Allen-Bradley

160 SSC™ Variable Speed Controller (Series A)

0.37 – 2.2 kW (1/2 – 3 HP)
FRN 4.01, 4.04, 4.07

Installation Manual

Table of Contents

Index

Please Read!

This manual is intended to ***guide*** qualified personnel in the 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 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 cannot assume responsibility or liability for actual use based upon the illustrative uses and applications.

No patent liability is assumed by Allen-Bradley Company with respect to use of information, circuits or equipment described in this text.

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 the product.

Bulletin 160 SSC™ Controller

For Ratings of 1/2 - 3 HP (0.37 – 2.2kW)

Purpose of this Document

This document revises the Bulletin 160 SSC Controller User Manual (Publication 160–5.0, February 1996).

Summary of Update

Replace pages 2–5, 2–7, and 2–8 of the User Manual with the information on the following pages.

ATTENTION: Read the following sections carefully before installing the Bulletin 160 SSC Controller.

Control Wiring Requirements

- run all signal wiring in either a shielded cable, or a separate steel conduit.
- only connect shield wire at control terminal block common terminals 3 and 7.
- do not exceed control wiring length of 15 meters (50 feet).
- use Belden 8760 (or equivalent) – 18AWG (0.750mm2), twisted pair, shielded or 3 conductor.

① *Control signal cable length is highly dependent on electrical environment and installation practices. To improve noise immunity the control terminal block* ***common*** *must be connected to earth ground. Consult factory for longer control signal cable length applications.*

Table 2.D Control Terminal Block Specifications

Terminal	Max/Min Wire Size mm^2 (AWG)	Max/Min Wire Torque Nm. (lb.in.)
TB3	2.5-0.5 (14-22)	0.8-0.4 (8-4)

ATTENTION: The controller is supplied with an internal 12V supply. Dry contacts or open collectors are required for discrete control inputs. If an external voltage is applied, component failure could occur.

ATTENTION: Read the following sections carefully before installing the Bulletin 160 SSC.

Control Wiring – Analog Signal Follower Model

Parameter **59 – [Frequency Source]** is used to select the source of the frequency command. The *frequency source* (which controls the output frequency of the controller) can be commanded internally using **P58 – [Internal Frequency]** or via the Control Terminal Block (TB3) using a:

- remote potentiometer.
- –10 to +10VDC analog input.
- 4–20mA analog input.

Refer to Chapter 5, parameters 58–60 for factory default settings.

ATTENTION: *Connect and use only one frequency source at any time.* If more than one frequency source is connected or in use at the same time, unintended operation could occur.

If you use **P58 – [Internal Frequency]**, TB3 – terminal 2 must be tied to *Common* (TB3 – terminal 3) to ensure that unintended operation does not occur.

Control Wiring – Preset Speed Mode

You can control the output frequency of the controller via contact closure input to SW1, SW2, and SW3. A program keypad module is required to change the factory default settings. Refer to Chapter 5, parameters 61–70 for the

Control Wiring (continued)

Bulletin 160 Analog Signal Follower models (catalog # 160X–XAXXNSFlXX) can be operated using either a unipolar (frequency control only) or bipolar (frequency and direction control) analog input. *Use Parameter 46 – [Input Mode] to select the control method for start, stop, and direction control.* There are four settings from which to choose (shown in Table 2.E below). For all settings, the controller will reverse when the voltage on the analog input transitions from positive to negative. In two-wire control (Parameter 46 – settings 1 and 3), negative voltage on the analog input will start the controller, which may be unintended. This applies to both a negative offset in the analog command, or noise which causes the analog input to go negative. Refer to Table 2.E below for the recommended installation instructions for all Parameter 46 settings.

ATTENTION: Read the following sections carefully before installing the Bulletin 160 SSC.

Table 2.E Recommended Wiring Instructions

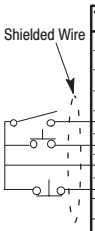
Parameter 46 Setting	Direction Control	Analog Signal Follower Model		Preset Speed Model
		Uni-polar Input	Bi-polar Input	
0	Forward Only	Refer to Figure 2.6	Refer to Figure 2.6	Refer to Figure 2.6
	Forward and Reverse			
1	Forward Only	Refer to Figure 2.7b	Do not use this setting	Refer to Figure 2.7a
	Forward and Reverse	Refer to Figure 2.7c or 2.7d		
2	Forward Only	Refer to page 3-1	Refer to page 3-1	Refer to page 3-1
	Forward and Reverse			
3	Forward Only	Consult factory for additional information prior to installation.	Do not use this setting	Refer to Figure 2.8
	Forward and Reverse			

ATTENTION: When changing the parameter setting for **P46 – [Input Mode**], you must cycle power for the change to take effect.

ATTENTION: The program keypad module stop key simulates momentary pushbutton operation. For “two wire” control schemes (**P46 – [Input Mode]**, setting “1”) the program keypad module stop button will only provide a “stop” function while the stop key is depressed.

Figure 2.6 – TB3 Three Wire Control (Setting 0)

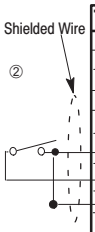
Applies to Analog Signal Follower and Preset Speed Models



TB3	Terminal	Signal	Specification
	1		
	2		
	3		
	4		
	5	**Reverse**	Control closure input①
	6	**Start**	Contact closure input①
	7	**Common**	Common③
	8	**Stop**	Contact closure input required to operate controller①
	9		
	10		
	11		

Figure 2.7b – TB3 Two Wire "Run Forward"④ Control (Setting 1)

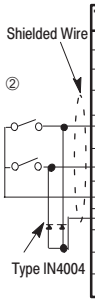
Applies to Analog Signal Follower Models Only



TB3	Terminal	Signal	Specification
	1		
	2		
	3		
	4		
	5		
	6	**Run Forward**	Contact closure input①
	7	**Common**	Common③
	8	**Stop**	Contact closure input required to operate controller①
	9		
	10		
	11		

Figure 2.7d – TB3 Two Wire "Run Forward/Run Reverse"⑤ Control (Setting 1)

Applies to Analog Signal Follower Models Only



TB3	Terminal	Signal	Specification
	1		
	2		
	3		
	4		
	5	**Run Reverse**	Contact closure input①
	6	**Run Forward**	Contact closure input①
	7	**Common**	Common③
	8	**Stop**	Contact Closure input required to operate controller①
	9		
	10		
	11		

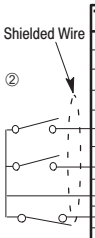
Explanation of Symbols

= N.O. Momentary = N.C. Momentary

= N.O. Maintained = N.C. Maintained

Figure 2.7a – TB3 Two Wire "Run Forward/Run Reverse" Control (Setting 1)

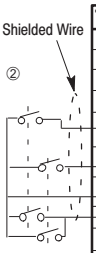
Applies to Preset Speed Models Only



TB3	Terminal	Signal	Specification
	1		
	2		
	3		
	4		
	5	**Run Reverse**	Contact closure input①
	6	**Run Forward**	Contact Closure input①
	7	**Common**	Common③
	8	**Stop**	Contact closure input required to operate controller①
	9		
	10		
	11		

Figure 2.7c – TB3 Two Wire "Run Forward/Run Reverse" ⑤ Control (Setting 1)

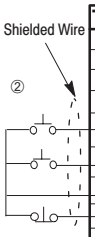
Applies to Analog Signal Follower Models Only



TB3	Terminal	Signal	Specification
	1		
	2		
	3		
	4		
	5	**Run Reverse**	Contact closure input①
	6	**Run Forward**	Contact closure input①
	7	**Common**	Common③
	8	**Stop**	Contact closure input required to operate controller①
	9		
	10		
	11		

Figure 2.8 – TB3 Momentary "Run Forward/Run Reverse" Control (Setting 3)

Applies to Preset Speed Models Only



TB3	Terminal	Signal	Specification
	1		
	2		
	3		
	4		
	5	**Run Reverse**	Contact closure input①
	6	**Run Forward**	Contact closure input①
	7	**Common**	Common③
	8	**Stop**	Contact closure input required to operate controller①
	9		
	10		
	11		

① *Internal 12V supply.*

② *If both Run Forward and Run Reverse inputs are closed at the same time an undetermined state could occur.*

③ *Do not exceed control wiring length of 15 meters (50 feet). Control signal cable length is highly dependent on electrical environment and installation practices. To improve noise immunity the control terminal block common must be connected to earth ground. Consult factory for longer control signal cable length applications.*

④ *Upon power up of the controller, FAULT 22 (stop input not present) will occur. To clear the fault, you must cycle the input to the Run Forward command.*

⑤ *Upon power up of the controller, FAULT 22 (stop input not present) will occur. To clear the fault, you must cycle the input to the Run Forward or Run Reverse commands.*

Document Update

160 SSC™ Variable Speed Controller (Series B)

This publication provides new information for the 160 SSC Variable Speed Controller User Manual, publication 160-5.9, dated December, 1996. **Please place this document in your manual for future reference.**

Important Note

Bulletin 160 SSC Controllers with a catalog number suffix of "S01," (i.e. 160S-AA02N**S01**) will have the "Motor Stall Fault" (F06, page 6-2) detection feature disabled. All other features specified in the User Manual will be operational.

Rockwell *Automation*
Allen-Bradley

Rockwell Automation helps its customers receive a superior return on their investment by bringing together leading brands in industrial automation, creating a broad spectrum of easy-to-integrate products. These are supported by local technical resources available worldwide, a global network of system solutions providers, and the advanced technology resources of Rockwell.

Worldwide representation.

Argentina • Australia • Austria • Bahrain • Belgium • Bolivia • Brazil • Bulgaria • Canada • Chile • China, People's Republic of • Colombia • Costa Rica • Croatia • Cyprus Czech Republic • Denmark • Dominican Republic • Ecuador • Egypt • El Salvador • Finland • France • Germany • Ghana • Greece • Guatemala • Honduras • Hong Kong Hungary • Iceland • India • Indonesia • Iran • Ireland • Israel • Italy • Jamaica • Japan • Jordan • Korea • Kuwait • Lebanon • Macau • Malaysia • Malta • Mexico Morocco • The Netherlands • New Zealand • Nigeria • Norway • Oman • Pakistan • Panama • Peru • Philippines • Poland • Portugal • Puerto Rico • Qatar • Romania • Russia Saudi Arabia • Singapore • Slovakia • Slovenia • South Africa, Republic of • Spain • Sweden • Switzerland • Taiwan • Thailand • Trinidad • Tunisia • Turkey • United Arab Emirates United Kingdom • United States • Uruguay • Venezuela

Rockwell Automation Headquarters, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414 382-2000, Fax: (1) 414 382-4444

Publication 160-5.9DU3 – April, 1997

P/N 40055-188-01 (A)

Document Update

160 SSC™ Variable Speed Controller (Series B)

This publication provides new and updated material for the 160 SSC Variable Speed Controller User Manual, publication 160-5.9, dated December, 1996. Please place this document in your manual for future reference.

EMC Directive 89/336/EEC

This controller is a component intended for implementation in machines or systems for the industrial environment. It has been tested to meet the Council Directive 89/336 Electromagnetic Compatibility (EMC) and all applicable standards.

Important: The conformity of the controller and filter to any standard does not guarantee that the entire installation will conform. Many other factors can influence the total installation and only direct measurements can verify total conformity. It is therefore the responsibility of the machine manufacturer, to ensure, that the conformity is met.

Essential Requirements for a Conforming EMC Installation

1. An input line filter module (see "*Accessories*" in Appendix A) must be installed to reduce conducted emissions. When using the filters listed in Appendix A, the maximum motor cable lengths must be 75 meters (250 feet) for controllers rated 200-240V AC, and 40 meters (133 feet) for controllers rated 380-460V AC.
2. The controller system must be mounted in a shielded enclosure to reduce radiated emissions.
3. Grounding of equipment and cable shields must be solid, with low impedance connections.
4. Motor and control cables entering the shielded enclosure must have EMC-tested shielded cable clamps, or grounded metal conduit.
5. All motor cables must use shielded cable, or be in grounded metal conduit.
6. All control and signal wiring must use shielded cable or be in grounded metal conduit.
7. The Common terminals (TB3-3 & 7) must have a solid connection to PE (protective earth).

General Instructions for an EMC Compliant Installation

Refer to Figure 1.

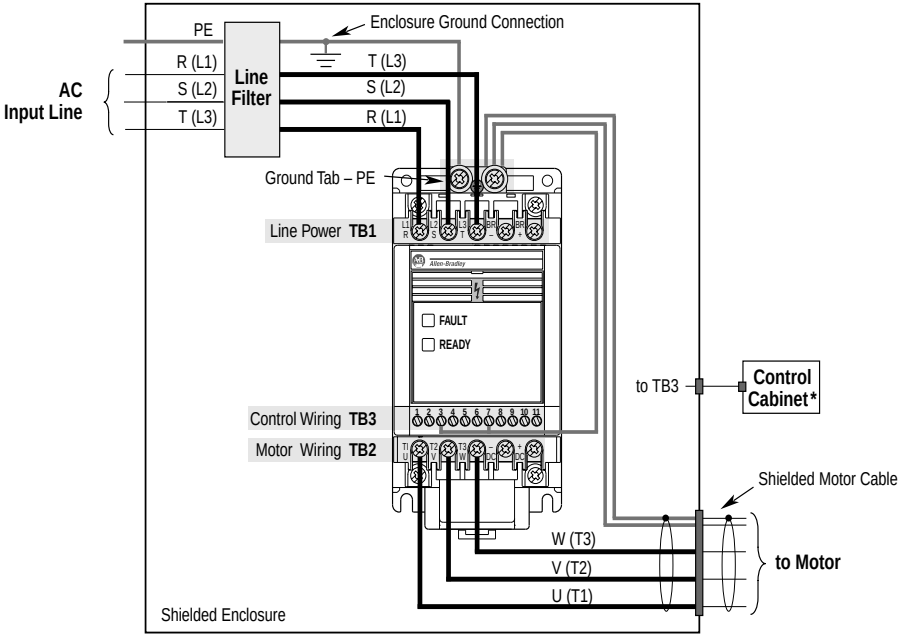
Shielded Enclosure

- Typical NEMA or IEC metal enclosures are adequate.
- The ground connection of the shielded enclosure must be solidly connected to the PE terminal of the controller. Good conductivity must be assured – grounding must provide a low impedance path to high frequency signals.
- All wiring, except input power leads, must use shielded cable.
- Input power, output power and control wiring inside the enclosure must be physically separated.
- Input power, output power and control wiring outside the enclosure must use separate shielded cables, or separate conduit.

Cable Clamps

- Use suitable EMC-tested cable clamps only.
- The connection area must be 360 degrees around the shielded cable.
- The cable clamps also provide strain-relief for the cable.
- When using conduit, the contact point of metal entry connections must be free of paint or non-conductive surfaces and solidly connected with good conductivity to the enclosure.

Figure 1 Recommended Grounding Configuration



▮ = EMC Tested Shielded Cable Clamp (or Metal Conduit)

***** When the control circuitry is located outside of the 160 enclosure.

Motor Cable

- The cable between the controller and motor must be a 4-wire shielded cable (three phases and ground). Refer to Figures 2 & 3.
- When using a line filter module as specified in Appendix A, motor cable lengths shall be limited to 75 meters (250 feet) for controllers rated 200-240V AC and 40 meters (133 feet) for controllers rated 380-460V AC.
- Inside the shielded enclosure, shielded motor cable must be used as close to the controller's output terminals as possible. The shield must be solidly connected to the PE terminal of the controller.
- Where the shielded motor cable exits the enclosure, an EMC-tested cable clamp, or metal conduit must be used to solidly connect the cable shield to the enclosure.
- The shield on the motor side must be solidly connected to the motor housing with an EMC-tested cable clamp, or conduit, providing good conductivity from the cable shield to the motor housing.

Figure 2 Motor Connections

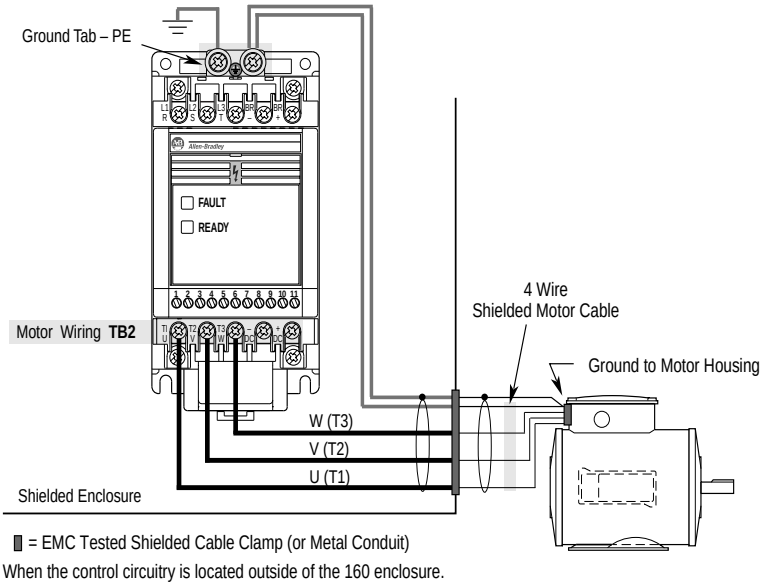
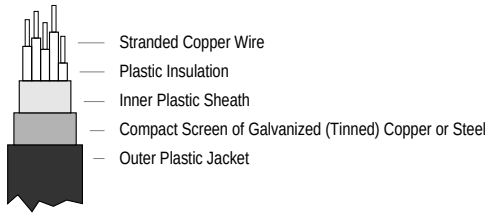


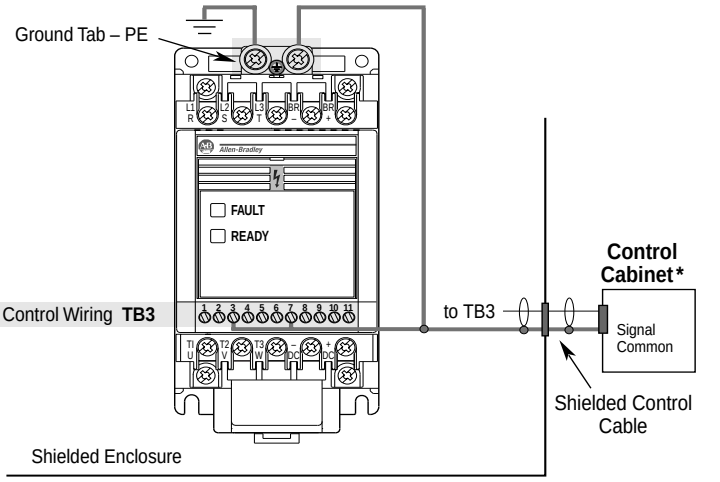
Figure 3 Shielded Motor and Control Cable Example



Control Cable

- Control wiring must use shielded cable, or grounded metal conduit. Refer Figures 3 and 4.
- The shield must be connected to signal common at both ends of the cable.
- The Common terminals (TB3-3 & 7) must be solidly connected (and as short as possible) to the PE terminal of the controller.

Figure 4 Control Connections



▮ = EMC Tested Shielded Cable Clamp (or Metal Conduit)

***** When the control circuitry is located outside of the 160 enclosure.

Rockwell Automation Headquarters, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414 382-2000, Fax: (1) 414 382-4444

Publication 160-5.9DU2 – May 1997

General Information

Receiving – It is your responsibility to thoroughly inspect the equipment before accepting the shipment from the freight company. Check the item(s) received against the purchase order. If any items are obviously damaged, do not accept delivery until the freight agent notes the damage on the freight bill.

If you find any concealed damage during unpacking notify the freight agent. Also, leave the shipping container intact and have the freight agent make a visual inspection of the equipment in order to verify damage.

Unpacking – Remove all packing material, wedges, or braces from within and around the controller. Remove all packing material from the heat sink.

Inspection – After unpacking, check the item(s) nameplate catalog number against the purchase order. An explanation of the catalog numbering system for the Bulletin 160 controller is included as an aid for nameplate interpretation. Refer to the following page for complete nomenclature.

IMPORTANT: Before you install and start up the controller, inspect the mechanical integrity of the system (e.g., look for loose parts, wires, connections, etc.).

General Precautions

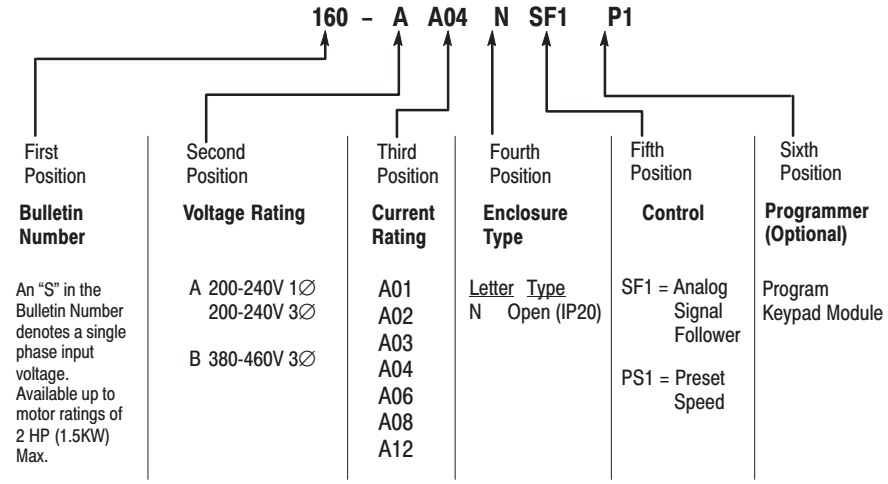
In addition to the precautions listed throughout this manual, you must read and understand the following statements which are general to the system.

ATTENTION: This controller contains ESD (Electrostatic Discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference A–B Publication 8000–4.5.2, “Guarding Against Electrostatic Damage” or any other applicable ESD protection handbook.

ATTENTION: An incorrectly applied or installed controller can result in component damage or reduction in product life. Wiring or application errors such as undersizing the motor, supplying an incorrect or an inadequate AC supply, or excessive ambient temperatures may result in system malfunction.

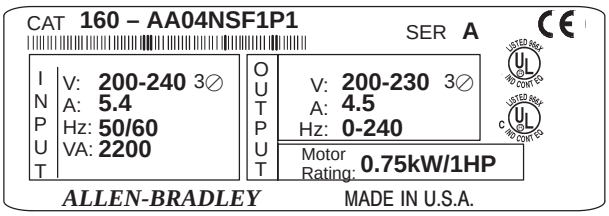
ATTENTION: Only personnel familiar with the controller and associated machinery should plan or implement the installation, start–up, and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.

Figure 1.1 – Catalog Number Code Explanation



Motor Rating			Voltage Rating A				
			Output Current Rating At Listed Voltages – Rating A				
Current Rating	HP	kW	180V	200V	208V	230V	240V
A02	1/2	0.37	2.3A	2.3A	2.3A	2.1A	2.0A
A03	3/4	0.55	3.0A	3.0A	3.0A	2.7A	2.6A
A04	1	0.75	4.5A	4.1A	3.9A	3.6A	3.4A
A08	2	1.50	8.0A	7.8A	7.5A	6.8A	6.5A
A12	3	2.20	12A	11A	10.6A	9.6A	9.2A

Motor Rating			Voltage Rating B				
			Output Current Rating At Listed Voltages – Rating B				
Current Rating	HP	kW	342V	380V	400V	415V	460V
A01	1/2	0.37	1.2A	1.2A	1.2A	1.1 A	1.0 A
A02	3/4	0.55	1.7A	1.7A	1.6A	1.5A	1.4A
A03	1	0.75	2.3A	2.2A	2.1A	2.0A	1.8A
A04	2	1.50	4.0A	4.0A	3.9A	3.7A	3.4A
A06	3	2.20	6.0A	5.8A	5.5A	5.3A	4.8A



← Nameplate Information

Nameplate is located on the side of the unit.

Conventions Used In This Manual

Parameter numbers and names are shown in bold typeface and follow the format PXX – [*] where P denotes parameter, XX denotes the two digit parameter number, and * represents the parameter name. For example, **P01 – [Output Frequency]**.

Installation and Storage

Take these actions to prolong controller life and performance:

- store within an ambient temperature range of -40° to +85°C
- store within a relative humidity range of 0% to 95%, non–condensing
- protect the cooling fan by avoiding dust or metallic particles
- avoid storing or operating the controller where it could be exposed to a corrosive atmosphere
- protect from moisture and direct sunlight
- operate at an ambient temperature range of 0° to +50°C

To maintain proper working conditions, install the controller on a flat, vertical and level surface. Use mounting screws up to 4.5mm (0.177 inches) in diameter or mount on 35mm DIN Rail.

EMC Directive 89/336/EEC Compliance

This product complies with Electromagnetic Compatibility (EMC) Directive 89/336/EEC, when the following requirements for a conforming installation are applied:

- an input line filter must be installed to reduce conducted emissions. Refer to the accessory list in Appendix A.
- the controller system must be mounted in a shielded enclosure to reduce radiated emissions. A typical NEMA or IEC metal enclosure is adequate.
- motor cables must be in conduit, or have shielding/armor with equivalent attenuation to reduce radiated emissions.
- motor cable lengths are as specified in table 2.A.
- control and signal wiring must be in conduit or have shielding with equivalent attenuation.

Important: The conformity of this controller and filter to any standard does not guarantee that the entire installation will conform. Many factors can influence the total installation and only direct measurements can verify total conformity.

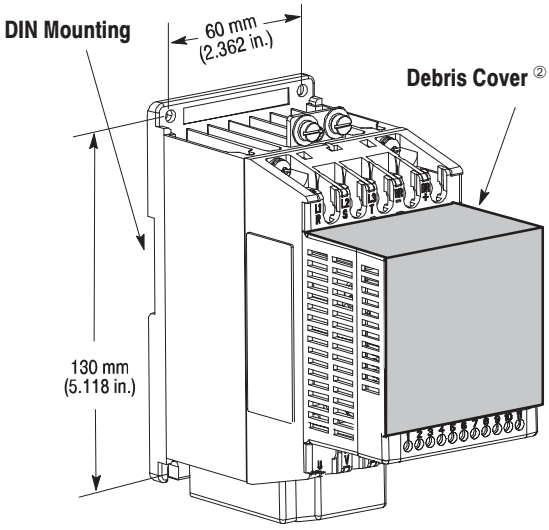
A copy of the Declaration of Conformity (DOC) is available from your local Allen–Bradley sales office.

Figure 2.1 – Mounting Requirements

Description	Metric	English
Min. Panel Thickness (14 GA)	1.9 mm	.0747 in.
Mounting Base Screws	m4 x 0.7	# 8–32
Mounting Torque	1.13 to 1.56 Nm.	10–14 lb. in.

Note: See Appendix A for details on controller dimensions and weights.

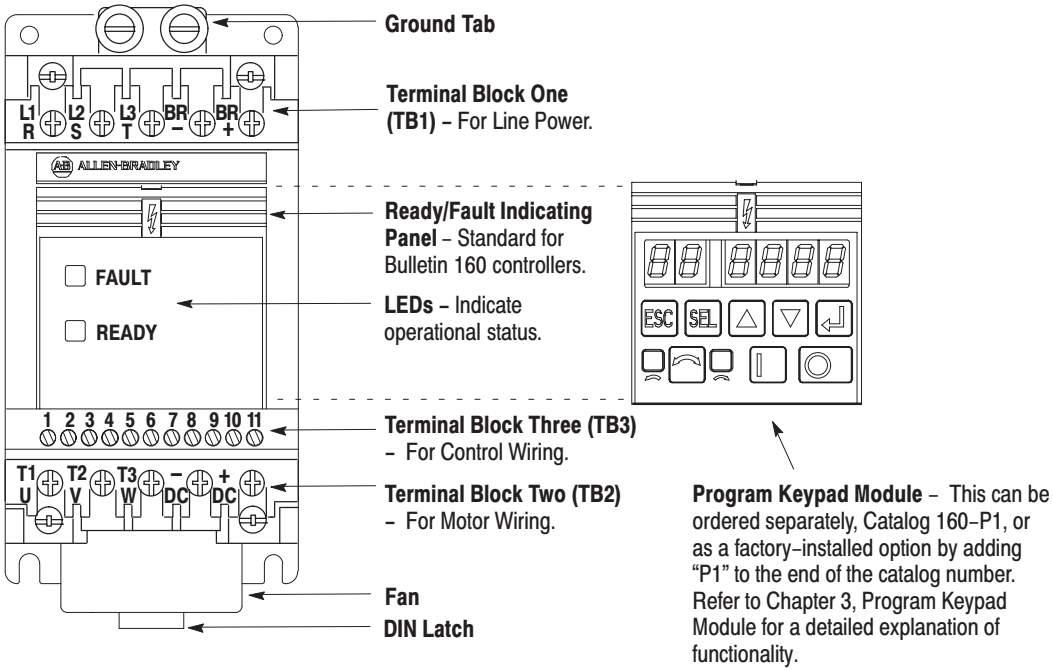
Note: There must be a minimum of 12.5mm (0.5 inches) clearance around all sides of the controller. Use either DIN rail or mounting holes. ①



① *Use the drilling template at the back of the manual for mounting the controller.*

② *Leave debris cover attached during controller installation to protect from falling debris. To ensure proper controller operation, remove cover before applying power.*

Figure 2.2 – Controller Features



Controller Features

Figure 2.2 above details the features of both the Analog Signal Follower and Preset Speed models.

Note: The features are the same for single and three phase units.

Controller Operation Without a Program Keypad Module

Bulletin 160 controllers are fully functional without the use of a program keypad module. All control functions can be performed from the control terminal block (TB3). A program keypad module is required to change the factory default parameter settings.

Diagnostics For Controllers Without a Program Keypad Module

There are two indicators provided to display the controller's status condition.

The **READY** (green) indicator illuminates when the DC bus is charged and the controller is ready to run.

The **FAULT** (red) indicator illuminates when a controller fault condition exists. Refer to Chapter 6 for details on how to clear a fault and general troubleshooting procedures.

Motor Cable Recommendations

A variety of cable types are acceptable for variable speed controller installations. For many installations, *unshielded* cable is adequate, provided it can be separated from sensitive circuits. As an approximate guide, allow a spacing of 1 meter (3.3 feet) for every 10 meters (33 feet) of unshielded length. If you cannot separate motor cables from sensitive circuits, or if you must run motor cables from multiple controllers (more than three) in a common conduit or cable trays, *shielded* motor cable is recommended to reduce system noise.

Motor cables should be four–conductor with the ground lead and shield (if using shielded cable) connected to the controller ground terminal and the motor frame ground terminal.

Long Motor Cable Effects

Installations with long motor cables may require the addition of output reactors to reduce voltage reflections at the motor, and reduce cable charging current. Capacitive charging of long motor cables may draw current in excess of the controller rating. The output reactor should be installed between the controller output terminals and the motor, and mounted near the controller. The controller should be installed as close to the motor as possible.

Note: If your application requires motor cable lengths exceeding the recommendations listed below, contact your local Allen–Bradley Sales Office.

Table 2.A Recommended Shielded Motor Cable Lengths

	Recommended Max. Cable Length m (ft.)			
Controller Type kW (HP)	**Voltage**	**Economy Motor (1000V)**	**Standard Motor (1200V)**	**Inverter Rated Motor (1600V)**
0.37 (0.5)	230	61 (200)	61 (200)	61 (200)
0.56 (0.75)	230	107 (350)	107 (350)	107 (350)
0.75 (1.0)	230	122 (400)	122 (400)	122 (400)
1.5 (2.0)	230	152 (500)	152 (500)	152 (500)
2.2(3.0)	230	152 (500)	152 (500)	152 (500)
0.37 (0.5)	460	12 (40)①	20 (60)①	30 (100)
0.56 (0.75)	460	12 (40)①	20 (60)①	30 (100)
0.75 (1.0)	460	12 (40)①	20 (60)①	38 (125)
1.5 (2.0)	460	12 (40)①	20 (60)①	46 (150)
2.2(3.0)	460	12 (40)①	20 (60)①	90(275)

① *These recommended cable lengths are based on reflected wave limitations, while all other recommended cable lengths listed above are based on capacitive charging of long, shielded motor cables.*

Power Wiring For Preset Speed and Analog Signal Follower Models

Table 2.B
Power Terminal Block Specifications

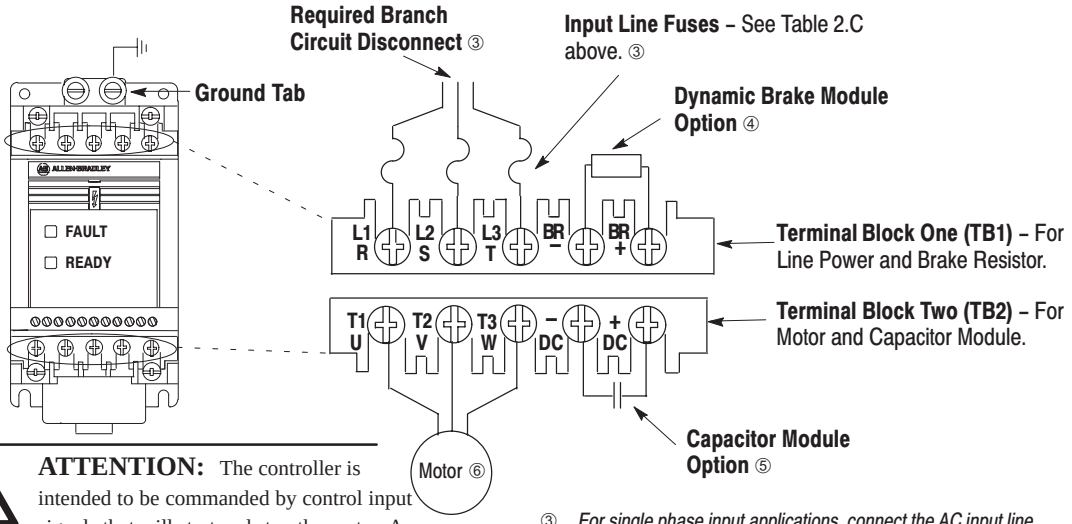
Terminal	Screw Size	Max/Min Wire Size mm^2 (AWG)	Max/Min Torque Nm. (lb.in.)
TB1	M4	4–0.75 (12–18)	1.81–1.35 (16–12)
TB2	M4	4–0.75 (12–18)	1.81–1.35 (16–12)

Table 2.C Recommended AC Input Line Fuse
UL Class J, CC, or BS88 (or equivalent)

3∅ Rating kW (HP)	1∅ Rating kW (HP)	Fuse 230V Rating	Fuse 460V Rating
.37 (1/2)	–	6	3(4) ①
.55 (3/4)	.37 (1/2)	6	3(4) ①
.75 (1)	.55 (3/4)	10	6 ②
1.5 (2)	0.75 (1)	15(16)	10 ②
2.2 (3)	1.5 (2)	25	15(16) ②

( ) *Denotes European sizes.*
① *Must be dual element time delay, Gould AJT or equivalent.*
② *If blowing fuses is a problem, use dual element type fuses.*

Figure 2.3 – Power Wiring For Analog Signal Follower and Preset Speed Models



ATTENTION: The controller is intended to be commanded by control input signals that will start and stop the motor. A device that routinely disconnects then reapplies line power to the controller for the purpose of starting and stopping the motor should not be used. If it is necessary to use this method for starting and stopping or if frequent cycling of power is unavoidable, make sure that it does not occur more than *once* a minute.

ATTENTION: Do not connect power factor correction capacitors to controller output terminals T1, T2, and T3 (U, V, and W).

③ *For single phase input applications, connect the AC input line to input terminals (L1) R and (L2) S.*

④ *Connection for dynamic brake resistors for all models.* ***Note: P52 – [DB Enable]*** *must be enabled for proper operation. See Appendix A for part numbers.*

⑤ *Connection for an external capacitor module. Provides extended ride through capability and improved inherent braking performance. See Appendix A for part number.*

⑥ *Bulletin 160 controllers are* and *listed as motor overload protective devices. An external overload relay is not required for single motor applications.*

Control Wiring Requirements

- run all signal wiring in either a shielded cable, or a separate steel conduit.
- only connect shield wire at control terminal block **common** terminals 3 and 7.
- do not exceed control wiring length of 15 meters (50 feet). ①
- use Belden 8760(or equivalent) – 18AWG ($0.750mm^2$), twisted pair, shielded or 3 conductor.

① *Control signal cable length is highly dependent on electrical environment and installation practices. To improve noise immunity the control terminal block **common** must be connected to earth ground. Consult factory for longer control signal cable length applications.*

Table 2.D Control Terminal Block Specifications

Terminal	Max/Min Wire Size mm^2 (AWG)	Max/Min Torque Nm. (lb.in.)
TB3	2.5–0.5 (14–22)	0.8–0.4 (8–4)

ATTENTION: The controller is supplied with an internal 12V supply. Dry contacts or open collectors are required for discrete control inputs. If an external voltage is applied, component failure could occur.

Control Wiring – Analog Signal Follower Model

You can control the output frequency of the controller via the Control Terminal Block (TB3) using a remote potentiometer, a –10 to +10 VDC analog input, a 4–20mA analog input, or **P58 – [Internal Frequency]**. **Note:** Only one frequency source may be connected at a time. If the frequency reference potentiometer and the 4–20 mA reference are connected at the same time, an undetermined frequency reference will result. If the –10 to +10 VDC analog input is not used, it should be tied to terminal block common terminal 7 to improve noise immunity. Refer to Chapter 5, ***parameters P58–P60*** for factory default settings.

Control Wiring – Preset Speed Model

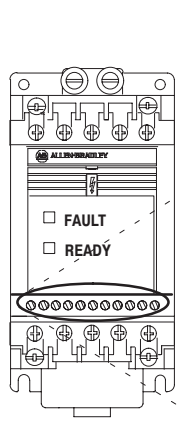
You can control the output frequency of the controller via contact closure input to SW1, SW2, and SW3. A program keypad module is required to change the factory default settings. Refer to Chapter 5, ***parameters 61–70*** for the eight preset frequency factory default settings and switch configurations.

Wiring Diagrams

Note: Refer to the diagrams on the following pages for control wiring information.

Control Wiring

Figure 2.4 – TB3 Control Wiring for Analog Signal Follower Model



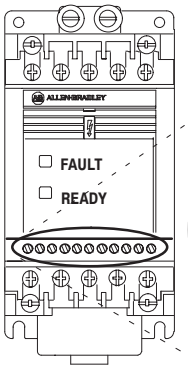
Shielded Wire

③

TB3	Terminal	Signal	Specification
	1	+ 10V Pot	10 kΩ Potentiometer, 2 Watts
	2	Pot Wiper or +10/–10 VDC Input	Controller Input Impedance = 100 kΩ
	3	Common	
	4	4–20mA Input	Controller Input Impedance = 250 Ω
	5	Reverse	Contact closure input ①
	6	Start	Contact closure input ①
	7	Common	Common ②
	8	Stop	Contact closure input required to operate controller ①
	9	Normally Closed	Customer–programmable relay outputs. Resistive load 0.4A at 125 VAC 2A at 30 VDC. Inductive load 0.2 A at 125 VAC 1A at 30 VDC.
	10	Relay Common	
	11	Normally Open	

= N.O. Momentary Contact
= N.C. Momentary Contact
= N.O. Maintained Contact

Figure 2.5 – TB3 Control Wiring for Preset Speed Model



Shielded Wire

③

TB3	Terminal	Signal	Specification
	1	SW1	Contact closure input ①
	2	SW2	Contact closure input ①
	3	Common	Common ②
	4	SW3	Contact closure input ①
	5	Reverse	Contact closure input ①
	6	Start	Contact closure input ①
	7	Common	Common ②
	8	Stop	Contact closure input required to operate controller ①
	9	Normally Closed	Customer–programmable relay outputs. Resistive load 0.4A at 125 VAC 2A at 30 VDC. Inductive load 0.2 A at 125 VAC 1A at 30 VDC.
	10	Relay Common	
	11	Normally Open	

= N.O. Momentary Contact
= N.C. Momentary Contact
= N.O. Maintained Contact

① *Internal 12V supply.*

② *Do not exceed control wiring length of 15 meters (50 feet). Control signal cable length is highly dependent on electrical environment and installation practices. To improve noise immunity the control terminal block* ***common*** *must be connected to earth ground. Consult factory for longer control signal cable length applications.*

③ *This diagram shows "three wire" control. Refer to the following page for diagrams of other control wiring methods.*

Control Wiring (continued)

Use **P46 – [Input Mode]** to select the control method for start, stop, and direction control. There are four settings from which to choose:

- Setting 0 – three wire control (this is the factory default setting).
- Setting 1 – two wire "run forward/run reverse"control. **Note:** The "run" inputs must be maintained.
- Setting 2 – program keypad module control. See page 3–1.
- Setting 3 – momentary "run forward/run reverse" control. **Note:** The "run" inputs do not need to be maintained.

ATTENTION: When changing the parameter setting for **P46 – [Input Mode]**, you must cycle power for the change to take effect.

ATTENTION: The program keypad module stop key simulates momentary pushbutton operation. For "two wire" control schemes (**P46 – [Input Mode]**, setting "1") the program keypad module stop button will only provide a "stop" function while the stop key is depressed.

Explanation of Symbols:

= N.O. Momentary Contact

= N.C. Momentary Contact

= N.O. Maintained Contact

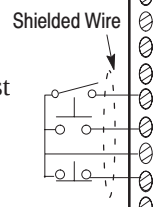
= N.C. Maintained Contact

① *Internal 12V supply.*

② *If both Run Forward and Run Reverse inputs are closed at the same time an undetermined state could occur.*

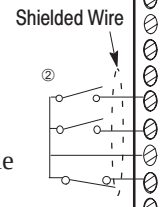
③ *Do not exceed control wiring length of 15 meters (50 feet). Control signal cable length is highly dependent on electrical environment and installation practices. To improve noise immunity the control terminal block* ***common*** *must be connected to earth ground. Consult factory for longer control signal cable length applications.*

Figure 2.6 – TB3 Three Wire control (Setting 0)



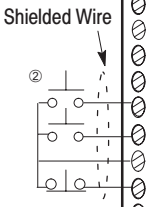
TB3 Terminal	Signal	Specification
1		
2		
3		
4		
5	Reverse	Contact closure input ①
6	Start	Contact closure input ①
7	Common	Common ③
8	Stop	Contact closure input required to operate controller ①
9		
10		
11		

Figure 2.7 – TB3 Two wire "Run forward/run reverse control (Setting 1)



TB3 Terminal	Signal	Specification
1		
2		
3		
4		
5	Run Reverse	Contact closure input ①
6	Run Forward	Contact closure input ①
7	Common	Common ③
8	Stop	Contact closure input required to operate controller ①
9		
10		
11		

Figure 2.8 – TB3 Momentary "Run forward/run reverse" control (Setting 3)



TB3 Terminal	Signal	Specification
1		
2		
3		
4		
5	Run Reverse	Contact closure input ①
6	Run Forward	Contact closure input ①
7	Common	Common ③
8	Stop	Contact closure input required to operate controller ①
9		
10		
11		

Notes:

Features

The program keypad module is located on the front panel of the controller. It features the following:

- five keys on the module for display or programming controller parameters
- three keys for control inputs to the controller
- directional LEDs
- a 6 digit, seven segment LED display

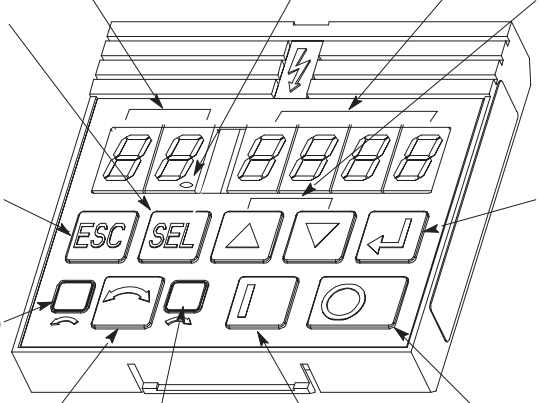
Display Mode

The controller always powers up in the display mode. While in this mode you may view all read only controller parameters, but not modify them.

Program Mode

You enter the program mode by pressing the ESC key. While in program mode, you can edit any programmable controller parameters. Refer to Chapter 5 for programming steps.

Figure 3.1 – Program Keypad Module Features



These two digits display the active parameter number for both display and program parameters, which are designated as P## throughout this manual.

The ***SELect*** key is only used while in program mode. It enables the editing of a parameter value. When you press this key the program mode indicator flashes.

The ***ESCape*** key allows you to toggle between the display mode and program mode. When in program mode, this key also disables the editing of a parameter value.

The ***counter clockwise LED*** illuminates constantly when the motor rotates in reverse direction. ①

Pressing the ***reverse*** key causes the motor to ramp down to 0 Hz and then ramp up to its set speed in the opposite direction. ②

When the ***program mode indicator*** flashes, you can edit the parameter value. When in display mode, the program indicator does not display.

The ***clockwise LED*** illuminates constantly when the motor rotates in forward direction. ①

The ***start*** key initiates a start command when the controller is programmed for local start/stop control (when **P46 – [Input Mode]** is set to "2").

These four digits display the parameter value or fault code number.

Use the ***up/down*** arrow keys to scroll through a list of parameters, or increase and decrease parameter values. Press and hold either key to increase scrolling speed.

Pressing the ***enter*** key while in programming mode causes the current value displayed to be entered into memory. When you press this key the program mode indicator remains on, but stops flashing.

The ***stop*** key initiates the motor to "Coast", "Ramp" or "DC Brake" to stop depending on the setting of **P34–[Stop Mode]**.

① *Indicates commanded direction. Actual motor rotation could be different if motor leads are not connected properly. See Chapter 4, Startup for details on how to verify motor rotation.*

② *When the motor is running, pressing this key causes the (currently illuminated) LED to flash indicating motor rotation while decelerating to zero. The opposite LED will illuminate indicating the commanded direction.*

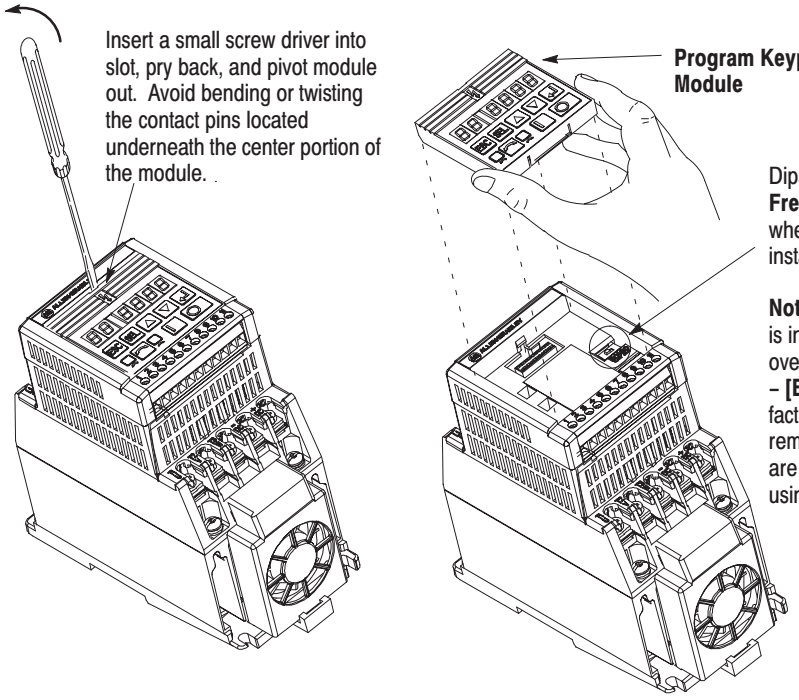
ATTENTION: The program keypad module **stop** key simulates momentary pushbutton operation. For "two wire" control schemes (**P46 – [Input Mode]**, setting "1") the program keypad module stop key will only provide a "stop" function while the stop key is depressed.

Removing Program Keypad Module

ATTENTION: Ensure that you disconnect line power and wait one minute before installing or removing the program keypad module. Failure to do so may result in personal injury or death.

ATTENTION: This controller contains ESD (Electrostatic Discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference A–B publication 8000–4.5.2, "Guarding Against Electrostatic Damage" or any other applicable ESD protection handbook.

Figure 3.2 – Removing Program Keypad Module



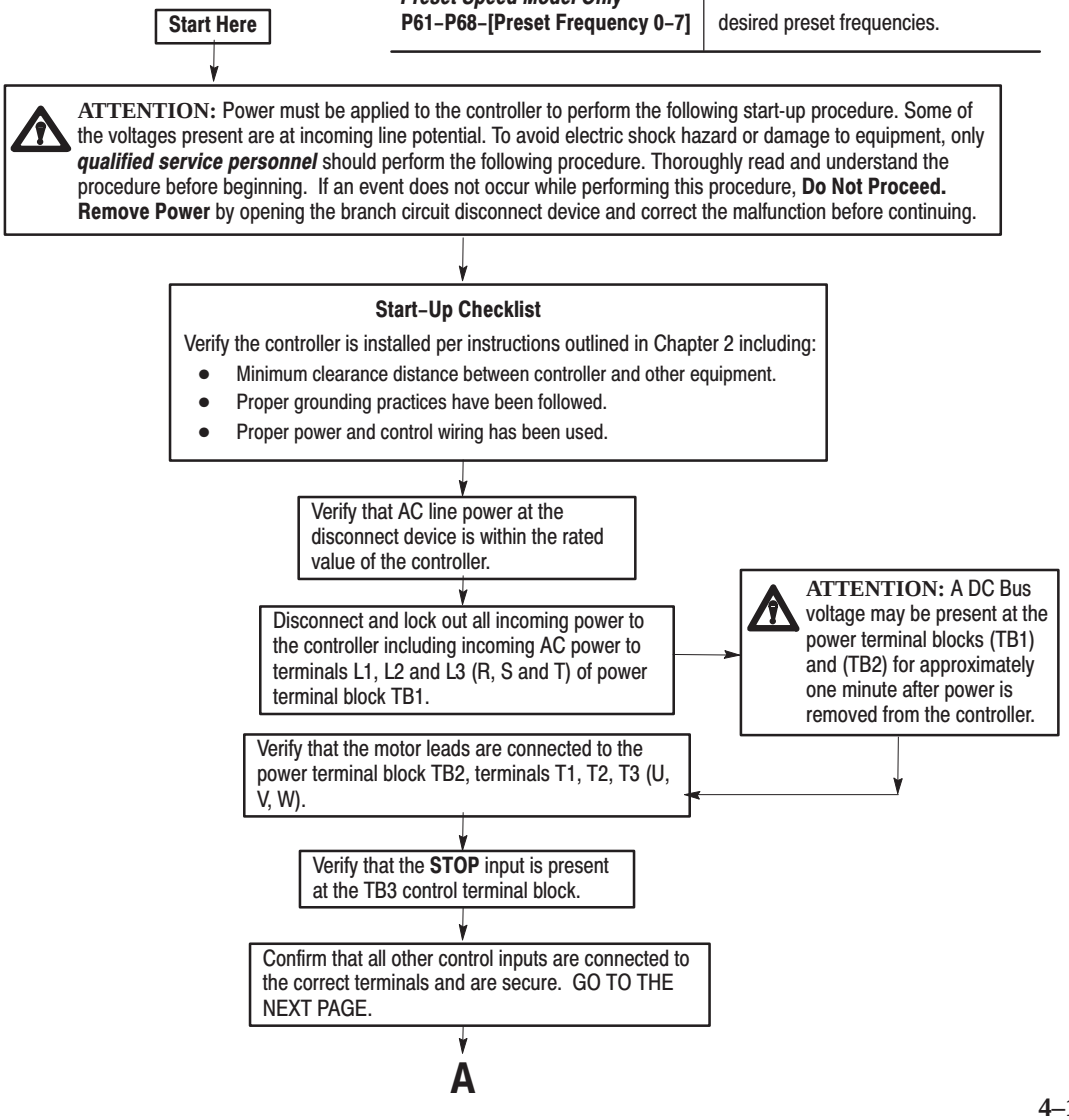
Installing Program Keypad Module

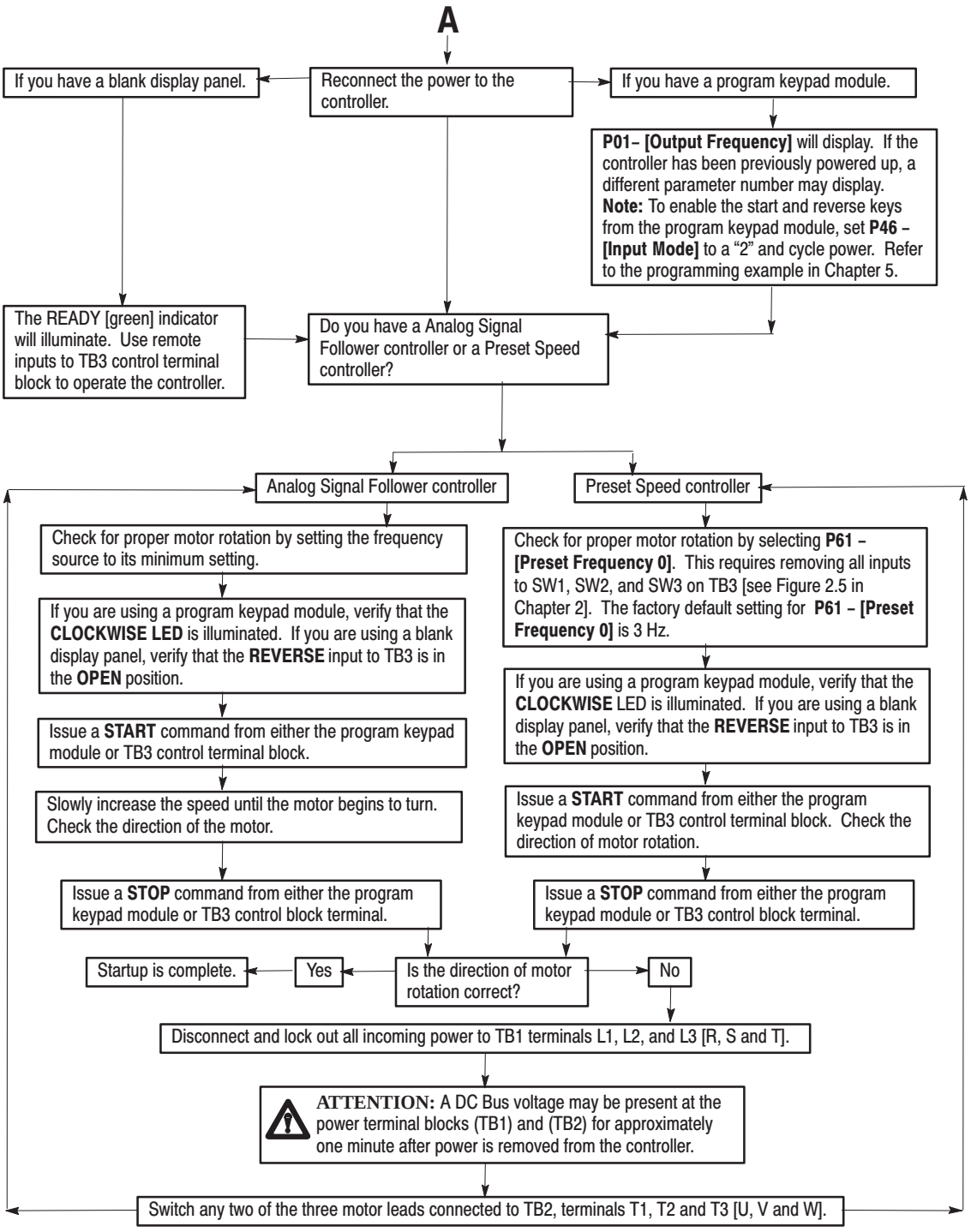
Insert the module bottom end first and then press on the symbol at the top of the module until the module is fully seated. The module is fully seated when its face is flush with the edges of its surrounding case.

Chapter 5 provides a comprehensive description of all controller parameters. Review the factory default settings. If your controller is equipped with a Program Keypad Module these parameters can be changed to meet your specific application requirements. An example of how to program a parameter is shown at the beginning of Chapter 5.

Commonly Changed Parameters

Parameter	Set to...
P30–[Accel Time 1]	desired accel time.
P31–[Decel Time 1]	desired decel time.
P33–[Maximum Frequency]	maximum frequency required.
P34–[Stop Mode Select]	desired stopping mode.
P35–[Base Frequency]	motors rated nameplate frequency.
P36–[Base Voltage]	motors rated nameplate voltage.
P42–[Motor Overload Current]	motor nameplate Full Load Amps [FLA].
P46–[Input Mode]	desired control method.
P47–[Output Configure]	desired output functionality.
Preset Speed Model Only	
P61–P68–[Preset Frequency 0–7]	desired preset frequencies.




A
If you have a blank display panel.
Reconnect the power to the controller.
If you have a program keypad module.
P01– [Output Frequency] will display. If the controller has been previously powered up, a different parameter number may display. Note: To enable the start and reverse keys from the program keypad module, set P46 – [Input Mode] to a "2" and cycle power. Refer to the programming example in Chapter 5.
The READY [green] indicator will illuminate. Use remote inputs to TB3 control terminal block to operate the controller.
Do you have a Analog Signal Follower controller or a Preset Speed controller?
Analog Signal Follower controller
Preset Speed controller
Check for proper motor rotation by setting the frequency source to its minimum setting.
If you are using a program keypad module, verify that the CLOCKWISE LED is illuminated. If you are using a blank display panel, verify that the REVERSE input to TB3 is in the OPEN position.
Issue a START command from either the program keypad module or TB3 control terminal block.
Slowly increase the speed until the motor begins to turn. Check the direction of the motor.
Issue a STOP command from either the program keypad module or TB3 control block terminal.
Check for proper motor rotation by selecting P61 – [Preset Frequency 0]. This requires removing all inputs to SW1, SW2, and SW3 on TB3 [see Figure 2.5 in Chapter 2]. The factory default setting for P61 – [Preset Frequency 0] is 3 Hz.
If you are using a program keypad module, verify that the CLOCKWISE LED is illuminated. If you are using a blank display panel, verify that the REVERSE input to TB3 is in the OPEN position.
Issue a START command from either the program keypad module or TB3 control terminal block. Check the direction of motor rotation.
Issue a STOP command from either the program keypad module or TB3 control block terminal.
Startup is complete.
Yes
Is the direction of motor rotation correct?
No
Disconnect and lock out all incoming power to TB1 terminals L1, L2, and L3 [R, S and T].
ATTENTION: A DC Bus voltage may be present at the power terminal blocks (TB1) and (TB2) for approximately one minute after power is removed from the controller.
Switch any two of the three motor leads connected to TB2, terminals T1, T2 and T3 [U, V and W].

Overview of Parameters

This chapter covers both *display* and *program* parameters. *Display* parameters are **read only** (they cannot be programmed), while *program* parameters **can be changed** to fit your motor control requirements. You must have a Program Keypad Module to view/change *display* and *program* parameters. The table below describes which parameters apply to the Preset Speed and Analog Signal Follower models. Refer to the programming example below for programming instructions.

Parameter Type	Parameter Numbers	
	Analog Signal Follower Model	***Preset Speed Model***
Display	1 through 14	1 through 15
Program	30 through 60	30 through 57 and 61 through 70

The following pages contain descriptions of both display and program parameters. Any parameter description that is shaded pertains only to the Preset Speed or Analog Signal Follower model. Refer to the legend to the right.

= *Parameter applies only to the Analog Signal Follower model*

= *Parameter applies only to the Preset Speed model*

Programming Example

The following is an example of the programming steps required to change a *program group* parameter setting. In this example, parameter **31 – [Decel Time]** is changed from its factory default setting of 10.0 seconds to 2.2 seconds. Refer to Chapter 3, page NO TAG for an explanation of Program Keypad Module display and programming keys. **Note:** To reset **ALL** values to original factory default settings, refer to **P56 – [Reset Defaults]**.

Action	Description	Keypad Display
ESC	1. To program the value of a *program group* parameter, enter the program group by pressing the ESCape key. The "program mode indicator" will illuminate.	30. 10.0 Program Mode Indicator
△	2. Press up/down keys until the desired parameter displays. In this case, press the up key until parameter **31 – [Decel Time]** displays.	31. 10.0
SEL	3. Press the SELect key. The program mode indicator flashes indicating that you can use the up/down keys to change the parameter value.	31. 10.0 Program Mode Indicator Flashes
▽	4. Change the decel time value from the factory default of 10 seconds to 2.2 seconds by pressing the down key until 2.2 displays. **Note:** Continuously holding the up or down key will cause the value to increase or decrease as long as the key is pressed.	31. 2.2
↵	5. When the desired value displays, press the ENTER key. This writes the new value to memory. The program mode indicator will stop flashing and the display will flash once indicating that the new value has been accepted.	31. 2.2 Program Mode Indicator Stops Flashing 31. 10.0 Program Mode Indicator Stops Flashing
ESC	**Note:** If at any time (while in the program mode) you wish to abort the editing process, press the ESCape key. The original value of the parameter will remain unchanged and you will be exited from the program mode.	

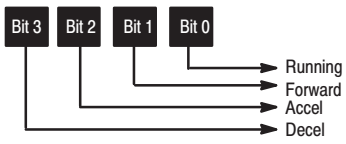
Display Group Parameters

This group of parameters consists of commonly viewed controller operating conditions such as controller output frequency, output voltage, output current and frequency command. All parameters in this group are *read only.*

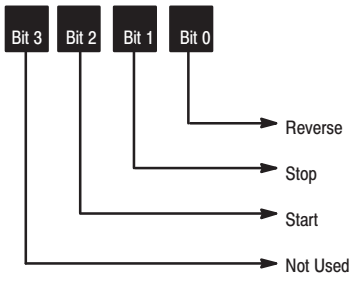
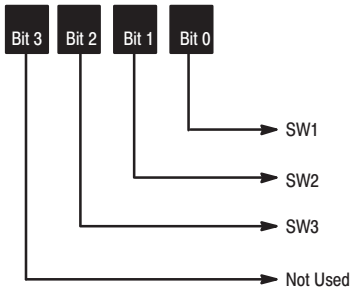
Display Group

You may find it necessary for the controller to display a specific parameter each time it is powered up. (This is especially useful when troubleshooting and making system adjustments). Follow these steps to make the controller power up at a specific *display* parameter:

1. While in display mode, increment to the parameter you wish to see when the controller powers up.
2. Press the ESC key twice. When you cycle power to the controller it will display the parameter that you set. **Note:** If you change any *program group* parameters, the controller (when powered up) will show the last *display* parameter that was present before you went into *program* mode.

P#	Parameter Description	Min/Max Range	Units
01	**[Output Frequency]** Displays the output frequency at TB2 terminals T1, T2 and T3 (U, V and W).	0 to 240 Hz	0.1 Hz
02	**[Output Voltage]** Displays the output voltage present at TB2 terminals T1, T2 and T3 (U, V and W).	0 to [Max Voltage]	1 Volt
03	**[Output Current]** Displays the output current present at TB2 terminals T1, T2 and T3 (U, V and W).	0 to 2 Times Controller Rated Output Current	0.01Amps
04	**[Output Power]** Displays the output power present at TB2 terminals T1, T2 and T3 (U, V and W).	0 to 2 Times Rated Controller Output Power	0.01 kW
05	**[Bus Voltage]** Displays the DC Bus Voltage level.	0 to 400 – [230V] 0 to 800 – [460V]	1 Volt
06	**[Frequency Command]** Displays the frequency that the controller is commanded to output. This command may come from any of the frequency sources selected by **P59 – [Frequency Select]** or from a currently selected preset frequency.	0 to 240	0.1 Hz
07	**[Last Fault]** Displays the coded last fault number. If a fault is currently active (has not been cleared) the display will flash. See Chapter 6 for fault code descriptions.	0 to 48	Numeric Value
08	**[Heatsink Temperature]** Displays the temperature of the controller heatsink.	0 to 150	1 Degree C
09	**[Controller Status]** Displays the status of the controller in a binary coded format. **Note:** A "0" = inactive and a "1" = active. 	0000 to 1011	Binary Number

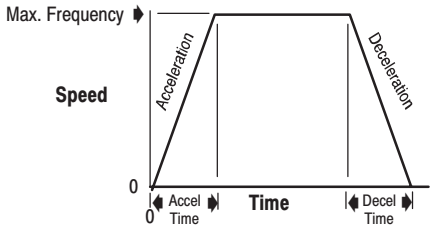
Display Group

P#	Parameter Description	Min/Max Range	Units
10	**[Controller Type]** Used by Allen–Bradley field service personnel.	Numeric Value	Numeric Value
11	**[Control Version]** Displays version of controller firmware. Used by Allen–Bradley field service personnel.	Fixed Value	Numeric Value
12	**[Input Status]** Displays the open (0) and closed (1) state of the parallel inputs in binary coded format. 	0000 to 0111	Binary Number
13	**[Power Factor Angle]** Displays the angle in electrical degrees between motor voltage and motor current.	0.00 to 90.00	0.01 degrees
14	**[Memory Probe Display]** Used by Allen–Bradley field service personnel.	Numeric Value	Numeric Value
15	**[Preset Status]** Displays the open (0) and closed (1) state of Terminal Block Three (TB3) inputs SW1, SW2, and SW3 in binary coded format. This parameter applies to the Preset Speed model only. 	0000 to 0111	Binary Number

= *This parameter applies only to the Preset Speed model.*

Program Group Parameters

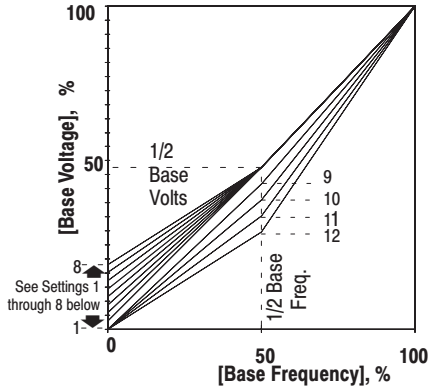
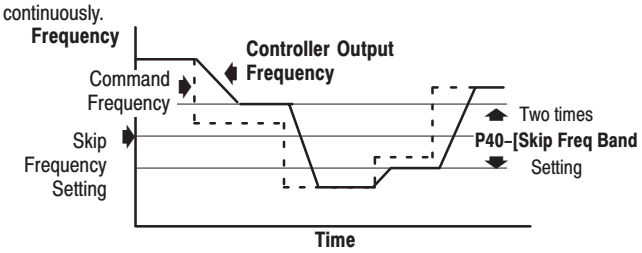
This group contains parameters whose values *can* be programmed. Refer to the "Programming Example" outlined earlier in this chapter. Unless otherwise stated, parameters that are programmed while the controller is running take immediate effect.

Program Group				
P#	**Parameter Description**	**Min/Max Range**	**Units**	**Factory Default**
30	**[Accel Time 1]** Time for the controller to ramp from 0.0 Hz. to **P33 – [Maximum Frequency]**. The rate is linear for any increase in command frequency unless **P53 – [S–Curve]** is set to a value other than "0". 	0.1 to 600	0.1 Seconds	10.0 Seconds
31	**[Decel Time 1]** Time for the controller to ramp from **P33 – [Maximum Frequency]** to 0.0 Hz. The rate is linear for any decrease in command frequency unless **P53 – [S–Curve]** is set to a value other than "0". See **P30–[Accel Time]** figure above.	0.1 to 600	0.1 Seconds	10.0 Seconds
32①	**[Minimum Frequency]** Lowest frequency that controller will output continuously. **Note:** This parameter cannot be programmed while the controller is running.	0 to 240	1 Hz	0 Hz
33①	**[Maximum Frequency]** Highest frequency the controller will output. **Note:** This parameter cannot be programmed while the controller is running.	0 to 240	1 Hz	60 Hz
34	**[Stop Mode Select]** Determines stopping mode used by the controller when a stop is initiated. Refer to the **P44 – [DC Hold Time]** and **P45 – [DC Hold Volts]** diagrams. **Settings:** 0 = Ramp to Stop 1 = Coast to Stop 2 = DC Injection Braking	0 to 2	Numeric Value	0
35	**[Base Frequency]** Set value to motor's rated nameplate frequency.	10 to 240	1 Hz	60 Hz ②
36	**[Base Voltage]** Set value to motor's rated nameplate voltage.	20 to 460 for 460V units and 20 to 230 for 230V units	1 Volt	460 Volts for 460V units and 230 for 230V units

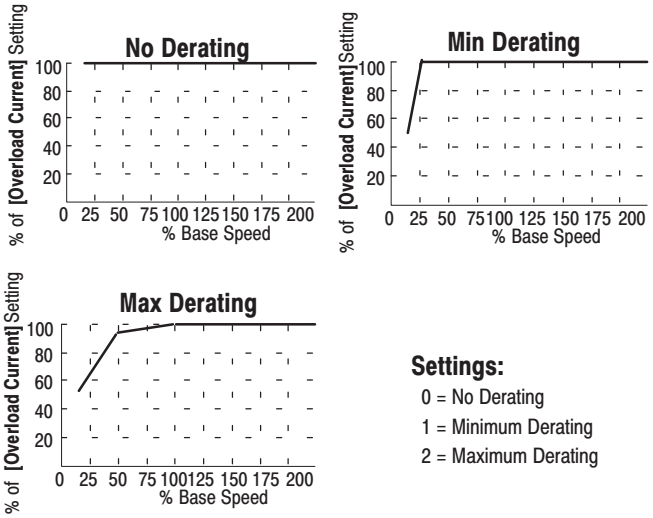
① *The analog inputs to the controller (i.e.,4–20mA, 0 to +10 V, or remote potentiometer) can be scaled to* ***P32 – [Minimum Frequency]*** *and* ***P33 – [Maximum Frequency]*** *by programming* ***P60 – [Analog Scale Teach].***

② *For controllers without a program keypad module, you can change* ***P35 – [Base Frequency]*** *to 50 Hz via a dipswitch located under the blank front panel. See the Removing Program Keypad Module section in Chapter 3.*

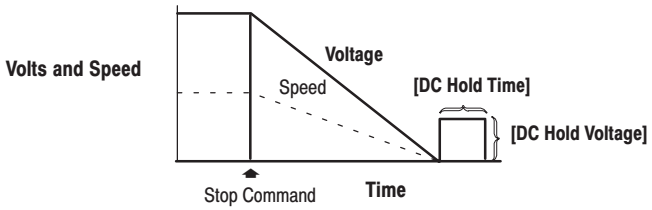
Program Groups

P#	Parameter Description	Min/Max Range	Units	Factory Default
37	**[Maximum Voltage]** Sets the highest voltage that the controller will output. **P37 – [Maximum Voltage]** must be greater than or equal to **P36 – [Base Voltage]**.	20 to 460 for 460V units and 20 to 230 for 230V units	1 Volt	460 Volts for 460V units and 230 for 230V units
38	**[Boost Select]** Sets the boost voltage and redefines the Volts per Hz curve.  **Setting** / **Boost Voltage % of [Base Voltage]**: 0 = 0; 1 = 2.5; 2 = 5.0; 3 = 7.5; 4 = 10.0; 5 = 12.5; 6 = 15.0; 7 = 17.5; 8 = 20.0 **Setting** / **Fan/Pump Curves** ①: 9 = 45.0; 10 = 40.0; 11 = 35.0; 12 = 30.0 ① *Break Point Voltages in % of **[Base Voltage]**.*	0 to 12	Numeric Value	4
39	**[Skip Frequency]** Works in conjunction with **P40 – [Skip Frequency Band]** creating a range of frequencies at which the controller will *not* operate continuously. 	0 to 240	1 Hz	240 Hz
40	**[Skip Frequency Band]** Determines the band around the **P39 – [Skip Frequency]** parameter. The actual band width will be 2 times **[Skip Frequency Band]** – 1/2 the band above and 1/2 the band below. A value of zero will disable the skip frequency.	0 to 30	1 Hz	0 Hz

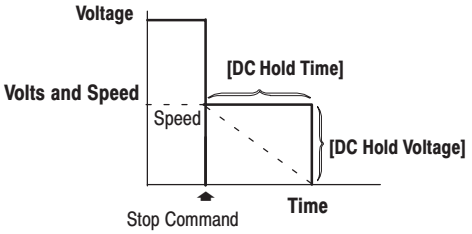
Program Group

P#	Parameter Description	Min/Max Range	Units	Factory Default
41	**[Motor Overload Select]** Selects the derating factor for the I^2t overload function.  **Settings:** 0 = No Derating 1 = Minimum Derating 2 = Maximum Derating	0 to 2	Numeric Value	0
42	**[Motor Overload Current]** Set to motor nameplate full load Amps (FLA).	25% to 200%	.01 Amperes	115% of Controller Rating
43	**[Current Limit]** Maximum output current allowed before current limiting occurs. Value set in percent of controller rated output current.	20% to 190%	1 %	150%
44	**[DC Hold Time]** Time that **P45 – [DC Hold Volts]** voltage will be applied to the motor when **P34 – [Stop Mode Select]** is set to either "DC Brake" or "Ramp" mode.	0 to 15	1 Second	0 Seconds
45	**[DC Hold Voltage]** DC Voltage level applied to the motor during braking when **P34 – [Stop Mode Select]** is set to either "DC Brake" or "Ramp" mode.	0 to 115	1 Volt	0 Volts

Ramp Mode



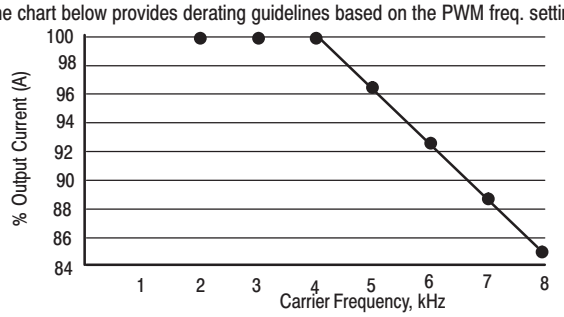
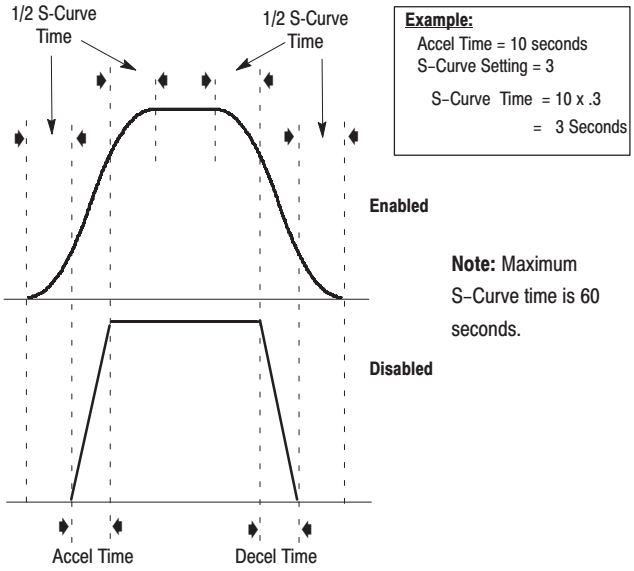
DC Brake Mode



Program Group

P#	Parameter Description	Min/Max Range	Units	Factory Default
46	**[Input Mode]** Configures the TB3 control inputs for either "3 wire" or "2 wire run–fwd/run–rev control". Also enables/disables the program keypad module input control. **Note:** This parameter cannot be programmed while the controller is running. **Also, power must be cycled for the change to take effect.** **Settings:** 0 = "3 wire" control 1 = "2 wire" control 2 = Program Keypad Module control 3 = Momentary "Run Forward/ Run Reverse" Control	0 to 3	Numeric Value	0
47	**[Output Configure]** Configures the TB3 relay output functionality. *0* = ***Controller Ready/Faulted*** — energized and returns to shelf state when power is removed or when a fault occurs. *1* = ***At Frequency*** — the controller reaches commanded frequency. *2* = ***Controller Running*** — the controller is running. *3* = ***Reverse*** — the controller is commanded to run in the reverse direction. *4* = ***Motor Overload*** — when a motor overload condition exists. *5* = ***Ramp Regulated*** — the ramp regulator is modifying the programmed accel/decel times to avoid an overcurrent or overvoltage fault from occurring. *6* = ***Above Frequency*** — the controller exceeds the frequency value set in **P48 – [Output Threshold]**. *7*= ***Above Current*** — the controller exceeds the value set in **P48 – [Output Threshold]**. **Note:** Value for **P48 – [Output Threshold]** must be entered in % of controller rated output current. *8* = ***Above DC Bus Voltage*** — the controller exceeds the DC bus voltage value set in **P48 – [Output Threshold]**. *9* = ***Retries Exhausted*** — the number of retries for **P50 – [Restart Tries]** is exceeded.	0 to 9	Numeric Value	0
48	**[Output Threshold]** Determines the on/off point for the TB3 output relay when **[P47 – Output Configure]** is set to 6, 7, and 8. **Settings** / **Ranges**: 6 — 0 to 240 Hz; 7 — 0 to 150 %; 8 — 0 to 815 Volts	0 to 815	Numeric Value	0

Program Group

P#	Parameter Description	Min/Max Range	Units	Factory Default
49	**[PWM Frequency]** Carrier frequency for the PWM output waveform. The chart below provides derating guidelines based on the PWM freq. setting.  **Note**: Ignoring derating guidelines can cause reduced controller performance.	2.0 to 8.0	0.1kHz	4.0 kHz
50	**[Restart Tries]** Maximum number of times the controller will attempt to reset a fault.	0 to 9	Numeric Value	0
51	**[Restart Time]** Time between restart attempts.	0.5 to 300	0.1 Seconds	10.0 Seconds
52	**[DB Enable]** Enables/disables dynamic braking. 0 = Disable, 1 = Enable **Note:** This parameter cannot be programmed while the controller is running.	0 to 1	Numeric Value	0
53	**[S-Curve]** Enables a fixed shape S-Curve. See formula below: **Formula:** S-Curve Time = Accel or Decel Time x "S-Curve" setting (in percent) ①  **Example:** Accel Time = 10 seconds S-Curve Setting = 3 S-Curve Time = 10 x .3 = 3 Seconds **Note:** Maximum S-Curve time is 60 seconds. ① *See values in the **Min/Max Range** column*	S-Curve Setting 0 = 0% 1 = 10% 2 = 20% 3 = 30% 4 = 40% 5 = 50% 6 = 60% 7 = 70% 8 = 80% 9 = 90% 10 = 100%	Numeric Value	0

Program Group

P#	Parameter Description	Min/Max Range	Units	Factory Default
54	**[Clear Fault]** Setting this parameter to a "1" performs a fault reset. When the fault reset function is complete, the value is automatically set back to "0". **Note:** This parameter cannot be programmed while the controller is running.	0 to 1	Numeric Value	0
55	**[Memory Probe Address]** Used by Allen–Bradley field service personnel.	Numeric Value	Numeric Value	Numeric Value
56	**[Reset Defaults]** All parameters and their associated factory defaults are reset when set to a value of "1". When the default function is complete, this parameter will set itself back to a "0". This parameter cannot be programmed while the controller is running. **Note: An F48 – [Reprogram Fault] will occur and must be cleared by cycling the STOP input to the controller.** **Note: P46–[Input Mode Select]** factory defaults to "3 wire" control. If using keypad control, change parameter setting back to a "2" to regain program keypad control.	0 to 1	Numeric Value	0
57	**[Program Lock]** When set to a "1", this parameter protects all controller parameters from being changed by unauthorized personnel.	0 to 1	Numeric Value	0

Program Group – Analog Signal Follower Model Only

P#	Parameter Description	Min/Max Range	Units	Factory Default
58	**[Internal Frequency]** Digital frequency setpoint from the program keypad module. Value of frequency command when **P59 – [Frequency Select]** is set to a "1".	0 to 240	0.1 Hz	60.0
59	**[Frequency Select]** Selects the source of the frequency command for the controller. **Settings:** 0 = frequency source from analog input to TB3 control terminal block. 1 = frequency source from digital setpoint programmed into **P58 – [Internal Frequency]**.	0 to 1	Numeric Value	0=Analog
60	**[Analog Scale Teach]** Scales the 0–10V ① ,4–20 mA analog input, or remote potentiometer input to operate between **P32 – [Minimum Frequency]** and **P33 – [Maximum Frequency]**. To scale to **P33 – [Maximum Frequency]**, set analog input to maximum value, increment parameter to a "1", and then press the enter key. To scale to **P32 – [Minimum Frequency]**, set analog input to minimum value, increment parameter to a "2", and then press the enter key. **Note:** The parameter resets to "0" after you press the enter key. ① *If you are using a bipolar input (–10 to +10V), do not scale the input to the minimum frequency setting.*	0 to 2	Numeric Value	0

= *This parameter applies only to the Analog Signal Follower model.*

Program Group – Preset Speed Model Only

P#	Parameter Description	Min/Max Range	Units	Factory Default
61	**[Preset Frequency 0]** The programmed value sets the frequency that the controller outputs when selected.	0 to 240	0.1 Hz	3 Hz
62	**[Preset Frequency 1]** The programmed value sets the frequency that the controller outputs when selected	0 to 240	0.1 Hz	20 Hz
63	**[Preset Frequency 2]** The programmed value sets the frequency that the controller outputs when selected.	0 to 240	0.1 Hz	30 Hz
64	**[Preset Frequency 3]** The programmed value sets the frequency that the controller outputs when selected.	0 to 240	0.1 Hz	40 Hz
65	**[Preset Frequency 4]** The programmed value sets the frequency that the controller outputs when selected.	0 to 240	0.1 Hz	45Hz
66	**[Preset Frequency 5]** The programmed value sets the frequency that the controller outputs when selected.	0 to 240	0.1 Hz	50 Hz
67	**[Preset Frequency 6]** The programmed value sets the frequency that the controller outputs when selected.	0 to 240	0.1 Hz	55 Hz
68	**[Preset Frequency 7]** The programmed value sets the frequency that the controller outputs when selected.	0 to 240	0.1 Hz	60 Hz
69	**[Accel Time 2]** The programmed value sets the acceleration time for P65 to P68 [Preset Frequencies 4–7]. The rate is linear for any increase in command frequency unless **P53 – [S–Curve]** is set to a value other than "0"	0.1 to 600	0.1 Sec.	20.0 Sec.
70	**[Decel Time 2]** The programmed value sets the deceleration time for P65 to P68 [Preset Frequencies 4–7]. The rate is linear for any decrease in command frequency unless **P53 – [S–Curve]** is set to a value other than "0"	0.1 to 600	0.1 Sec.	20.0 Sec.

= This parameter applies only to the Preset Speed model

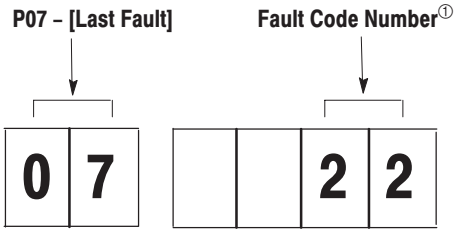
Preset Accel/Decel Chart For Preset Speed Model Only

TB3– SW3	TB3– SW2	TB3– SW1	Preset	Accel	Decel
0	0	0	Preset 0	**P30 –[Accel Time 1]**	**P31 – [Decel Time 1]**
0	0	1	Preset 1		
0	1	0	Preset 2		
0	1	1	Preset 3		
1	0	0	Preset 4	**P69 – [Accel Time 2]**	**P70 – [Decel Time 2]**
1	0	1	Preset 5		
1	1	0	Preset 6		
1	1	1	Preset 7		

Refer to Figure 2.5 for the Preset Speed model control wiring diagram.

Fault Information

Figure 6.1 – Fault Display



① See Table 6.A below for fault descriptions.

Controllers equipped with a program keypad module will flash the display when a fault is present. If a fault occurs, parameter **07 – [Last Fault]** displays. You can cross reference the number that appears on the display **(e.g., 22)** with the fault numbers listed in Table 6.A.

Fault LED – (Without Program Keypad Module)

Controllers without a program keypad module come equipped with a fault LED. When the fault LED illuminates, a fault condition exists.

Tips To Clear a Fault

IMPORTANT: If a fault occurs, it is important to address and correct the fault as well as the condition that caused the fault.

To clear a fault, perform one of the following:

- Press the program keypad's stop button.
- Cycle power to the controller.
- Cycle the TB3 stop input signal to the controller.
- Set **P54 – [Clear Fault]** parameter to a "1".

Table 6.A Bulletin 160 Fault Descriptions

Fault Number	Fault Indication	Fault Description	Corrective Action
03	Power Loss Fault	DC Bus voltage remains below 85% nominal on power up for longer than 5 seconds.	Monitor incoming AC line for low voltage or line power interruption.
04	Under Voltage Fault	DC Bus voltage fell below the minimum. For controllers rated at input voltage 200–240 VAC, undervoltage trip occurs at 210 VDC bus voltage (equivalent to 150 VAC incoming line voltage). For controllers rated at input voltage 380–460 VAC, undervoltage trip occurs at 390 VDC bus voltage (equivalent to 275 VAC incoming line voltage).	Monitor incoming AC line for low voltage or line power interruption.
05	Over Voltage Fault	DC Bus maximum voltage exceeded. For controllers rated at input voltage 200–240 VAC, overvoltage trip occurs at 410 VDC bus voltage (equivalent to 290 VAC incoming line voltage). For controllers rated at input voltage 380–460 VAC, overvoltage trip occurs at 815 VDC bus voltage (equivalent to 575 VAC incoming line voltage).	Bus overvoltage caused by motor regeneration. Monitor incoming AC line for excessive voltage. Extend the decel time or install dynamic brake module or external capacitor module. See Appendix A.

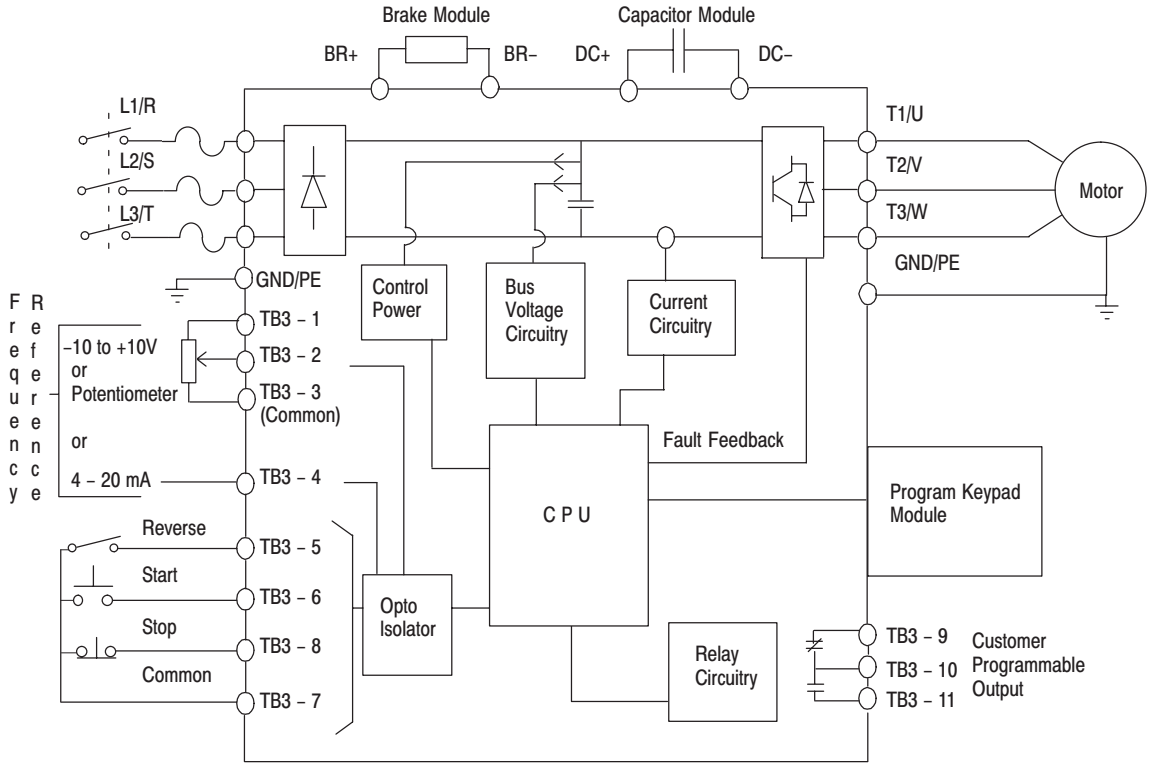
Table 6.A Bulletin 160 Fault Descriptions (continued)

Fault Number	Fault Indication	Fault Description	Corrective Action
06	Motor Stall Fault	Motor has stalled. Motor load is excessive.	Longer acceleration time or a reduced load required.
07	Motor Overload Fault	Internal electronic overload trip. Excessive motor load exists.	Reduce motor load until controller output current does not exceed the current set by **P42 – [Motor Overload Current]**. Reduce **P38 – [Boost Volts]**.
08	Over Temperature Fault	Excessive heat detected.	Clear blocked or dirty heat sink fins. Check ambient temperature. Check for blocked or non–operating fan.
12	Overcurrent Fault	Overcurrent detected in hardware trip circuit.	Check short circuit at the controller output or excessive load conditions at the motor.
22	Controller Reset Fault	Stop input not present.	Check stop connection at TB3, terminal 8.
32	EEPROM Fault	EEPROM has invalid data.	Reset EEPROM using **P56 – [Reset Defaults]**.
33	Max Retries Fault	Controller failed to reset fault within the number of retries set in **P50 – [Restart Tries]**.	Repair system fault.
38	Phase U Fault	Phase to ground fault detected between controller and motor in phase U.	Check the wiring between the controller and motor. Check motor for grounded phase.
39	Phase V Fault	Phase to ground fault detected between controller and motor in phase V.	Check the wiring between the controller and motor. Check motor for grounded phase.
40	Phase W Fault	Phase to ground fault detected between controller and motor in phase W.	Check the wiring between the controller and motor. Check motor for grounded phase.
41	UV Short Fault	Excessive current has been detected between these two controller output terminals.	Check the motor and external wiring to the controller output terminals for a shorted condition.
42	UW Short Fault	Excessive current has been detected between these two controller output terminals.	Check the motor and external wiring to the controller output terminals for a shorted condition.
43	VW Short Fault	Excessive current has been detected between these two controller output terminals.	Check the motor and external wiring to the controller output terminals for a shorted condition.
46	Power Test Fault	Fault detected during initial start-up sequence.	Check controller wiring. Check motor wiring.
48	Reprogram Fault	Occurs when controller parameters are reset to defaults.	Clear fault.

Table 6.B Troubleshooting

Problem	Corrective Action
Motor does not start (No output voltage to motor).	1. Check power circuit. • Check supply voltage. • Check all fuses and disconnects. 2. Check motor. • Verify that motor is connected properly. 3. Check control input signals. • Verify that START signal is present. • Verify that STOP signal is present. • Verify that RUN FORWARD and RUN REVERSE signals are NOT both active. 4. Check **P46 – [Input Mode Select**]. • If **P46 – [Input Mode Select]** is set to "2", only the program keypad module **Start** button will start the motor.
Controller Started but motor NOT rotating. (**P01 – [Output Frequency]** displays "0.0").	1. Check motor. • Verify that motor is connected properly. 2. Check frequency source **P06 – [Frequency Command]**. • Verify that frequency signal is present at terminal block TB3. –10- +10V signal 4–20 mA signal • Verify that Preset Frequencies are set properly. 3. Check control input signals. • Verify that SW1, SW2 and SW3 are correct. (Refer to the chart at the end of Chapter 5). 4. Check parameter settings. • Verify that **P59 – [Freq Select]** is showing desired frequency source. • Verify that **P58 – [Internal Frequency**] is the desired value.
Motor not accelerating properly.	1. Check motor. • Verify that motor is connected properly. • Verify that no mechanical problems exist. 2. Check parameter settings. • Verify that **P30 – [Accel Time 1]** or **P69 – [Accel Time 2]** is set properly. • Verify that **P43 – [Current Limit]** is set properly. • Verify that **P38 – [Boost Volts]** is set properly.
Can not operate in "RUN FWD/ RUN REV" mode.	1. Verify that **P46 – [Input Mode Select]** is set to "1". 2. Verify that power has been cycled for above change to take effect. 3. Verify that both RUN FORWARD and RUN REVERSE switches are NOT closed simultaneously.

Block Diagram of Bulletin 160 Analog Signal Follower



Controller Specifications

Tables A.1 and A.2 contain information that is unique to each SSC™ Controller rating. Table A.3 contains information that applies to all Controller ratings.

Table A.1 – Specifications for Controllers Rated 200 – 240V Single and Three Phase Input

	Controller Catalog Number				
Single Phase (input)	**160S–AA02**	**160S–AA03**	**160S–AA04**	**160S–AA08**	
Three Phase (input)	**160–AA02**	**160–AA03**	**160–AA04**	**160–AA08**	**160–AA12**
Output Ratings					
3 Phase Motor Rating kW (HP)	0.37 (1/2)	0.55 (3/4)	0.75 (1)	1.5 (2)	2.2 (3)
Output Current (A) Max	2.3	3.0	4.5	8.0	12.0
Power Dissipation (Watts)	20	25	40	70	105
Input Ratings					
Input Voltage, Frequency	200/240V Single Phase and Three Phase, 50/60 Hz				
Operational Range (V)	180-265V				
Input kVA	1.1	1.4	2.2	3.7	5.7
Environmental Specifications					
Cooling Method	Convection Cooled		Fan Cooled		
AC Dynamic Braking Torque ①					
With external Dynamic Brake Module (%)	300	233	200	150	115
Without external Dynamic Brake Module (%)	100	100	100	50	50

Table A.2 – Specifications for Controllers Rated 380 – 460V Three Phase Input

	Controller Catalog Number				
Three Phase (input)	**160–BA01**	**160–BA02**	**160–BA03**	**160–BA04**	**160–BA06**
Output Ratings					
3 Phase Motor Rating kW (HP)	0.37 (1/2)	0.55 (3/4)	0.75 (1)	1.5 (2)	2.2 (3)
Output Current (A) Max	1.2	1.7	2.3	4.0	6.0
Power Dissipation (Watts)	25	30	40	65	80
Input Ratings					
Input Voltage, Frequency	380/460V Three Phase, 50/60 Hz				
Operational Range (V)	340–506V				
Input kVA	1.1	1.6	2.2	3.7	5.7
Environmental Specifications					
Cooling Method	Convection Cooled		Fan Cooled		
AC Dynamic Braking Torque ①					
With external Dynamic Brake Module (%)	300	233	200	150	115
Without external Dynamic Brake Module (%)	100	100	100	50	50

① *Estimated. Actual value depends on motor characteristics.*

Table A.3 – Specifications For All Controller Ratings

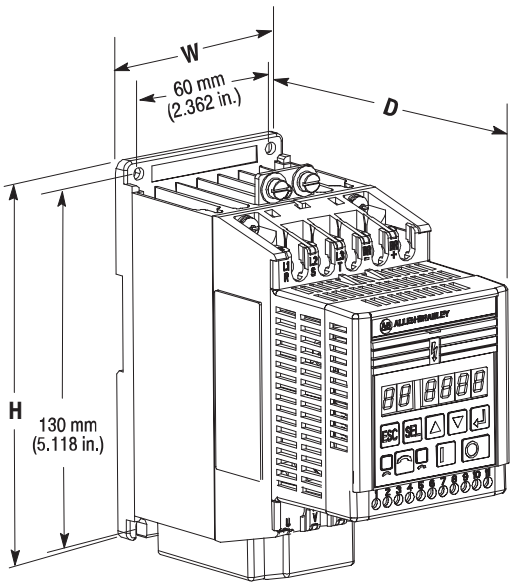
Input/Output Ratings (All Controller Ratings)	
Output Voltage (V)	Adjustable from 0V to input voltage
Output Frequency (Hz)	0 to 240 Hertz Programmable
Efficiency (%)	97.5% (Typical)
Transient Protection	Standard 2 kV (Optional 6 kV using MOV module). See accessories on page A–5.
Environmental Specifications (All Controller Ratings)	
Enclosure	IP 20
Ambient Temperature	0°C to 50°C
Storage Temperature	-40°C to 85°C
Relative Humidity	0 to 95% (non condensing)
Vibration	1.0 G Operational – 2.5 G Non–operational
Shock	15 G Operational – 30 G Non–operational
Altitude	1,000 m (3,300 ft.) without derating
Control Inputs (All Controller Ratings)	
Control Input Type	For dry contact closure input – the controller has an internal 12V power supply that provides 10–mA (typical) current flow. Also accepts open collector/solid state input with maximum leakage current of 50 μA
Start, Stop, Forward/Reverse	Configurable inputs for 2 or 3 wire control
SW1, SW2, SW3 **(Preset Speed Model only)**	Configurable Inputs for control of 8 preset speeds and 2 Accel/Decel times
Approvals and Standards Compliance (All Controller Ratings)	
Approvals	UL508C, CSA 22.2, 89/336/EEC①
Designed to meet these standards	IEC 146–1–1 FCC Class A① and B① VDE 0871① and 0875①
Control Inputs (Analog Signal Follower only –All Controller Ratings)	
External Speed Potentiometer	1K to 10K Ohms, 2 Watts Minimum
Analog Input (4 to 20mA)	Input Impedance 250 Ohms
Analog Input (–10 to +10 V DC)	Input Impedance 100 K Ohms
Control Output (All Controller Ratings)	
Programmable Output (Form C Relay contact)	Resistive rating: 0.4A @125V AC, 0.2A @ 230 V AC, 2A @ 30V DC Inductive rating: 0.2A @ 125V AC, 0.1A @ 230V AC, 1A @30V DC

① With external filters.

Table A.3 – Specifications For All Controller Ratings (continued)

Control Features (All Controller Ratings)	
PWM Algorithm	Sine Weighted PWM with Harmonic Compensation
Switching Device (3–Phase Output)	IGBT (Intelligent Power Module)
V/Hz Ratio	Programmable
Carrier Frequency	Adjustable from 2kHz to 8kHz in 100 Hz Increments (Factory default is 4 kHz)
DC Boost	Adjustable – Select from a family of Boost Curves
Current Limiting	Trip Free Operation, Co-ordinated for Controller and Motor Protection – Programmable from 20% to 190% of Controller Output Current
Motor Protection	I^2t Overload Protection – 150% for 60 seconds, 200% for 30 seconds
Overload Pattern #0	Flat response over speed range (no speed compensation)
Overload Pattern #1	Speed compensation below 25% of Base Speed
Overload Pattern #2	Speed compensation below 100% of Base Speed
Acceleration/Deceleration Time(s)	0.1 to 600 Seconds
S–Curve Accel/Decel Time(s)	0 to 100% of Accel/Decel time – not to exceed 60 seconds
Stopping Modes	3 modes (programmable)
Ramp to stop	0.1 to 600 seconds
Coast	Stops all PWM Output
DC Brake to stop	Applies DC Voltage to the Motor for 0 to 15 seconds
Protective Features (All Controller Ratings)	
Overcurrent	200% hardware limit, 300% instantaneous fault
Excessive Temperature	Embedded temperature sensor trips if heatsink temperature exceeds 95°C
Over/Under Voltage	DC Bus voltage is monitored for safe operation. For controllers rated at input voltage 200–240 VAC, overvoltage trip occurs at 410 VDC bus voltage (equivalent to 290 VAC incoming line voltage). For controllers rated at input voltage 380–460 VAC, overvoltage trip occurs at 815 VDC bus voltage (equivalent to 575 VAC incoming line voltage). For controllers rated at input voltage 200–240 VAC, undervoltage trip occurs at 210 VDC bus voltage (equivalent to 150 VAC incoming line voltage). For controllers rated at input voltage 380–460 VAC, undervoltage trip occurs at 390 VDC bus voltage (equivalent to 275 VAC incoming line voltage).
Control Ride Through	Minimum ride through is 0.5 seconds – typical value 2 seconds
Ground Short	Any output short to ground, detected prior to start
Faultless Ride Through	100 Milliseconds
Output Short Circuit	Any output phase to phase short
Programming (All Controller Ratings)	
Programmer	Optional, Removable Program Keypad Module
Type of Display	6 character LED – two digit parameter number and four digit value
Local Controls	SPEED, RUN, STOP, and DIRECTION controls

Figure A.1 – Controller Dimensions



Controllers Rated 200 – 240V Single Phase

Overall Dimensions	160S AA02	160S AA03	160S AA04	160S AA08[1]
H mm (inches)	152 (6.00)	152 (6.00)	152 (6.00)	152 (6.00)
W mm (inches)	72 (2.83)	72 (2.83)	72 (2.83)	72 (2.83)
D mm (inches)	136 (5.4)	136 (5.4)	136 (5.4)	136 (5.4)
Weight Kg. (lbs.)	0.8 (1.76)	0.8 (1.76)	0.9 (1.98)	0.9 (1.98)

Controllers Rated 200 – 240V 3 Phase

Overall Dimensions	160 AA02	160 AA03	160 AA04	160 AA08	160 AA12
H mm (inches)	152 (6.00)	152 (6.00)	152 (6.00)	152 (6.00)	152 (6.00)
W mm (inches)	72 (2.83)	72 (2.83)	72 (2.83)	72 (2.83)	130 (5.12)
D mm (inches)	136 (5.4)	136 (5.4)	136 (5.4)	136 (5.4)	136 (5.4)
Weight Kg. (lbs.)	0.8 (1.76)	0.8 (1.76)	0.9 (1.98)	0.9 (1.98)	1.1 (2.46)

Controllers Rated 380 – 460V 3 Phase

Overall Dimensions	160 BA01	160 BA02	160 BA03	160 BA04	160 BA06
H mm (inches)	152 (6.00)	152 (6.00)	152 (6.00)	152 (6.00)	152 (6.00)
W mm (inches)	72 (2.83)	72 (2.83)	72 (2.83)	72 (2.83)	130 (5.12)
D mm (inches)	136 (5.4)	136 (5.4)	136 (5.4)	136 (5.4)	136 (5.4)
Weight Kg. (lbs.)	0.8 (1.76)	0.8 (1.76)	0.8 (1.98)	0.9 (1.98)	1.1 (2.46)

[1] *External capacitor modules are provided with this model and mount separately.*

Use the drilling template at the back of the manual for mounting the controller.

Accessories

For All Controller Ratings – 0.37 to 2.2kW (1/2 to 3 HP)							
Controller Ratings			**Dynamic Brake Module**	**MOV Module**	**Line Reactors Open Style**	**Line Filters**	**Capacitor Module**
Input Voltage Rating	**HP**	**kW**	**Cat. No.**	**Cat. No.**	**Cat. No.**	**Cat. No.**	**Cat. No.**
200–240V 50/60Hz 1 Phase	1/2	0.37	160–BMA1	160–MMA1	–	160S–LFA1	160–CMA1
	3/4	0.55	160–BMA1	160–MMA1	–	160S–LFA1	160–CMA1
	1	0.75	160–BMA1	160–MMA1	–	160S–LFA1	160–CMA1
	2	1.5	160–BMA2	160–MMA1	–	160S–LFA1	①
200–230V 50/60Hz 3 Phase	1/2	0.37	160–BMA1	160–MMA1	1321–3R4–A	160–LFA1	160–CMA1
	3/4	0.55	160–BMA1	160–MMA1	1321–3R4–A	160–LFA1	160–CMA1
	1	0.75	160–BMA1	160–MMA1	1321–3R8–A	160–LFA1	160–CMA1
	2	1.5	160–BMA2	160–MMA1	1321–3R8–A	160–LFA1	160–CMA1
	3	2.2	160–BMA2	160–MMA1	1321–3R18–A	160–LFA2	160–CMA1
380–460V 50/60Hz 3 Phase	1/2	0.37	160–BMB1	160–MMB1	1321–3R2–B	160–LFB1	160–CMB1
	3/4	0.55	160–BMB1	160–MMB1	1321–3R2–B	160–LFB1	160–CMB1
	1	0.75	160–BMB1	160–MMB1	1321–3R4–B	160–LFB1	160–CMB1
	2	1.5	160–BMB2	160–MMB1	1321–3R4–B	160–LFB1	160–CMB1
	3	2.2	160–BMB2	160–MMB1	1321–3R8–B	160–LFB1	160–CMB1

① Included with controller.

Replacement Parts and Accessories

For Controller Ratings – 0.37 to 2.2kW (1/2 to 3 HP)			
Fan Replacement Kit	**Ready/Fault Panel**	**Program Keypad Module**	**DeviceNet Communication Module**
Cat. No.	**Cat. No.**	**Cat. No.**	**Cat. No.**
160–FRK1	160–B1	160–P1	160–DN1

Notes:

Numbers

A

B

C

D

E

F

G

I

M

N

O

P

R

S

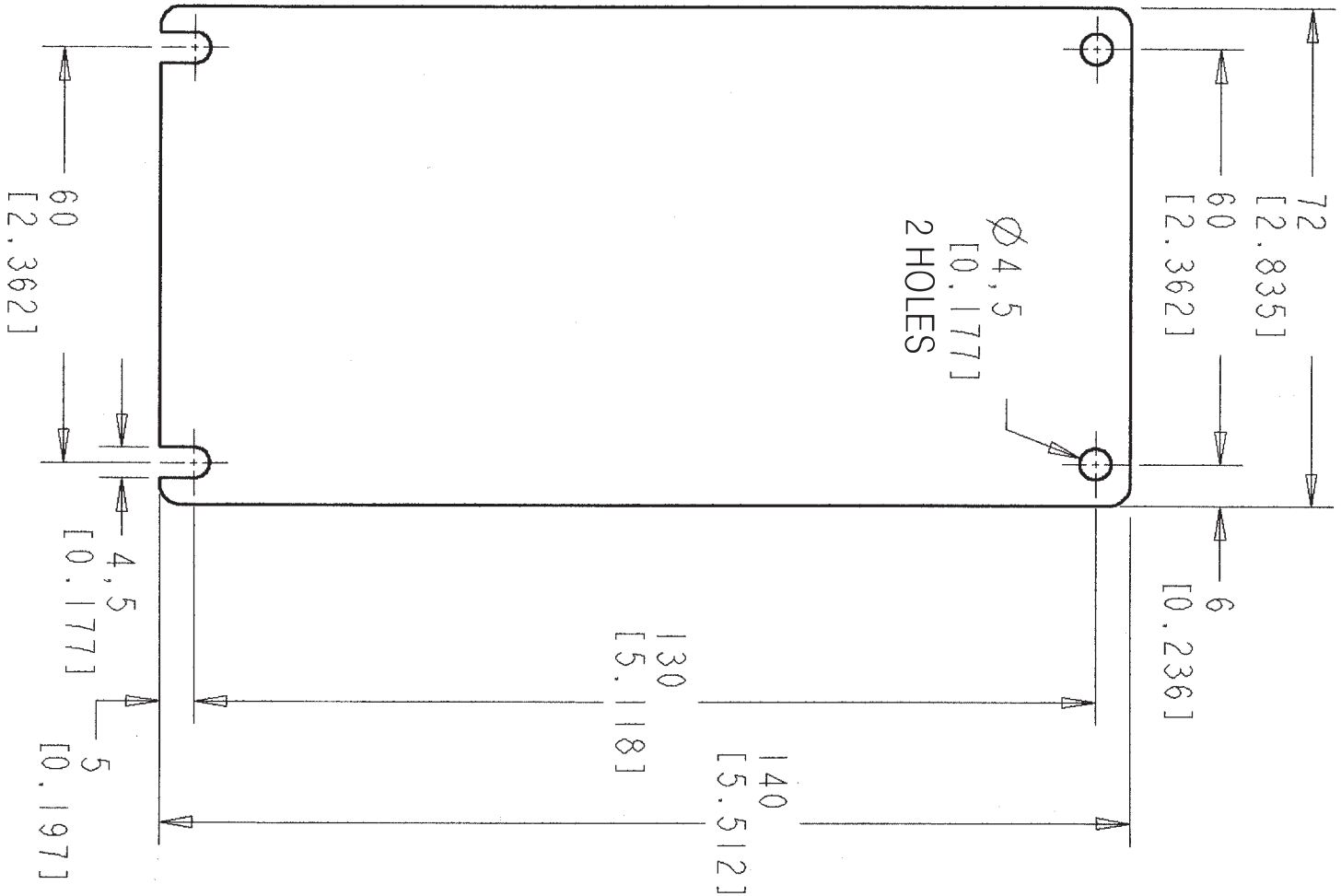
T

U

V

W

Attach template to mounting surface
and drill four (4) 4.5 mm (0.177 inches) diameter holes.
Dimensions are in millimeters [inches].



Rockwell Automation

Allen-Bradley

Allen-Bradley, a Rockwell automation business, has been helping its customers improve productivity and quality for more than 90 years. We design, manufacture and support a broad range of automation products worldwide. They include logic processors, power and motion control devices, operator interfaces, sensors and a variety of software. Rockwell is one of the world's leading technology companies.

Worldwide representation.

Argentina • Australia • Austria • Bahrain • Belgium • Brazil • Bulgaria • Canada • Chile • China, PRC • Colombia • Costa Rica • Croatia • Cyprus • Czech Republic • Denmark Ecuador • Egypt • El Salvador • Finland • France • Germany • Greece • Guatemala • Honduras • Hong Kong • Hungary • Iceland • India • Indonesia • Ireland • Israel • Italy Jamaica • Japan • Jordan • Korea • Kuwait • Lebanon • Malaysia • Mexico • Netherlands • New Zealand • Norway • Pakistan • Peru • Philippines • Poland • Portugal Puerto Rico • Qatar • Romania • Russia–CIS • Saudi Arabia • Singapore • Slovakia • Slovenia • Soth Africa, Republic • Spain • Sweden • Switzerland • Taiwan • Thailand Turkey • United Arab Emirates • United Kingdom • United States • Uruguay • Venezuela • Yugoslavia

Allen-Bradley Headquarters, 1201 South Second Street, Milwaukee, WI 53204 USA, Tel: (1) 414 382-2000 Fax: (1) 414 382-4444

Publication 0160–5.0 – July 1997
Supersedes Publication 0160-5.0 – February 1996 and 0160–5.0–DU – June, 1996

40055-141-01(D)