

## SL10U

Adjustable Speed Control  
for Hurst Permanent Magnet  
90 VDC Motors



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# Safety Warnings



**Note:** This symbol  denotes an important safety message. Please read these sections carefully before performing any instructions contained in this manual.

- Have a qualified electrical maintenance technician install, adjust and service this equipment. Follow the National Electrical Code and all other applicable electrical and safety codes, including the provisions of the Occupational Safety and Health Act (OSHA), when installing equipment.
- Reduce the chance of an electrical fire, shock, or explosion by proper grounding, over current protection, thermal protection, and enclosure. Follow sound maintenance procedures.

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## General Information

The Model SL10U Minarik adjustable speed control is a full-wave, solid-state device that is designed to control and vary the speed of Hurst 90 VDC permanent magnet motors. The control has choke/capacitor filtering to ensure quiet, smooth and cool running. In a typical application, 2% base speed regulation is provided with the help of temperature, line voltage and IR compensation. The control has a speed range of 15:1, also has adjustable IR compensation and a maximum speed adjustment to limit high-speed operation.

## Features

- Choke/Capacitor Filtering
- Temperature Compensation
- 2% Base Speed Regulation (Typical Application)
- Maximum Speed Adjustment
- Adjustable IR Compensation
- Line Starting and Stopping
- Line Voltage Compensation
- Full Wave Armature Supply

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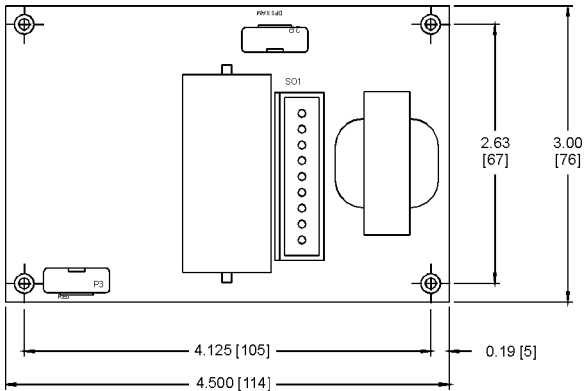
## Specifications

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Input Voltage	115 VAC, 50/60 Hz Single Phase
Maximum Input Current	0.12 Amperes
Output Armature Voltage	0 - 90 VDC
Output Armature Current	0.07 Amperes
Horsepower Range	1/250 – 1/50
Weight	8.0 Ounces
Ambient Temperature Range	10° – 40° C

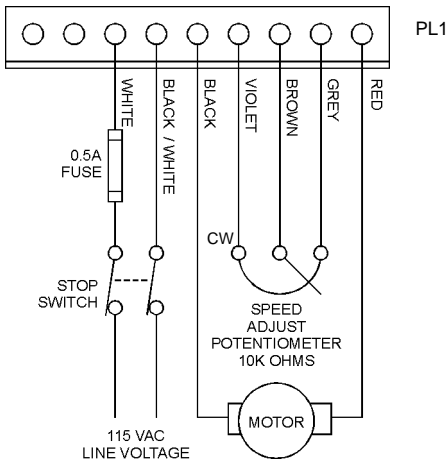
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## Dimensional Data



ALL DIMENSIONS IN INCHES [MILLIMETERS]

**Figure 1. Dimensions**



**Figure 2. SL10U Connections**

## Installation



### Warning

The SL10U is not isolated from earth ground. Unless an isolation transformer is used, circuit components are at a potential of 115 volts above ground. Please refer to Safety Warnings on page i before installing.

The SL10U is an uncased chassis model and is designed to be installed in original equipment. The speed adjust pot (P1) and its mounting hardware is supplied with the control. Mount the speed adjust pot through a 3/8" hole with the insulator disc between the pot and the inside of the panel. The lock washer is placed between the outside of the panel and the locknut. Mount the chassis to appropriate subplates using the four threaded (6-32) mounting stand-offs (refer to figure 1 on page 4 for mounting dimensions). The chassis has adequate heat sinking to properly dissipate the load-generated heat and can be either vertically or horizontally mounted.

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Leave enough room around the outer dimensions of the chassis to allow access to the chassis after installation for removal, installing wiring, calibration and other related reasons. Connect the SL10U as shown in Figure 2 (page 5), and as described below.

1. Connect the speed adjust pot to its appropriate wires. These 3 wires should NOT be bundled with the motor and power line leads because induced voltages could cause erratic operation. If the speed adjust pot requires wiring longer than 18 inches (0.5m), a shielded cable must be used. Do not ground both ends of the shield.
2. Connect the motor to its appropriate wires. If the motor rotates in the wrong direction, remove line voltage and reverse the motor armature leads. Do NOT plug reverse the motor.

3. Connect the power line to its appropriate wires. The hot leg of the power line should be fused with a fast blow 0.5 amp fuse to protect the control. The motor may be started and stopped with the power line at any speed setting on the speed adjust pot. The motor coasts to a stop when the power line is disconnected. If dynamic braking is desired, see *Dynamic Braking* on page 29.

Minarik strongly recommends the installation of an emergency stop switch as shown in Figure 2 (page 5). The switch must be rated at a minimum of 250 VAC and 150% of the maximum motor armature rating.

## Alternative Wiring

By utilizing additional components the SL10U may be operated by external signal control, have multiple preset speeds, dynamic braking, limit switch operation, etc. Please refer to **Application Notes** (page 14) for these and other modes of operation.

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## Calibration



### Warning

Dangerous voltages exist on the printed circuit board. Contact with components and/or printed circuitry could cause serious injury or fatality. Please refer to the Safety Warnings on page i.

**IMPORTANT:** A non-metallic screwdriver should be used when adjusting the trim pots to avoid any possibility of the screwdriver's blade contacting live circuitry and shorting the circuitry or allowing contact with any dangerous or fatal voltages.

## Maximum Speed and Regulation (IR COMP) Adjustment

Two potentiometers, located on the control PC board, are provided for adjustment of the maximum motor speed and regulation of the motor's speed.

## **MAXIMUM SPEED ADJUSTMENT**

This feature is provided to allow the motor speed to be adjusted between 85 to 115% of motor name plate rated speed when the speed adjust knob is set at maximum.

## **REGULATION (IR COMPENSATION)**

Regulation is obtained by circuitry which raises the armature voltage to maintain speed when increased loading tends to slow the motor down.

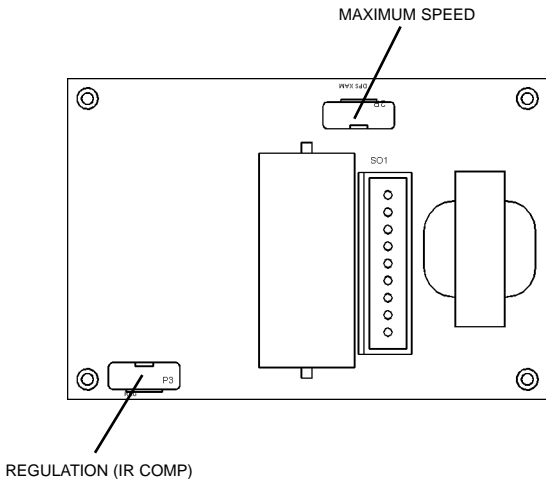
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## Standard Calibration

The control has been factory calibrated and no further adjustments should be necessary. However, since the control was calibrated using a speed adjust pot (P1) of 10K ohms and the pot shipped with the control has a tolerance of  $\pm 5\%$ , the maximum speed could be higher or lower than 1800 RPM. If the maximum speed is not satisfactory, if the control has been repaired, or if you want to make any changes, then follow the procedure listed below.

1. Disconnect the power line.
2. Set the speed adjust knob to "0" (full CCW).
3. Set the MAXIMUM SPEED trim pot to full CCW (refer to Figure 3 on page 13).
4. Set the REGULATION trim pot to full CCW (refer to Figure 3 on page 13).
5. Read and follow the SAFETY WARNING on page i.
6. With no load on the motor, apply 115 VAC to the control and advance the speed adjust knob to "100" (full CW).

7. Adjust the MAXIMUM SPEED trim pot for motor base speed at no load.
8. Load the motor to full load and adjust the REGULATION trim pot to obtain the same speed as at no load.



**Figure 3. Maximum Speed and Regulation Trimpot Locations**

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## Application Notes



### Warning

The components shown in the following circuitry should only be connected by qualified electrical personnel familiar with the construction, operation, and hazards of all the components used. Personal injury and/or equipment damage may occur if components are improperly connected, installed, adjusted, or serviced. Also refer to the Safety Warnings on page i.

**DISCLAIMER** - The following circuitry does not purport to cover all possible details or variations, nor to provide for every possible contingency to be met with connection, installation, operation, or maintenance, and no warranty of fitness for purpose is expressed or implied. Furthermore, Minarik Corporation assumes no responsibility for the use of any circuitry described and makes no representation that they are free from patent infringement.

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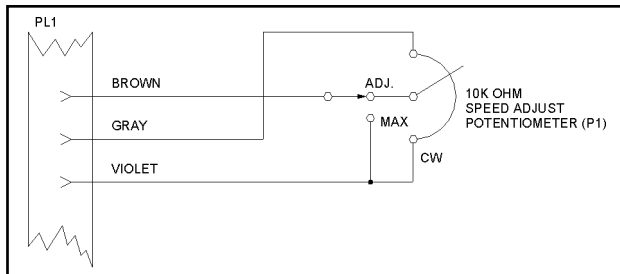
## Speed Adjustment

The speed adjust potentiometer (P1), supplied with the control, is only one of many methods which can be used to control the motor speed. With any alternative methods, these precautions must be followed for proper control operation:

- a. A 10K ohm ( $\pm 5\%$ ) total resistance path must be maintained between the gray and violet leads.
- b. Any replacement resistors or potentiometers must be capable of carrying 10 milliamps.
- c. The three speed adjust circuit leads (brown, gray and violet) should NOT be bundled with the motor or power line leads.
- d. If the length of the three speed adjust circuit leads exceeds 18 inches (0.5m), then a shielded cable must be used. Do not ground both ends of the shield.

## Adjustable / Maximum Speed

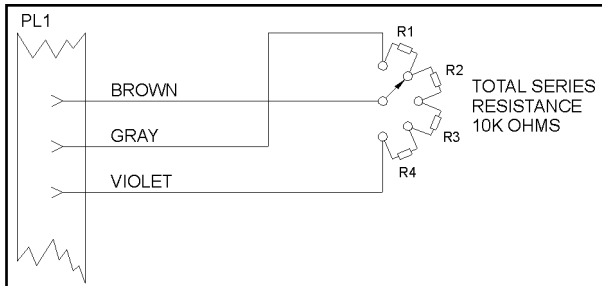
The addition of a single pole, double-throw switch or relay contact allows a selection of a continuously variable or a fixed maximum speed (see Figure 4 below). This is useful in applications where a fast return to the “home” position is desired after certain operations have been accomplished at slower adjustable speeds.



**Figure 4. Adjustable / Fixed Speeds**

## Multiple Fixed Speeds

This is accomplished by using a multi-position switch with the correct number of positions for the desired number of fixed speeds and the same number of resistors with a total series resistance of 10K Ohms to replace speed adjust pot (P1). See Figure 5 below.

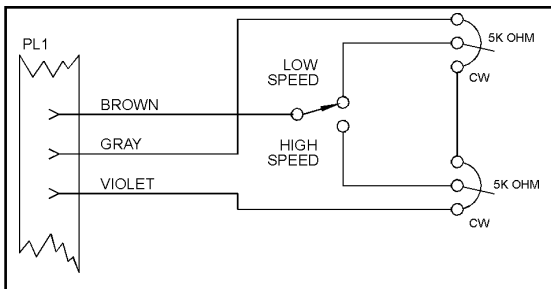


**Figure 5. Multiple Fixed Speeds**

## Adjustable Speeds in Two or More Non-Overlapping Speed Ranges

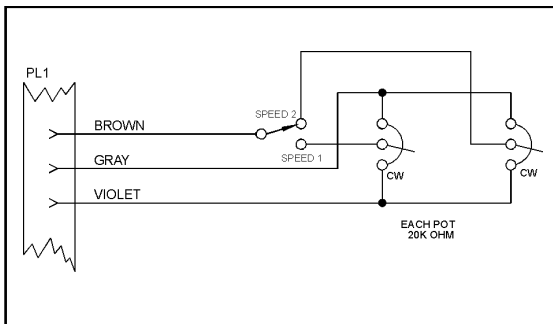
This is accomplished by replacing the speed adjust pot (P1) with two or more potentiometers connected in series (total series resistance must be 10K Ohms) and a multi-position switch. Illustrated is a connection diagram for two speed control with high and low speed adjust pots. See Figure 6 below.

**Figure 6.**  
**Two Non-Overlapping  
Speed Ranges**



## Multiple Full Range Adjustable Speeds

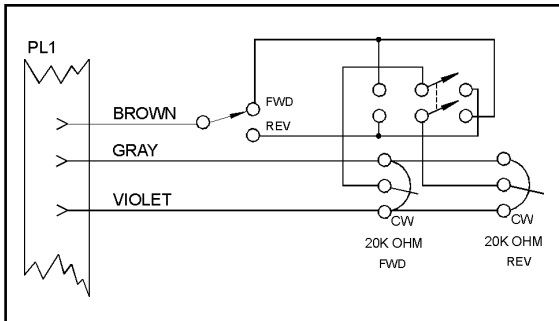
This is accomplished by replacing the speed adjust pot (P1) with two or more potentiometers connected in parallel (total parallel resistance must be 10K Ohms) and a multi-position switch. Illustrated is a connection diagram for two full range adjustable speeds. See Figure 7.



**Figure 7. Two Full Range Adjustable Speeds**

## Independent Forward and Reverse Speeds

This is accomplished by replacing the speed adjust pot (P1) with two 20K Ohm potentiometers connected in parallel (equals 10 Ohms) with a SPDT switch and a DPDT switch to select operating station. See Figure 8 below.

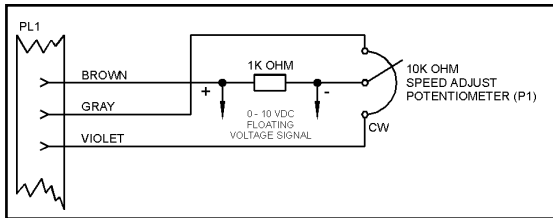


**Figure 8.**  
**Independent**  
**Forward and**  
**Reverse**  
**Speeds**

## External Signal Control

Use a 0 - 10 VDC analog voltage signal that is isolated from earth ground to drive the motor from 0 to 1800 RPM (Figure 9). This is accomplished by wiring a 1K ohm resistor in series with the speed adjust pot wiper and applying the DC voltage across the resistor. Use the speed adjust pot to set the motor's minimum speed.

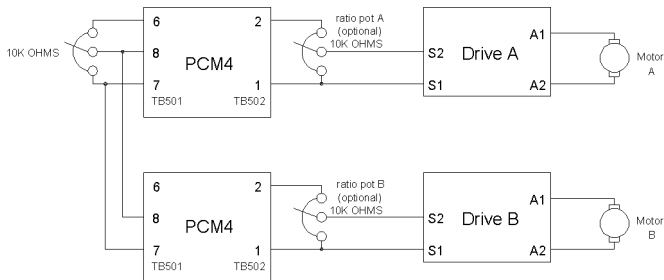
If only a grounded signal is available, use a Minarik PCM4 Process Control Module to convert the signal to ungrounded (floating).



**Figure 9.**  
**External**  
**Signal Control**

## Simultaneous Speed Control of Multiple Systems

Multiple drives can be controlled with a single speed adjust potentiometer using a PCM4 at the input of each drive to provide isolation (Figure 10). Optional ratio potentiometers can be used to scale the PCM4 output voltage, allowing independent control of each drive.

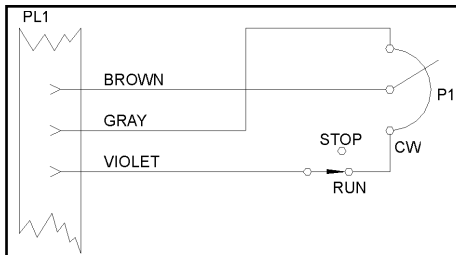


**Figure 10. Simultaneous Speed Control of Multiple Systems**

## Run / Stop Circuits

### Run / Stop Using Normally Closed Contacts

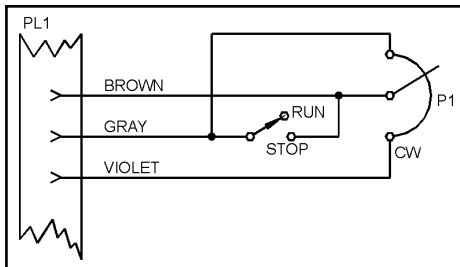
This is accomplished by inserting a set of normally closed contacts in series with the violet wire that connects to the speed adjust pot. When the contacts are opened, the motor will coast to a stop. This method is desirable when dynamic braking is not needed, but frequent starts and stops are required. This method also has the advantage of not having to switch the AC power line or the DC armature line. See Figure 11.



**Figure 11. Run / Stop Using Normally Closed Contacts**

## Run / Stop Using Normally Open Contacts

This is accomplished by inserting a set of normally open contacts in parallel with the gray and brown wires that connect to the speed adjust pot. When the contacts are closed, the motor will coast to a stop. This method is desirable when dynamic braking is not needed, but frequent starts and stops are required. This method



also has the advantage of not having to switch the AC power line or the DC armature line. See Figure 12.

**Figure 12. Run / Stop Using Normally Open Contacts**

## Reversing Circuits



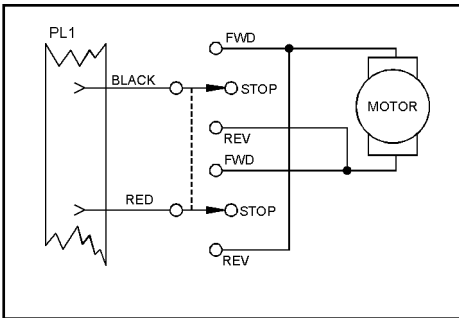
### Warning

Plug reversing the motor (not allowing the motor to come to a stop before reversing) will cause excessively high currents to flow in the armature circuit, which can damage the control and/or motor and is not recommended. If rapid reversing is required, use one of the dynamic braking circuits listed in this manual.

## Reversing with a Toggle or Rotary Switch

This can be accomplished by using a DPDT, center off switch. When power is applied to the control and the switch is in the center position, the motor is stopped. When the switch is actuated in one direction, the motor will run forward. The motor will coast to a stop when the switch is placed in the STOP position. When the switch is actuated in the other direction, the motor will run in reverse. See Figure 13.

**Figure 13. Reversing with Toggle Switch**



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## Reversing with Relays

This is accomplished with two 3PDT relays and three momentary operated pushbutton switches (two with normally open contacts and one with normally closed contacts). L1 and L2 supply power to the relay holding circuitry. Normally, if the FORWARD, STOP and REVERSE pushbuttons are to be located remotely from the control, low voltage relay coils are used. In operation, power is applied to the SL10U control and the appropriate voltage to L1 and L2. When PB1 is actuated, the motor will run forward. When PB2 is actuated, the motor will stop. When PB3 is actuated, the motor will run in reverse. When the motor is running, a change in direction is not possible without actuating PB2 (STOP) first. See Figure 14 on page 28.

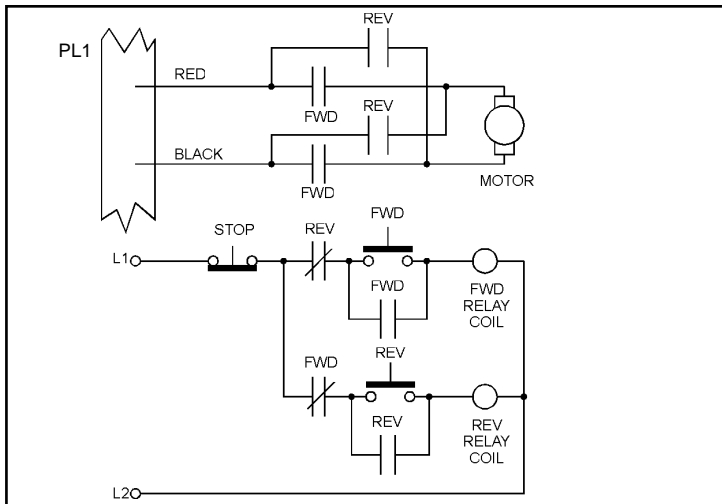


Figure 14. Reversing with Relays

## **Dynamic Braking**

### **DC Permanent Magnet Motor Dynamic Braking Theory**

In operation, a permanent magnet (PM) field DC motor has the armature connected to its DC power supply. The interaction of the magnetic field created by the field and the current flowing in the armature winding causes the motor to run. A voltage called the counter electromotive force (CEMF) is generated in the armature conductors, when rotated in a magnetic field.

When the motor is running, the CEMF opposes the power supply voltage and limits the armature current to a sufficient value to supply adequate output shaft torque. Braking is accomplished by disconnecting the armature from the DC power and shorting the armature leads with a current limiting resistor. As soon as this is done, the armature and its driven load will begin to stop.

Since the armature is still rotating in a magnetic field, it will continue to generate a CEMF, which is proportional to the strength of the magnetic field. The armature will also cause a current flow opposite to that of the power supply to flow in the current limiting (braking) resistor, which will in turn cause the motor to try and reverse itself. In the process of trying to reverse itself, the speed will be rapidly reduced from the original direction. As the speed decreases, so does the CEMF.

When the motor reaches zero speed, the CEMF is also zero and the motor has been dynamically braked to a stop. The speed of braking is controlled by the braking (current limiting) resistor's resistance. The lower the resistance, the greater the current flow. And, since the reversing current or braking torque is proportional to the current flow, the faster the stopping. For the SL10U a jumper wire instead of a resistor gives optimum braking.

## Dynamic Braking Circuit Cautions

### Gearmotor Caution

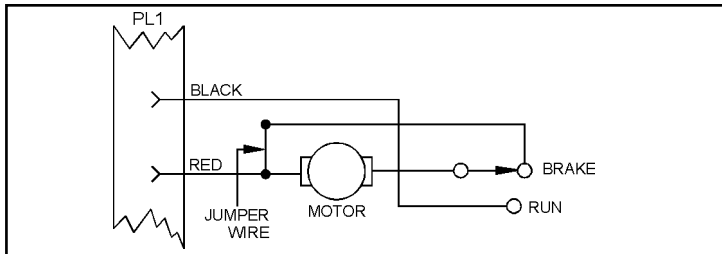
Care must be taken when using dynamic braking with gearmotors connected to inertial type loads. Forces can be developed which may be destructive to the gearing.

**IMPORTANT:** Dynamic braking is only for fast stopping and NOT for holding a load.

**IMPORTANT:** For motors rated 1/17 horsepower and lower, a brake resistor is not necessary since the armature resistance is high enough to stop the motor without demagnetization. Replace the dynamic brake resistor with 12 gauge wire.

## Run/Stop with Dynamic Braking using a Toggle Switch

This can be accomplished with a SPDT toggle switch and a 12 AWG jumper wire in place of a dynamic braking resistor. Power is applied to the control. When the toggle switch is set to RUN, the motor starts running. When the toggle switch is set to BRAKE, the motor is dynamically braked to a stop. See Figure 15.

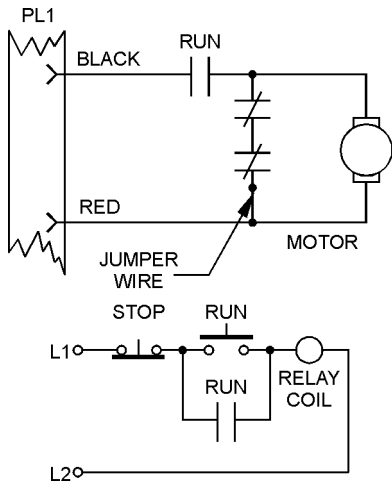


**Figure 15. Run / Stop Dynamic Braking with Toggle Switch**

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## **Run/Stop Dynamic Braking using a Relay**

This can be accomplished with a DPDT relay, two momentary operated pushbutton switches (one normally open and one normally closed) and a 12 AWG jumper wire in place of a dynamic braking resistor. Normally, if the RUN and STOP pushbuttons are to be located remotely from the control, a low voltage relay coil is used. In operation, power is applied to the SL15U control and the appropriate voltage to L1 and L2. When PB1 is actuated, the motor will run and when PB2 is actuated, the motor will dynamically brake to a stop. See Figure 16 (page 34).

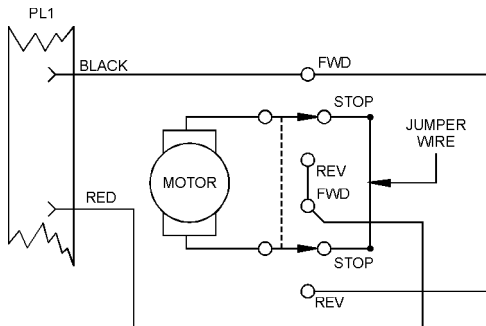


**Figure 16. Run / Stop Dynamic Braking using a Relay**

## **Reversing with Dynamic Braking Circuits**

### **Reversing with Dynamic Braking using a Rotary Switch**

This can be accomplished with a 2-pole, 3-position rotary switch and a 12 AWG jumper wire in place of a dynamic braking resistor. When power is applied to the control and the rotary switch is switched to FORWARD, the motor starts running in one direction. When the rotary switch is switched to BRAKE, the motor is dynamically braked to a stop. When the rotary switch is switched to REVERSE, the motor starts running in the opposite direction. See Figure 17, page 36.

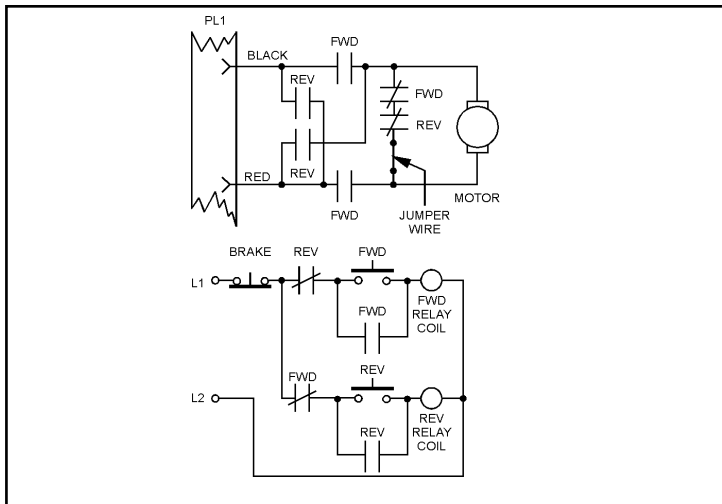


**Figure 17. Rotary Switch Reversing with Dynamic Braking**

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## Reversing with Dynamic Braking using Relays

This can be accomplished with two 3PDT relays, three momentary operated pushbutton switches (two with normally open contacts and one with normally closed contacts) and a jumper wire in place of a dynamic braking resistor. L1 and L2 supply power to the relay holding circuitry. Normally, if the PB1 (FORWARD), PB2 (BRAKE), and PB3 (REVERSE) pushbuttons are to be located remotely from the control, low voltage relay coils are used. In operation, power is applied to the SL15U control and the appropriate voltage to L1 and L2. When PB2 is actuated, the motor will dynamically brake to a stop. When PB3 is actuated, the motor will run in reverse. When the motor is running, a change in direction is not possible without actuating PB2 (BRAKE) first. See Figure 18, page 38.



**Figure 18. Reversing with Dynamic Braking using Relays**

## Limit Switch Circuits



### Warning

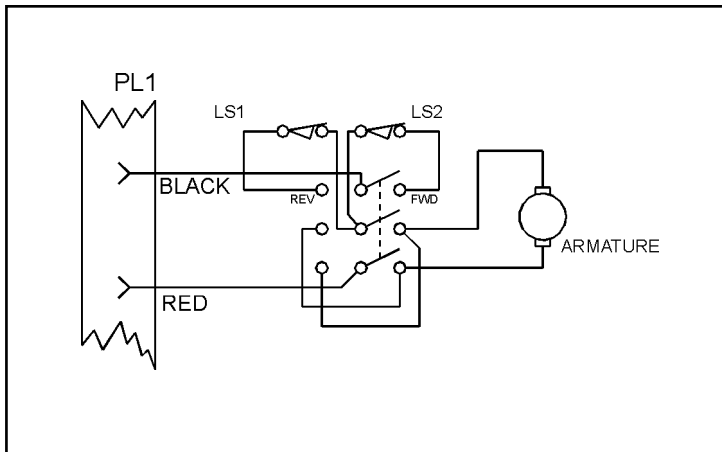
Be sure to use some type of override device on the limit switch actuators so that motor coast does not damage limit switches or allow limit switches to deactivate.

Care must be taken when using dynamic braking with gearmotors connected to inertial type loads. Forces can be developed which may be destructive to the gearing.

**IMPORTANT:** Dynamic braking is only for fast stopping and NOT for holding a load.

## **Toggle Switch Reversing with Limit Switches**

This can be accomplished with a 3PDT, center OFF toggle switch and two normally closed limit switches. When power is applied to the control and the toggle switch is in the center position, the motor is STOPPED. When the toggle switch is actuated in one direction, the motor runs forward until the limit switch is actuated and the motor stops. When the toggle switch is actuated in the other direction, the motor will run in reverse until the limit switch is actuated and the motor stops. See Figure 19.



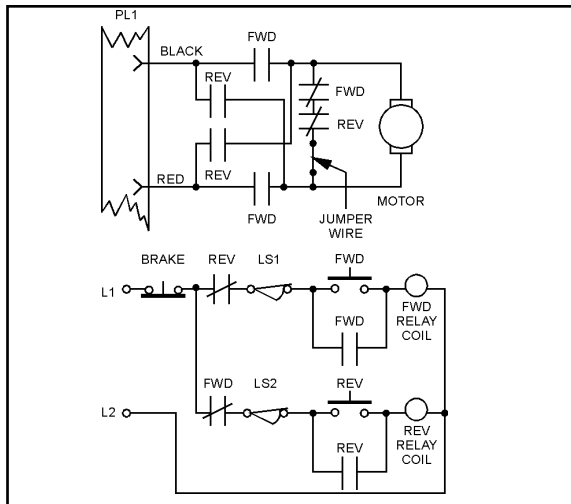
**Figure 19. Toggle Switch Reversing with Limit Switches**

## **Relay Reversing with Dynamic Braking and Limit Switches**

This can be accomplished with two 3PDT relays, three momentary operated pushbutton switches (two with normally open contacts and one with normally closed contacts), two normally closed limit switches and a 12 AWG jumper wire in place of a dynamic braking resistor. L1 and L2 supply power to the relay holding circuitry. Normally, if the FORWARD, BRAKE and REVERSE pushbuttons are to be located remotely from the control, low voltage relay coils are used.

In operation, power is applied to the SL10U control and the appropriate voltage to L1 and L2. When PB1 is actuated, the motor will run forward until the limit switch is actuated and the motor dynamically brakes to a stop. When PB3 is actuated, the motor will run in reverse until the other limit switch is actuated and the motor dynamically brakes to a stop. When PB2 is actuated, the motor will dynamically brake to a stop. When the motor is running, a change in direction is not possible without actuating PB2 (BRAKE) first. If dynamic braking is not desired eliminate the jumper wire.

Refer to Figure 20 (page 44) for an illustration of relay reversing with dynamic braking and limit switches.



**Figure 20. Relay Reversing / Braking with Limit Switches**

## Troubleshooting

Before proceeding check the following:

- Be sure the power line is the same voltage as that listed on the control nameplate.
  - Check to see that the line fuse is of the same value as shown on the control nameplate.
- I. Read and follow the SAFETY WARNING on page i.

- II. Set speed control pot, P1, at zero on the dial and apply power. If the line fuse blows, disconnect the power and check the following:
  - A. Transient suppressor, DAS, may be shorted.
  - B. One or more of the diodes (D2, D3, D4, or D5) may be shorted.
    - 1. Disconnect the motor from the control.
    - 2. Across each of the diodes, resistance should read high in one direction and low in the opposite direction.
  - C. Motor cable may be shorted or grounded.

III. Connect the motor to the control, apply power, and advance the speed adjust knob to the maximum setting on the dial:

- A. If the line fuse continues to blow:
  - 1. The motor may be overloaded.
    - a. Disconnect the power from the control.
    - b. Disconnect the load from the motor.
    - c. Apply power. Motor should run at full speed without blowing the fuse.
  - 2. Motor armature may be shorted or grounded. Disconnect the motor cable. An ohmmeter reading on the motor cable armature connections should read approximately 380 ohms. A reading from either side of the armature connections to the motor frame should show open (use high ohm scale).
  - 3. The filter capacitor (C4), may be shorted.

4. A diode (D2, D3, D4, or D5) may be open causing the fuse to blow at no load or very light load. This may be due to high armature current.
  5. Diode (D1) may be shorted.
- B. If the fuse does not blow, but the motor will not run:
1. The speed control potentiometer (P1) may be open.
  2. The rectifier (SCR) may be defective.
  3. A Transistor (Q1, Q2, or Q3) may be defective.
  4. The filter choke (X1) may be open.
  5. The zener diode (Z1) may be shorted.
- IV. If the motor runs at high speed regardless of the speed control potentiometer setting:
- A. The rectifier (SCR) may be shorted.
  - B. A transistor (Q2 or Q3) may be shorted.

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## Parts List

REFERENCE	PART NUMBER	DESCRIPTION
C1	010-0020	0.02 MFD 500 VOLT
C2	010-0034	0.15 MFD 100 VOLT
C3	011-0015	50 MFD 6 VDC
C4	011-0018	50 MFD 350 VDC
C5	010-0032	0.1 MFD 500 VOLT
D1	071-0012	1 AMP 600 VDC SILICON DIODE
D3-D5	071-0007	3 AMP 600 VDC SILICON DIODE
DAS	075-0002	TRANSIENT SUPPRESSOR
P1	120-0006	10K OHM 5 WATT POT
P2	121-0023	25K OHM 1/4 WATT POT
P3	121-0002	100 OHM 1/4 WATT POT
PL1	164-0056	11 TERMINAL CONNECTOR (FEMALE)
Q1	070-0009	D5E44 OR 2N5354
Q2	070-0010	2N3638 OR 2N5354
Q3	070-0011	2N2923

REFERENCE	PART NUMBER	DESCRIPTION
R1	031-0033	1K OHM 1/2 WATT
R2	032-0005	22K OHM 1 WATT
R3	031-0029	470 OHM 1/2 WATT
R4	032-0005	22K OHM 1 WATT 10%
R5-R7	031-0040	56K OHM 1/2 WATT
R8-R9	031-0047	33K OHM 1/2 WATT
R10-R11	031-0032	820 OHM 1/2 WATT
R12	031-0046	27K OHM 1/2 WATT
R13	031-0012	47 OHM 1/2 WATT
R14	032-0020	10 OHM 5 WATT
SO1	164-0054	9 TERMINAL CONNECTOR (MALE)
SCR	072-0024	8 AMP 400 VOLT SCR
TH	033-0002	3K OHM THEMISTOR
X1	240-0004	MINARIK CHOKE
Z1	071-0002	1N4747 ZENER DIODE

## NOTES

## Notes

## **Unconditional Warranty**

### **A. Warranty**

Minarik Corporation (referred to as "the Corporation") warrants that its products will be free from defects in workmanship and material for twelve (12) months or 3,000 hours, whichever comes first, from date of manufacture thereof. Within this warranty period, the Corporation will repair or replace, at its sole discretion, such products that are returned to Minarik Corporation, 901 East Thompson Avenue, Glendale, CA 91201-2011 USA.

This warranty applies only to standard catalog products, and does not apply to specials. Any returns for special controls will be evaluated on a case-by-case basis. The Corporation is not responsible for removal, installation, or any other incidental expenses incurred in shipping the product to and from the repair point.

### **B. Disclaimer**

The provisions of Paragraph A are the Corporation's sole obligation and exclude all other warranties of merchantability for use, express or implied. The Corporation further disclaims any responsibility whatsoever to the customer or to any other person for injury to the person or damage or loss of property of value caused by any product that has been subject to misuse, negligence, or accident, or misapplied or modified by unauthorized persons or improperly installed.

### **C. Limitations of Liability**

In the event of any claim for breach of any of the Corporation's obligations, whether express or implied, and particularly of any other claim or breach of warranty contained in Paragraph A, or of any other warranties, express or implied, or claim of liability that might, despite Paragraph B, be decided against the Corporation by lawful authority, the Corporation shall under no circumstances be liable for any consequential damages, losses, or expense arising in connection with the use of, or inability to use, the Corporation's product for any purpose whatsoever.

An adjustment made under warranty does not void the warranty, nor does it imply an extension of the original 12-month warranty period. Products serviced and/or parts replaced on a no-charge basis during the warranty period carry the unexpired portion of the original warranty only.

If for any reason any of the foregoing provisions shall be ineffective, the Corporation's liability for damages arising out of its manufacture or sale of equipment, or use thereof, whether such liability is based on warranty, contract, negligence, strict liability in tort, or otherwise, shall not in any event exceed the full purchase price of such equipment.

Any action against the Corporation based upon any liability or obligation arising hereunder or under any law applicable to the sale of equipment or the use thereof, must be commenced within one year after the cause of such action arises.



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