Minarik Automation & Control

USER'S MANUAL

MAC Series

Models:

MAC05–D240AC
MAC08–D240AC
MAC05–D240AC-PCM
MAC08–D240AC-PCM

Variable-frequency drives for 3-phase AC motors

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

Illustrations

Tables

General Information

Minarik MAC Series drives are voltage-vector-controlled, microprocessor-based, variable-frequency AC motor drives. With a 115 or 230 VAC, 50/60 Hz, single-phase input, MAC drives are factory calibrated for an output of 0* to 60 Hz. They will operate any 1 HP or smaller, 115- or 208/230-volt, three-phase AC induction motor through a speed range of zero* through nameplate speed. They can be user calibrated for 0* through 400 Hz output.

Using proprietary power-control circuitry, the MAC can also double the input line voltage. This allows users to plug the MAC into a 115 VAC line, but control a 208/230 VAC motor.

Although MAC inverters can operate over a 100:1 speed range, most motors will operate over a 10:1 speed range with constant torque at 0* to 60 Hz and constant horsepower above 60 Hz. (Inverter-duty motors may operate satisfactorily over a 20:1 speed range.) Some motors can be satisfactorily operated at speeds as low as 100 rpm (speed range 25:1). Below 100 rpm, some motors may show signs of “stepping” or “cogging”, or they may run warmer.

**Actual minimum frequency will depend on motor type and the load to which it is connected.*

The MAC carrier frequency is true 16.5 kHz.† Many AC drive manufacturers count the leading and trailing edge of the modulated signal, thereby doubling the published carrier frequency; however, their fundamental frequency is only half (8 kHz in this case). By this method, the MAC's carrier frequency would be 33 kHz. The MAC is one of the only drives on the market with *truly* silent operation.

MAC Series drives feature solid-state reversing with adjustable acceleration and deceleration. They also feature adjustable current limit and I^2T class 10 current trip to protect the motor, the control and the driven machine from damage caused by motor overload or machine jamming. The MAC may also interface with motor thermal protection through the enable circuit.

Many 3-phase inverter manufacturers claim that they can run single-phase motors effectively. This is normally accomplished by wiring only 2 phases; however, this primitive method may cause instabilities due to the lack of feedback from one of the motor connections. Furthermore, motor torque will be reduced considerably because the phases are still 120º apart. The MAC can efficiently operate a single-phase motor because the ASIC changes the phase shift to 90º in order to develop maximum torque.

† *In silent mode.*

The MAC is very efficient when the two (2) torque boost settings are properly adjusted; the accel torque boost is applied only during acceleration. Other drives, with only one torque boost setting, can cause motor overheating by applying too much during steady-state operating conditions.

Caution should be taken when operating fan-cooled motors at low speeds because their fans may not move sufficient air to properly cool the motor. Minarik recommends “inverter-duty” motors when the speed range is beyond 10:1.

IMPORTANT INFORMATION

In addition to standard 3-phase induction motors, the following motor types may be used with the MAC:

- Permanent split capacitor (PSC)
- Shaded pole
- AC synchronous
- AC stepping: 28.8, 72 and 200-RPM type.

The following motor types MAY NOT be used:

- Split phase
- Capacitor start
- Repulsion induction
- Series Universal AC/DC
- Any motor with starting switch (centrifugal or relay) and/or separate starting winding.

MAC Series Features

- **Microprocessor-based**
- **Voltage-vector-control drive**
- **True 16.5 kHz carrier frequency (in silent mode)**
- **Solid-state circuitry**
- **Adjustable minimum and maximum speed**
- **Adjustable acceleration and deceleration**
- **Solid-state reversing**
- **Adjustable current limit**
- **I^2T current trip (class 10)**
- **Adjustable torque power boost during acceleration**
- **Adjustable voltage boost at low speeds**
- **Adjustable slip compensation**
- **Multiple motor operation**
- **Doubled-voltage output option selected by jumper**
- **Optional optical isolation circuitry (MACxx-PCM only)**
- **Able to run single- and three-phase motors**

Notes

Specifications

Drive Model Number	Peak Phase Current (ADC)	Continuous Phase Current (ADC)	HP Range with 120 VAC Applied*	HP Range with 240 VAC Applied
MAC05-D240AC(-PCM)	5	2.5	1/15–1/4*	1/6 – 1/2
MAC08-D240AC(-PCM)	8†	4	1/4–1/2*	1/2 – 1

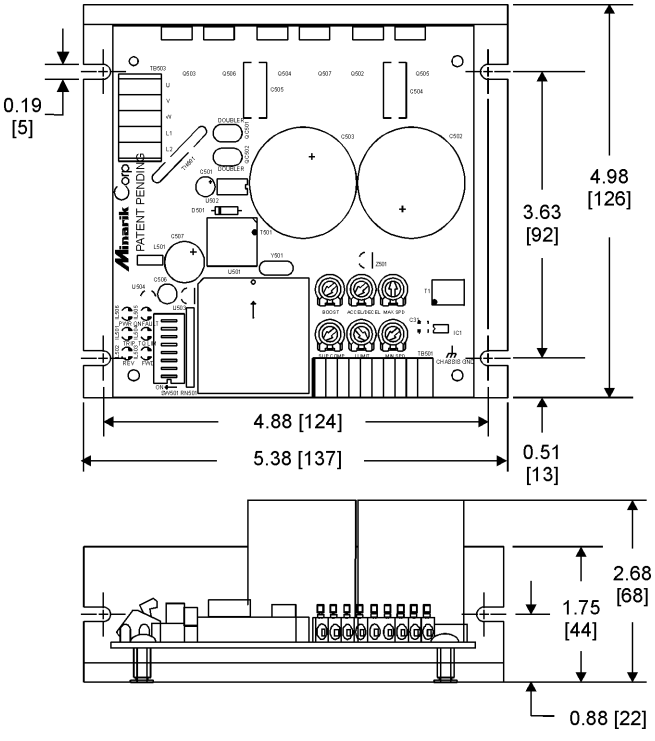
AC Voltage Input Range	120/240 VAC ± 10%, 50/60 Hz single phase
Output Frequency Range	3 – 400 Hz
Selectable Carrier Frequency	11 kHz or 16.5 kHz
Minimum Output Frequency Range	0–11 Hz
Maximum Output Frequency Range	40–400 Hz
Acceleration Time Range (no load)	0.5 – 10 seconds
Deceleration Time Range (no load)	0.5 – 10 seconds
Analog Input Voltage Range (S1 (-) to S2 (+))**	0 – 10 VDC
Input Impedance	~ 50k ohms
Isolation (-PCM drives only)	2500 VAC optical
Slip Compensation	better than 1%
Vibration	0.5G max (20–50 Hz) 0.1G max (>50 Hz)
Weight	1.2 lb
Ambient Operating Temperature Range	10 – 40ºC†

† MAC08-D240AC is rated at 5 amps continuous AC @ 25º C ambient (when run in silent mode) or without heat sink. Derate to 4 amps continuous AC above 25º C (when run in silent mode), or use heat sink kit p/n 223-0269.

*Horsepower is doubled when voltage doubler terminals are jumpered and using 120 VAC input. Refer to the *Operation* section for more information.

**The voltage signal must be ungrounded when using a non-PCM MAC drive. MAC-PCM drives may use grounded or isolated reference voltage signals.

Dimensions



ALL DIMENSIONS IN INCHES [MILLIMETERS]

Figure 1. Dimensions

Installation

Mounting

Warning

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

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 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. Six 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.

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 120 or 240 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 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.

Isolation (-PCM drives only)

The reference circuit (S1, S2 and S3) is optically isolated from the rest of the drive electronics via HCPL7840. It will accept either a grounded or isolated signal reference.

All drive inputs (inhibit, enable, brake and direction) are also optically isolated from the rest of the drive electronics via HCPL0453. It will accept a grounded or isolated bit-type open collector (or switch) input.

Fusing

MAC series drives require external AC power line fuses. Connect the external line fuse(s) in series with the AC voltage input (see Figure 4, page 10). Use fast-acting fuses rated for 250 VAC or higher.

Heat sinking

MAC08-series drives require an additional heat sink (Minarik® part number 223-0269) when the continuous phase current is above 5 amps. All other MAC series drives have sufficient heat sinking in their basic configuration. 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.

Speed adjust potentiometer

Warning

Be sure that the potentiometer tabs do not make contact with the 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 2). 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 (S1, S2, S3)separate from power leads (L1, L2, U, V, W).

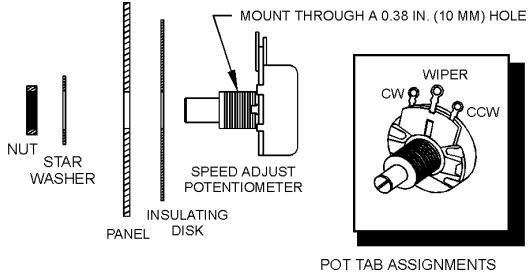


Figure 2. Speed Adjust Potentiometer

Cage-clamp terminals

MAC Series drive connections include cage-clamp terminals (see Figure 3). To insert a wire into a terminal:

1. Press down on the lever arm using a small screwdriver.
2. Insert wire into the wire clamp.
3. Release the lever arm to clamp wire.

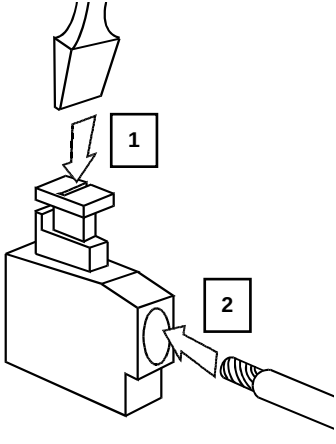


Figure 3. Cage-Clamp Terminal

Connections

Warning

Do not install, remove, or rewire this equipemnt with power applied. Failure to heed this warning may result in fire, explosion, 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 drive current and 250 volts.

Connect the drive's power and line fuse(s) to terminal board TB503 as shown in Figure 4, page 10. Connect the drive's signal inputs and optional switches to terminal board TB501 as shown in Figure 5, page 12. For voltage signal follower connections, refer to Figure 22, page 45.

Connect the motor as shown in Figure 6 or 7, depending on the type of motor being used. Refer to Figure 6 (page 14) for single-phase motor installation. Refer to Figure 7 (page 16) for three-phase motor installation.

Power and fuse connections

1. Connect the input power leads to TB503 terminals L1 and L2.
2. Install a line fuse on L1 as shown. Do not install a line fuse on L2 unless the input voltage is 240 VAC.
3. **Minarik strongly recommends the installation of a master power switch in the voltage input line, as shown in Figure 4.** The switch contacts should be rated at a minimum of 200% of drive current and 250 volts.

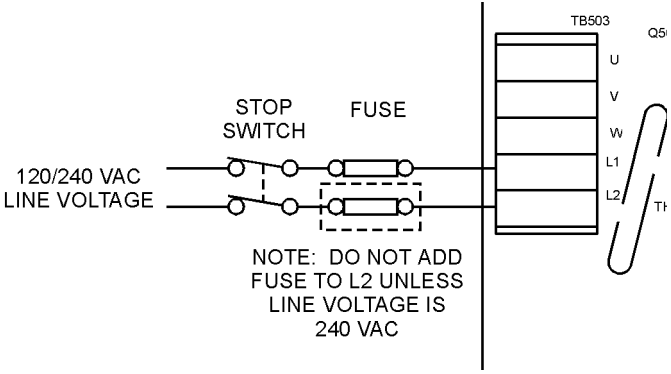


Figure 4. Power and Fuse Connections

Signal and optional switch connections

Warning

Allowing the RUN/BRAKE switch to remain in the BRAKE position for an extended period of time may cause motor overheating. Minarik recommends that you disable the drive (as shown in Figure 10, page 27) or remove power if the motor is to remain idle. Disable the drive or remove power after the motor has come to a stop.

1. Connect a speed adjust potentiometer to terminals S1, S2 and S3 on terminal board TB503 (see Figure 5, page 12). Make sure the potentiometer is connected so that the motor speed will increase as the wiper (S2) is turned clockwise (CW).
2. Connect a single-pole, single-throw ENABLE/DISABLE switch between the EN and COM terminals as shown in Figure 5.
3. Connect a single-pole, single-throw RUN/BRAKE switch between the BRK and COM terminals as shown in Figure 5. Closing the switch will cause the drive to regeneratively brake to a stop.
4. Connect a single-pole, single-throw FWD/REV switch between the DIR and COM terminals as shown in Figure 5. Opening or closing the switch will cause the drive to change the direction of motor shaft rotation.

The drive will brake the motor before reversing, so there is no need to wait for the motor to coast to a stop before changing direction. The amber FWD or REV LED will blink as the drive decelerates the motor but before it has changed direction.

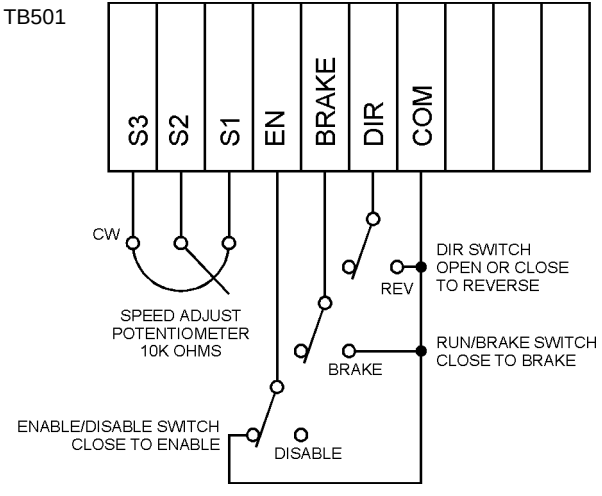


Figure 5. Signal and Optional Switch Connections

Motor connections

Single-phase motors

Ensure that DIP switch 5 on SW501 is set to ON for single-phase motor operation.

It is very important that terminal U be left open (no connection) for single-phase operation.

If the motor and capacitor are sold separately, Minarik highly recommends buying only the motor and operating in 2-phase mode. The resulting speed range will be considerably wider, while starting torque will approach that of a 3-phase motor.

Connect the motor as shown in Figure 6 (page 14). Ensure that the prewired capacitor and its associated motor coil are connected to terminals V and W as shown. This connection may be internal if using a 2-wire motor. If the motor has three leads, you must make this connection yourself.

If the motor capacitor is permanently mounted to the motor by the factory, Minarik recommends leaving the capacitor attached (thereby reducing the potential for human error) and running the drive and motor in single-phase mode.

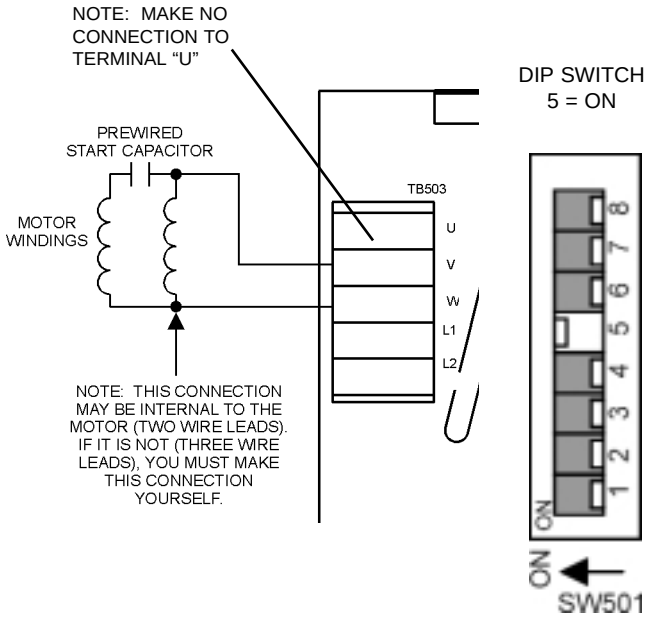


Figure 6. Motor Connections for Single-Phase Operation (Motor With Pre-Wired Capacitor)

Three-phase motors

NOTE: Ensure that DIP switch 5 on SW501 is set to OFF for three-phase motor operation.

Connect a three-phase motor to terminals U, V and W as shown in Figure 7 (page 16).

Table 1. Motor Phase DIP Switch Settings

MOTOR PHASE	DIP SWITCH #5 SETTING
1 OR 2	ON
3	OFF

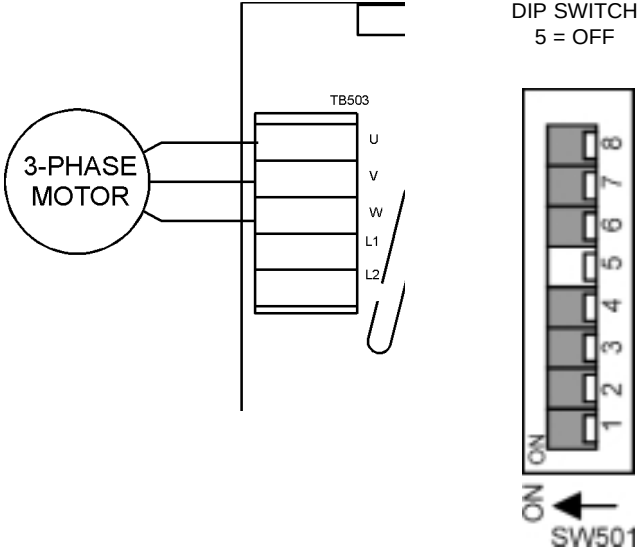


Figure 7. Motor Connections for Three-Phase Motors

Operation

Warning

Dangerous voltages exist on the drive when it is powered, and up to 30 seconds after power is removed and the motor stops. BE ALERT. High voltages can cause serious or fatal injury.

Do not use the voltage-doubling feature when line voltage is greater than 120 VAC. This will result in severe damage to the motor and drive, possible explosion and severe injury.

Do not remove or install the voltage doubler jumper with line voltage applied.

Voltage doubler

Warning

Do not use the voltage-doubling feature when line voltage is greater than 120 VAC. This will result in severe damage to the motor and drive, possible explosion and severe injury.

Warning

Do not remove or install voltage doubler jumper with line voltage applied. Do not apply line voltage greater than 120 VAC.

Jumper wire, if used, must be 14 AWG (1.63 mm) or greater. Minarik highly recommends using the jumper included with the MAC drive.

MAC-series drives are equipped with a unique voltage-doubling feature, for use when 240 VAC input voltage is not available. This feature increases the 120 VAC MAC drives' output from 120 VAC to 240 VAC, for use with 230V motors. The drive current output remains the same.

To enable voltage doubling:

1. Verify that the line voltage source is 120 VAC. Do not apply power at this time.
2. Add a jumper to the voltage doubling terminals. Refer to Figure 8 for terminal location.

Table 2. Voltage Doubler Configuration

Jumper Setting	Input Voltage	Output Voltage
⚠ OFF	120/240 VAC	120/240 VAC
ON	120 VAC	240 VAC

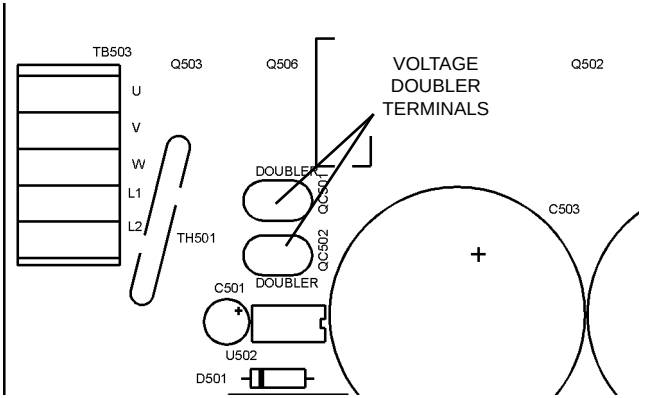


Figure 8. Voltage Doubler Terminals

Before applying power

1. Verify that no conductive material is present on the PCB.
2. Verify that the voltage output is properly set by installing or removing a jumper on the voltage doubler terminals, as required. Refer to Figure 8 (page 19).
3. Verify that the correct voltage is connected to the inputs before applying power. Ensure that 120 VAC ONLY is applied if the doubler circuits are jumpered.
4. Verify that all DIP switches are correctly set for the motor under load.
5. Set the speed adjust potentiometer to zero (full CCW). If a voltage input signal is used, set the input signal to zero.
6. Set the FWD-REV switch (if installed) to the desired direction. If no switch is installed, install or remove a jumper across the DIR and COM terminals, as required.
7. Set the ENABLE/DISABLE switch (if installed) to ENABLE. If no switch is installed short the EN and COM terminals on TB501.
8. Set the RUN/BRK switch (if installed) to RUN, or remove the jumper between the BRK and COM terminals on TB501.

Startup

NOTE: When power is applied, a one-second delay will occur before motor operation.

1. Apply 120 or 240 VAC, 50/60 Hz, single-phase power to the drive. The green POWER LED will come on. If it does not, check the external line fuses to ensure that they are properly installed and not blown. The amber FWD or REV LED will light, indicating the direction of motor shaft rotation.
2. Gradually turn the speed adjust potentiometer clockwise to the desired setting. If a voltage input signal is used, slowly increase the signal to the desired level. The motor shaft will rotate at a speed which is proportional to the input signal or potentiometer wiper position.
3. If you attempt to start and the red TQ LIMIT LED comes on, the control has entered torque limit mode. To avoid this occurrence, you may:

    a. increase the current limit setting (up to a maximum of 150% of the motor nameplate current rating);
    b. lengthen the acceleration time enough to accommodate the needed starting torque by adjusting the ACCEL/DECEL trimpot; or
    c. increase the accel torque power boost by setting the BOOST trimpot DIP switches.

To reverse motor direction:

When the motor is running in the forward direction, the amber FWD LED will light; when the motor is running in reverse, the amber REV LED will come on. To reverse the direction of motor shaft rotation while the motor is running, set the FWD/REV switch to the opposite position. If no FWD/REV switch is installed, open or short the DIR and COM terminals on TB501, as required. The amber LED showing the newly selected direction will light the instant the motor changes direction.

When a new direction is selected, there is no need to close the BRAKE input or open the ENABLE input. The control will automatically decelerate the motor down to zero speed and then reverse direction, accelerating and decelerating at a rate controlled by the ACCEL/DECEL trimpot setting. The amber LED showing the direction of rotation will blink while decelerating until the motor shaft changes direction.

Starting and stopping methods

Braking

Warning

Allowing the RUN/BRAKE switch to remain in the BRAKE position for an extended period of time may cause motor overheating. Minarik recommends that you disable the drive or remove power if the motor is to remain idle. See Figure 5 (page 12) for ENABLE/DISABLE switch installation.

To brake the motor, close the RUN/BRAKE switch, or place a jumper across the BRK and COM teminals of TB501. See Figure 5, page 12, for switch installation.

To coast the motor to a stop without disconnecting power:

Note: When the ENABLE input is closed, a one-second delay will occur before power-up .

Open the ENABLE/DISABLE switch, or remove the jumper between the EN and COM terminals of TB501. See Figure 5, page 12, for switch installation.

I²T trip operation (class 10 characteristics)

I²T trip level is based on the current limit setting. It protects the drive from phase-to-phase short circuits, a mechanical jam, or other potentially catastrophic conditions. If an overload or jam occurs, the amber FWD or REV LED will go out and the red CURRENT LED and TRIP LED will come on. After the overload or jam has been corrected, open, then close the ENABLE input to reset and restart the drive.

Line starting and line stopping

Warning

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

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

Decelerate to minimum speed

The circuit shown in Figure 9 may be used to decelerate a motor to a minimum speed. Closing the switch between S2 and S1 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 S2 and S1 is closed. Calibrate the ACCEL\ DECEL trimpot to control the acceleration and deceleration ramp. Set the switch to the RUN position to accelerate the motor to set speed.

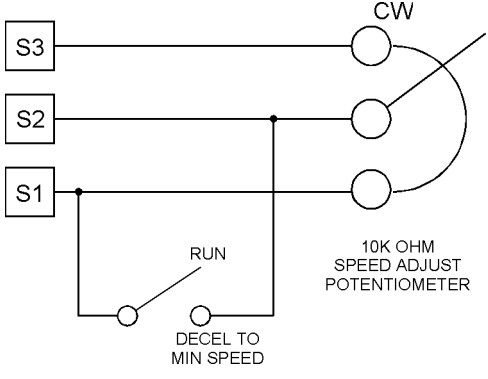


Figure 9. Run/Decelerate to Minimum Speed Switch

Decelerate to minimum with DC injection braking

Warning

Allowing the RUN/BRAKE switch to remain in the BRAKE position for an extended period of time may cause motor overheating. Minarik recommends that you disable the drive (as shown in Figure 10) or remove power if the motor is to remain idle. Disable the drive or remove power after the motor has come to a stop.

The MAC series is equipped with DC injection braking, for use with high-inertia applications.

As a rule, DC motors do not convert AC ripple in the DC voltage to mechanical energy; instead, it is dissipated as waste heat. AC motors perform in the opposite fashion: any DC component of an AC voltage is converted to mechanical energy and acts as drag on an AC motor. Because DC voltage induces a “steady-state” magnetic field through the motor windings, the poles of the armature and rotor will tend to align themselves magnetically. Thus, the motor will not only slow down, but stop completely if the DC voltage is great enough.

When injection braking is selected and the drive is disabled, the normal AC phase output to the motor from the drive is set to its minimum frequency. The drive simultaneously introduces a DC voltage (not to exceed the threshold set by the CURRENT LIMIT trimpot) into the motor stator. The motor will brake while the signal is applied, then coast to a stop. This stops the motor much more quickly and efficiently than simply coasting to a stop, while avoiding high currents which may damage the motor and drive.

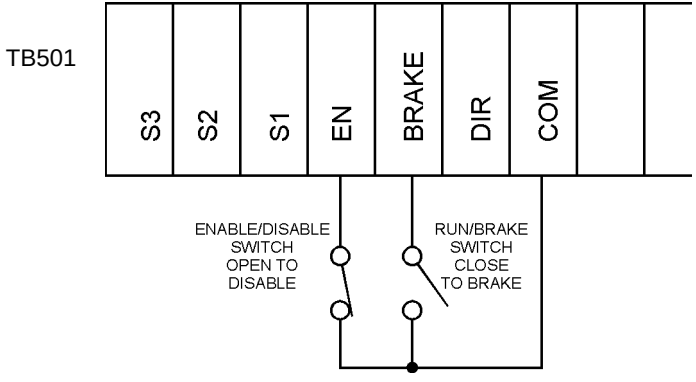


Figure 10. RUN-BRAKE switch with optional ENABLE-DISABLE Switch

Drive thermal protection

MAC series drives have built-in thermal protection. If the power stage temperature reaches 100º C, the drive will turn off. The red TRIP LED will then light to indicate a temperature overload condition.

Thermal protection of the motor

The enable input can also act as a motor thermal protection circuit for motors having a built-in thermal protector. These thermal protectors are operated only by motor heat and open the enable circuit when the motor reaches a temperature which could cause damage to the motor windings.

Normally, these thermal protectors automatically close the circuit when the motor has cooled to a safe temperature. In operation, when the drive is disabled, or when the motor overheats, the thermal protector opens the circuit.

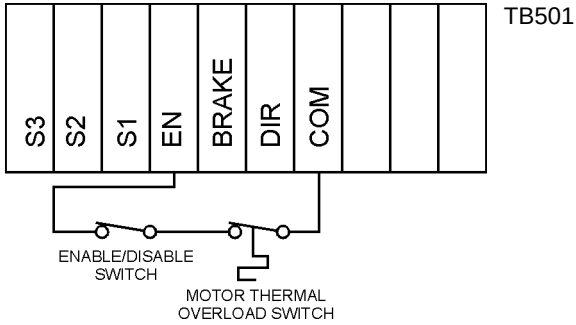


Figure 11. Thermal Overload Switch with Optional Enable/Disable Switch

Calibration

Warning

Dangerous voltages exist on the drive when it is powered, and up to 30 seconds after power is removed and the motor stops. When possible, disconnect the voltage input from the drive 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.

MAC Series drives have six user-adjustable trimpots. Each drive is factory calibrated to its maximum horsepower rating. Readjust the calibration trimpot settings to accommodate lower horsepower motors. See Figure 12 for trimpot location.

All adjustments increase with CW rotation and decrease with CCW rotation. Each trimpot is identified on the printed circuit board.

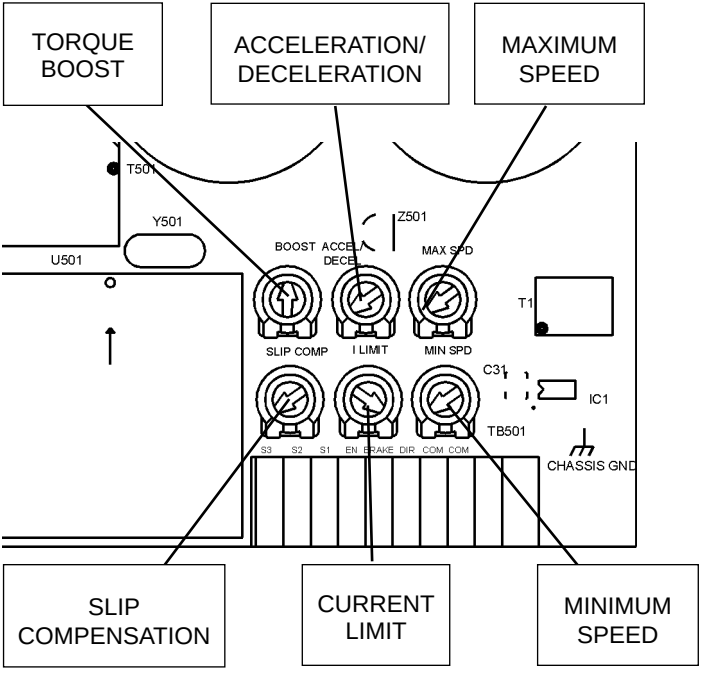
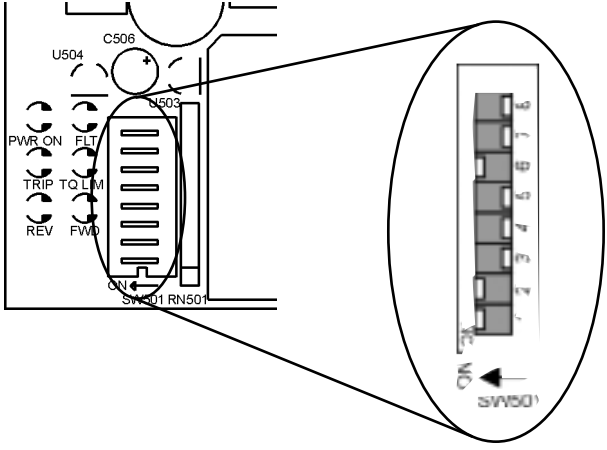


Figure 12. Calibration Trimpot Layout

Max Frequency DIP Switch Settings



NOTE: Whenever a DIP switch state is changed, it will be ignored by the microprocessor until the drive is disabled, then re-enabled.

NOTE: DIP switches are shown in their initial settings prior to drive calibration.

Figure 13. DIP Switch Layout and Initial Settings

Table 3. Max Frequency DIP Switch Settings (SW501)

	DIP SWITCH SETTING			BASE SPEED DIP SWITCH SETTING			
MAX FREQUENCY[1] (Hz)	1	2	3	6	BASE[3]	6	BASE[4]
60†	ON	ON	OFF	ON	60	OFF	60
120	OFF	ON	OFF	OFF	60	OFF	120
240	ON	OFF	OFF	ON	60	OFF	240
400[2]	OFF	OFF	NA	OFF	400	NA	400
50	ON	ON	ON	ON	50	ON	50
100	OFF	ON	ON	OFF	50	ON	100
200	ON	OFF	ON	ON	50	ON	200
400	OFF	OFF	NA	OFF	400	NA	400

† = Default (factory) setting.

Footnotes

1. Max frequency should match the motor's nameplate frequency. If you intend to overspeed the motor by exceeding its nameplate rating, contact the motor manufacturer to assure you do not exceed the motor's mechanical limits.

2. For this setting, the motor should be rated at 400 Hz.

3. Frequency at which nameplate base speed is achieved. This is also the point at which the drive switches from constant torque to constant horsepower.

4. If the base speed is extended, low-end torque will be reduced so that the motor can achieve desired torque through the entire speed range. Speed can only be extended with a 208/230/230V motor.

Calibration Procedure Setup for 60 Hz Motors (See Figure 12):

1. Set all trimpots except I LIMIT and TQ BOOST full counterclockwise (CCW).
2. Set the I LIMIT trimpot full CW.
3. Set the TQ BOOST trimpot to the 12 o'clock position.
4. Set DIP switches 1, 2, and 6 to ON; set DIP switches 3, 4, 5, 7 and 8 to OFF. See Figure 13 (page 32) for DIP switch location.
5. Set the speed adjust pot or reference signal to zero speed.

Silent Mode

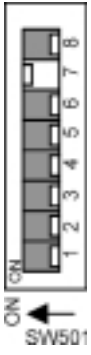
NOTE: If you observe instability in the motor (motor seems to run rough), refer to *Troubleshooting* (page 46).

MAC drives are shipped with a fundamental carrier frequency of 11 kHz (22 kHz with double-edge modulation). Although this mode is very efficient, you may wish to switch to silent mode (16 kHz or 32 kHz with double-edge modulation). To switch to silent mode:

1. Disable the drive (or remove AC line power).
2. Set DIP switch 7 to ON (see Figure 14).
3. Enable the drive (or apply AC line power).

Table 4. Carrier Frequency DIP Switch Settings

MODE†	DIP SWITCH #7 SETTING
SILENT	ON††
NORMAL	OFF



SILENT MODE “ON”

Figure 14. Carrier Frequency Mode DIP Switch Layout

† Silent mode operates with a fundamental carrier frequency of 16/32 kHz. Normal mode operates with a fundamental carrier frequency of 11/22 kHz.

†† Factory (default) setting.

MINIMUM SPEED (MIN SPD)

Apply power to the drive. Slowly rotate the MIN SPD trimpot CW until the motor begins to turn, then slowly rotate the pot CCW until the motor just stops. This step calibrates the MIN SPD pot to zero speed without hysteresis.

MAXIMUM SPEED (MAX SPD)

Rotate the speed adjust pot full CCW. Using a hand-held tachometer or analog frequency meter as a reference, adjust the MAX SPD trimpot until the desired speed or frequency is reached.

CURRENT LIMIT (I LIMIT)

Warning

Do not exceed 115% of the motor nameplate rating. The "modified" I^2T algorithm in the microprocessor allows you to reach 150% – and, under certain circumstances, 200%.

1. Ensure that motor speed is set to maximum.
2. Clip a clamp-on ammeter around one of the motor leads.
3. Load the motor shaft to 115% of the motor nameplate rating.
4. Rotate the I LIMIT trimpot CCW until the CURRENT LIMIT LED (not the TRIP LED) lights. Then rotate the I LIMIT trimpot CW until the LED just turns off.
5. Release the motor load (unlock the shaft).

SLIP COMPENSATION (SLIP COMP)

Increase the motor speed to maximum. Slowly load the motor until the AC phase current is at its maximum (100%). If the motor slowed at all, rotate the SLIP COMP trimpot CW until the motor shaft rotates at the original set speed.

ACCELERATION/DECELERATION (ACCEL/DECEL)

Quickly set the speed adjust pot to zero speed (full CCW) and note the time the motor takes to stop. If the deceleration time differs from the desired time, adjust the ACCEL/DECEL trimpot until the desired time is reached. Rotating the ACCEL/DECEL pot CW slows acceleration, thereby increasing the ramp time.

Rotating the ACCEL/DECEL pot full CCW does not allow the motor to slow faster than it can coast. (To stop more quickly, you may close the BRAKE input to inject DC into the motor.)

Set the speed adjust pot to zero (full CCW). Disable the drive by opening the ENABLE/DISABLE switch or removing the jumper from the EN and COM terminals.

Torque Boost Adjustment

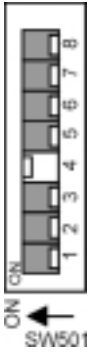
OPTIONAL: To increase system efficiency, the torque boost may be increased at this time. Torque boost should be set to zero if the motor has no load or a slight load. If the drive trips, or the TQ LIMIT LED flickers or illuminates during acceleration, you must increase the torque boost setting. To increase torque boost, perform the following:

1. Disable the drive.
2. Set DIP switch 4 to ON (Figure 15). This will set the accel torque boost to 115%.
3. Enable the drive and rotate the speed adjust pot full CW (maximum speed). If the motor accelerates quickly enough and does not go into current limit, calibration is complete.

The drive is now calibrated for optimum efficiency and minimal motor heating.

Table 5. Torque Boost DIP Switch Settings

TORQUE BOOST	DIP SWITCH #4 SETTING
115%	ON
100%	OFF



TORQUE BOOST
SET TO 115%

Figure 15. Torque Boost DIP Switch Setting

Application Notes

Thermal Protection Switch Installation

To provide additional protection for the motor and drive, install a thermal overload protection switch as shown in Figure 16. An option is to install an ENABLE/DISABLE switch in series with the thermal protection switch (Figure 17).

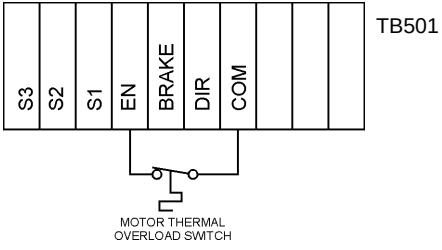


Figure 16. Thermal Overload Protection Switch Installation

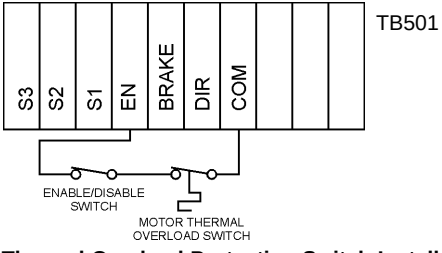


Figure 17. Thermal Overload Protection Switch Installation With Optional Enable/Disable Switch

Independent adjustable speeds with FWD-REV switch

Replace the speed adjust potentiometer with two single-pole multi-position switches, and two or more potentiometers in parallel, with a total parallel resistance of 10K ohms. Figure 18 shows the connection of two independent speed adjust potentiometers that can be mounted at two separate operating stations.

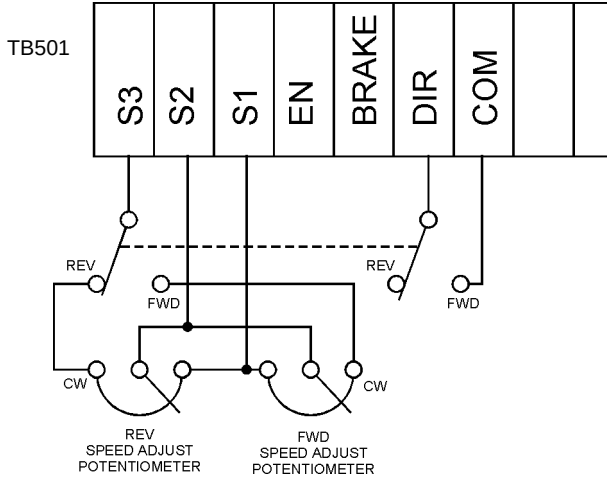


Figure 18. Independent Adjustable Speeds

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 open, momentary operated pushbutton for the JOG pushbutton.

Connect the RUN/JOG switch and JOG pushbutton to terminal board TB501 as shown in Figure 19. 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.

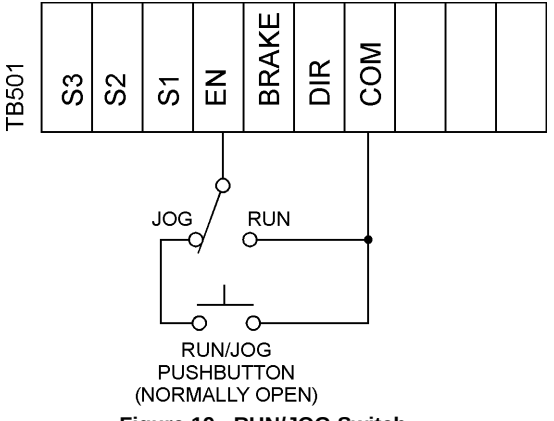


Figure 19. RUN/JOG Switch

Single speed potentiometer control of multiple motors

The MAC series of controls is capable of operating up to eight 3-phase motors simultaneously. All motors must be of the same type and must control similar loads. Connect each motor as shown in Figure 20 below.

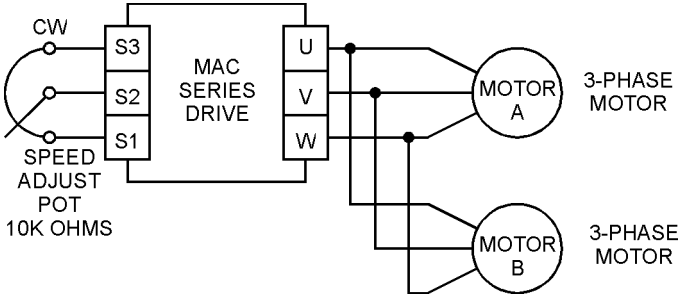
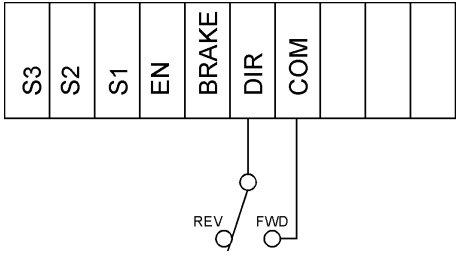
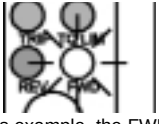


Figure 20. Single Speed Potentiometer Control of Multiple Motors

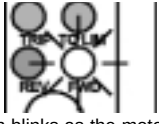
Reversing

To reverse the direction of motor shaft rotation, remove or install a jumper between the DIR and COM terminals of TB501, as required. An option is to install a single-pole, two-position switch as shown in Figure 21. The drive will brake the motor before reversing, so there is no need to wait for the motor to coast to a stop before changing direction. The amber FWD or REV LED will blink as the drive decelerates the motor but before it has changed direction.





In this example, the FWD LED is lit when the motor is running in the forward direction...



...then blinks as the motor decelerates before changing direction...

...then the REV LED lights as the motor begins running in the reverse direction.

Figure 21. Reversing Circuit Connection

Voltage follower

Instead of using a speed adjust potentiometer, the drive may be wired to follow a 0 to +10 VDC isolated voltage signal (Figure 22). Connect the signal common (–) to S1. Connect the signal high or (+) to S2. Make no connection to S3. A potentiometer can be used to scale the analog input voltage.

NOTE: An isolated reference signal must be used with the non-PCM MACdrive. Do not use a grounded reference with any non-PCM MAC series drive.

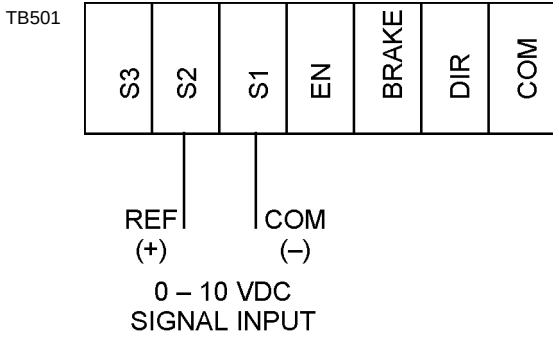


Figure 22. Voltage Follower Connections

Troubleshooting

Warning

Dangerous voltages exist on the drive when it is powered, and up to 30 seconds after power is removed and the motor stops. When possible, disconnect the voltage input from the drive while troubleshooting. Be alert. High voltages can cause serious or fatal injury.

Before troubleshooting

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

- Disconnect AC voltage input from the drive. Wait 30 seconds for power to discharge. The green POWER LED will blink while power is discharging.
- Check the drive closely for damaged components.
- Check that no wire chips or other foreign material has become lodged on the printed circuit board.
- Verify that every connection is correct and in good condition.
- Verify that there are no short circuits or grounded connections.
- Check that the drive's rated phase current and RMS voltage are consistent with the motor ratings.

Diagnostic LEDs

MAC-series drives contain six diagnostic LEDs (see Figure 23, pg. 49):

POWER ON (green)

The green POWER ON LED lights when power is applied to the drive.

FAULT (red)

The red FAULT LED lights in any of the following conditions:

1. Failure of the power stage or its components.
2. The monitor detects an overcurrent condition of more than 250% of the drive's rating.
3. A short between any two of the three AC phases.
4. Loss of phase.

TRIP I^2T (red)

The red TRIP LED lights when a thermal overload has occurred. The TRIP and TQ LIM LEDs light at the same time if the motor load exceeds 250% of the motor's rated current or I^2T class-10 conditions. If the TRIP and TQ LIM LEDs are lit at the same time, the drive has gone into current overload.

REV (amber)

The amber REV LED lights to show the motor is moving in the reverse direction. The LED blinks when the direction input has changed until the motor changes direction.

FWD (amber)

The amber FWD LED lights to show the motor is moving in the forward direction. The LED blinks when the direction input has changed until the motor changes direction.

TQ LIM (red)

The red TQ LIM (torque limit) LED will light at the same time as the TRIP LED if the current required to move the load exceeds the I LIMIT trimpot setting.

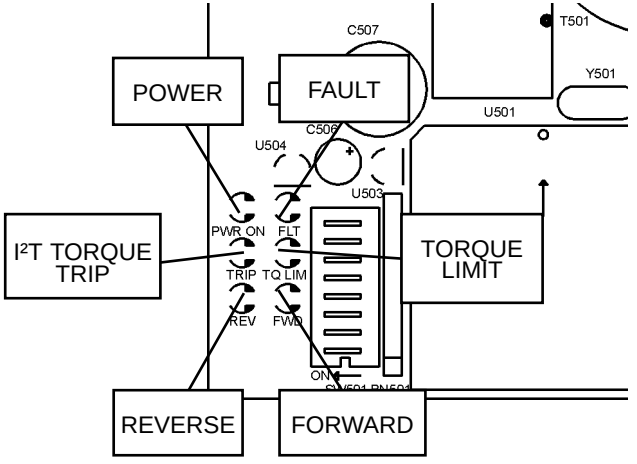


Figure 23. Diagnostic LED Layout

LED fault indications

Green POWER LED does not light when power is applied.

1. The input voltage may be too low. Check that the input voltage is above 90 VAC.
2. Check that the external fuse(s) is/are not blown. Replace if necessary.
3. Check the connections to the terminal block for loose, broken or miswired leads.

Green POWER LED blinks after power is turned off.

1. Power has been removed from the drive and the power supply is discharging.

Red TRIP LED is lit steadily (does not blink) at the same time as the TQ LIM LED .

1. The motor load has exceeded the I^2T class 10 current characteristics. Check there is no phase-to-phase short.
2. If no short exists, check that there is no jammed load.

Red TRIP LED is lit steadily (does not blink); red TQ LIM LED is not lit.

1. The drive has gone into thermal overload (drive temperature has exceeded 100º C).

Red FAULT LED is lit.

1. The control has a power stage failure.
2. The motor load is more than 250% above current limit setting.
3. The motor has a phase-to-phase short circuit or possible loss of phase.

Red TQ LIMIT LED is lit.

1. The I LIMIT trimpot is out of calibration and must be adjusted. See Calibration for information on adjusting the trimpot.
2. The motor load is greater than 115% of the torque limit setting, but less than 250%.
3. Torque boost is set too high.

Amber REV LED blinks; FWD LED not lit.

The drive was running in the reverse direction when the direction (DIR) input state was changed. The REV LED blinks until the direction of motor shaft rotation is actually reversed.

Amber FWD LED blinks; REV LED not lit.

The drive was running in the forward direction when the direction (DIR) input state was changed. The FWD LED blinks until the direction of motor shaft rotation is actually reversed.

Clearing LED fault indications

Reset all LED fault indications using the following procedure:

1. Disable the drive by opening the ENABLE input (remove the jumper between the EN and COM terminals of TB501).
2. Re-install the jumper between the EN and COM terminals of TB501 to close the ENABLE input and restart the drive.

To make this process easier, Minarik recommends installing a single-pole, single-throw DISABLE/ENABLE switch between the EN and COM terminals of terminal board TB501. See *Signal and Optional Switch Connections* on page 12 for an illustration.

Problem	Possible Cause	Suggested Solution
External line fuse blows	1. Line fuses are the wrong size. 2. Motor or motor cable is shorted to ground. 3. Nuisance tripping caused by a combination of ambient conditions and high-current spikes (i.e. reversing).	1. Check that line fuses are properly sized for the motor being used. 2. Check motor cable and motor for shorts. 3. Add a blower to cool the drive components; increase I LIMIT settings (page 36).
External line fuse does not blow, but the motor does not run	1. Speed adjust potentiometer or voltage input signal is set to zero speed. 2. Speed adjust potentiometer or voltage input signal is not properly connected to drive input; connections are open. 3. Drive is “tripped” off or has gone into thermal overload.	1. Increase the speed adjust potentiometer setting or voltage input signal. 2. Check connections to input. Verify that connections are not open. 3. Check diagnostic LEDs for drive condition. Remove motor load.

Possible Cause	Problem	Suggested Solution
External line fuse does not blow, but the motor does not run (cont.)	4. Drive has been disabled.	4. Ensure that EN and COM terminals are properly connected.
	5. Drive is in brake mode.	5. Ensure that BRAKE terminal is not shorted to COM terminal.
	6. Drive is in current limit.	6. Verify that motor is not jammed. Increase I LIMIT setting if it is set too low.
	7. Drive is not receiving AC voltage input.	7. Apply AC line voltage to L1 and L2.
	8. Motor is not connected.	8. Connect motor to drive outputs U, V and W.
Motor runs too slow or too fast at set speed	1. Switches are set incorrectly.	1. Verify all switch settings.
	2. MIN or MAX SPD are not calibrated.	2. Calibrate MIN and MAX SPD trimpots (page 36).
Motor will not reach the desired speed	1. Base speed DIP switches are incorrectly set.	1. Reset DIP switches.
	2. MAX SPD setting is too low.	2. Increase MAX SPD setting (page 36).

Problem	Possible Cause	Suggested Solution
Motor will not reach the desired speed (cont.)	3. BOOST and SLIP COMP settings are too low. 4. Nominal input voltage may be too low for motor 5. Motor is overloaded.	3. Recalibrate BOOST and SLIP COMP settings (pp 37-38). 4. Compare motor voltage to input voltage; replace motor if necessary (see page 11) 5. Check motor load. Resize the motor if necessary.
Motor pulsates or surges under load	1. SLIP COMP is set too high. 2. Motor “bouncing” in and out of torque limit. 3. Possible instabilities in silent mode (1 HP motors only)	1. Adjust the SLIP COMP setting slightly CCW until the motor speed stabilizes (page 37). 2. Make sure motor is not undersized for load; adjust I LIMIT setting CW (page 36). 3. Disable drive; set DIP switch #7 to ON; re-enable drive.

Possible Cause	Problem	Suggested Solution
Motor does not reverse	1. Bad FWD/REV switch connection. 2. Reversing circuit not working properly.	1. Check FWD/REV switch connection. 2. Check reversing circuit by shorting FWD/REV terminal to COM terminal with jumper wire.
TQ is unsatisfactory at high speeds.	1. I LIMIT set too low. 2. TQ BOOST set too low. 3. Load may exceed rating of motor/drive. 4. Nominal input voltage may be too low for motor.	1. Check I LIMIT setting (page 36). 2. Check boost setting. 3. “Fix” load (i.e., straighten mounting, coupling, etc.); or replace motor and drive with motor and drive rated for higher horsepower. 4. Compare motor voltage to input voltage. Replace motor if necessary (see page 10).

Problem		Suggested Solution
Drive goes into current limit or I^2T trip on power-up	1. Motor is undersized for load. 2. TQ BOOST set too high. 3. Accel torque boost is set to ON. 4. Leads from drive to motor are too long, or wire gauge is too small.	1. Resize motor or use proper drive for motor. 2. Reduce TQ BOOST trimpot setting (page 38). 3. Set torque boost SW501 DIP switch #4 to OFF. 4. Shorten leads and/or increase wire gauge.

Replacement Parts

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

Table 6. Replacement Parts

Model No.	Symbol	Description	Minarik® P/N
MAC05-D240AC	C502-503	1000 uF, 200 VDC Capacitor	011-0096
	Q502-Q507	IGBT	070-0085
	TH501	20-amp Thermistor	033-0007
	TB501	10-pin Terminal Block	160-0153
	TB503	5-pin Terminal Block	160-0114
		10K ohm Potentiometer Kit	202-0100
MAC05-D240AC-PCM	Same parts as above		
MAC08-D240AC	Same parts as above, except:		
	C502-503	1500 uF, 250 VDC Capacitor	011-0089
	TH501	30-amp Thermistor	033-0009
MAC08-D240AC-PCM	Same parts as above		

Potentiometer Kit Contains:

10K ohm, 5W Potentiometer
3/8-32 X 1/2 Nut
3/8 INT Tooth Lock Washer
Potentiometer Insulating Washer

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 from date of manufacture thereof. Within this warranty period, the Corporation will repair or replace such products that are returned to Minarik Corporation, 901 East Thompson Avenue, Glendale, CA 91151-2011 USA.

This warranty shall not apply to any product that has been repaired by unauthorized persons. 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.

Minarik Automation & Control
901 E Thompson Avenue
Glendale, CA 91201-2011
Tel: (800) MINARIK (646-2745)
Fax: (800) 394-6334
www.minarikcorp.com
Document number 250-0275, Revision 2
Printed in the U.S.A – 01/01
North America $12.00, Outside North America $15.00