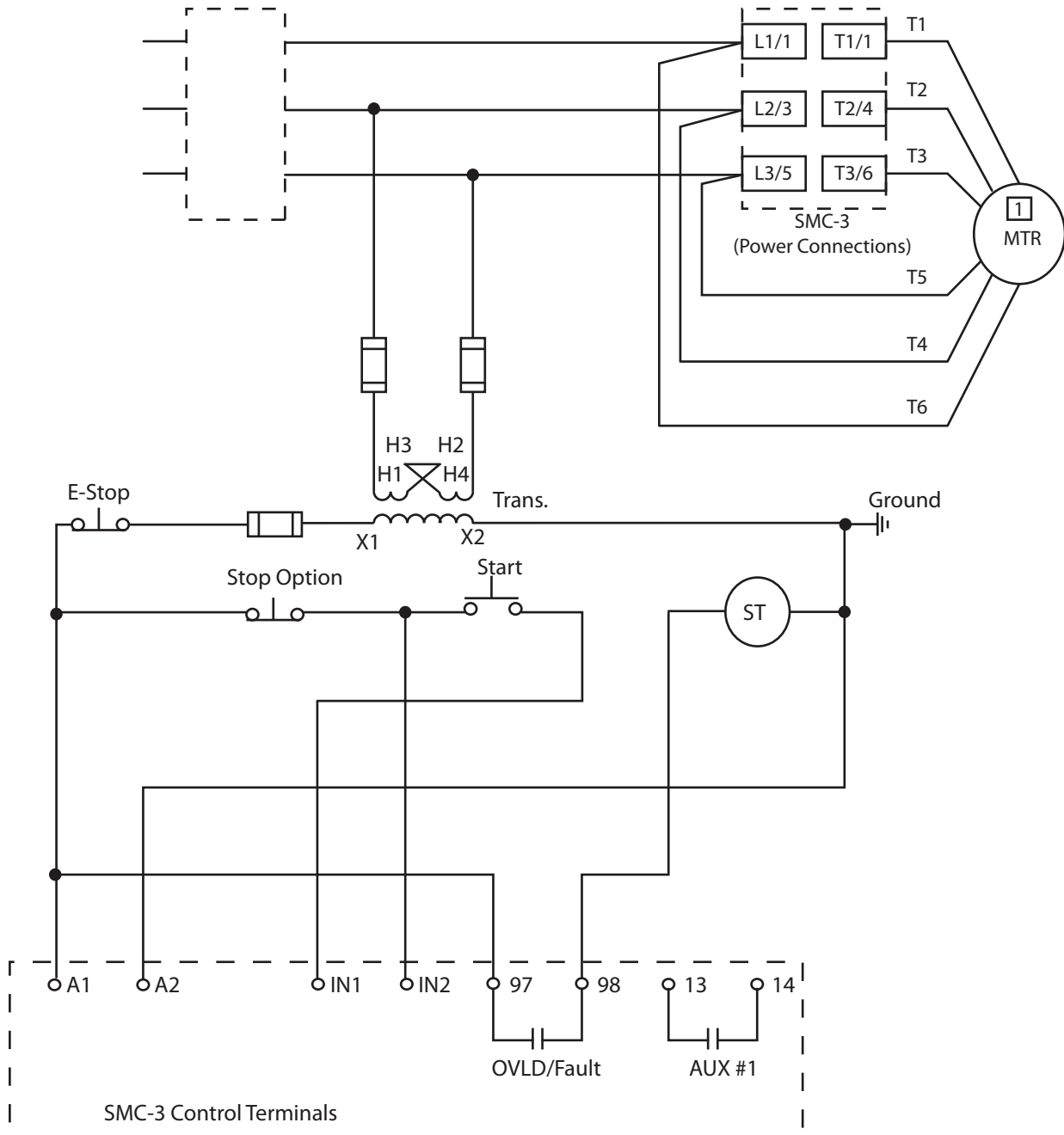
The time it takes the motor to accelerate the load to full speed is crucial. When the transition from start to run takes place before the motor is up to speed, there is a surge in current much like an open transition. Since the SMC controllers are closed transition, they do not switch to the bypass contactor until the current has fallen below 120% of the motors full load current. If the programmed start time has elapsed and the motor has not reached rated speed, the device continues to run with the SCRs operating at full voltage until the current drops below the 120% threshold. During this time the motor and SMC controller is subjected to increased thermal energy, which could result in an overload trip, branch circuit trip, or an internal over-temperature fault. The easiest way to avoid this problem is to verify that the ramp time is long enough to accelerate the load to full speed before the device transitions. If limiting the starting time is the concern, then the current limit level should be increased to bring the motor up-to-speed faster.

The use of a soft starter wired inside-the-delta means that a portion of the motor windings are connected to line power at all times. This differs from other Soft Starter products where the voltage at the terminals was mainly due to the leakage current of the solid-state switching devices (SCRs). As always, take care when you work in and around the motor connections and leads.

In some instances where the SCR is shorted or the motor is defective, the breaker upstream could be instantaneously tripped off line when power is applied. Two common methods for offering line isolation during this occurrence adding a shunt trip unit on the circuit breaker, or adding an isolation contactor. Both methods make certain that power is disconnected from the SMC controller and load when the controller senses a fault condition. Wiring diagrams of the two options are shown in [Figure 11 on page 15](#) through [Figure 16 on page 20](#). If you select an isolation method, size the contactor for the FLA current of the motor.



Figure 11 - SMC-3 Controller Wiring Diagram: Three-Wire Control Shunt Trip Circuit Breaker



**Figure 12 - SMC-3 Wiring Diagram: Three-Wire Control with Optional Isolation Contactor**

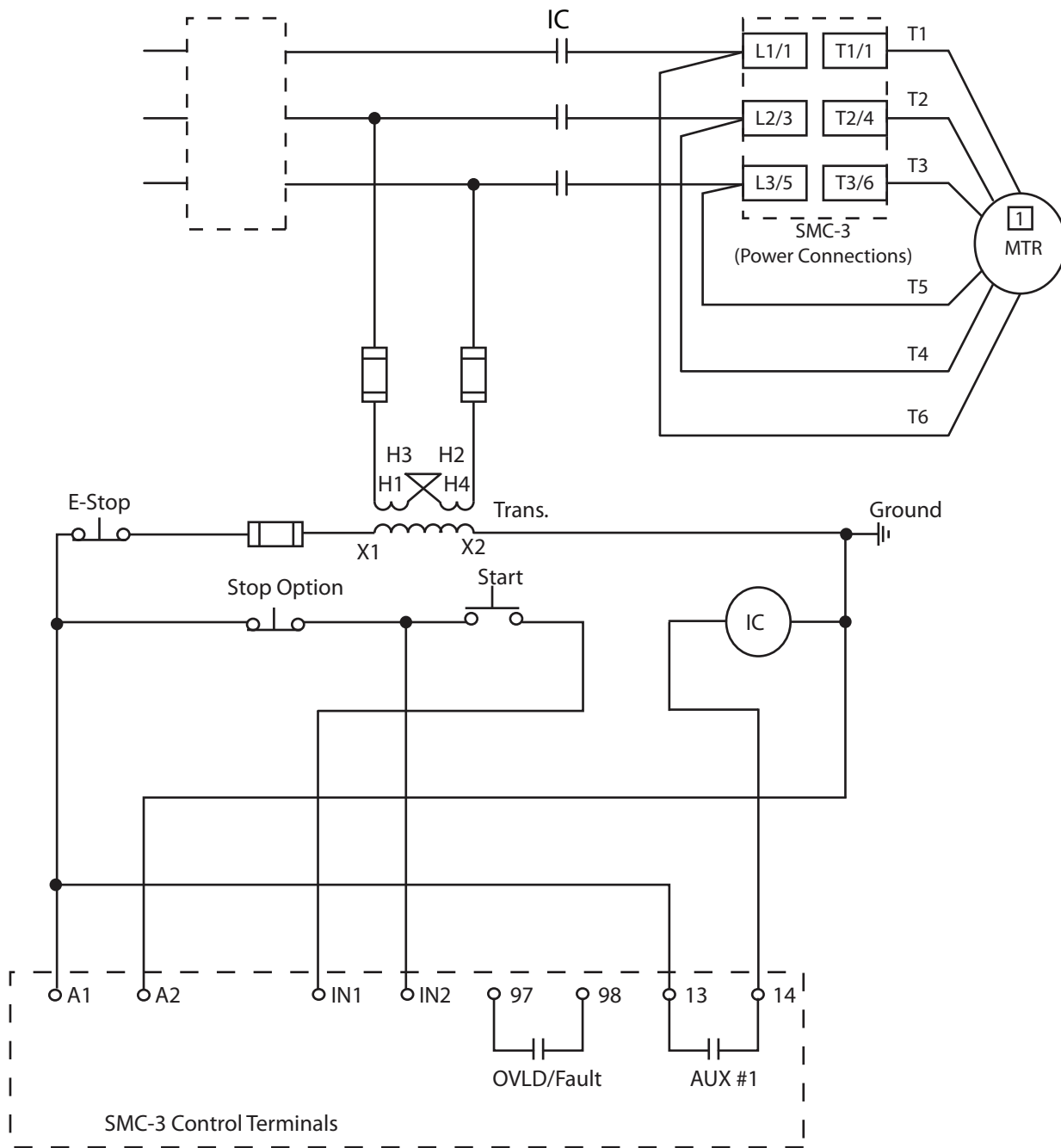




Figure 13 - SMC Flex Wiring Diagram: Three-wire Control with Optional Isolation Contactor

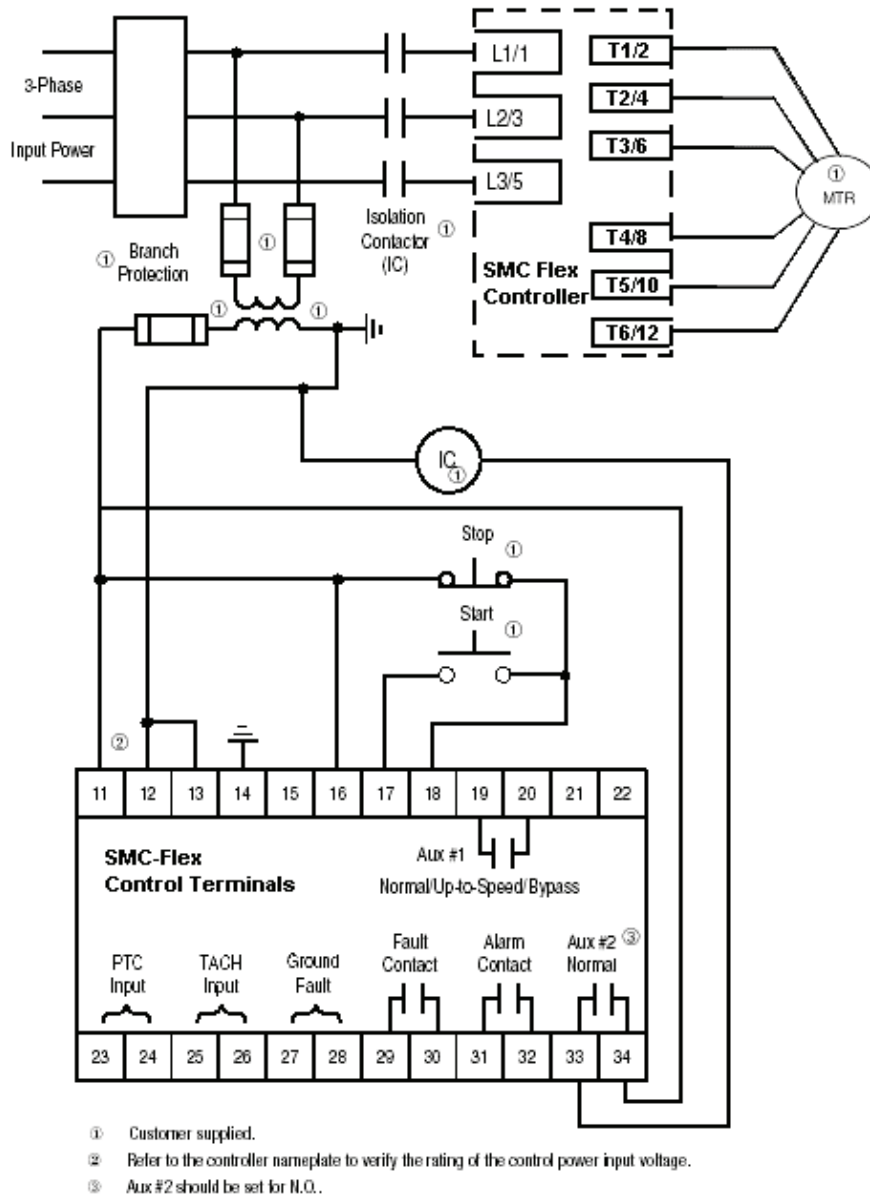
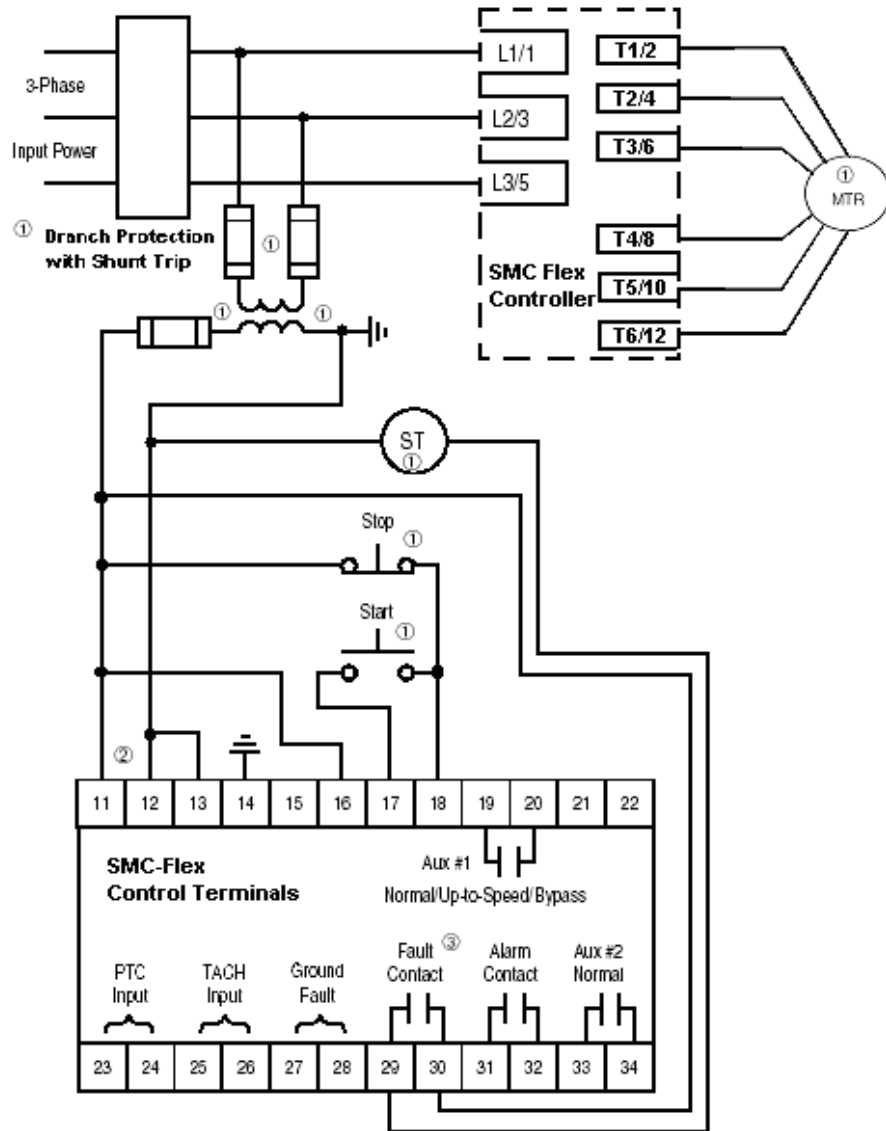
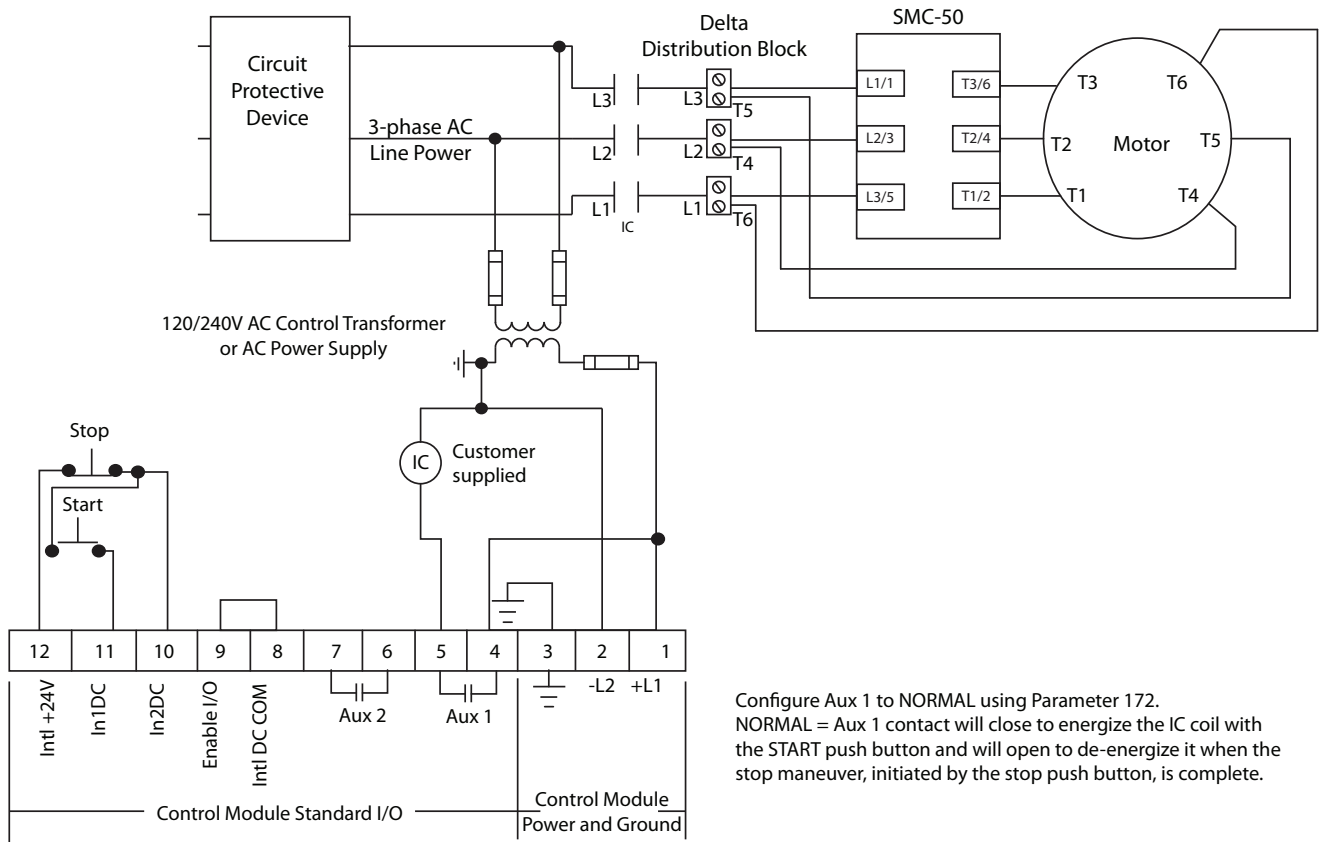


Figure 14 - SMC Flex Wiring Diagram: Three Wire Control with Shunt Trip Circuit Breaker



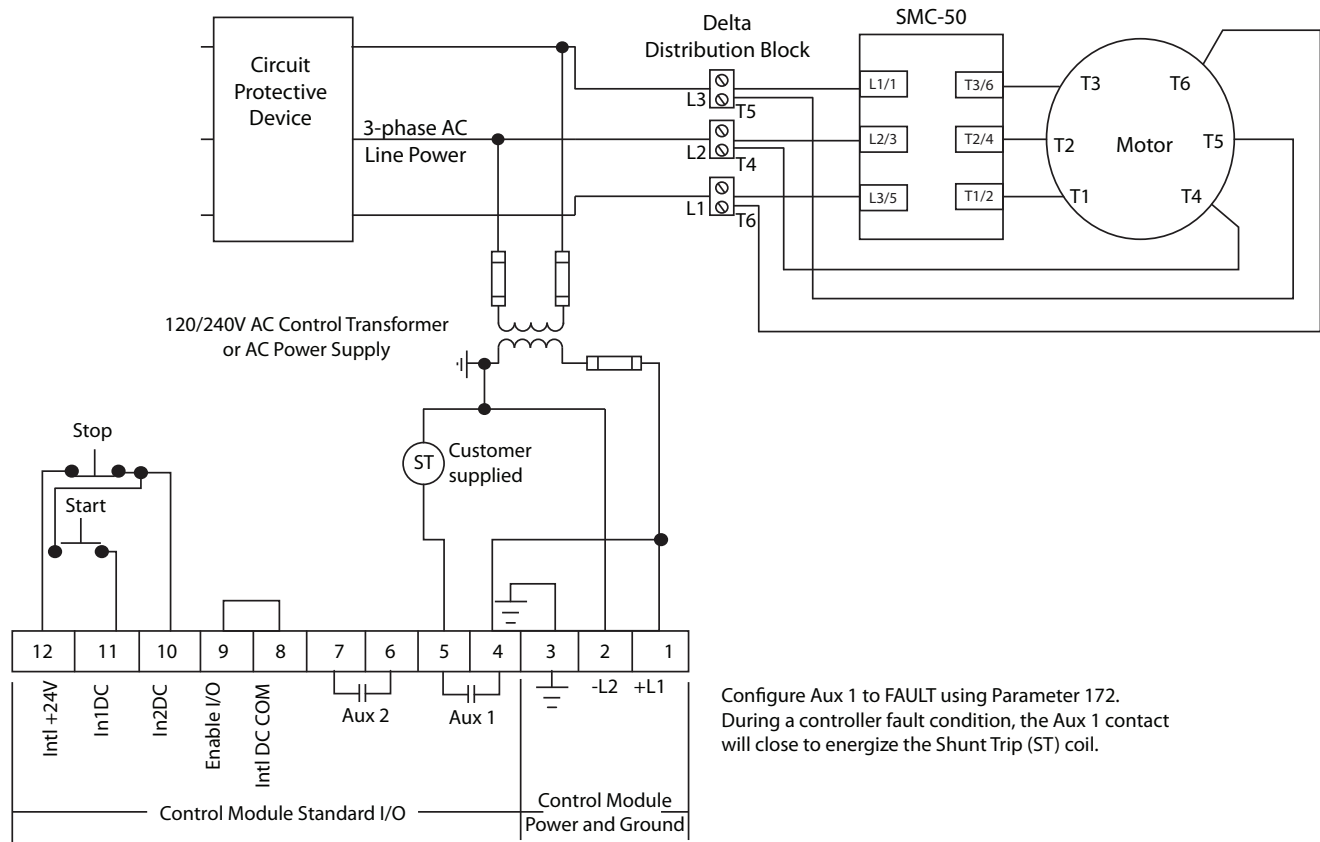
- ① Customer supplied.
- ② Refer to the controller nameplate to verify the rating of the control power input voltage.
- ③ Fault Contact should be set to N.O.

**Figure 15 - SMC-50 Wiring Diagram: Three-Wire Control with Isolation Contactor**



Configure Aux 1 to NORMAL using Parameter 172.  
 NORMAL = Aux 1 contact will close to energize the IC coil with the START push button and will open to de-energize it when the stop maneuver, initiated by the stop push button, is complete.

**Figure 16 - SMC-50 Wiring Diagram: Three-Wire Control with Shunt Trip Circuit Breaker**



## Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
Bulletin 150 Smart Motor Controller (SMC™) Family Brochure, publication <a href="#">150-BR144</a>	Provides overview of soft starter product offerings.
SMC Flex Solid-State Motor Controller Application Techniques, publication <a href="#">150-AT002</a>	Provides description of features and application considerations for the SMC Flex soft starter.
SMC-50 White Paper - New Control Advances; Sensorless Linear Acceleration, publication <a href="#">150-WP005</a>	Discusses starting and stopping methods for the SMC-50 soft starter, and discussion of when to use certain features in applications.
SMC Flex Specifications, publication <a href="#">150-TD006</a>	Provides specifications for the SMC Flex soft starter.
SMC-3 Specifications, publication <a href="#">150-TD007</a>	Provides specifications for the SMC-3 soft starter.
SMC-50 Solid-State Smart Motor Controller User Manual, publication <a href="#">150-UM011</a>	Provides usage instructions and specifications for the SMC-50 soft starter.
Industrial Automation Wiring and Grounding Guidelines, publication <a href="#">1770-4.1</a>	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, <a href="http://www.rockwellautomation.com/global/certification/overview.page">http://www.rockwellautomation.com/global/certification/overview.page</a>	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at <http://www.rockwellautomation.com/global/literature-library/overview.page>. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

**Notes:**

## Rockwell Automation Support

Use the following resources to access support information.

<b>Technical Support Center</b>	Knowledgebase Articles, How-to Videos, FAQs, Chat, User Forums, and Product Notification Updates.	<a href="http://www.rockwellautomation.com/knowledgebase">www.rockwellautomation.com/knowledgebase</a>
<b>Local Technical Support Phone Numbers</b>	Locate the phone number for your country.	<a href="http://www.rockwellautomation.com/global/support/get-support-now.page">www.rockwellautomation.com/global/support/get-support-now.page</a>
<b>Direct Dial Codes</b>	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	<a href="http://www.rockwellautomation.com/global/support/direct-dial.page">www.rockwellautomation.com/global/support/direct-dial.page</a>
<b>Literature Library</b>	Installation Instructions, Manuals, Brochures, and Technical Data.	<a href="http://www.rockwellautomation.com/literature">www.rockwellautomation.com/literature</a>
<b>Product Compatibility and Download Center (PCDC)</b>	Get help determining how products interact, check features and capabilities, and find associated firmware.	<a href="http://www.rockwellautomation.com/global/support/pcdc.page">www.rockwellautomation.com/global/support/pcdc.page</a>

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Rockwell Automation maintains current product environmental information on its website at <http://www.rockwellautomation.com/rockwellautomation/about-us/sustainability-ethics/product-environmental-compliance.page>.

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