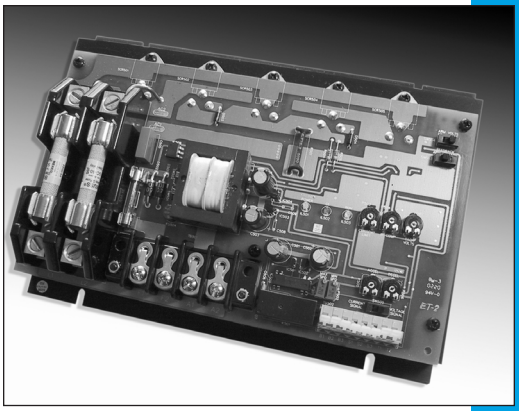
Minarik Automation & Control

MM501U



User's Manual

SCR, Dual-Voltage, Adjustable Speed Drive for DC Brush Motors

 MVD091302
Printed in the United States of America.

Safety Warnings

- This symbol ⚠ denotes an important safety tip or warning. **Please read these instructions carefully** before performing any of the procedures contained in this manual.

- **DO NOT INSTALL, REMOVE, OR REWIRE THIS EQUIPMENT WITH POWER APPLIED.** Have a qualified electrical 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.

⚠ **It is possible for a drive to run at full speed as a result of a component failure.** Minarik strongly recommends the installation of a master switch in the main power input to stop the drive in an emergency.

Circuit potentials are at 115 VAC or 230 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Use a non-metallic screwdriver for adjusting the calibration trimpots. Use approved personal protective equipment and insulated tools if working on this drive with power applied.

Contents

Tables

Illustrations

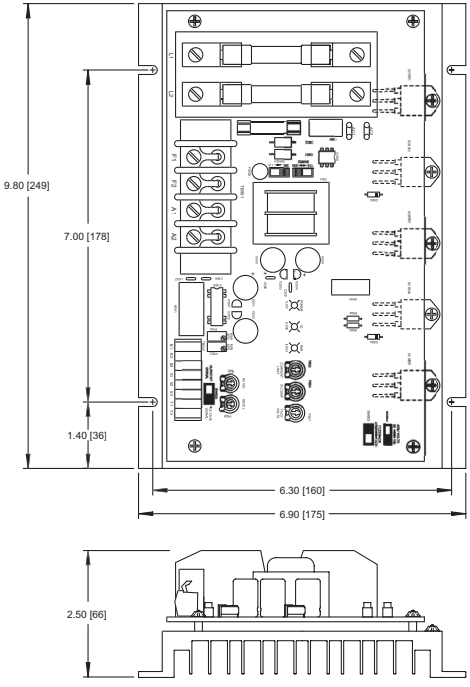
Specifications

Model Number	MM501U
Type	Open Chassis
Line Fuse Rating	40A (Buss Type SC-40 or equivalent)
Field Fuse Rating	3A, fast-acting
Horsepower Range @ 90 VDC Output	1 - 2.5 HP
Horsepower Range @ 180 VDC Output	2 - 5 HP
Maximum Armature Voltage Range @ 115 VAC Input	0 - 90 VDC
Maximum Armature Voltage Range @ 230 VAC Input	0 - 180 VDC
Minimum Speed Adjustment Range @ 115 VAC Input	0 - 60 VDC
Minimum Speed Adjustment Range @ 230 VAC Input	0 - 120 VDC
Maximum Armature Current	25 ADC
Field Voltage @ 115 VAC Input	50 VDC (F1 to L1) or 100 VDC (F1 to F2)
Field Voltage @ 230 VAC Input	100 VDC (F1 to L1) or 200 VDC (F1 to F2)
Form Factor	1.37
Acceleration Time Range (no load)	
0 - 90 VDC Armature Voltage	0.5 - 12 seconds
0 - 180 VDC Armature Voltage	0.5 - 12 seconds
Deceleration Time Range (no load)	
0 - 90 VDC Armature Voltage	0.5 - 12 seconds
0 - 180 VDC Armature Voltage	0.5 - 12 seconds
Analog Input Voltage Range	
(grounded and isolated signal; S1 to S2)	0 - 10 VDC
Speed Adjustment Potentiometer	10Kohm
Approximate Input Impedance	
(S1 to S2; voltage signal setting)	100K ohm
Speed Regulation (% of base speed)	
Armature Feedback	1% or better
Tachogenerator Feedback	0.1%
Tachogenerator Feedback Voltage Range	7 - 50 VDC per 1000 RPM
Weight	3.8 lb
Ambient Operating Temperature Range *	see notes

Notes:

* 10º - 40ºC when mounted flat (horizontally), or in an enclosure whose volume is between 4 and 6 cubic feet; 10ºC - 50ºC when mounted upright (with heatsink fins vertical) in an enclosure greater than 6 cubic feet.

Dimensions



ALL DIMENSIONS IN INCHES [MILLIMETERS]
FOUR (4) MOUNTING SLOTS 0.19 [5] X 0.30 [8] DEEP

Figure 1. MM501U Dimensions

Installation

Mounting

Warning

Do not install, rewire, or remove this control with input power applied. Doing so may cause fire or serious injury. Make sure you have read and understood the Safety Warnings on page i before attempting installation.

- Drive components are sensitive to electrostatic fields. Avoid direct contact with the circuit board. Hold drive by the chassis only.
- Protect the drive from dirt, moisture, and accidental contact.
- Provide sufficient room for access to the terminal block and calibration trimpots.
- Mount the drive away from heat sources. Operate the drive within the specified ambient operating temperature range.
- Prevent loose connections by avoiding excessive vibration of the drive.
- Mount drive with its board in either a horizontal or vertical plane (vertical mounting is preferred; see Figure 1, page 2). Four 0.19 in. (5 mm) wide slots in the chassis accept #8 pan head screws. Fasten either the large base or the narrow flange of the chassis to the subplate.
- The chassis must be earth grounded. Use a star washer beneath the head of at least one of the mounting screws to penetrate the anodized chassis surface and to reach bare metal.

Fuses

MM501U drives have two 40A line fuses installed in Fuse Holder 501 (FH501). Line fuses are rated for maximum rated horsepower. Resize line fuses if using a smaller horsepower motor. Size fuses for approximately 150% of the maximum motor armature current.

One 3A field fuse (FU503) is also installed on the drive. This fuse does not have to be resized if using a smaller horsepower motor.

Wiring

Warning

Do not install, remove, or rewire this equipment with power applied. Failure to heed this warning may result in fire, explosion, or serious injury.

Circuit potentials are at 115 or 230 VAC above ground. To prevent the risk of injury or fatality, avoid direct contact with the printed circuit board or with circuit elements.

Do not disconnect any of the motor leads from the drive unless power is removed and the drive is disabled. Opening any one motor lead may destroy the drive.

- Use 18 AWG wire for speed adjust potentiometer wiring. Use 16 AWG wire for field (F1, F2) wiring. Use 14 AWG wire for AC line (L1, L2) and motor (A1, A2) wiring.

Cage-clamp Terminal Block

MM501U drives use a cage-clamp terminal block for terminal block 502 (TB502). To connect a wire to the cage-clamp terminal block (see Figure 2), use a small screwdriver to press down on the lever arm. Insert a wire stripped approximately 0.25 inches (6 mm) into the opening in front of the terminal block. Release the lever arm to clamp the wire.

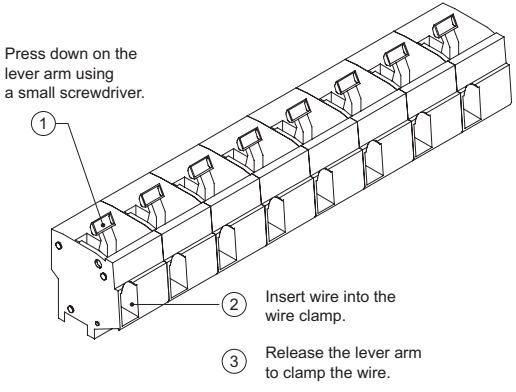


Figure 2. Cage-Clamp Terminal Block

Speed adjust potentiometer

Warning

Be sure that the potentiometer tabs do not make contact with the potentiometer enclosure. Grounding the input will cause damage to the drive.

Mount the speed adjust potentiometer through a 0.38 in. (10 mm) hole with the hardware provided (Figure 3). Install the circular insulating disk between the panel and the 10K ohm speed adjust potentiometer.

Twist the speed adjust potentiometer wire to avoid picking up unwanted electrical noise. If speed adjust potentiometer wires are longer than 18 in. (457 mm), use shielded cable. Keep speed adjust potentiometer wires separate from power leads.

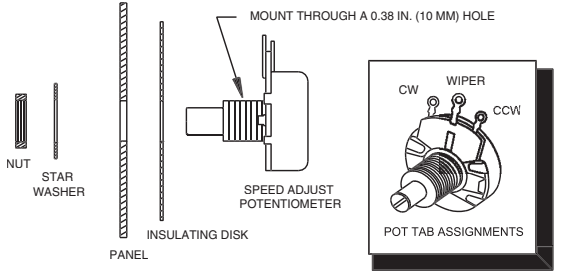


Figure 3. Speed Adjust Potentiometer

Shielding guidelines

Warning

Under no circumstances should power and logic leads be bundled together. Induced voltage can cause unpredictable behavior in any electronic device, including motor controls.

As a general rule, Minarik recommends shielding of all conductors.

If it is not practical to shield power conductors, Minarik recommends shielding all logic-level leads. If shielding logic leads is not practical, the user should twist all logic leads with themselves to minimize induced noise.

It may be necessary to earth ground the shielded cable. If noise is produced by devices other than the drive, ground the shield at the drive end. If noise is generated by a device on the drive, ground the shield at the end away from the drive. Do not ground both ends of the shield.

If the drive continues to pick up noise after grounding the shield, it may be necessary to add AC line filtering devices, or to mount the drive in a less noisy environment.

Connections

Warning

Do not connect this equipment with power applied. Failure to heed this directive may result in fire or serious injury.

Minarik strongly recommends the installation of a master power switch in the voltage input line, as shown in Figure 4, page 10. The switch contacts should be rated at a minimum of 200% of motor nameplate current and 250 volts.

Power, fuse and motor connections

Connect the power input leads, an external line fuse and a DC motor to the drive's printed circuit board (PCB) as shown in Figure 4, page 10.

Power input

Connect the AC line power leads to terminals L1 and L2, or to a double-throw, single-pole master power switch (recommended).

Motor

Minarik drives supply motor voltage from A1 and A2 terminals. It is assumed throughout this manual that, when A1 is positive with respect to A2 , the motor will rotate clockwise (CW) while looking at the output shaft protruding from the front of the motor. If this is opposite of the desired rotation, simply reverse the wiring of A1 and A2 with each other.

Connect a DC motor armature to PCB terminals A1 and A2 as shown in Figure 4, page 10. **Ensure that the motor voltage rating is consistent with the drive's output voltage.**

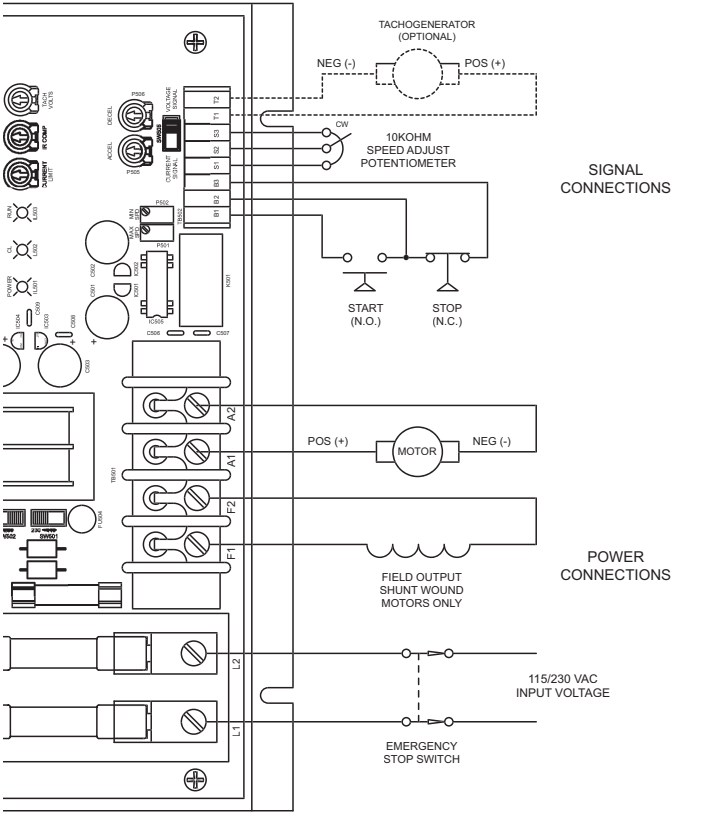


Figure 4. MM501U Connections

Field Output

The field output is for shunt wound motors only. **DO NOT make any connections to the field output when using a permanent magnet motor.** Table 1 lists the field output connections.

Table 1. Field Ouptut Connections

Line Voltage (VAC)	Approximate Field Voltage (VDC)	Field Connections
115	50	F1 and L1
115	100	F1 and F2
230	100	F1 and L1
230	200	F1 and F2

Use 18 AWG wire to connect the field output to a shunt wound motor.

Start/Stop Pushbuttons

The drive can be operated with Start/Stop pushbuttons to start and stop the motor (pushbuttons are not included with the drive). See Figure 4 (page 10) for connections. Connect a momentary operated, normally closed STOP pushbutton to B2 and B3. Connect a momentary operated, normally open START pushbutton to B2 and B3. If the Start/Stop pushbuttons are not used, jumper terminal B1 and B3. As an added safety feature, the Start/Stop pushbutton terminals (B1, B2, and B3) are isolated from earth ground.

Tachogenerator Feedback

Using tachogenerator feedback will improve speed regulation from approximately 1% of motor base speed to approximately 0.1% of motor base speed. Use tachogenerators rated from 7 VDC per 1000 RPM to 50 VDC per 1000 RPM. Connect the tachogenerator to terminals T1 (-) and T2 (+) of terminal block 502 (TB502). See Figure 4 (page 10) for tachogenerator feedback connections.

Voltage Signal

Instead of using a speed adjust potentiometer, the drive may be wired to follow a grounded or ungrounded 0 - 10 VDC signal. Connect the signal input (+) to S2 and the signal common (-) to S1 (see Figure 5, page 13). Make no connections to S3. NOTE: Set SW505 to VOLTAGE SIGNAL if the drive is following a voltage signal.

Current Signal

The MM501U can follow a 4 - 20 mA current signal. Connections are the same as the voltage follower. Connect the signal input to S1 and S2 (see Figure 5, page 13). Make no connections to S3. NOTE: Set SW503 to CURRENT SIGNAL when the drive is follow a current signal.

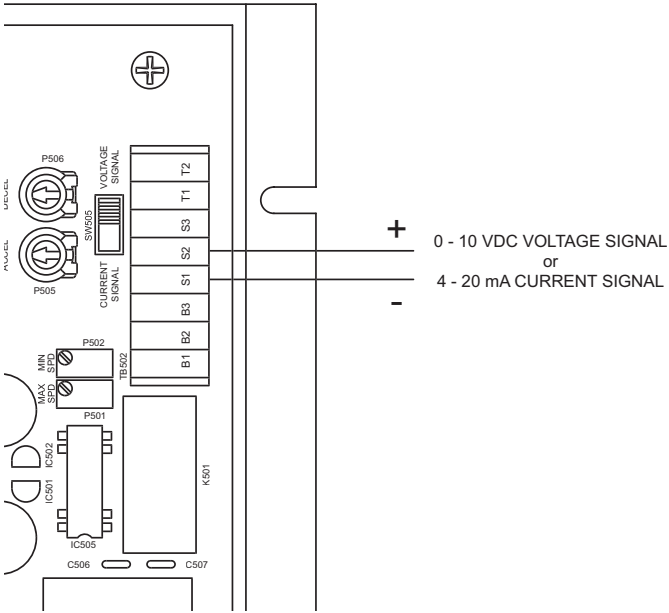


Figure 5. Voltage or Current Signal Connections

Operation

Warning

Dangerous voltages exist on the drive when it is powered. BE ALERT. High voltages can cause serious or fatal injury. For your safety, use personal protective equipment (PPE) when operating this drive.

To avoid drive or motor damage, change switch settings only when the drive is disconnected from the AC line voltage. Make sure all switches are set to their correct position.

Before applying power

- Verify that no conductive material is present on the printed circuit board.
- Set SW501 and SW502 to either 115 or 230 to match the AC line voltage.
- Set SW503 to either TACH for tachogenerator feedback or ARM for armature feedback.
- Set SW504 to either 90 or 180 to match the motor armature voltage.
- Set SW505 to either CURRENT SIGNAL or VOLTAGE SIGNAL to match the input signal being used. If a speed adjust potentiometer is being used, set the switch to VOLTAGE SIGNAL.

Startup

1. Turn the speed adjust potentiometer full counterclockwise (CCW). If the drive is following a voltage signal, set the voltage signal to 0 VDC. If the drive is following a current signal, set the current signal to minimum.

2. Apply AC line voltage.

3. Slowly advance the speed adjust potentiometer clockwise (CW). If a voltage or current signal is used, slowly increase the voltage or current signal. The motor slowly accelerates as the potentiometer is turned CW, or the voltage or current signal is increased. Continue until the desired speed is reached.

4. Remove AC line voltage from the drive to coast the motor to a stop.

Diagnostic LEDs

The MM501U is equipped with the following diagnostic LEDs:

- POWER: Lights whenever AC line voltage is applied to the drive.
- CURRENT LIMIT (CL): Lights whenever the drive reaches current limit.
- RUN: Lights whenever the motor is rotating.

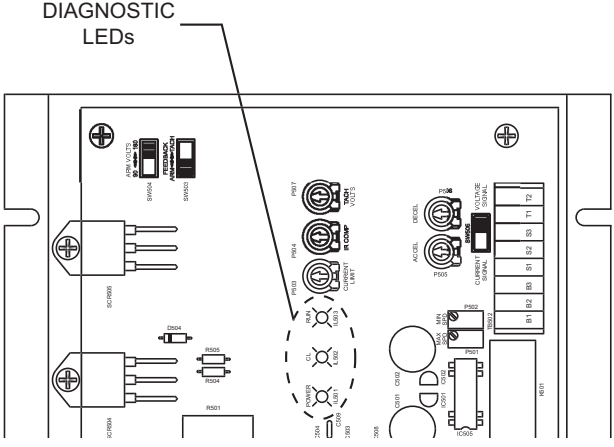


Figure 6. Diagnostic LED Locations

Line starting and line stopping

Line starting and line stopping (applying and removing AC line voltage) is recommended for infrequent starting and stopping of a drive only. When AC line voltage is applied to the drive, the motor accelerates to the speed set by the speed adjust potentiometer. When AC line voltage is removed, the motor coasts to a stop.

Start/Stop Pushbuttons.

Start/Stop pushbuttons allow you to accelerate the motor to set speed, and to decelerate the motor to a stop. See Figure 4, page 10 for connection information.

Dynamic Braking

Dynamic braking may be used to rapidly stop a motor (Figure 7, page 19). For the RUN/BRAKE switch, use a three-pole, double-throw switch rated for at least the maximum DC armature voltage and maximum braking current.

Size the dynamic braking resistor according to the motor current rating (Table 2, page 18). The dynamic brake resistance listed in the table is the smallest recommended resistance allowed to prevent possible demagnetization of the motor. The motor stops less rapidly with higher brake resistor values.

Table 2. Recommended Dynamic Brake Resistor Sizes

Motor Armature Current Rating (ADC)	Minimum Dynamic Brake Resistor Value (Ohms)	Minimum Dynamic Brake Resistor Power (Watts)
Less than 2	1	1
2 - 3	5	5
3 - 5	10	10
5 - 10	20	20
10 - 17	40	50
17 - 30	100	200

For motors rated 1/17 horsepower and less, a dynamic 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.

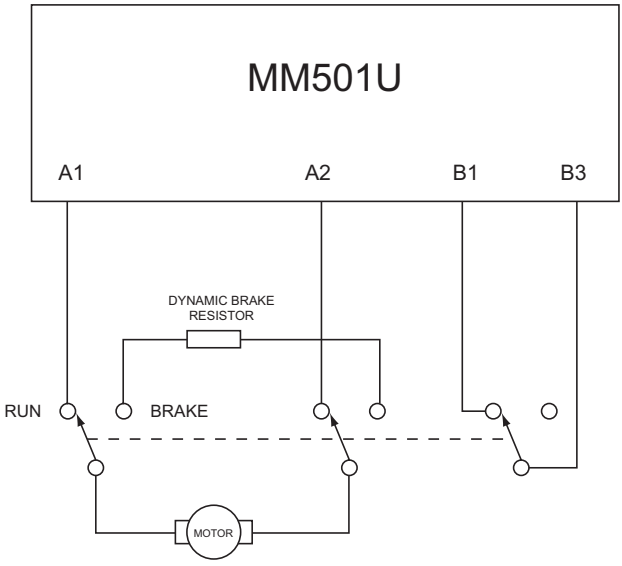


Figure 7. Dynamic Brake Connection

Calibration

Warning

Dangerous voltages exist on the drive when it is powered. When possible, disconnect the voltage input from the drive before adjusting the trimpots. If the trimpots must be adjusted with power applied, use insulated tools and the appropriate personal protection equipment. BE ALERT. High voltages can cause serious or fatal injury.

The MM501U is factory calibrated with a 2 HP, 180 VDC motor. Re-adjust the calibration trimpot settings to accommodate motors with different ratings.

All adjustments increase with CW rotation, and decrease with CCW rotation. Use a non-metallic screwdriver for calibration. Each trimpot is identified on the printed circuit board. See Figure 8, page 21 for trimmer pot locations on the PCB.

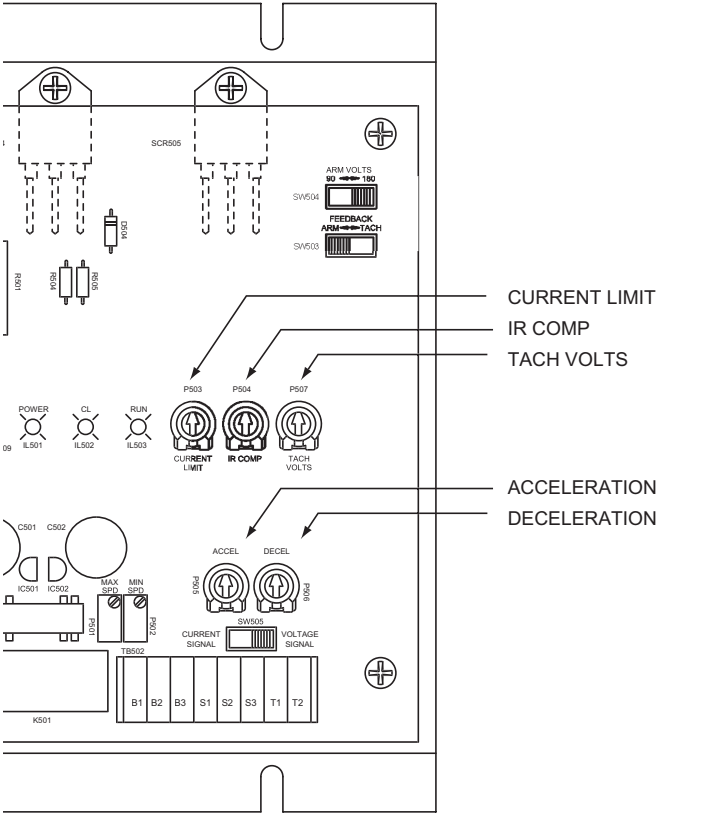


Figure 8. Calibration Trimpot Layout

Maximum Speed (MAX SPD)

The MAX SPD trimpot setting determines the maximum speed. It is factory set for maximum rated motor speed.

To calibrate MAX SPD:

1. Set the MAX SPD trimpot full CCW.
2. Turn the speed adjust potentiometer full CW.
3. Adjust the MAX SPD trimpot CW until the desired maximum motor speed is reached.

Minimum Speed (MIN SPD)

The MIN SPD setting determines the motor speed when the speed adjust potentiometer is turned full CCW. It is factory set to zero speed.

To calibrate MIN SPD:

1. Set the MIN SPD trimpot full CCW.
2. Turn the speed adjust potentiometer full CCW.
3. Adjust the MIN SPD trimpot CW until the desired maximum motor speed is reached.

Current Limit

Warning

TORQUE should be set to 120% of motor nameplate current rating. Continuous operation beyond this rating may damage the motor. If you intend to operate beyond the rating, contact your Minarik representative for assistance.

The CURRENT LIMIT setting determines the maximum armature output of the drive. It is factory set at 120% of rated motor current. Re-calibrate the CURRENT LIMIT when using a lower current rated motor. See Figure 9, page 25 for approximate trimpot settings or re-calibrate using the following procedures:

1. With the power disconnected from the drive, connect a DC ammeter in series with the armature.
2. Set the TORQUE trimpot to minimum (full CCW).
3. Set the speed adjust potentiometer to maximum speed (full CW).
4. Carefully lock the motor armature. Be sure that the motor is firmly mounted.
5. Apply line power. The motor should be stopped.
6. Slowly adjust the TORQUE trimpot CW until the armature current is 120% of motor rated armature current.
7. Turn the speed adjust potentiometer CCW until the motor stops.
8. Remove line power.
9. Remove the stall from the motor.
10. Remove the ammeter in series with the motor armature if it is no longer needed.

IR Compensation (IR COMP)

The IR COMP trimpot setting determines the degree to which motor speed is held constant as the motor load changes. It is factory set for optimum motor regulation.

Refer to Figure 9 on page 25 for recommended settings or use the following procedure to recalibrate the IR COMP setting:

1. Set the IR COMP trimpot to minimum (full CCW).
2. Rotate the speed adjust potentiometer until the motor runs at midspeed without load (for example, 900 RPM for an 1800 RPM motor). A hand held tachometer may be used to measure motor speed.
3. Load the motor armature to its full load armature current rating. The motor should slow down.
4. While keeping the load on the motor, rotate the IR COMP trimpot CW until the motor runs at the speed measured in step 2. If the motor oscillates (overcompensation), the IR COMP trimpot may be set too high (CW). Turn the IR COMP trimpot CCW to stabilize the motor.
5. Unload the motor.

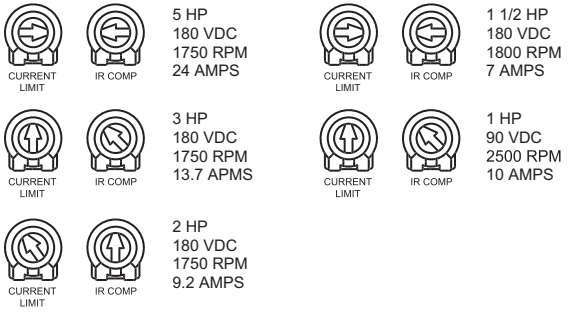


Figure 9. CURRENT LIMIT and IR COMP Settings

Acceleration (ACCEL)

The ACCEL setting determines the time the motor takes to ramp to a higher speed. See Specifications on page 1 for approximate acceleration times. The ACCEL setting is factory set to its minimum value (full CCW).

Turn the ACCEL trimpot CW to increase the acceleration time, and CCW to decrease the acceleration time.

Deceleration (DECEL)

The DECEL setting determines the time the motor takes to ramp to a lower speed. See Specifications on page 1 for approximate deceleration times. The DECEL setting is factory set to its minimum value (full CCW).

Turn the DECEL trimpot CW to increase the deceleration time, and CCW to decrease the deceleration time.

TACH VOLTS

Warning

Calibrate the TACH VOLTS setting only when a tachogenerator is used.

The TACH VOLTS setting, like the IR COMP setting, determines the degree to which motor speed is held constant as the motor load changes. To calibrate the TACH VOLTS trimpot:

1. Connect the tachogenerator to T1 and T2. The polarity is positive (+) for T1 and negative (-) for T2 when the motor is running in the forward direction.
2. Set switch 503 (SW503) to ARM for armature feedback.
3. Set the speed adjust potentiometer full CW. Measure the armature voltage across A1 and A2 using a voltmeter.
4. Set the speed adjust potentiometer to 0 (zero speed).
5. Set SW503 to TACH for tachogenerator feedback.
6. Set the IR COMP trimpot to full CCW.
7. Set the TACH VOLTS trimpot to full CW.
8. Set the speed adjust potentiometer to full CW.
9. Adjust the TACH VOLTS trimpot until the armature voltage is the same value as the voltage measured in step 3.

Check that the TACH VOLTS is properly calibrated. The motor should run at the same set speed when SW503 is set to either armature or tachogenerator feedback.

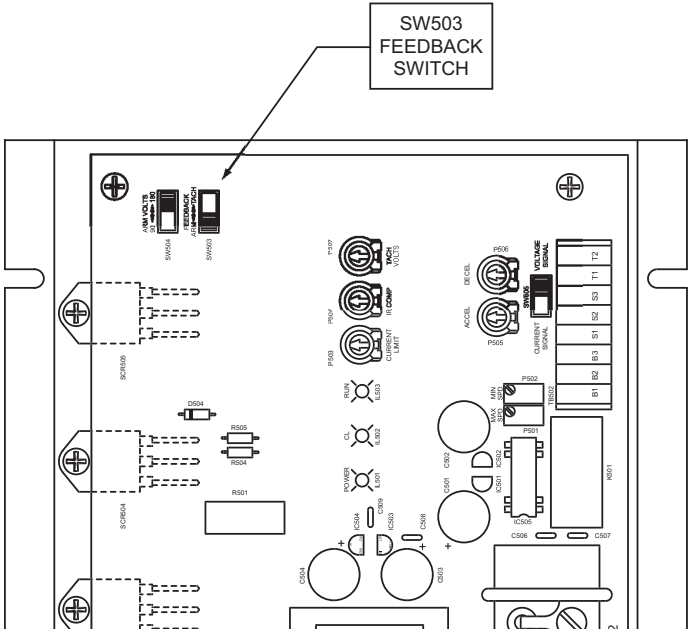


Figure 10. Feedback Switch (SW503) Location

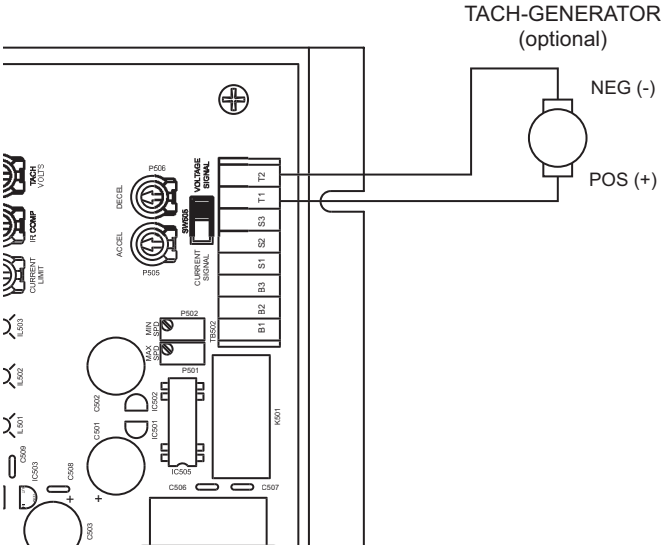


Figure 11. Tachogenerator Connections

Application Notes

Multiple Fixed Speeds

Replace the speed adjust potentiometer with series resistors with a total series resistance of 10K ohms (Figure 12). Add a single-pole, multi-position switch with the correct number of positions for the desired number of fixed speeds.

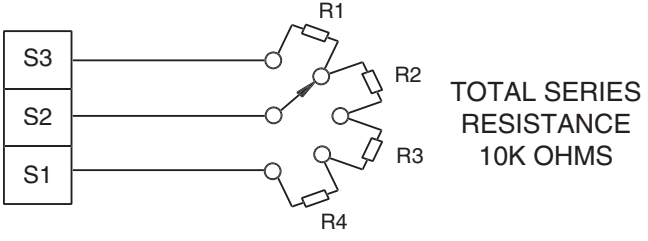


Figure 12. Multiple Fixed Speeds

Adjustable speeds using potentiometers in series

Replace the speed adjust potentiometer with a single-pole, multi-position switch, and two or more potentiometers in series, with a total series resistance of 10K ohms. Figure 13 shows a connection for fixed high and low speed adjust potentiometers.

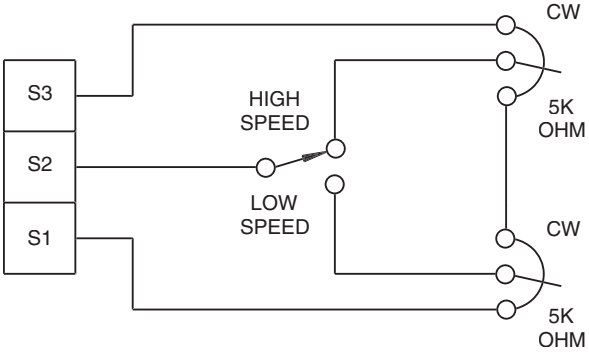


Figure 13. Adjustable Speeds Using Potentiometers in Series

Independent adjustable speeds

Replace the speed adjust potentiometer with a single-pole, multi-position switch, and two or more potentiometers in parallel resistance of 10K ohms. Figure 14 shows the connection of two independent speed adjust potentiometers that can be mounted at two separate operating stations.

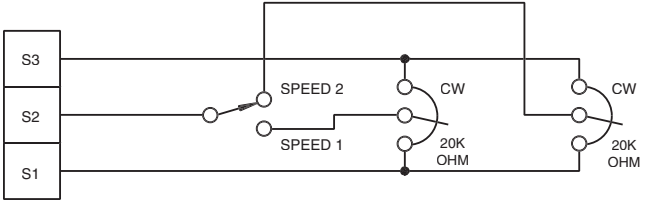


Figure 14. Independent Adjustable Speeds

Reversing

To reverse motor direction, use a dynamic brake and a three-pole, three-position switch rated for at least the maximum DC armature voltage and maximum braking current. See Figure 15 for connections. Wait for the motor to stop completely before switching it to either the forward or reverse direction. See the Dynamic Braking section on page 17 for sizing the dynamic brake resistor.

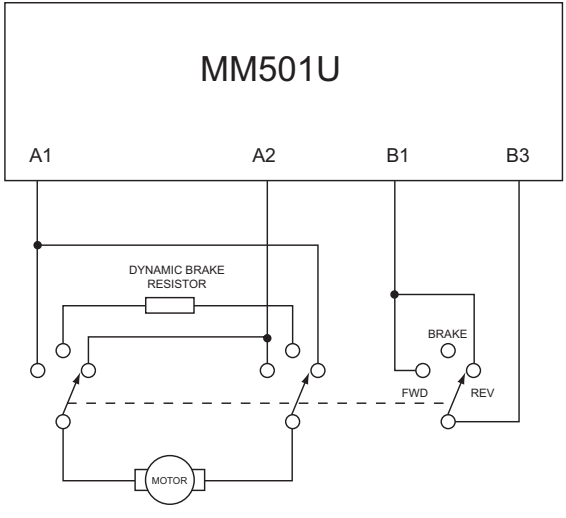


Figure 15. Reversing Circuit

Reversing with a DLC600 controller

A DLC600 controller, can be used in a reversing application. The DLC600 must be inhibited while braking. Without the inhibit feature, the DLC600 will continue to regulate. This will cause overshoot when the DLC600 is switched back to the drive.

Figure 16 show the connection of the reversing circuit to an MM501U drive and a DLC600. Note: Only one DLC option (Optical Encoder or Magnetic Pickup) may be used simultaneously.

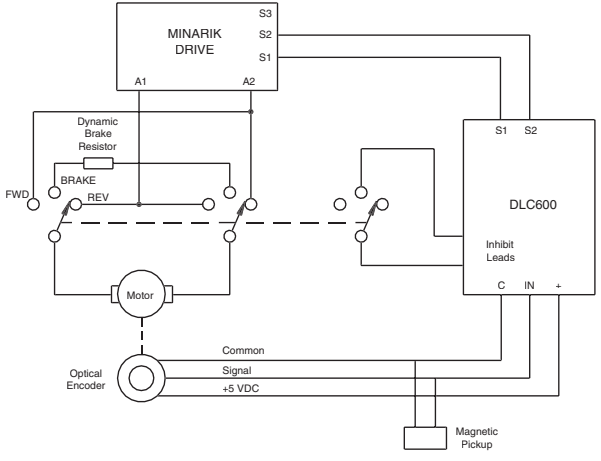


Figure 16. Independent Forward and Reverse Speeds

Troubleshooting

Warning

Dangerous voltages exist on the drive when it is powered. When possible, disconnect the drive while troubleshooting. High voltages can cause serious or fatal injury.

Before troubleshooting

Perform the following steps before starting any procedure in this section:

1. Disconnect AC line voltage from the drive.
2. Check the drive closely for damaged components.
3. Check that no wire chips or other foreign material has become lodged on the printed circuit board.
4. Verify that every connection is correct and in good condition.
5. Verify that there are no short circuits or grounded connections.
6. Check that the voltage selection switch settings match the AC line voltage.

For additional assistance, contact your local Minarik distributor, or the factory direct: 1-800-MINARIK (646-2745) or
Fax: 1-800-394-6334

Problem	Possible Causes	Suggested Solutions
Line fuse blows.	1. Line fuse is the wrong size. 2. Motor cable or armature is shorted to ground. 3. Nuisance tripping caused by a combination of ambient conditions and high-current spikes (i.e. reversing).	1. Check that the line fuse is correct for the motor size. 2. Check motor cable and armature for shorts. 3. Add a blower to cool the drive components; decrease CURRENT LIMIT setting, **or** resize motor and drive for actual load demand. Check for incorrectly aligned mechanical components or “jams”.

Problem	Possible Causes	Suggested Solutions
Line fuse does not blow, but the motor does not run.	1. Speed adjust potentiometer or reference voltage is set to zero speed.	1. Increase the speed adjust potentiometer setting or reference voltage.
	2. Speed adjust potentiometer or reference voltage is not connected to drive input properly; connections are open.	2. Check connections to input. Verify that connections are not open.
	3. The drive is not receiving AC line voltage.	3. Verify that the drive is receiving AC line voltage. The green POWER LED should be lit when AC line voltage is applied.
	4. Drive is in current limit. The red CURRENT LIMIT LED must be off.	4. If the red CURRENT LIMIT LED is on, verify that the motor is not jammed. It may be necessary to increase the CURRENT LIMIT trimpot setting.

Problem	Possible Causes	Suggested Solutions
Motor runs too fast.	1. MAX SPD not calibrated.	1. Calibrate MAX SPD.
Motor will not reach the desired speed.	1. MAX SPD setting is too low. 2. IR COMP setting is too low. 3. Motor is overloaded.	1. Increase MAX SPD setting. 2. Increase IR COMP setting. 3. Check motor load. Resize the motor and drive if necessary.
Motor pulsates or surges under load.	1. IR COMP is set too high. 2. Motor bouncing in and out of current limit.	1. Adjust the IR COMP setting slightly CCW until the motor speed stabilizes. 2. Make sure motor is not undersized for load; adjust CURRENT LIMIT trimpot CW.

Replacement Parts

Replacement parts are available form Minarik Corporation and its distributors for this drive series.

Table 3. Replacement Parts

Model No.	Symbol	Description	Minarik P/N
MM501U	D501,502	3A, 800V Diode	071-0003
	D503,504	1.5A, 600V PIV Diode	071-0012
	IC505	IS0122P IC	060-0106
	IC506	4N35 Opto-Coupler	060-0101
	R501	.002 OHM, 13W Resistor	032-0133
	SCR501-505	800V, 65A SCR	072-0059
	T501	3FD-436 Transformer	230-0072
	FU501,502	40A Fuse	050-0060
	FU503	3A, Fast-Acting Fuse	050-0021
		Heat Sink	223-0294
		10 Kohm Potentiometer Kit	202-0003

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 breech 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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