

# VARI SPEED 160

## Instruction Manual



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## FOREWORD

The Vari Speed 160 is a convenient way to control the speed or the torque of a DC motor. This control will adjust the power delivered to the motor to maintain the desired motor speed or torque. To simplify the use of this control, its features include:

1. Jumpers to convert the control from a speed control to a torque control.
2. Run terminals that use low level switch or relay contact closure (or d.c. solid state switch closure) to run the motor. Opening the run circuit stops the motor.
3. Deceleration or torque fall off that is normally very rapid but can be converted to be equal to acceleration or torque build up.

Additional features for speed control applications are:

4. Speed control. The speed may be continuously varied by a potentiometer or by process signal.
5. Internal adjustments control minimum speed, maximum speed, acceleration rate, IR compensation, and current limit for overload conditions.
6. Current limit automatically increases during acceleration to 1½ times the steady speed setting.

Additional features for torque control applications are:

7. Torque Control. The torque may be continuously varied by a potentiometer or by process signal.
8. Internal adjustments control minimum torque, maximum torque, torque build up rate and maximum motor speed under light or no load conditions.

Run and speed or torque control terminals have rectified AC line potential present and must therefore be isolated from ground as well as from the A.C. line.

The remainder of this manual will cover this control in much greater detail.

## SPECIFICATIONS

FOR SPEED CONTROL  
APPLICATIONSFOR TORQUE CONTROL  
APPLICATIONS

INPUT POWER .....	95 to 135VAC on 120VAC Models 195 to 260VAC on 240 VAC Models 50/60 HZ Single Phase	Same
OUTPUT RATING .....	0-90VDC on 120VAC Models 0-180VDC on 240VAC Models 0-5A, 0-10A, or 0-15A 0-½HP, 0-1HP, 0-2HP, 0-3HP	Same
ENCLOSURES AVAILABLE .....	Chassis or NEMA Enclosure	Same
AMBIENT TEMPERATURE RANGE ..	0° to 50°C. (32° to 122°F)	Same
MOUNTING POSITION .....	Vertical Mounting	Same
OPERATOR CONTROL PROVISIONS ..	Run-Stop, Speed Adjustment	Run-Stop, Torque Adjustment
INTERNAL CONTROLS .....	Max Speed, Min. Speed, Current Limit, IR Compensation, Acceleration Control	Max Torque, Min. Torque, Voltage Limit, Acceleration Control
MAXIMUM ADJUSTMENT RANGE ...	Approx. 50% to 110% of Base Speed	Approx. 50% to 110% Base Torque
MINIMUM ADJUSTMENT RANGE ...	Approx. 0% to 50% of Base Speed	Approx. 0% to 50% of Base Torque
IR COMPENSATION RANGE .....	Typical ½HP to 3HP	Set to Minimum
ACCELERATION CONTROL .....	Acceleration is linear and adjustable from .2 to 5 sec. to full speed. (Other ranges available.)	Torque build up is linear and adjustable from .2 to 5 sec. to full torque (Other ranges available.)
LIMIT .....	Current Limit. Adjustable from near 0 to 110% full output. Motor will stall with a sustained load exceeding the current set point. Current limit increases to approx. 1½ setting during acceleration.	Voltage Limit. Adjustable from near 0 to 90V or 180V. No load motor speed will not exceed the set point.
PROCESS SIGNAL INPUT .....	0-10VDC for 0 to full speed Input Resistance— 100K ohm Also useable 1-5 ma, 4-20 ma, 10-50 ma, Not isolated.	0-10VDC for 0 to full torque Input Resistance— 100K Also useable with 1-5 ma, 4-20 ma, or 10-50 ma. Not isolated.
TACHOMETER FEEDBACK .....	21VDC/1000RPM	
VARIATIONS DUE TO LINE VOLTAGE FLUCTUATIONS .....	The control will compensate to less than 2% speed change in less than 500 ms within input power range.	The control will compensate to less than 2% torque change in less than 500 ms within input power range.
VARIATIONS DUE TO THERMAL DRIFT .....	Control: Less than 2% of base speed. Motor (with Armature Feedback): Depends on application. Motor (with Tachometer Feedback): Less than 1% Consult factory.	Control: Less than 2% of full load current. Motor: Depends on application. Consult factory.
VARIATIONS DUE TO LOADING (90% Load Change) .....	Armature Feedback: Typical application 3% of Base Speed. Tachometer Feedback: 1/2% of set speed or 4RPM, whichever is greater.	Armature Feedback: Typical application 2% of Nameplate current.
FULL RANGE .....	Armature Feedback: 50:1 speed at full torque. Tachometer Feedback: 200:1 speed at full torque.	50:1 torque at full speed.

## OPERATIONAL CHARACTERISTICS AS A SPEED CONTROLLER

- RUN:** The run function causes the control to run when a closure is made and to stop when reopened.
- SPEED CONTROL:** The Vari Speed 160 provides for infinitely variable speed control of permanent magnet D.C. Motor and uses a full wave bridge. (S.C.R. and Diode configuration.) There is compensation for line voltage variation and variations in motor loading. At a given speed potentiometer setting and with a constant load the motor speed will vary less than 1% with an input voltage change of  $\pm 10\%$  of nominal. The no load to full load variations will be typically 3% with armature feedback or 1/2% of set speed with tachometer feedback. A major design parameter of the Vari Speed 160 was to limit overshoot, undershoot and settling time. These characteristics are more than adequate for almost all applications.
- ADJUSTABLE CURRENT LIMIT:** The Vari Speed 160 is provided with an adjustable current limit circuit which can be set to limit the steady state motor current to any value from zero to the control's full rated output. The control will automatically allow the motor to draw approximately 1 1/2 times the steady state current limit setting during acceleration.
- ADJUSTABLE ACCELERATION:** The linear ramp for controlling acceleration is adjustable. The time required for the motor to accelerate from zero speed to full speed can be adjusted from .2 sec. to 5 sec. as supplied. (Other ranges can be supplied. Consult Factory). Deceleration is always rapid but is field convertible to be equal to acceleration.
- PROCESS CONTROL SIGNALS:** A process control signal input may be used by connecting process signal (+) to SP2 and process (-) to SP3. The motor speed will track a 0-10VDC process voltage to better than 3% linearity. The input impedance is approx. 100K ohms. A 1-5 ma signal can be accommodated by shunting SP2 and SP3 with a 2K ohm, 1/2 watt resistor, for 4-20 ma, use a 500 ohm, 1/2 watt, or for 10-50 ma, use a 200 ohm, 1 watt resistor. An external potentiometer may be used to reduce the process signal to trim the control output to any desired speed. The motor will run anytime a signal is present even if the RUN circuit is open. Consult factory for additional current process signal information.

CAUTION: Process signal inputs are not isolated and are HOT to ground.

## OPERATIONAL CHARACTERISTICS AS A TORQUE CONTROLLER

- RUN:** The run function causes the control to run when a closure is made and to stop when reopened.
- TORQUE CONTROL:** The Vari Speed 160 provides for infinitely variable torque control of a permanent magnet D.C. motor. There is compensation for line voltage variation and variations in motor speed. At a given torque potentiometer setting and with a constant speed the motor torque will vary less than 1% with an input voltage change of +10%. The zero speed to full speed variations in torque will be typically 2%. A major design parameter of the Vari Speed 160 was to limit overshoot, undershoot and settling time. These characteristics are more than adequate for almost all applications.
- ADJUSTABLE VOLTAGE LIMIT:** The Vari Speed 160 is provided with an adjustable voltage limit circuit which can be set to limit the no load or light load motor voltage to any value from zero to the control's full rated output. This effectively limits motor speed during operations where the load torque is lower than the torque control setting.
- ADJUSTABLE TORQUE BUILD UP:** The linear ramp for controlling torque build up is adjustable. The time required for the motor to build up from zero torque to the control's full rated current can be adjusted from .2 sec. to 5 sec. as supplied. (Other ranges can be supplied. Consult factory). Torque fall off is always rapid but is field convertible to be equal to the torque build up rate.
- PROCESS CONTROL SIGNALS:** A process control signal input may be used by connecting process signal (+) to SP2 and process (-) to SP3. The motor torque will track a 0-10VDC process voltage to better than 3% linearity. The input impedance is approx. 100K ohms. A 1-5 ma signal can be accommodated by shunting SP2 and SP3 with a 2K ohm, 1/2 watt resistor, for 4-20 ma, use a 500 ohm, 1/2 watt, or for 10-50 ma, use a 200 ohm, 1 watt resistor. An external potentiometer may be used to reduce the process signal to trim the control output to any desired torque. The motor will develop torque any time a signal is present even if the RUN circuit is open. Consult factory for additional information on current process signal operation.

CAUTION: Process signal inputs are not isolated and are HOT to ground.

## INSTALLATION

1. **WARNING!** Improper installation of motor and controller may cause severe personal injury or equipment failure. Follow instruction manual, local, state and national safety codes for proper installation. Always disconnect power to controller before making any wiring changes, or before inspecting the controls or equipment.
2. The controller enclosure or chassis, motor frame, and any remote operator's stations must be connected to building ground for the safety of the operating personnel.
3. A fused disconnect, or circuit breaker, in incoming AC power is required. See page 16 for recommended fuse or circuit breaker ratings. The circuit breaker included in the enclosed models meets code requirements in many cases.
4. The Vari Speed "160" should be mounted vertically for coolest operation. During heavy loads, the controller may reach temperatures HOT to the touch. This is normal and expected. However, under the most extreme conditions, the surface of the controller should never exceed 75°C.
5. All electronic controls are subject to line spikes and noise generated by equipment such as arc welders, solenoids, dielectric heaters, etc. H.P.C. has provided all of the latest devices for protection against such an environment. However, it is suggested as an additional protection that shielded wire be used for run and speed control circuits into controller. Shields must be insulated and should be connected to F - .
6. To insure avoiding personal injury, use an AC line disconnect or controller circuit breaker to insure positive shutdown of controller and motor before working on this control or any equipment or machinery it is controlling.
7. When making internal adjustments on NEMA 4 and 12 controllers, (e.g. min./max. speed) remount cover upside down as shown in Illustration on page 15.
8. When remote mounting speed adjust potentiometer and function switches, keep in mind that all terminals are at rectified line potential with respect to ground and accidental grounding could cause permanent control damage.
9. **Grounding** - It is imperative that the controller enclosure, motor and remote operator's stations (when used) be connected to building ground for the safety of the operation personnel.
10. Do not apply AC line voltage to any terminals except AC1 and AC2. If voltages are applied to any other terminals, permanent damage may occur. Use only isolated contact closures for all other connections as shown in Wiring Information.
11. All terminals have high voltage with respect to ground present whenever AC power is turned on.
12. All remote connections to controller such as speed potentiometers, run circuits, tachometer, and process signals should use shielded cable. Shields must be insulated and should be connected to F-. These shields will have field voltage present whenever AC power is on.
13. The Vari Speed 160 is normally shipped as a speed control but may be converted to a torque control by moving the jumpers of J1, J2, and J3. Always disconnect power before working on the control.

Carefully pull the blue jumpers off the gold pins and replace according to this table:

JUMPER	TO CONTROL SPEED	TO CONTROL TORQUE
J1	A - C	B - C
J2	A - C	B - C
J3	OMIT	B - C

These jumpers are shown in the picture on page 13.

14. Standard deceleration is very rapid and not adjustable. This can be converted to match the acceleration time by cutting diode D16 off the circuit board. Both the acceleration and deceleration time will then be controlled by the acceleration adjustment. Both will be linear. For torque controls the torque build up and decay rates will then be equal. D16 is marked by an extra long diode component symbol on the printed circuit board as shown in the picture on page 17. The Vari Speed "160" may be ordered without D16 for adjustable equal acceleration and deceleration.
15. Current limit is factory set for the largest motor with which the controller is designed to be used. Current limit must be reduced by the customer to safely work with motors smaller than the full control rating.
16. The run terminals are normally jumpered together when the Vari Speed "160" is shipped from the factory. A separate run circuit may be used after removing this jumper. Open circuit voltage is 15 volts DC and closed circuit current is about 1 ma. Use switch or relay contacts that are designed to operate reliably at these low levels or use low leakage solid state switching devices that are isolated from ground.
17. The SP2 terminal circuit must never be disconnected and left open or "floating" when AC power is on or the motor may run at any speed or torque.

# START-UP PROCEDURE

Adjustments on the printed circuit board are labelled. Illustrations located in the back of the manual show locations of adjustments also.

1. Use caution during these procedures because high voltage will be present on the control and motor terminals and on the circuit board when the power is on, even if the motor is not turning.
2. Recheck to make sure that all connections are made properly according to the Instruction Manual, state, local and national safety codes.
3. Set speed (or torque if operated as torque controller) control potentiometer fully counterclockwise.
4. Turn on fused line disconnect (or circuit breaker).
5. If the run jumper has been removed, connect a temporary jumper between the run terminals or close the external run circuit.
6. Slowly rotate the speed control potentiometer clockwise. The motor should start slowly, and smoothly increase speed as the control potentiometer is rotated further clockwise. (If the control is used to control torque, the motor torque will increase smoothly as the potentiometer is turned clockwise. If the motor load is less than the torque control setting, the motor will accelerate to the speed limit setting.)

## SPEED CONTROLLER ADJUSTMENTS AFTER START-UP

### MAXIMUM SPEED ADJUSTMENT

This setting has been factory adjusted. However, if a higher or lower setting is required:

1. Start motor and allow it to warm up at least 30 minutes fully loaded. (Motor speed will increase with a rise in motor temp.)
2. With motor driving a full load and the speed control potentiometer turned all the way up, adjust the MAX trimpot until desired speed is set.
3. Go on to the minimum speed adjustment as there may be some interaction.

### MINIMUM SPEED ADJUSTMENT

1. Turn speed adjustment potentiometer fully counterclockwise.
2. Start control and adjust MIN trimpot until desired minimum speed is set. If desired minimum speed is zero, adjust trimpot so that motor just barely stops turning. This setting will give the best speed setting to motor speed linearity.
3. Recheck max. adjustment as some interaction is probable.

### CURRENT LIMIT ADJUSTMENT

This setting has been adjusted at the factory for the maximum limit for the horsepower rating of the drive. If a lower current limit is desired, one of two methods may be used. Warm up the motor for at least 30 minutes then use either method.

#### Method 1.

Turn off AC power. Lock up motor shaft in such a way that no damage will occur. Temporarily connect a DC ammeter in series with the motor armature. Turn LIMIT trimpot fully counterclockwise. Turn AC power on. Turn speed control potentiometer up. Start control and adjust LIMIT trimpot for full load current required. Turn off AC power, remove DC ammeter, and unlock the motor shaft; or

#### Method 2.

Start the control and load machine to maximum, the worst loading conditions you expect. Turn LIMIT trimpot, counterclockwise slowly until motor begins to slow down. At this point, turn pot slightly clockwise until motor regains original set speed.

### CONTROLLED ACCELERATION

This adjusts the rate of motor acceleration to set speed. The more clockwise the RATE trimpot is set, the slower the acceleration and therefore longer acceleration time. This simultaneously adjusts deceleration if diode D16 has been removed.

### IR COMPENSATION

1. If Tach Feedback is used, set IR fully counterclockwise, otherwise:
2. Start control with machine at no load. Set speed at about 2/3 and measure RPM's.
3. Load machine to full capacity, or motor rated load, whichever is lower. Adjust IR trimpot until no load and full load speeds match.
4. Repeat no load measurements since there is some interaction. Do not overcompensate.
5. Recheck MIN and MAX adjustment.

## TORQUE CONTROLLER ADJUSTMENTS AFTER START-UP

### IR COMPENSATION

Turn the IR trimpot fully counterclockwise.

### MAXIMUM TORQUE ADJUSTMENT

1. Start the controller and allow the motor to warm up at least 30 minutes fully loaded. (Motor torque will decrease with a rise in motor temp. unless using dancer feedback.)
2. With motor driving a full load and the torque control potentiometer turned fully clockwise, adjust the MAX trimpot until desired maximum torque is set.
3. Recheck MIN adjustment.

### MINIMUM TORQUE ADJUSTMENT

1. Turn torque control potentiometer to minimum.
2. Start control and adjust MIN trimpot on board until desired minimum torque is set. If desired minimum torque is zero, adjust trimpot so that motor just barely stops turning under no load conditions on the equipment. This setting will give the best torque linearity.
3. Recheck MAX adjustment.

### VOLTAGE LIMIT ADJUSTMENT

This adjustment may be used to limit maximum equipment speed when operating with no load. One of two methods of setting may be used:

#### Method 1.

Turn off AC power. Uncouple the motor shaft from the equipment. Turn LIMIT trimpot fully counterclockwise. Turn AC power on. Turn torque control potentiometer up. Start control and adjust LIMIT trimpot for full motor speed desired. Turn off power and couple the shaft; or

#### Method 2.

Start control and operate machine at minimum load. Turn the LIMIT trimpot counterclockwise slowly until motor begins to slow down under the lightest loading conditions you expect. Adjust the motor speed for the maximum desired speed.

### CONTROLLED ACCELERATION

This adjusts the rate of motor torque build up to set torque. The more clockwise the RATE trimpot is set, the slower the torque build up and therefore longer torque build up time. This simultaneously adjusts torque decay time if diode D16 has been removed.



## TROUBLE SHOOTING THE VARI SPEED 160

SYMPTOM	SOLUTION
Motor will not run	<ol style="list-style-type: none"> <li>1. Make sure circuit breaker and line disconnects are turned on.</li> <li>2. Check line fuses to see if they are good.</li> <li>3. Set control to 50%</li> <li>4. With power OFF and motor leads disconnected check for worn or improperly seated motor brushes. See brush table.</li> <li>5. Faulty circuit board.</li> <li>6. Faulty power components.</li> </ol>
Circuit Breaker Tripping	<ol style="list-style-type: none"> <li>1. Improper wiring – recheck wiring for shorts and shorts to ground.</li> <li>2. Motor brushes worn or improperly seated.</li> <li>3. Motor load is too heavy. Check for “Jam-up” or excessive load.</li> <li>4. Motor shorted. Check motor.</li> <li>5. Power component failure.</li> </ol>
No speed control No torque control	<ol style="list-style-type: none"> <li>1. Control potentiometer or wiring defective.</li> <li>2. Minimum adjust potentiometer (located on circuit board) mis-adjusted. Turn counterclockwise to correct.</li> <li>3. Maximum adjust potentiometer misadjusted turn clockwise to correct.</li> <li>4. Faulty power component.</li> <li>5. Tach polarity Incorrect.</li> </ol>
Motor will not run at 1725 rpm	<ol style="list-style-type: none"> <li>1. Improper setting of maximum adjustment on speed controller printed circuit board. Turn clockwise to increase speed.</li> <li>2. Limit may be set too low on torque controller.</li> <li>3. Motor may be overloaded. (Motor horsepower is less than required for load).</li> </ol>
Motor jumps after stop or before start signal	<ol style="list-style-type: none"> <li>1. CONSULT FACTORY.</li> </ol>
Motor speed erratic	<ol style="list-style-type: none"> <li>1. Worn brushes.</li> <li>2. Control potentiometer or associated circuit may be defective.</li> <li>3. IR comp adjustment set too high.</li> <li>4. Tachometer defective.</li> <li>5. Defective circuit boards. (Consult Factory)</li> </ol>
Motor will not stop with run circuit opened	<ol style="list-style-type: none"> <li>1. Faulty wiring in control circuit.</li> <li>2. IR comp adjustment set too high.</li> <li>3. Operating from process signal that remains at some voltage or current not corresponding to zero.</li> <li>4. Faulty circuit board.</li> <li>5. Faulty power components.</li> <li>6. Tach polarity incorrect.</li> </ol>

## TEST PROCEDURE FOR POWER COMPONENTS

NOTE: The following tests are to conclude that the components are good or bad.

CAUTION: Turn OFF all power for the following tests.

For the following controls, power module can be tested:

300316	300436
300336	300439
300346	300446
300416	300449

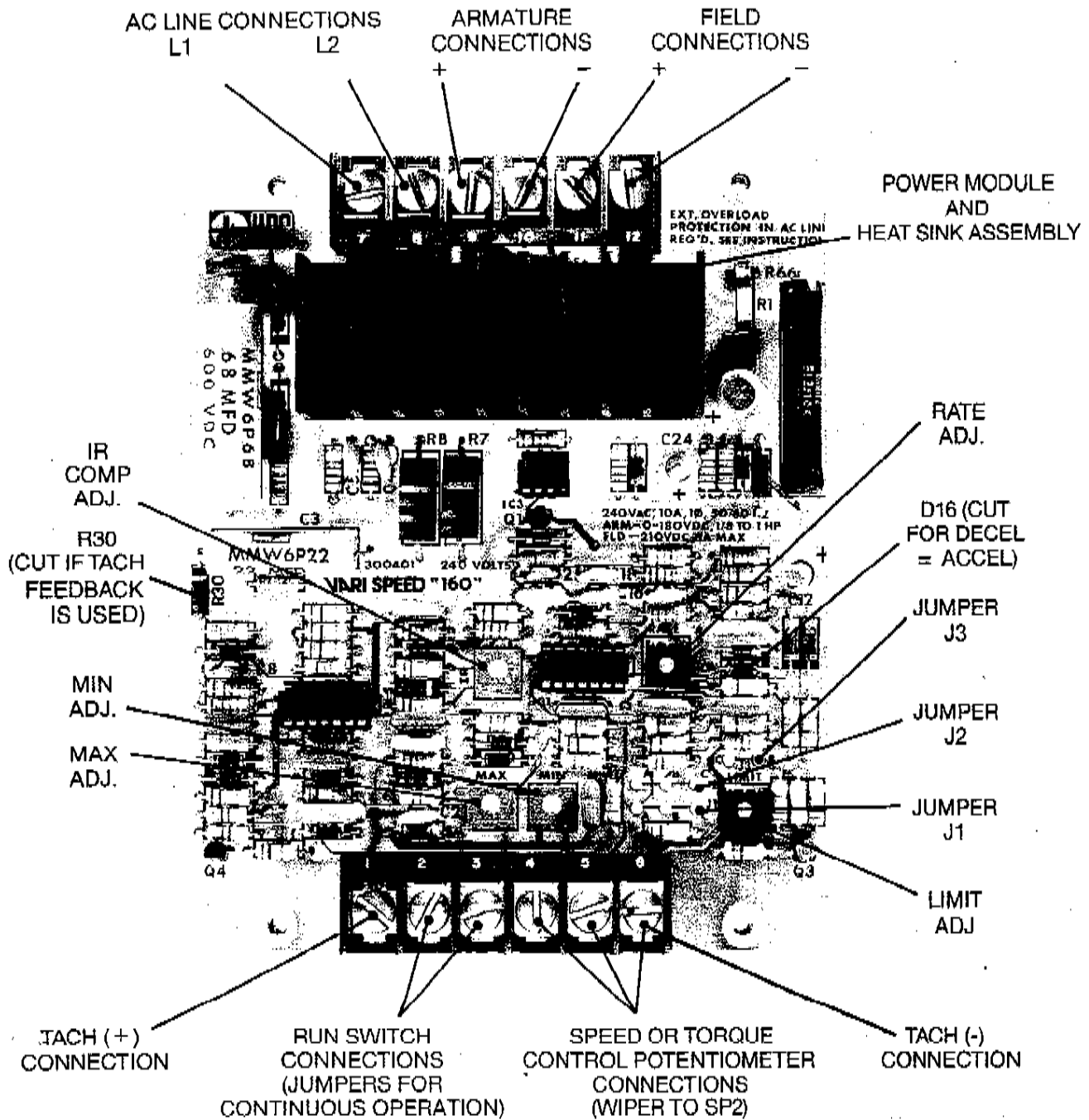
The 300301, 300331, 300341, 300401, 300431, and 300441 tests are made on the circuit board terminals.

1. Pull off all "fast on" connections. Set V.O.M. to RX 10K scale.
2. Check resistance from both AC terminals to (+) terminal. Both directions resistance should be greater than 1 Meg OHM.
3. Check resistance from both AC terminals to (-) terminal. Resistance should be greater than 1 Meg OHM in one direction and less than 50 K in the other direction.
4. Check resistance from (+) terminal to (-) terminal. Resistance should be greater than 1 Meg OHM in one direction and less than 50 K in the other direction.

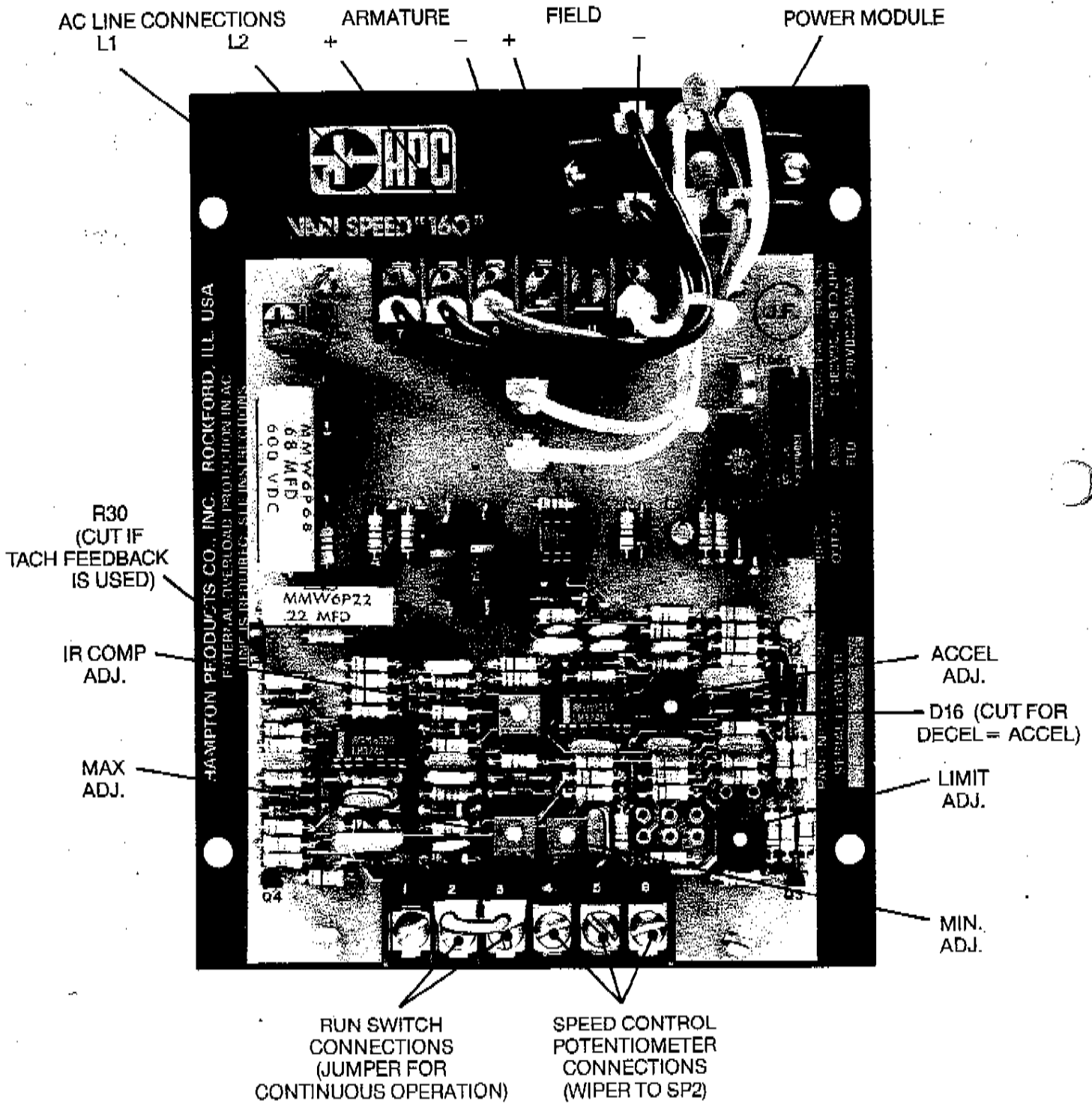
## SPARE PARTS LIST

Part No.	Description
944	Potentiometer 500K
2006	Circuit Breaker, 15A, 1 Pole
2008	Circuit Breaker, 5A, 1 Pole
2011	Circuit Breaker, 15A, 2 Pole
2012	Circuit Breaker, 20A, 2 Pole
2017	Circuit Breaker, 5A, 2 Pole
2025	Circuit Breaker, 15A, 1 Pole N4
2026	Circuit Breaker, 15A, 2 Pole N4
2030	Circuit Breaker, 5A, 1 Pole N4
2031	Circuit Breaker, 5A, 2 Pole N4
2032	Circuit Breaker, 20A, 2 Pole N4
2319	Power Module for 120V 1 HP Control
2320	Power Module for 240V 2 HP Control
2306	Power Module for 240V 3 HP Control

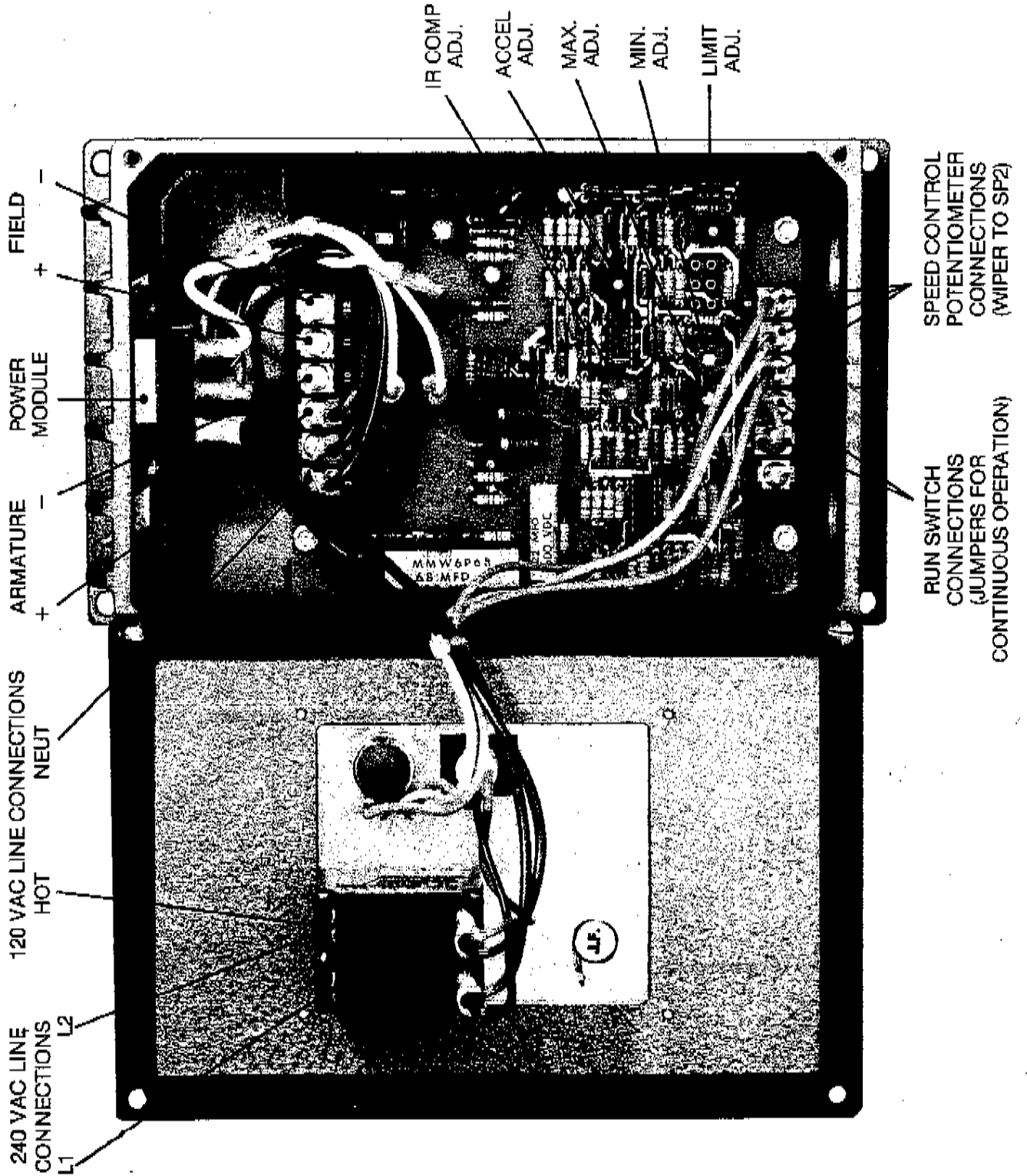
# ILLUSTRATION CHASSIS MOUNT - 5 AMP



# ILLUSTRATION CHASSIS MOUNT



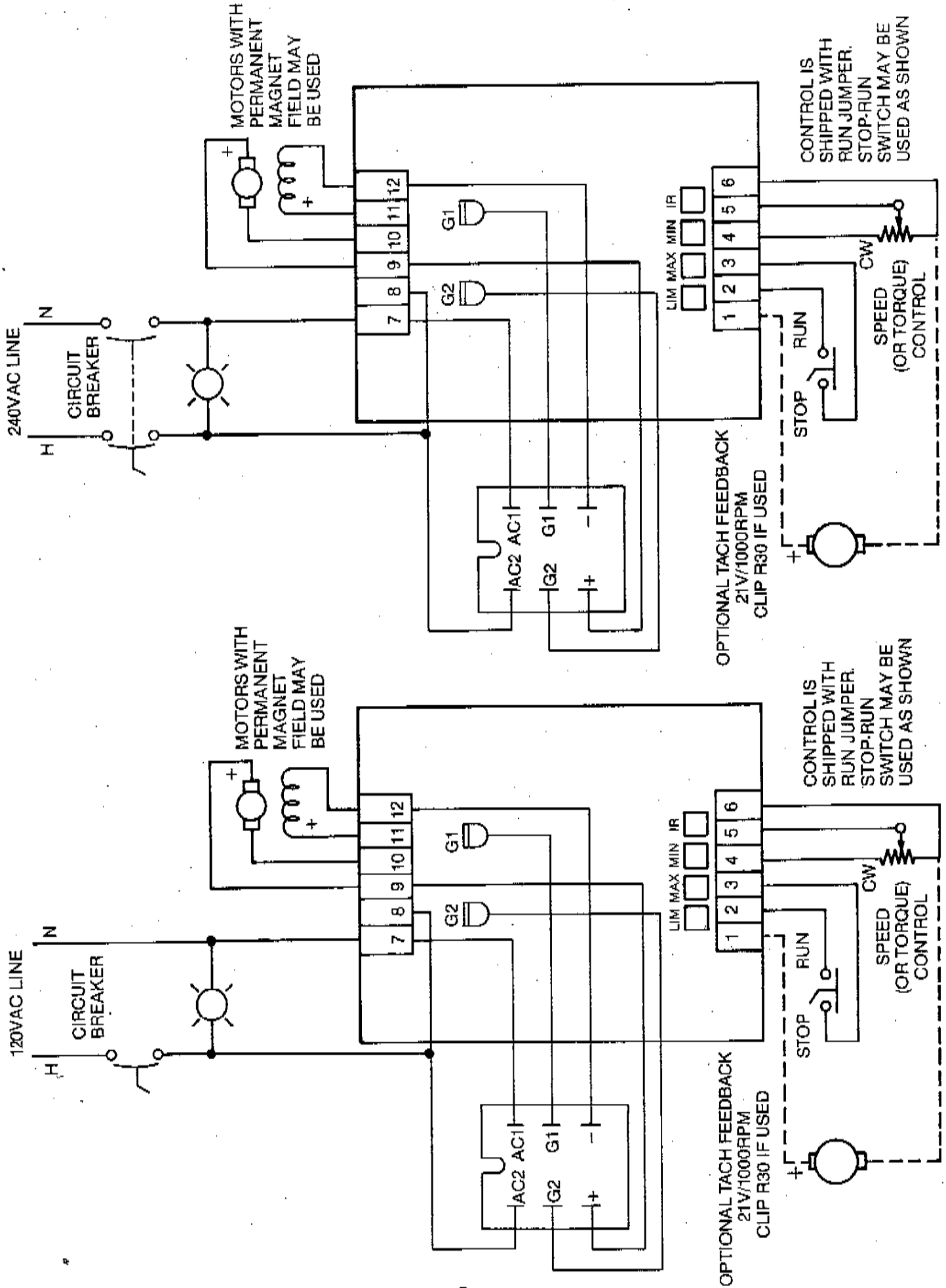
# ILLUSTRATION VARI SPEED 160, NEMA 12, 240 VOLT

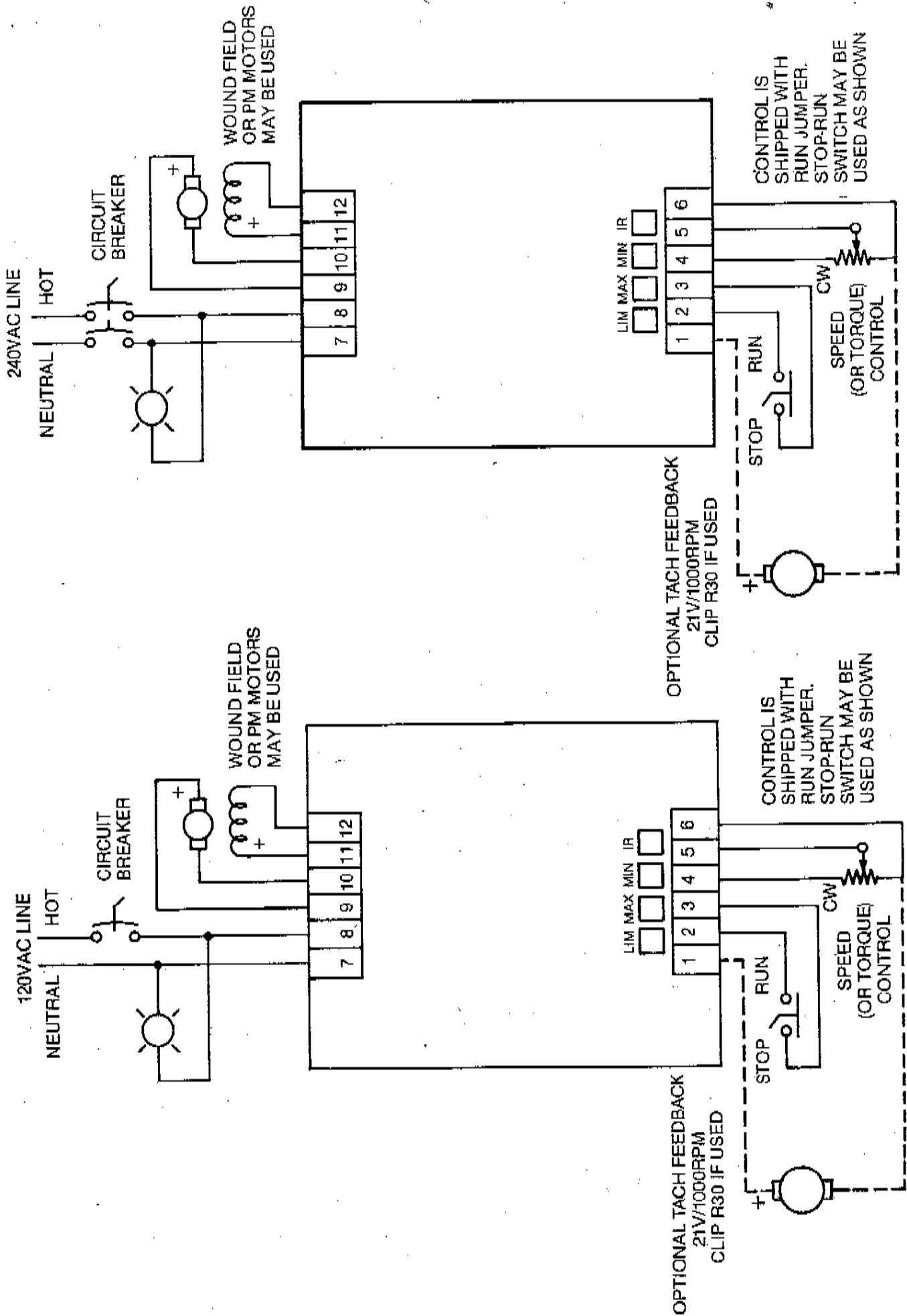


## RECOMMENDED AC LINE PROTECTION

AC LINE VOLTAGE	MOTOR HP	DUAL ELEMENT FUSE AMPS	CIRCUIT BREAKER		
			AMPS	POLES	HPC PART NO.
120	1/8	2-1/2	5	1	2008
	1/4	4	5	1	2008
	1/3	5	5	1	2008
	1/2	8	7-1/2	1	2014
	3/4	10	10	1	2007
	1	15	15	1	2006
240	1/8	1-1/2	5	2	2017
	1/4	2	5	2	2017
	1/3	2-1/2	5	2	2017
	1/2	4	5	2	2017
	3/4	5	5	2	2017
	1	8	7-1/2	2	2015
	1-1/2	10	10	2	2010
	2	15	15	2	2011
	3	20	20	2	2012

240 VAC LINE REQUIRES PROTECTION IN BOTH AC LINES

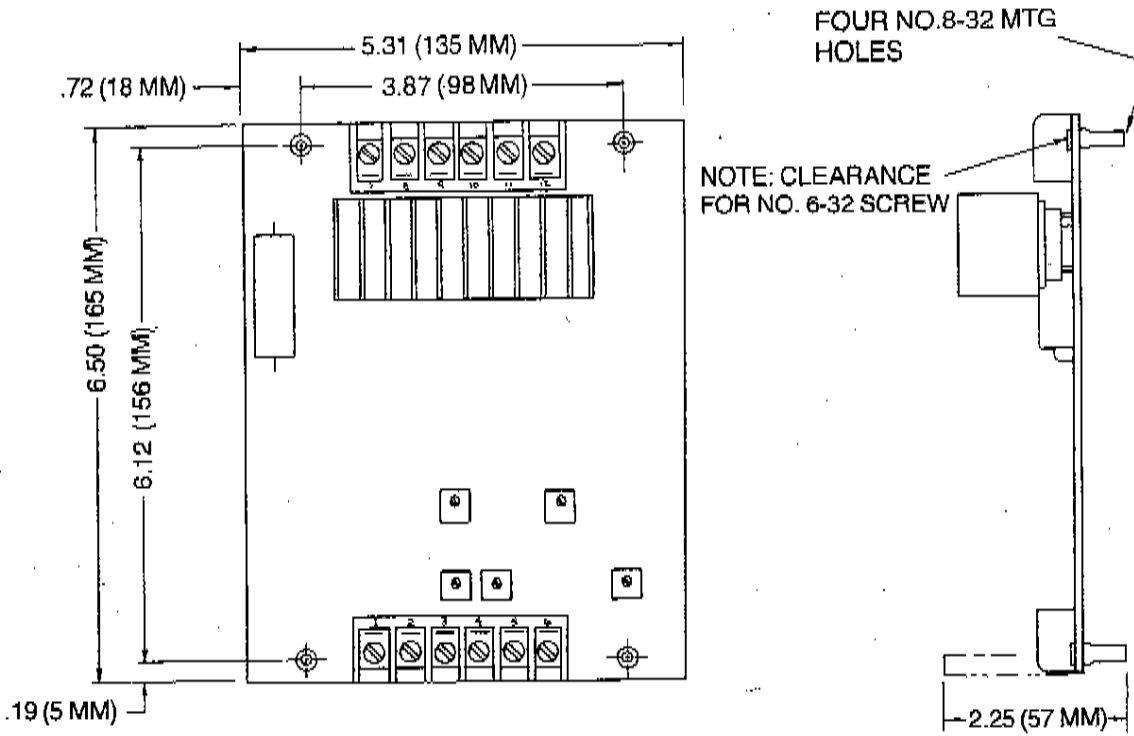




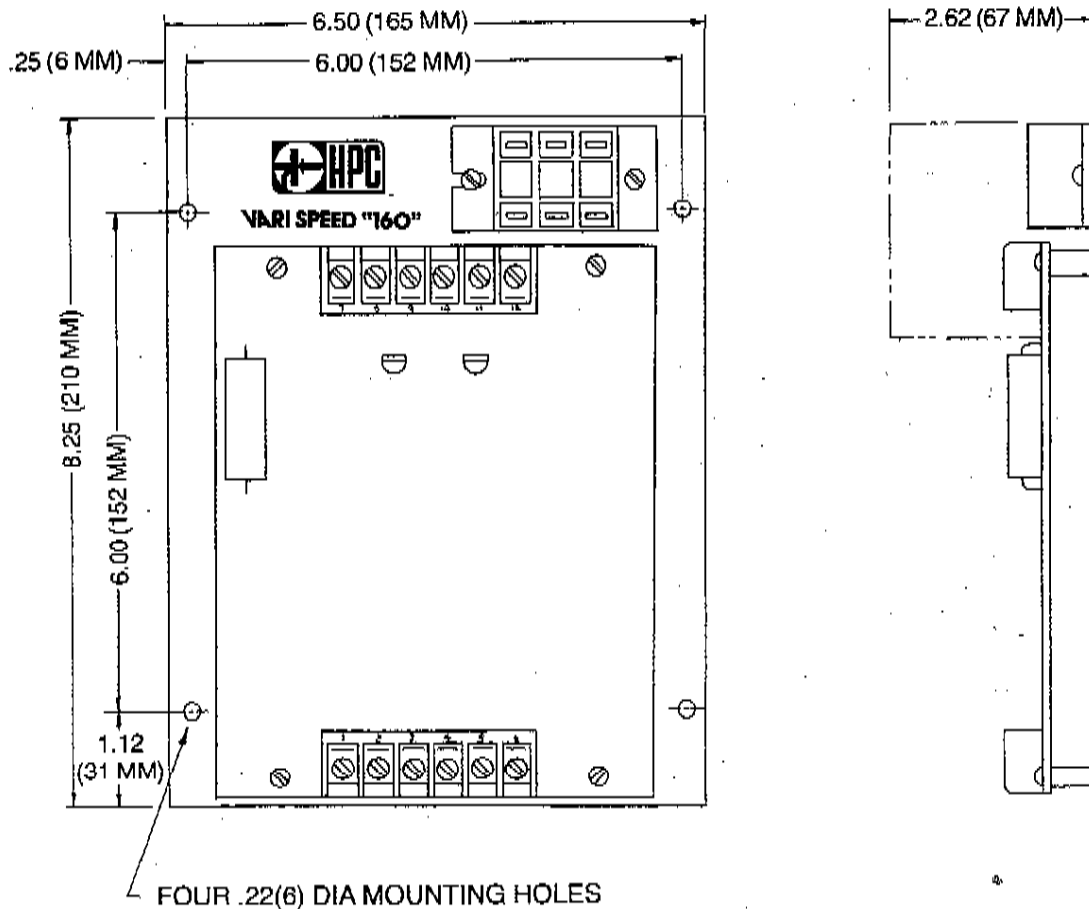


# OUTLINE DIMENSIONS

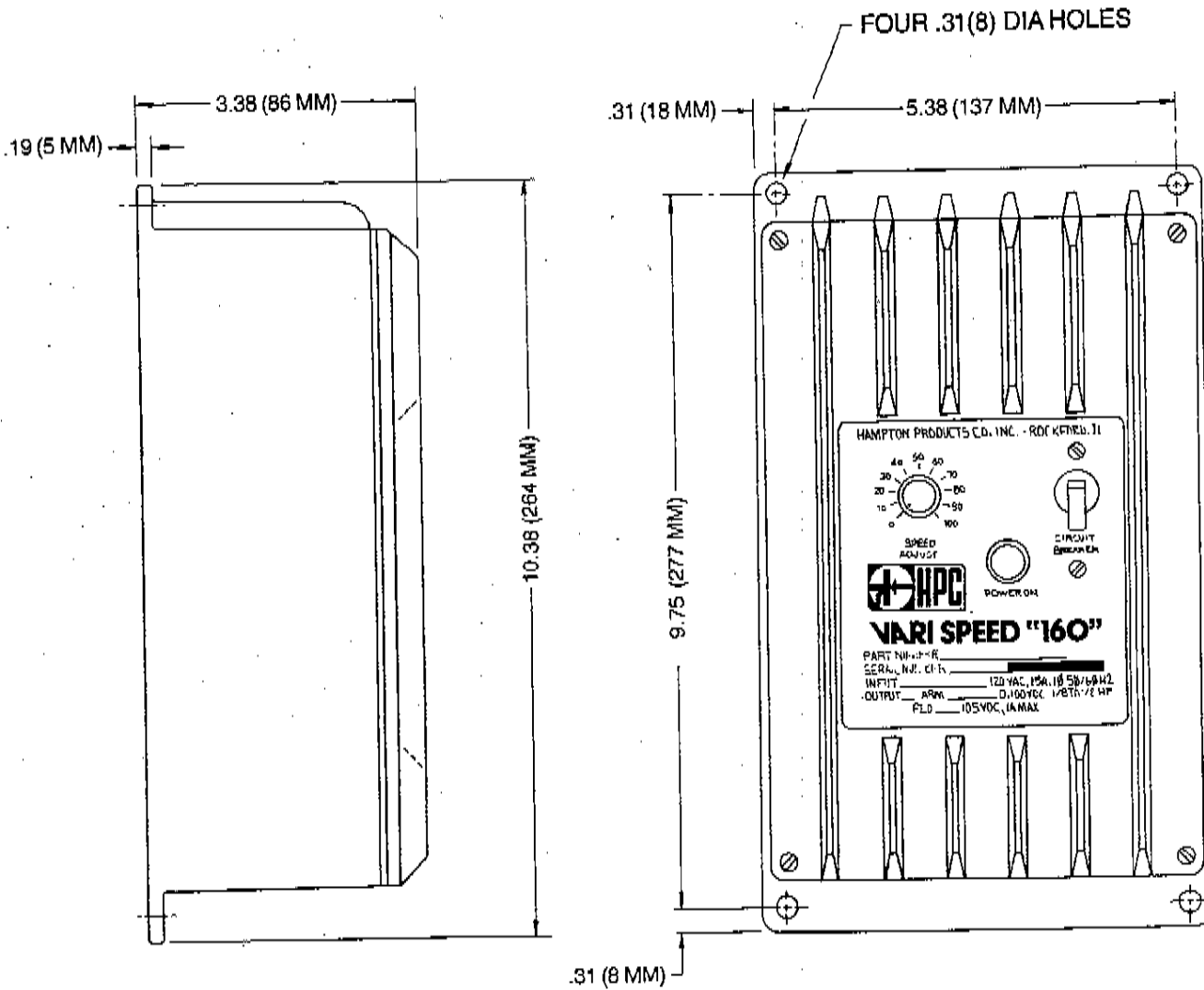
**CHASSIS MOUNT PART NO. 300301  
300401**



**LOW PROFILE CHASSIS MOUNT PART NO. 300316  
300416**

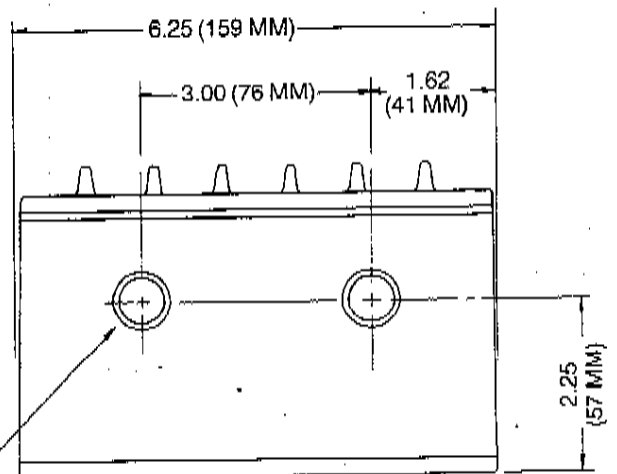


# OUTLINE DIMENSIONS



## NEMA 12 ENCLOSURE

	300431	300431
	300331	300436
PART NO.	300336	300439
	300341	300441
	300346	300446
		300440



TWO 1/2 - 14NPT HOLES