



# **USER'S MANUAL**

## **MM23002D Series**


SCR, Dual Voltage,  
Adjustable Speed Drives  
for PM DC Brush Motors

Copyright © 2006 by  
Minarik Drives

All rights reserved. No part of this manual may be reproduced or transmitted in any form without written permission from Minarik Drives. The information and technical data in this manual are subject to change without notice. Minarik Drives and its Divisions make no warranty of any kind with respect to this material, including, but not limited to, the implied warranties of its merchantability and fitness for a given purpose. Minarik Drives and its Divisions assume no responsibility for any errors that may appear in this manual and make no commitment to update or to keep current the information in this manual.

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

<b>Safety Warnings</b>	<b>i</b>
<b>Specifications</b>	<b>1</b>
<b>Model Number Suffix Definitions</b>	<b>2</b>
<b>Dimensions</b>	<b>3</b>
<b>Installation</b>	<b>7</b>
Chassis drives	7
Mounting	7
Wiring	8
Shielding guidelines	9
Speed adjust potentiometer	10
Line fusing	11
Heat sinking	12
Connections	12
Power, fuse and motor connections	13
Motor	13
Power input	13
Line fuse	13
Master power switch	14
Alternate speed adjust potentiometer connections	14
Voltage follower	16
Cased drives	17
Mounting (NEMA 1 enclosures)	17
Mounting (NEMA 12/4/4X enclosures)	18
Heat sinking	19
Line fusing	19
All drives	20
<b>Operation</b>	<b>22</b>
Switch settings	23
Before applying power	24
Speed Mode	25
Torque Mode	25
Speed Mode Startup	27
MM23002 and MM23012	27
MM23102, MM23112, MM23402 and MM23412	27
MM23202 and MM23212	28

---

Starting and Stopping Methods .....	29
Line starting and line stopping .....	29
Inhibit terminals .....	30
Decelerating to minimum speed .....	32
Dynamic braking .....	33
Dynamic brake resistor value .....	33
<b>Calibration .....</b>	<b>35</b>
MIN SPD .....	37
MAX SPD .....	37
TORQUE .....	38
IR COMP .....	39
ACCEL .....	40
DECEL .....	41
Torque Mode Calibration .....	42
<b>Application Notes .....</b>	<b>44</b>
Multiple fixed speeds .....	44
Adjustable speeds using potentiometers in series .....	45
Independent adjustable speeds .....	46
RUN / JOG switch .....	47
Leader-follower application .....	49
Single speed potentiometer control of multiple drives .....	50
Reversing .....	51
Reversing with a DIGI-LOK® controller .....	52
<b>Troubleshooting .....</b>	<b>53</b>
Before troubleshooting .....	53
Diagnostic LEDs .....	54
Power (PWR): .....	54
Current Limit (CURR LIMIT or CL): .....	54
Functional Diagrams .....	58
Replacement Parts .....	61
<b>Certificate of Compliance .....</b>	<b>63</b>
Line Filters .....	64
Armature Filters .....	65
<b>Unconditional Warranty .....</b>	<b>inside back cover</b>

## Illustrations

Figure 1. MM23002D and MM23012D Dimensions	3
Figure 2. MM23102D, MM23112D, MM23202D, and MM23212D Dimensions	4
Figure 3. MM23402D and MM23412D Dimensions	5
Figure 4. Heat Sink Dimensions	6
Figure 5. Speed Adjust Potentiometer	10
Figure 6. Chassis Drive Connections	15
Figure 7. Voltage Follower Connections	16
Figure 8. Cased Drive Connections	21
Figure 9. Voltage Switches	23
Figure 10. J503 SPEED/TORQUE Jumper Settings	26
Figure 11. J503 SPEED/TORQUE Jumper Location	26
Figure 12. INHIBIT Terminals	30
Figure 13. Inhibit Personality Configuration	31
Figure 14. Run/Decelerate to Minimum Speed Switch	32
Figure 15. Dynamic Brake Connection	34
Figure 16. Calibration Trimpot Layout	36
Figure 17. Recommended Torque and IR COMP Settings	42
Figure 18. Multiple Fixed Speeds	43
Figure 19. Adjustable Fixed Speeds Using Potentiometers in Series	44
Figure 20. Independent Adjustable Speeds	45
Figure 21. RUN / JOG Switch Connection to Inhibit Plug	46
Figure 22. RUN / JOG Switch Connection to Speed Adjust Potentiometer	47
Figure 23. Leader-Follower Application	48
Figure 24. Single Speed Potentiometer Control of Multiple Drives	49
Figure 25. Reversing Circuit Connection	50
Figure 26. Reversing with a DLC600	52
Figure 27. Diagnostic LED Locations	54
Figure 28. MM23000 Series Block Diagram	58
Figure 29. MM23102, MM23112, MM23402 and MM23412 Terminal Block Connections	59
Figure 30. MM23202 and MM23212 Terminal Block Connections	60

## Tables

Table 1. Recommended Line Fuse Sizes	11
Table 2. Replacement Parts	61
Table 3. Corcom® Filters	64
Table 4. Minarik® Filters	65

## Specifications

<b>Model</b>	<b>Max. Armature Current (Amps DC)</b>	<b>HP Range with 115 VAC Applied</b>	<b>HP Range with 230 VAC Applied</b>	<b>Style</b>
MM23012D	1.5	1/20–1/8	1/10–1/4	Chassis
MM23112D				NEMA 1
MM23212D				NEMA 1
MM23412D				NEMA 12/4/4X
MM23002D †	5.0	1/8–1/2	1/4–1	Chassis
MM23102D ‡				NEMA 1
MM23202D ‡				NEMA 1
MM23402D	10.0	1/8–1	1/4–2	NEMA12/4/4X

† Double maximum armature current and horsepower when drive is mounted on heat sink part number 223-0159.

‡ Double maximum armature current and horsepower when drive is mounted on heat sink part number 223-0174.

<b>AC Line Voltage</b>	115 VAC or 230 VAC $\pm 10\%$ , 50/60 Hz, single phase
<b>Armature Voltage (115 VAC Input)</b>	0–90 VDC
<b>Armature Voltage (230 VAC Input)</b>	0–180 VDC
<b>Form Factor</b>	1.37 at base speed
<b>Accel. Time Range</b>	
(for 0–90 VDC Armature Voltage)	0.5–17 seconds
(for 0–180 VDC Armature Voltage)	0.5–17 seconds
<b>Decel. Time Range</b>	
(for 0–90 VDC Armature Voltage)	coast to a stop–25 seconds
(for 0–180 VDC Armature Voltage)	coast to a stop–25 seconds
<b>Analog Input Voltage Range (input must be isolated; S1 to S2)</b>	0–2.5 VDC
<b>Input Impedance (S1 to S2)</b>	100K ohms
<b>Speed adjust potentiometer rating</b>	10k ohm, 5W (5k ohms acceptable)
<b>Load Regulation</b>	1% base speed or better

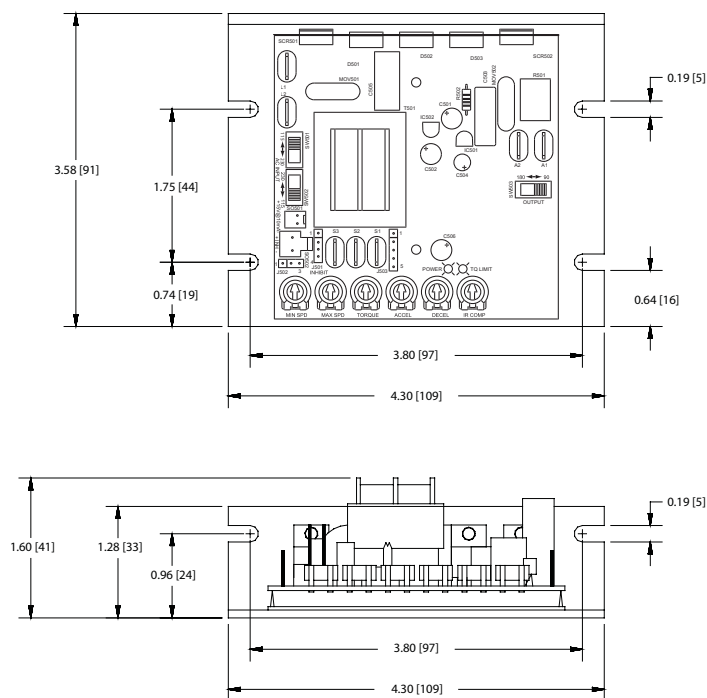
<b>Vibration</b>	0.5G max (0–50 Hz)
	0.1G max (>50 Hz)
<b>Safety Certification</b>	UL Recognized Component, file # E132235
	CSA Certified Component, file # LR41380
	CE Certificate of Compliance
<b>Ambient Temp. Range (chassis drive)</b>	10°C–55°C
<b>Ambient Temp. Range (cased drive)</b>	10°C–40°C

#### Model Number Suffix Definitions

- A: Basic drive
- C: Basic drive with current limit LED
- C-H: Basic drive with power supply header block.
- D: Basic drive with power supply header block, power and current limit LEDs, and torque mode.

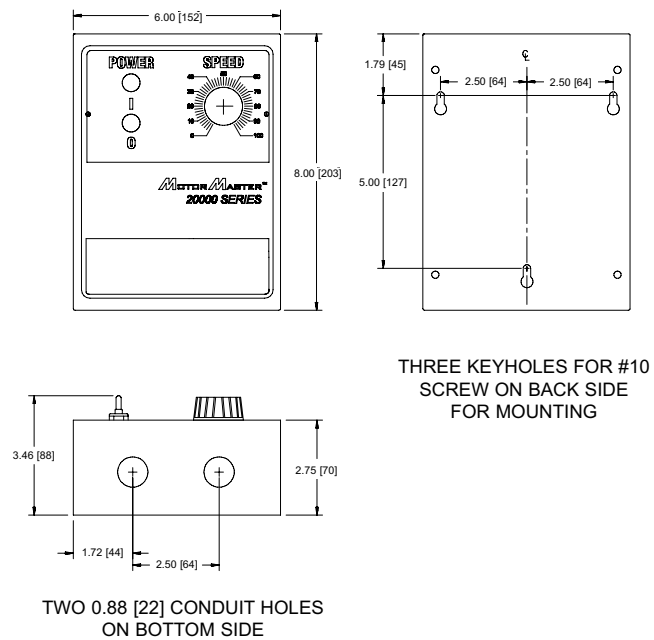


## Dimensions



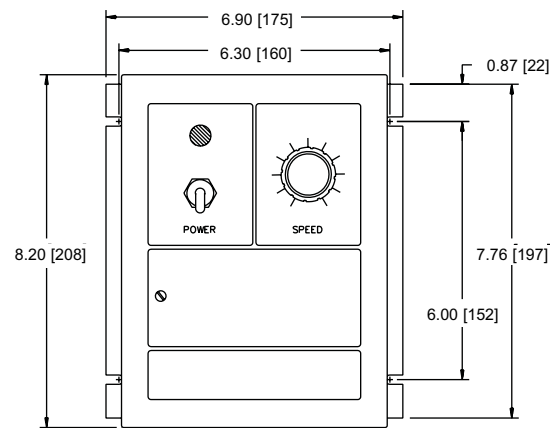
ALL DIMENSIONS IN INCHES [MILLIMETERS]

**Figure 1. MM23002D and MM23012D Dimensions**

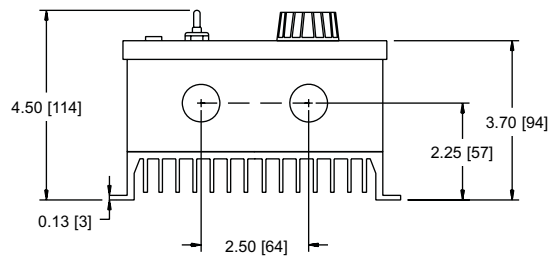


ALL DIMENSIONS IN INCHES [MILLIMETERS]

**Figure 2. MM23102D, MM23112D, MM23202D, and MM23212D Dimensions**

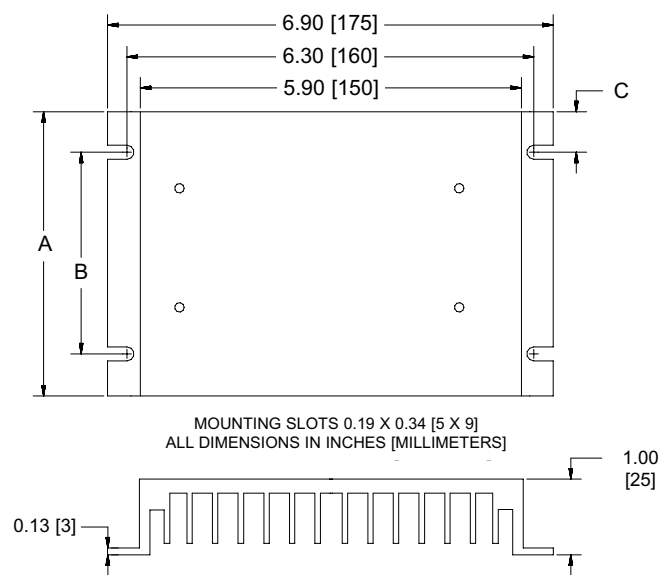


FOUR MOUNTING SLOTS 0.19 INCHES [5 MILLIMETERS] WIDE



TWO 0.88 [22] CONDUIT KNOCKOUTS ON BOTTOM SIDE  
ALL DIMENSIONS IN INCHES [MILLIMETERS]

**Figure 3. MM23402 and MM23412 Dimensions**



PART NO.	DIM "A"	DIM "B"	DIM "C"
223-0159	4.40 [112]	3.00 [76]	0.7 [18]
223-0174	7.78 [198]	6.00 [152]	0.89 [23]

Heat sinks sold separately.

**Figure 4. Heat Sink Dimensions**

## Installation

### Chassis drives

#### Mounting



#### Warning

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

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.

- Drive components are sensitive to electrostatic fields. Avoid contact with the circuit board directly. Hold the drive by the chassis only.
- Mount the drive with its board in either a horizontal or vertical plane. Six 0.19 inch (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.

## 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 or the drive is disabled. Opening any one motor lead may destroy the drive.

- Use 18-24 AWG wire for speed adjust potentiometer wiring.  
Use 14–16 AWG wire for AC line (L1, L2) and motor (A1 and A2) wiring.

## 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 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.

## Speed adjust potentiometer

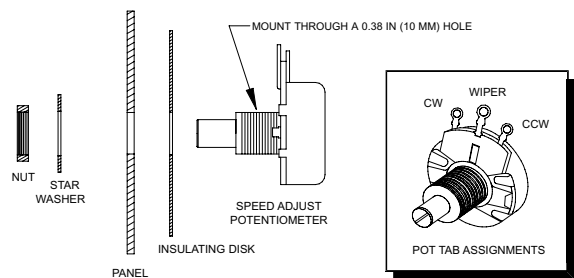


### Warning

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

On chassis drives, install the circular insulating disk between the panel and the 10K ohm speed adjust potentiometer. Mount the speed adjust potentiometer through a 0.38 inch (10 mm) hole with the hardware provided (Figure 5). Twist the speed adjust potentiometer wire to avoid picking up unwanted electrical noise. If potentiometer leads are longer than 18 inch (457 mm), use shielded cable.

All cased controls come with the speed adjust potentiometer installed.



**Figure 5. Speed Adjust Potentiometer**



## Line fusing

Minarik drives require an external fuse for protection. Use fast acting fuses rated for 250 VAC or higher, and approximately 150% of the maximum armature current. Fuse only the hot leg of the AC line that connects to L1 and leave L2 unfused when the AC line voltage is 115 VAC. Fuse both L1 and L2 when the AC line voltage is 230 VAC. Fuse blocks are included on cased drives only. Table 1 lists the recommended line fuse sizes.

**Table 1. Recommended Line Fuse Sizes**

<b>90 VDC Motor Horsepower</b>	<b>180 VDC Horsepower</b>	<b>Max. DC Armature Current (amps)</b>	<b>AC Line Fuse Size (amps)</b>
1/20	1/10	0.5	1
1/15	1/8	0.8	1.5
1/8	1/4	1.5	3
1/6	1/3	1.7	3
1/4	1/2	2.6	5
1/3	3/4	3.5	8
1/2	1	5.0	10
3/4	1 1/2	7.6	15
1	2	10	15

## Heat sinking

Model MM23002D requires an additional heat sink, Minarik part number 223-0159, when the continuous armature current is above 5 ADC. All other chassis drives have sufficient heat sinking in their basic configurations. Use a thermally conductive heat sink compound (such as Dow Corning® 340 Heat Sink Compound) between the drive chassis and heat sink surface for optimum heat transfer.

## Connections



### Warning

**Do not connect this equipment with power applied.**

Failure to heed this directive may result in fire or serious injury.

For chassis drives, Minarik strongly recommends the installation of a master power switch in the voltage input line as shown in Figure 6 (page 15). 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 6, page 15.

#### Motor

Connect a motor to PCB terminals A1 and A2. **Ensure that the motor voltage rating is consistent with the drive's output voltage.**

#### Power input

Connect the AC line power leads to terminals L1 and L2, or to a double-pole, single-throw master power switch as shown in Figure 6, page 15 (recommended).

#### Line fuse

Wire an external line fuse between the stop switch (if installed) and the L1 terminal on the PCB. An additional line fuse should be installed on L2 if the input voltage is 230VAC. The line fuse(s) should be rated at 250 volts and 150 - 200% of maximum motor nameplate current. Refer to the Table 1 on page 11 for fuse ratings.

**Master power switch**

If you use a chassis (uncased) drive, Minarik strongly recommends the installation of a master power switch in the voltage input line, as shown in Figure 6. The switch contacts should be rated at a minimum of 200% of motor nameplate current and 250 volts.

**Alternate speed adjust potentiometer connections**

Refer to Application Notes section (page 44) for additional speed adjust potentiometer connections.

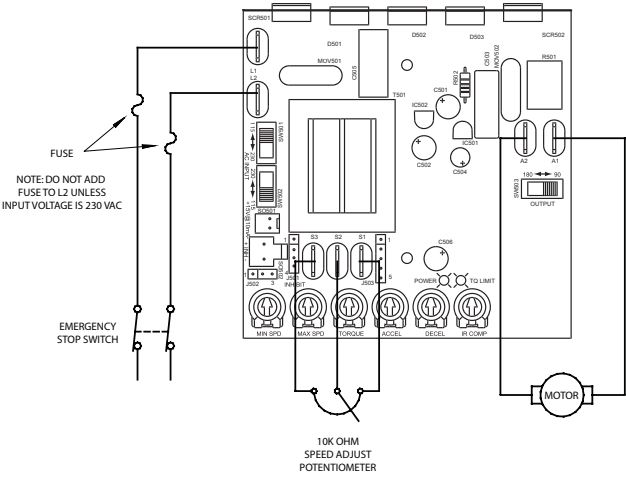
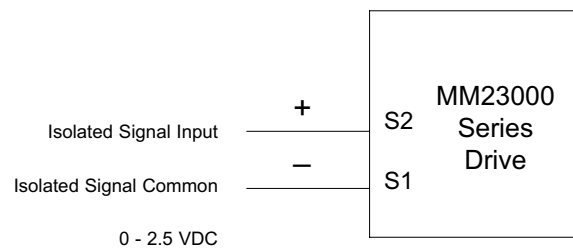


Figure 6. Chassis Drive Connections

### Voltage follower

Instead of using an external speed or torque adjust potentiometer, the drive may be wired to follow an analog input voltage signal that is **isolated** (Figure 7). The analog input voltage range is 0 - 2.5 VDC.

Connect the signal input (+) to S2. Connect the signal common (-) to S1. Make no connection to S3. A potentiometer can be used to scale the analog input voltage. An interface device such as Minarik model PCM4, may be used to scale and isolate an analog input voltage.



**Figure 7. Voltage Follower Connections**

## **Cased drives**

### **Mounting (NEMA 1 enclosures)**

NEMA 1 cased drives come with 0.88 inch (22 mm) conduit holes at the bottom of the case. The units may be vertically wall mounted or horizontally bench mounted using the three keyholes on the back of the case (see Figure 2, page 4).

1. For access to the keyholes and the terminal strip, remove the two screws from the front of the case by turning them counterclockwise. Grasp the front cover and lift it straight out.
2. Install the mounting screws in the three keyholes.
3. Install conduit hardware through the conduit holes at the bottom of the case. Connect external wiring to the terminal block. Refer to Figure 8 on page 21.
4. Reinstall the front cover. Avoid pinching any wires between the front cover and the case.
5. Replace the two screws to the front cover. Turn the screws clockwise to tighten.
6. Set the POWER switch to the OFF position before applying the AC line voltage.

**Mounting (NEMA 12 / 4 / 4X enclosures)**

NEMA 12 / 4 / 4X cased drives come with two 0.88 inch (22 mm) conduit knockout holes at the bottom of the case. The units may be vertically wall mounted using the four 0.19 inch (5 mm) slotted holes on the attached heat sink (see Figure 3, page 5). For motor loads less than 5 ADC, the drive may be bench mounted horizontally, or operated without mounting.

1. Install the mounting screws.
2. For access to the terminal strip, turn the slotted screw on the front cover counterclockwise until it is free from the case. The right side of the cover is hinged to the case. Pull the slotted screw to open the case.
3. Carefully remove the conduit knockouts by tapping them into the case and twisting them off with pliers.
4. Install conduit hardware through the 0.88 inch (22 mm) conduit holes. Connect external wiring to the terminal block.
5. Grasp the slotted screw and tilt the front cover back into place. Avoid pinching any wires between the front cover and the case.
6. Turn the slotted screw clockwise until tight to secure the front cover.
7. Set the POWER switch to the OFF position before applying the AC line voltage.



### **Heat sinking**

Models MM23102 and MM23202 require additional heat sinking when the continuous armature current is above 5 ADC. Use Minarik part number 223-0174. All other cased drives have sufficient heat sinking in their basic configurations. Use a thermally conductive heat sink compound (such as Dow Corning® 340 Heat Sink Compound) between the back of the drive case and heat sink surface for optimum heat transfer.

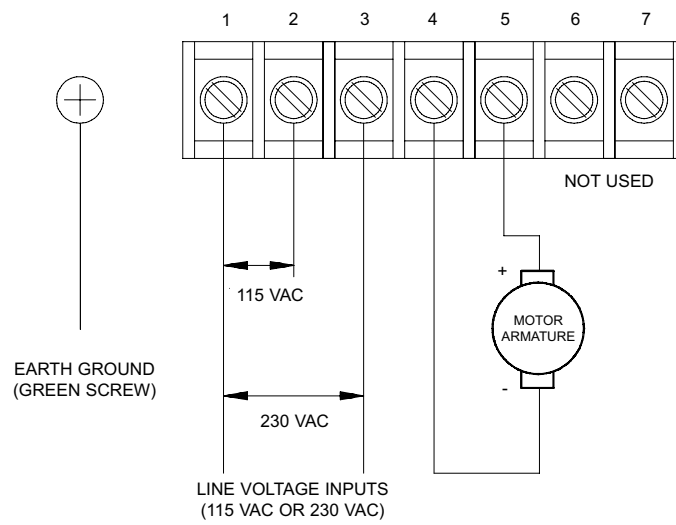
### **Line fusing**

15-amp line fuses are preinstalled on models MM23102, MM23202 and MM23402 and 3-amp line fuses are preinstalled on models MM23112, MM23212, and MM23412.

If the horsepower rating of the motor being used is less than the maximum horsepower rating of the drive, the line fuse may have to be replaced with a lower rated one. Refer to the “Recommended Line Fuse Sizes”, Table 1 on page 11 to install a lower rated fuse.

**All drives**

- 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 other heat sources. Operate the drive within the specified ambient operating temperature range.
- Prevent loose connections by avoiding excessive vibration of the drive.



**Figure 8. Cased Drive Connections**

## Operation



### Warning

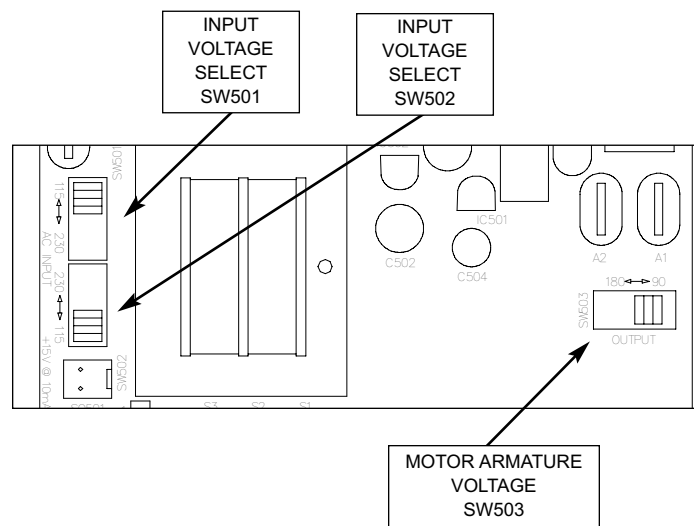
**Dangerous voltages exist on the drive when it is powered. BE ALERT.** High voltages can cause serious or fatal injury.

Change voltage switch settings only when the drive is disconnected from AC line voltage. Make sure both switches are set to their correct position. If the switches are improperly set to a lower voltage position, the motor will not run at full voltage and may cause damage to the transformer. If the switches are improperly set to a higher voltage position, the motor will overspeed, which may cause motor damage.

## Switch settings

Set voltage switch SW501 and SW502 to either 115V or 230V to match the AC line voltage.

Set voltage switch SW503 to either 90V or 180V to match the maximum armature voltage. Refer to Figure 9 for switch locations.



**Figure 9. Voltage Switches**

## Before applying power



### Warning

If the motor does not respond as desired to signal input, remove line power immediately. Refer to the Troubleshooting section on page 53 for assistance.

- Ensure that all selector switches are set to their proper positions.
- Verify that no conductive material is present on the printed circuit board.
- If using a 90 VDC or 130 VDC motor with 230 VAC line voltage, derate the nameplate motor speed and torque by at least 30%. Contact the factory for details.

**Warning**

TORQUE and MAX SPD trimpots must be recalibrated everytime the drive is switched between SPEED and TORQUE mode.

## Speed Mode

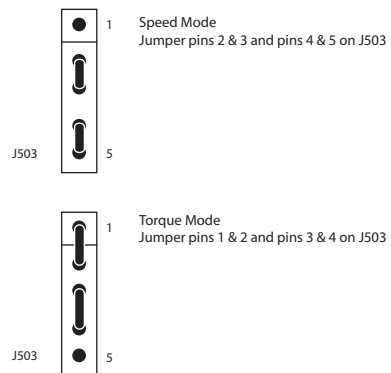
In Speed Mode, the external potentiometer adjusts the speed (voltage) of the motor. The on-board Torque trimpot sets the maximum torque available. The drive comes factory calibrated for speed mode.

To run the drive in Speed Mode, jumper pins 2 & 3 and pins 4 & 5 on J503. See Figure 10 and Figure 11 on page 26.

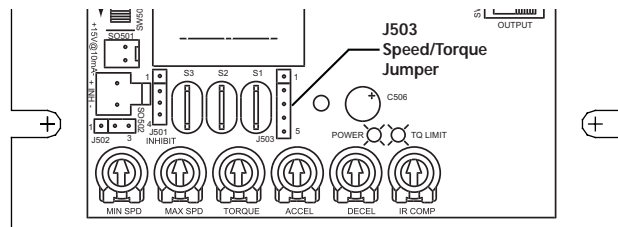
## Torque Mode

In Torque Mode, the external potentiometer adjusts the torque (current) of the motor. The on-board MAX SPD trimpot sets the maximum torque limit. The on-board TORQUE trimpot sets the maximum speed to the motor.

To run the drive in Torque Mode, jumper pins 1 & 2 and pins 3 & 4 on J503. See Figure 10 and 11 on page 26.



**Figure 10. J503 SPEED/TORQUE Jumper Settings**



**Figure 11. J503 SPEED/TORQUE Jumper Location**



## **Speed Mode Startup**

### **MM23002 and MM23012**

1. Turn the speed adjust potentiometer full counterclockwise (CCW).
2. Apply AC line voltage.
3. Slowly advance the speed adjust potentiometer clockwise (CW). The motor slowly accelerates as the potentiometer is turned CW. Continue until the desired speed is reached.
4. Remove AC line voltage from the drive to coast the motor to a stop.

### **MM23102, MM23112, MM23402 and MM23412**

1. Set the speed adjust potentiometer to “0” (full CCW).
2. Apply AC line voltage.
3. Set the POWER switch to the ON position.
4. Slowly advance the speed adjust potentiometer clockwise (CW). The motor slowly accelerates as the potentiometer is turned CW. Continue until the desired speed is reached.
5. Set the POWER switch to the OFF position to coast the motor to a stop.

**MM23202 and MM23212****Warning**

Do not change the FORWARD / REVERSE switch while the motor is running. The motor must come to a complete stop before reversing. Changing motor direction before allowing the motor to completely stop will cause excessively high current to flow in the armature circuit, and will damage the drive and/or motor.

1. Set the RUN / BRAKE switch to the BRAKE position.
2. Set the speed adjust potentiometer to "0" (full CCW).
3. Apply AC line voltage.
4. Set the POWER switch to the ON position.
5. Set the FORWARD / REVERSE switch to the desired direction of rotation.
6. Set the RUN/BRAKE switch to the RUN position.
7. Slowly advance the speed adjust potentiometer clockwise (CW). The motor slowly accelerates as the potentiometer is turned CW. Continue until the desired speed is reached.
8. To reverse direction:
  - a. Set the RUN / BRAKE switch to the BRAKE position.
  - b. Set the FORWARD / REVERSE switch to the desired direction of rotation.
  - c. Set the RUN / BRAKE switch to the RUN position.
9. To brake the motor, set the RUN / BRAKE switch to the BRAKE position. To coast the motor to a stop, set the POWER switch to the OFF position.

## Starting and Stopping Methods



### Warning

Minarik strongly recommends the installation of an emergency stop switch. The switch contacts should be rated at a minimum of 125 volts and 200% of maximum motor current.

For frequent starts and stops, short the inhibit terminals, decelerate to a minimum speed, or apply a dynamic brake to the motor. Do not use any of these methods for emergency stopping. They may not stop a drive that is malfunctioning.

**Removing AC line power (both L1 and L2) is the only acceptable method for emergency stopping.**

Frequent starting and stopping can produce high torque. This may cause damage to motors, especially gearmotors that are not properly sized for the application.

### Line starting and line stopping

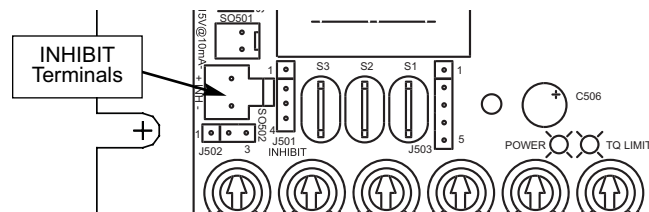
Line starting and line stopping (applying and removing AC line voltage) is recommended for infrequent starting and stopping of a drive only. When AC line voltage is applied to the drive, the motor accelerates to the speed set by the speed adjust potentiometer. When AC line voltage is removed, the motor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

## Inhibit terminals













Open or short the INHIBIT terminals to coast the motor to minimum or zero speed (see Figure 12 for INHIBIT terminal location). Reopen the INHIBIT terminals to accelerate the motor to set speed. The drive will exhibit different responses to shorting these terminals, depending on the way they are shorted (see Figure 13, page 31). The INHIBIT function is the same for Speed or Torque Mode.

Minarik Corporation offers two accessory plug harnesses for connecting to the INHIBIT terminals: part number 201-0024 [inhibit plug with 18 inch (46 cm) leads]; and part number 201-0079 [inhibit plug with 36 inch (91 cm) leads].

Twist inhibit wires and separate them from other power-carrying wires or sources of electrical noise. Use shielded cable if the inhibit wires are longer than 18 inches (46 cm). If shielded cable is used, ground only one end of the shield to earth ground. Do not ground both ends of the shield. See Shielding Guidelines, page 9.



**Figure 12. INHIBIT Terminals**

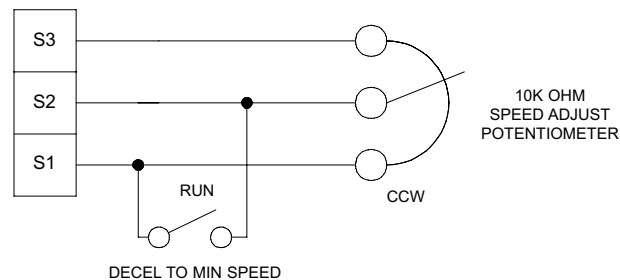
CONFIGURATION	DRIVE RESPONSE
<p>INHIBIT TERMINALS S0502</p>  <p>TERMINALS SHORTED</p> <p>1 2 3</p>  <p>J502</p> <p>1 2 3 4</p>  <p>J501</p>	<p><b>INHIBIT MIN MODE</b> INHIBITS TO MINIMUM SPEED WHEN INHIBIT TERMINALS ARE SHORTED</p>
<p>INHIBIT TERMINALS S0502</p>  <p>TERMINALS SHORTED</p> <p>1 2 3</p>  <p>J502</p> <p>1 2 3 4</p>  <p>J501</p>	<p><b>INHIBIT ZERO MODE</b> INHIBITS TO ZERO SPEED WHEN INHIBIT TERMINALS ARE SHORTED</p>
<p>INHIBIT TERMINALS S0502</p>  <p>TERMINALS SHORTED</p> <p>1 2 3</p>  <p>J502</p> <p>1 2 3 4</p>  <p>J501</p>	<p><b>INVERT INHIBIT MIN MODE</b> INHIBITS TO MINIMUM SPEED WHEN INHIBIT TERMINALS ARE OPENED</p>
<p>INHIBIT TERMINALS S0502</p>  <p>TERMINALS SHORTED</p> <p>1 2 3</p>  <p>J502</p> <p>1 2 3 4</p>  <p>J501</p>	<p><b>INVERT INHIBIT ZERO MODE</b> INHIBITS TO ZERO SPEED WHEN INHIBIT TERMINALS ARE OPENED</p>

NOTE: The MAX and MIN SPD pots must be recalibrated everytime the **inhibit mode** (J501 or J502) jumpers are changed.

**Figure 13. Inhibit Personality Configuration**

### Decelerating to minimum speed

The switch shown in Figure 14 may be used to decelerate a motor to a minimum speed. Closing the switch between S1 and S2 decelerates the motor from set speed to a minimum speed determined by the MIN SPD trimpot setting. If the MIN SPD trimpot is set full CCW, the motor decelerates to zero speed when the switch between S1 and S2 is closed. The DECEL trimpot setting determines the rate at which the drive decelerates. By opening the switch, the motor accelerates to set speed at a rate determined by the ACCEL trimpot setting.



**Figure 14. Run/Decelerate to Minimum Speed Switch**

## Dynamic braking



### Warning

Wait for the motor to completely stop before switching it back to RUN. This will prevent high armature currents from damaging the motor or drive.

Dynamic braking may be used to rapidly stop a motor (Figure 15, page 34). The RUN/BRAKE switch must be sized appropriately for braking current. For the dynamic brake resistor, use a high power wirewound resistor.

### Dynamic brake resistor value

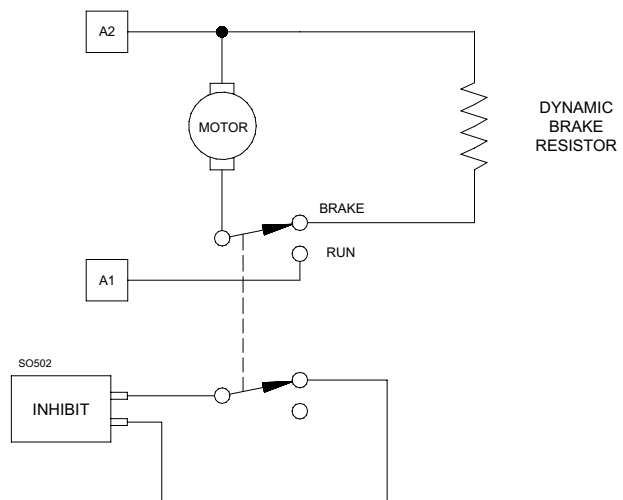
Sizing the dynamic brake resistor depends on load inertia, motor voltage, and braking time. Use a lower ohm-value, higher-wattage dynamic brake resistor to stop a motor more rapidly.

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 with 12 gauge wire. See below equations to determine approximate size of dynamic brake resistor.

$$\frac{\text{RATED MOTOR VOLTAGE}}{2 \times \text{RATED MOTOR CURRENT}} = \text{TOTAL RESISTANCE}$$

$$\text{TOTAL RESISTANCE} - \text{ARMATURE RESISTANCE} = \text{DYNAMIC BRAKE RESISTANCE}$$

$$\frac{\text{RATED MOTOR VOLTAGE} \times \text{RATED MOTOR CURRENT}}{20} = \text{RESISTOR WATTAGE (approximately)}$$



**Figure 15. 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.

MM23002 series drives have six user adjustable trimpots: MIN SPD, MAX SPD, ACCEL, DECEL, TORQUE, and IR COMP. Each drive is factory calibrated to its maximum current rating. Readjust the calibration trimpot settings to accommodate lower current rated motors.

All trimpot settings increase with clockwise (CW) rotation, and decrease with counterclockwise (CCW) rotation. Use a non-metallic screwdriver for calibration. Each trimpot is identified on the printed circuit board.

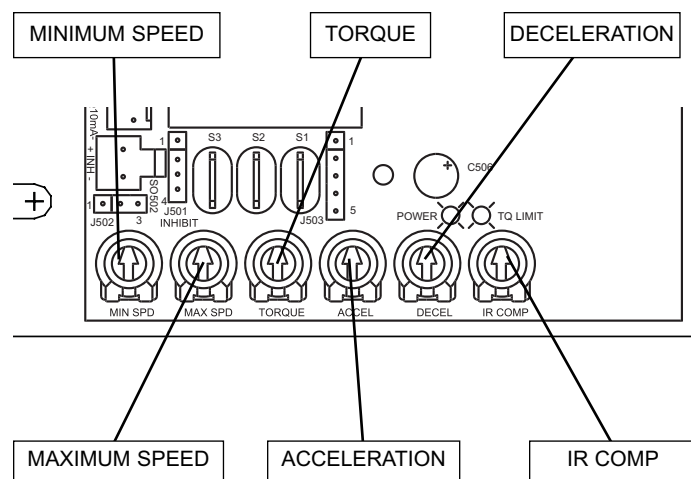


Figure 16. Calibration Trimpot Layout

## **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.

Use the following procedure to set MIN SPD:

1. Set the speed adjust potentiometer full CCW.
2. Adjust the MIN SPD trimpot until the motor has stopped (for zero speed setting), or is running at the desired minimum speed.

## **MAX SPD**

The MAX SPD setting determines the motor speed when the speed adjust potentiometer is turned full CW. It is factory set for maximum rated voltage.

Use the following procedure to set MAX SPD:

1. Set the speed adjust potentiometer full CW.
2. Adjust the MAX SPD trimpot until the motor is running at the desired maximum speed.

## TORQUE



### Warning

TORQUE should be set to 150% 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 TORQUE setting determines the maximum torque for accelerating and driving the motor. To calibrate TORQUE refer to the recommended TORQUE settings in Figure 17 on page 43, or use the following procedure:

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 slowly until the armature current is 150% 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 COMP

The IR COMP trimpot setting determines the degree to which motor speed is held constant as the motor load changes.

Use the following procedure to recalibrate the IR COMP setting:

1. Turn the IR COMP trimpot full CCW.
2. Set 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 until the motor runs at the speed measured in step 2. If the motor does not maintain set speed as the load changes, gradually rotate the IR COMP trimpot CW. 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 speed.
5. Unload the motor.

See Figure 17 (page 43) for recommended IR COMP settings.

## 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. ACCEL is factory set for the fastest acceleration time (full CCW).

Use the following procedure to set the acceleration time:

1. Set the speed adjust potentiometer full CCW. The motor should run at minimum speed (as set by the MIN SPD trimpot, page 37).
2. Turn the speed adjust potentiometer full CW and measure the time it takes the motor to go from minimum to maximum speed.
3. If the time measured in step 2 is not the desired acceleration time, turn the ACCEL trimpot CW for a slower acceleration time, or CCW for a faster acceleration time. Repeat steps 1 through 3 until the acceleration time is correct.

## 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. DECEL is factory set for the fastest deceleration time (full CCW).

Use the following procedure to set the deceleration time:

1. Set the speed adjust potentiometer full CW. The motor should run at maximum speed (as set by MAX SPD trimpot, page 37).
2. Turn the speed adjust potentiometer full CCW and measure the time it takes the motor to go from maximum to minimum speed.
3. If the time measured in step 2 is not the desired deceleration time, turn the DECEL trimpot CW for a slower deceleration time, or CCW for a faster deceleration time. Repeat steps 1 through 3 until the deceleration time is correct.

## Torque Mode Calibration



### Warning

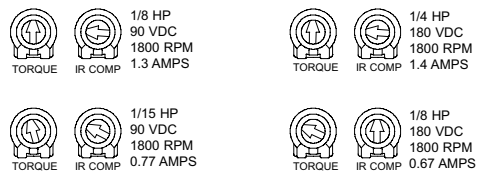
TORQUE and MAX SPD trimpots must be recalibrated every time the drive is switched between Speed and Torque modes.

1. Disconnect power from the drive and connect a DC voltmeter across the armature.
2. Set the MAX SPD and TORQUE trimpots to the 12 o'clock position.
3. Set the external potentiometer to full CW.
4. Apply line power.
5. Adjust the TORQUE trimpot so the motor is running at the motor's maximum rated input voltage (nameplate rating).
6. Remove line power and the DC voltmeter. Be sure the motor is firmly mounted. Connect a DC ammeter in series with the armature. Carefully lock the motor armature.
7. Apply line power.
8. With the external potentiometer set to full CW, slowly adjust the MAX SPD trimpot until the motor draws 100% of the motor's rated armature current (nameplate rating).
9. Remove the line power, stall from motor and ammeter.

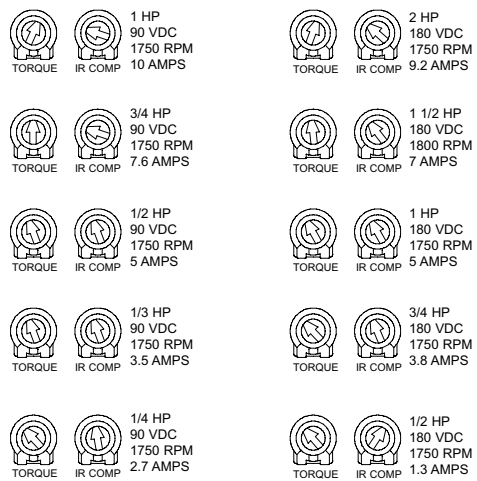


### Speed Mode Recommended Settings

MODELS MM23012, MM23112, MM23212, and MM23412



MODELS MM23002, MM23102, MM23202, and MM23402



**Figure 17. Recommended Torque and IR COMP Settings**  
(actual settings may vary with each application)

## Application Notes

### Multiple fixed speeds

Replace the speed adjust potentiometer with series resistors with a total series resistance of 5K ohm or 10K ohms (Figure 18). Add a single pole, multi-position switch with the correct number of positions for the desired number of fixed speeds.

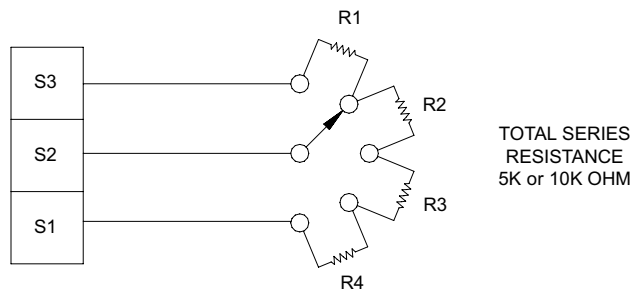
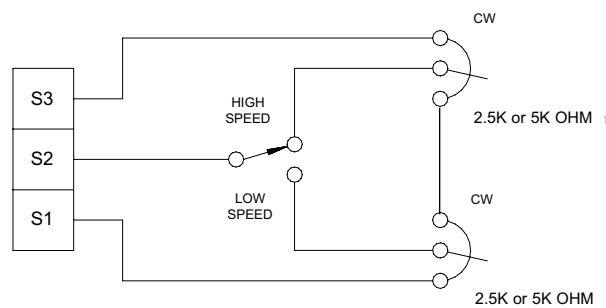


Figure 18. Multiple Fixed Speeds

## 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 5K or 10K ohms. Figure 19 shows a connection for fixed high and low speed adjust potentiometers.

The maximum speed adjust trimpot must be recalibrated if this option is selected. Refer to MAX SPD in the **Calibration** section (page 37) for more information.



**Figure 19. Adjustable Fixed 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, with a total parallel resistance of 5K or 10K ohms. Figure 20 shows the connection of two independent speed adjust potentiometers that can be mounted at two separate operating stations.

The maximum speed adjust trimpot must be recalibrated if this option is selected. Refer to MAX SPD in the **Calibration** section (page 37) for more information.

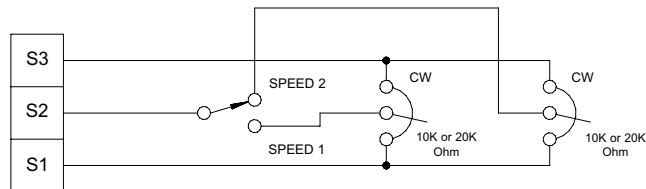
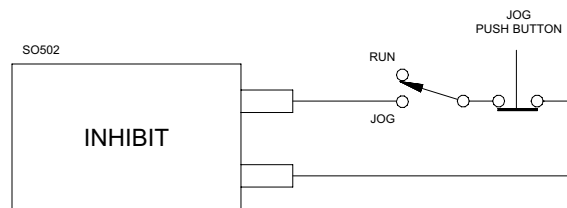


Figure 20. Independent Adjustable Speeds

## RUN / JOG switch

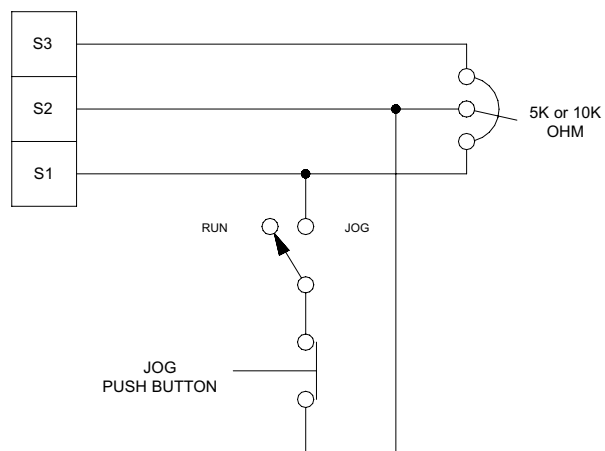
Using a RUN / JOG switch is recommended in applications where quick stopping is not needed and frequent jogging is required. Use a single pole, two position switch for the RUN / JOG switch, and a single pole, normally closed, momentary operated pushbutton for the JOG pushbutton.

In the first wiring option, connect the RUN / JOG switch and JOG pushbutton to the inhibit plug as shown in Figure 21. The motor coasts to a stop when the RUN / JOG switch is set to JOG. Press the JOG pushbutton to jog the motor. Return the RUN / JOG switch to RUN for normal operation.



**Figure 21. RUN / JOG Switch Connection to Inhibit Plug**

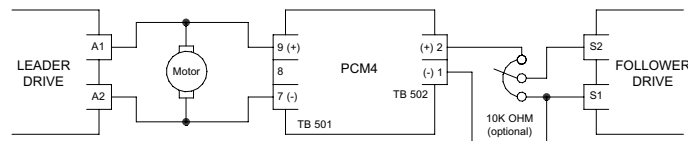
In the second wiring option, connect the RUN / JOG switch and the JOG pushbutton as shown in Figure 22. When the RUN / JOG switch is set to JOG, the motor decelerates to minimum speed (minimum speed is determined by the MIN SPD trimpot setting). Press the JOG pushbutton to jog the motor. Return the RUN / JOG switch to RUN for normal operation.



**Figure 22. RUN / JOG Switch Connection to Speed Adjust Potentiometer**

## Leader-follower application

In a leader-follower application, use a PCM4 to monitor the speed of the leader motor (Figure 23). The PCM4 isolates the leader motor from the follower drive, and outputs a voltage proportional to the leader motor armature voltage. The follower drive uses this voltage reference to set the speed of the follower motor. An optional ratio potentiometer may be used to scale the PCM4 output voltage.



**Figure 23. Leader-Follower Application**

## Single speed potentiometer control of multiple drives

Multiple drives can be controlled with a single speed adjust potentiometer using a PCM4 at the input of each drive to provide isolation (Figure 24). Optional ratio potentiometers can be used to scale the PCM4 output voltage, allowing independent control of each drive.

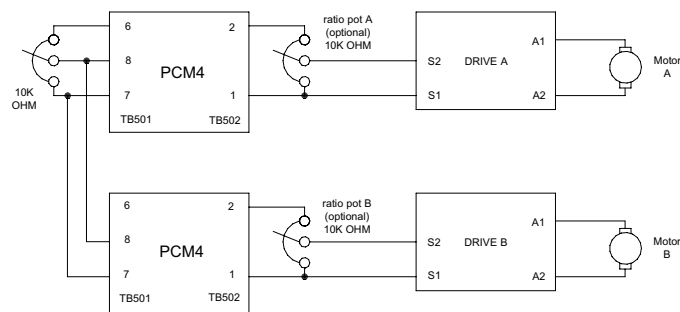
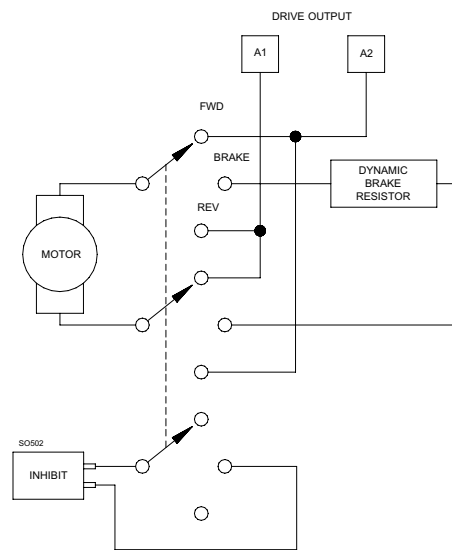


Figure 24. Single Speed Potentiometer Control of Multiple Drives



## Reversing

A dynamic brake may be used when reversing the motor direction (Figure 25). Use a three pole, three position switch rated for at least the maximum DC armature voltage and maximum braking current. Wait for the motor to stop completely before switching it to either the forward or reverse direction. See the Dynamic braking section, page 33, for recommended dynamic brake resistor sizes

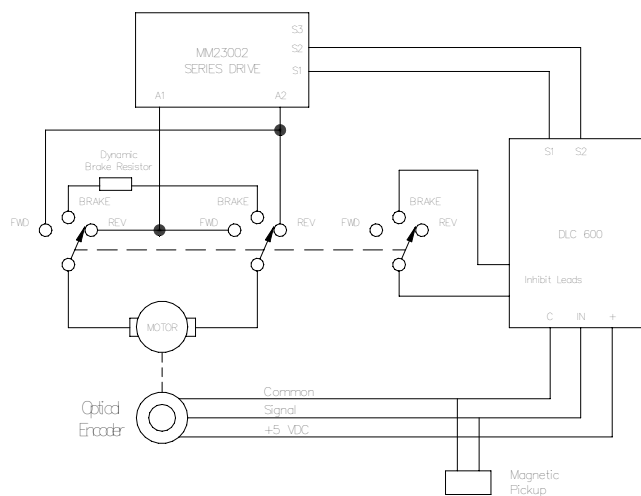


**Figure 25. Reversing Circuit Connection**

## Reversing with a DIGI-LOK® controller

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

Figure 26 shows the connection of the reversing circuit to a MM23002 series drive and DLC600. **Note:** Only one DLC option (Optical Encoder or Magnetic Pickup) may be used at a time.



**Figure 26. Reversing with a DLC600**

## 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 conductive 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 and output voltages.
7. Check that the drive's rated armature output is consistent with the motor ratings.

For additional assistance, contact your local Minarik® distributor, or the factory direct by telephone at:

1-800-MINARIK (646-2745) or Fax: 1-800-394-6334

## Diagnostic LEDs

All MM23002 series drives are equipped with two diagnostic LEDs. Refer to Figure 27 for LED location.

### Power (PWR):

Lights whenever the AC line voltage is applied to the drive.

### Current Limit (CURR LIMIT or CL):

Lights whenever the drive reaches current limit.

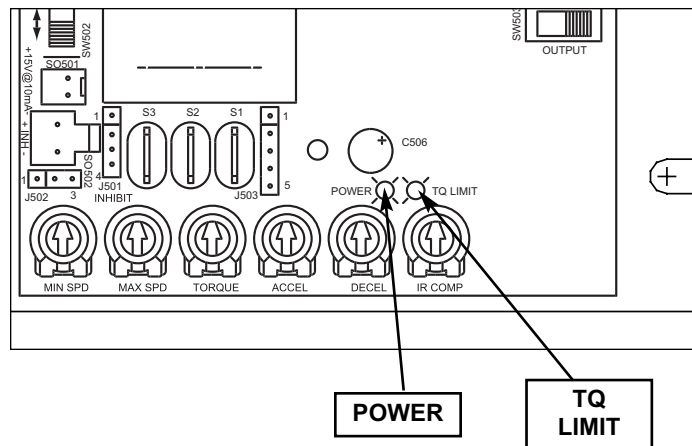


Figure 27. Diagnostic LED Locations

Problem	Possible Causes	Suggested Solutions
Line fuse blows.	<ol style="list-style-type: none"><li>1. Line fuse is the wrong size.</li><li>2. Motor cable or armature is shorted to ground.</li><li>3. Nuisance tripping caused by a combination of ambient conditions and high-current spikes (i.e. reversing).</li></ol>	<ol style="list-style-type: none"><li>1. Check that the line fuse is correct for the motor size.</li><li>2. Check motor cable and armature for shorts.</li><li>3. Add a blower to cool the drive components; decrease TORQUE settings, <b>or</b> resize motor and drive for actual load demand, <b>or</b> check for incorrectly aligned mechanical components or "jams".</li></ol>

<b>Problem</b>	<b>Possible Causes</b>	<b>Suggested Solutions</b>
Line fuse does not blow, but the motor does not run.	<ol style="list-style-type: none"> <li>1. Speed adjust potentiometer is set to zero speed.</li> <li>2. INHIBIT terminals are jumpered.</li> <li>3. S2 is shorted to S1.</li> <li>4. Drive is in current limit.</li> <li>5. Drive is not receiving AC line voltage.</li> <li>6. Motor is not connected.</li> </ol>	<ol style="list-style-type: none"> <li>1. Increase the speed adjust potentiometer setting.</li> <li>2. Remove jumper from the INHIBIT terminals.</li> <li>3. Remove short.</li> <li>4. Verify that motor is not jammed. Increase TORQUE setting if they are set too low.</li> <li>5. Apply AC line voltage to L1 and L2.</li> <li>6. Connect motor to A1 and A2.</li> </ol>
Motor does not stop when the speed adjust potentiometer is full CCW.	<ol style="list-style-type: none"> <li>1. MIN SPD setting is too high.</li> </ol>	<ol style="list-style-type: none"> <li>1. Calibrate MIN SPD.</li> </ol>
Motor runs in the opposite direction (non-reversing drives).	<ol style="list-style-type: none"> <li>1. Motor connections to A1 and A2 are reversed.</li> </ol>	<ol style="list-style-type: none"> <li>1. Reverse connections to A1 and A2.</li> </ol>

<b>Problem</b>	<b>Possible Causes</b>	<b>Suggested Solutions</b>
Motor runs too fast.	1. MAX SPD and MIN SPD are set too high.	1. Calibrate MAX SPD and MIN SPD.
Motor will not reach the desired speed.	1. MAX SPD setting is too low. 2. IR COMP setting is too low. 3. TORQUE setting is too low. 4. Motor is overloaded.	1. Increase MAX SPD setting. 2. Increase IR COMP setting. 3. Increase TORQUE setting. 4. Check motor load. Resize the motor 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 TORQUE trimpot CW.

## Functional Diagrams

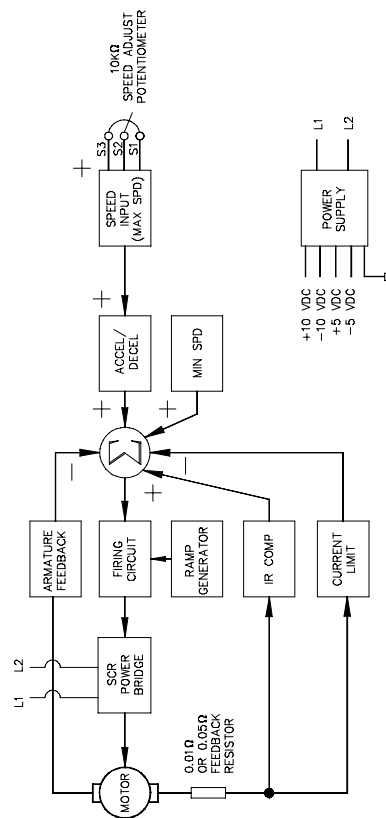
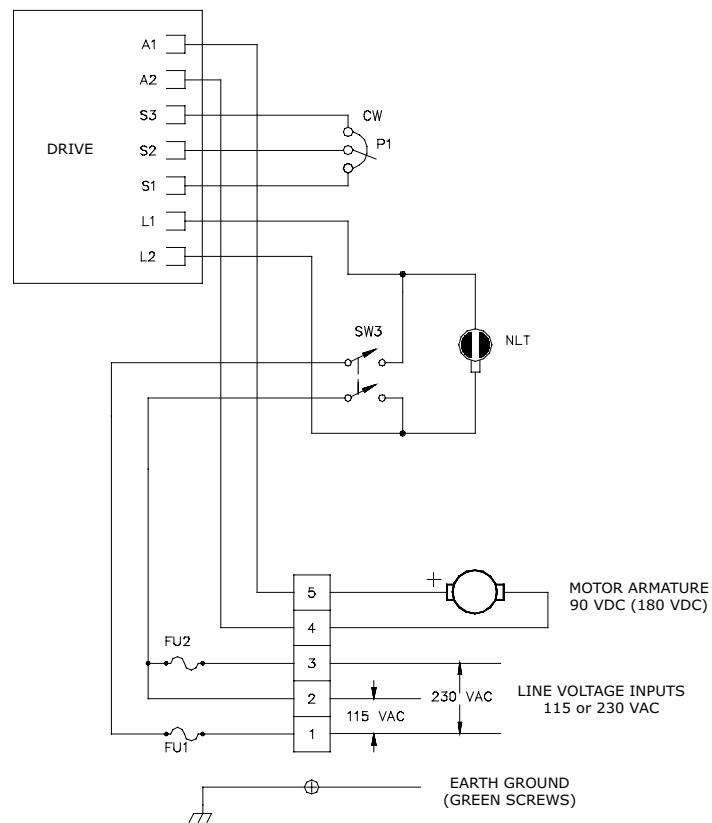
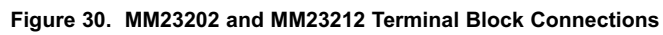


Figure 28. MM23000 Series Block Diagram





**Figure 29. MM23102, MM23112, MM23402 and MM23412  
Terminal Block Connections**



**Figure 30. MM23202 and MM23212 Terminal Block Connections**

## Replacement Parts

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

**Table 2. Replacement Parts**

Model No.	Symbol	Description	Minarik P/N
<b>MM23002</b>	SCR501, 501	800 V, 20 A SCR	072-0043
	D501-503	800V, 20 A Diode	071-0039
	R501	0.01 Ohm, 5W Resistor	032-0129
	T501	3FD-224-001 Transformer	230-0083
		10K Ohm potentiometer kit.	202-0031
<b>MM23012</b>	Same as MM23002 except:		
	SCR501, 501	600 V, 8 A SCR	072-0024
	D501-503	600 V, 3 A Diode	071-0007
	R501	0.05 Ohm, 5W Resistor	032-0089
<b>MM23102</b>	Same as MM230002 except potentiometer kit, and including:		
		Case Bottom	223-0170
		Case Cover	223-0169
		240 V Pilot Light	040-0043
		10K Ohm, 1/2 W Potentiometer	120-0047
		Knob	140-0013
	SW3	DPST Power Switch	080-0037
		15 A, 3AB Fuse	050-0018
<b>MM23112</b>	Same as MM23012 except potentiometer kit. Same as MM23102 except fuse. Include:		
		3 A, 3AG Fuse	050-0021
<b>MM23202</b>	Same as MM23112 except case cover, and including:		
		Case Cover	223-0168
		40 Ohm, 40W Resistor	032-0076
	SW4	DPST Run/Brake Switch	080-0037
	SW5	DPST FWD/REV Switch	080-0037

**Table 2. Replacement Parts (continued)**

<b>Model No.</b>	<b>Symbol</b>	<b>Description</b>	<b>Minarik P/N</b>
<b>MM23212</b>		Same as MM23012 except potentiometer kit. Same as MM23202 except fuse, Include: 3 A, 3AG Fuse	050-0021
<b>MM23212</b>		Same as MM23012 except potentiometer kit, and including: Knob 240 V Pilot Light DPST Power Switch Power Switch Boot 10K Ohm, 1/2 W Potentiometer 3A 3AG Fuse Heat Sink Case	140-0013 040-0043 080-0030 155-0050 120-0047 050-0021 223-0182 223-0104
<b>MM23402</b>		Same as MM23002 except pot kit. Same parts as MM23412 (knob, case) except fuse, and including: 15 A, 3AB Fuse	050-0018
<b>MM23412</b>		Same as MM23402 except heat sink and case, and including: Heat Sink Case 20 Ohm, 40 W Resistor FWD/BRAKE/REV Switch Rotary Switch Knob	223-0183 223-0106 032-0062 081-0010 140-0014

---

## Certificate of Compliance

Minarik Corporation hereby certifies that its MM23000 series drives have been approved to bear the “CE” mark provided the conditions of approval have been met by the end user.

The MM23000 series has been tested to the following test specifications:

**EN55011:1991 (emissions), and  
EN50082-1:1992 (immunity)**

Compliance allows Minarik’s MM23000 series to bear the CE mark.

The end user, as described herein, falls into one of two categories:

1. The Consumer will deploy a stand-alone unit as an integral, yet external, portion of the machine being operated.
2. The Original Equipment Manufacturer (OEM) will implement the product as a component of the machine being manufactured.

In addition to EMI/RFI safeguards inherent in the MM23000 series’ design, external filtering is required.

---

## Line filters

Minarik requires the Corcom® line filters listed below.

**Table 3. Corcom® Filters**

<b>Nameplate Current of Motor Wired to the Drive</b>	<b>Corcom® Filter Part Number</b>
0 to 4 amps	6VV1
4.1 to 13 amps	20VV1

The line filters should be wired to the AC line within 0.25 meters of the drive. The ground connection from the line filter must be wired to solid earth ground (resistance less than 500 ohms); not machine ground. This is very important!

If the end-user is using a CE-approved motor, the correct line filter listed above is all that is necessary to meet the EMC directives listed herein.

## Armature filters

If the end-user is not using a CE-approved motor, a second filter on the armature must be deployed. This filter will have the Minarik part number CEXXMM, where XX is the motor current rating listed on the nameplate. Minarik® Filters are listed below.

**Table 4. Minarik® Filters**

<b>Nameplate Current of Motor Wired to the Drive</b>	<b>Minarik® Filter Part Number</b>
0 to 4 amps	CE4MM
4.1 to 13 amps	CE20MM

The filters listed above must be wired to the DC output of the drive, as close to the drive as possible.

The end user must use the filters listed in this section to comply with CE. The OEM may choose to provide alternative filtering that encompasses the Minarik drive and other electronics within the same panel.

The OEM has this liberty because CE is a machinery directive. Whether or not every component in the OEM's machinery meets CE, the OEM must still submit his machine for CE approval.

Thus, no component must necessarily meet CE within the machine, as long as the OEM takes the necessary steps to guarantee the machine does meet CE. By the same token, even if every component in the OEM's machine does meet CE, the machine will not necessarily meet CE as a machine.

Using CE-approved wiring practices (such as proper shielding) and the filters listed in this section help the drive meet EN55011 (1991 emissions standard) and EN50082-1 (1992 immunity standard).



## **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.



**MINARIK DRIVES**  
**[www.minarikdrives.com](http://www.minarikdrives.com)**

14300 De La Tour, South Beloit, IL 61080  
Phone: (800) MINARIK or (815) 624-5959; Fax: (815) 624-6960  
Document Number: 250-0382, Revision 5  
Printed in the U.S.A. -- June 2006