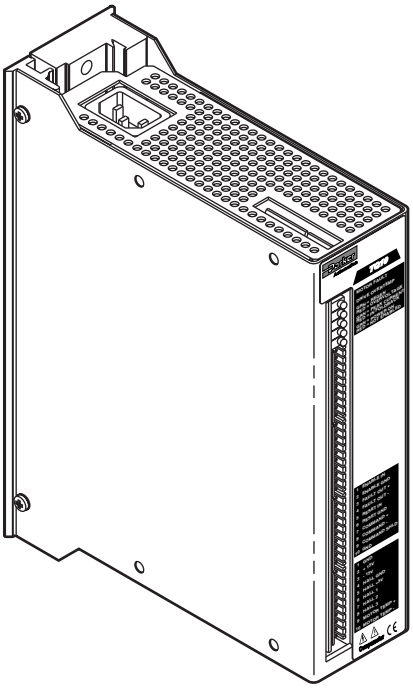
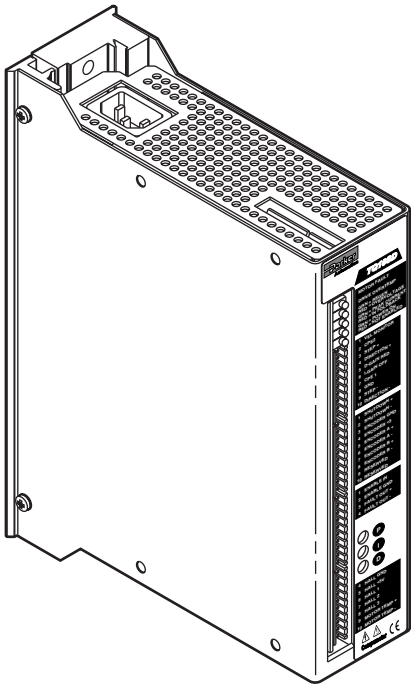
Compumotor

TQ10 Torque Servo Drive

TQ10SD Step & Direction Servo Drive

User Guide





Compumotor Division
Parker Hannifin Corporation
p/n 88-015115-02 A October 1997

Parker

IMPORTANT

User Information

To ensure that the equipment described in this User Guide, as well as all the equipment connected to and used with it, operates satisfactorily and safely, all applicable local and national codes that apply to installing and operating the equipment must be followed. Since codes can vary geographically and can change with time, it is the user's responsibility to identify and comply with the applicable standards and codes. **WARNING:** ***Failure to comply with applicable codes and standards can result in damage to equipment and/or serious injury to personnel.***

Personnel who are to install and operate the equipment should study this user guide and all referenced documentation prior to installation and/or operation of the equipment.

In no event will the provider of the equipment be liable for any incidental, consequential, or special damages of any kind or nature whatsoever, including but not limited to lost profits arising from or in any way connected with the use of this user guide or the equipment.

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Since Parker Compumotor constantly strives to improve all of its products, we reserve the right to change this User Guide and equipment mentioned therein at any time without notice.

Technical Assistance ⇨ *Contact your local automation technology center (ATC) or distributor,* ***or ...***

North America and Asia:
Compumotor Division of Parker Hannifin
5500 Business Park Drive
Rohnert Park, CA 94928
Telephone: (800) 358-9070
Fax: (707) 584-3793
FaxBack: (800) 936-6939
BBS: (707) 584-4059
e-mail: tech_help@cmotor.com

Europe *(non-German speaking)***:**
Parker Digiplan
21 Balena Close
Poole, Dorset
England BH17 7DX
Telephone: 0202-690911
Fax: 0202-600820

Germany, Austria, Switzerland:
HAUSER Elektronik GmbH
Postfach: 77607-1720
Robert-Bosch-Str. 22 • D-77656 Offenburg
Telephone: (0781) 509-0
Fax: (0781) 509-176

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CHANGE SUMMARY

TQ10 & TQ10SD Servo Drive User Guide

Revision A
October 1997

The following is a summary of the primary technical changes to this document since the previous version was released. This document, p/n 88-015115-02 A, supersedes 88-015115-01 **E**.

DIP switch Functionality (pages 8-11)

Change – The DIP switches controlling foldback have been redefined, and there are now three (vs. two) DIP switches on the bottom of the product. Please check the back-cover drawings and update your internal documentation as necessary. The changes are outlined below and are explained in more detail in the applicable sections.

Foldback Functionality (pages 57-58)

Change – The threshold for the foldback timer is now selectable, and the setting to disable foldback has changed. Foldback will now respond, under typical conditions, to AC currents such as are created when a position loop is driven into instability. Previously, foldback had been insensitive to AC currents.

Motor Pole Compensation Range (pages 10-11)

Change – The range has been increased by the addition of a third DIP switch on the bottom of the product. This allows improved current-loop performance with a wider range of motor electrical pole frequencies, including all Parker Neometric 70mm and some of the 92mm motors. If the new switch, SW3-3 is placed in the OFF (up) position, settings are backward-compatible with earlier product.

Reset Input Functionality (page 28)

Change – Asserting the RESET input will now reset controller, as well as drive faults. This is accomplished by cycling +5 volt power to the controller. The effect of asserting the RESET input is identical with cycling power, except that power to the encoder and hall sensors is not interrupted by RESET.

Enable Input Low-State Threshold (page 24)

Change – Threshold has been increased by approximately one volt for improved noise immunity in applications where this signal originates at some distance from the drive.

Example in Tuning Procedure (pages 38-40)

Change – The example in the *TQ10 Tuning Procedure* has been changed.

Revised Peak Current for SM Motors (page 43)

Change – Maximum allowable peak current for several Compumotor SM Series motors is now lower. New peak current values are *three times* the rated continuous current. Previously, peak current values were *five times* the rated continuous current. The new peak currents are listed in *Motor Specifications – Compumotor SM Series Servo Motors,* which is in *Chapter 3—Specifications*.

Compumotor NeoMetric Series Motors Added (pages 44-45)

Addition – Specifications, speed/torque curves, and dimensions for three new Compumotor NeoMetric Series motors have been added to this User Guide.

Speed/Torque Curves Revised for SM Motors (pages 46-47)

Change – The speed/torque curves for Compumotor SM Series motors have been redrawn. The new curves show the peak torque that will be produced from the revised peak current (discussed in the paragraph above).

New Back Cover Illustration

Change – The illustration on the back cover of this User Guide has been updated to incorporate the changes listed in this change summary.

Product Type: TQ10 and TQ10SD Servo Drives

The above products are in compliance with the requirements of directives

- **72/23/EEC Low Voltage Directive**
- **93/68/EEC CE Marking Directive**

TQ10 Drives, when installed according to the procedures in the main body of this User Guide, may not necessarily comply with the Low Voltage Directive (LVD) of the European Community. To install TQ10 Drives so that they comply with LVD, you must follow the additional procedures described in Appendix B, *LVD Installation Instructions*. If you do not follow these instructions, the protection of the product may be impaired.

The TQ10 Series of drives are sold as complex components to professional assemblers. As components, they are not required to be compliant with Electromagnetic Compatibility Directive 89/336/EEC. However, information is offered in Compumotor's *EMC Installation Guide* on how to install these drives in a manner most likely to minimize the effects of drive emissions and to maximize the immunity of drives from externally generated interference.

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CHAPTER ONE

1 Introduction

IN THIS CHAPTER

- TQ10 Torque Drive – Description & Block Diagram
- TQ10SD Step & Direction Drive – Description & Block Diagram

Introduction

This User Guide describes two products.

- **TQ10 Torque Servo Drive** – Accepts a ±10V analog command input signal from a controller, and produces a corresponding amount of motor current.
- **TQ10SD Step & Direction Servo Drive** – Accepts step and direction signals from industry standard indexers, and produces a corresponding amount of motor rotation.

Names in this User Guide

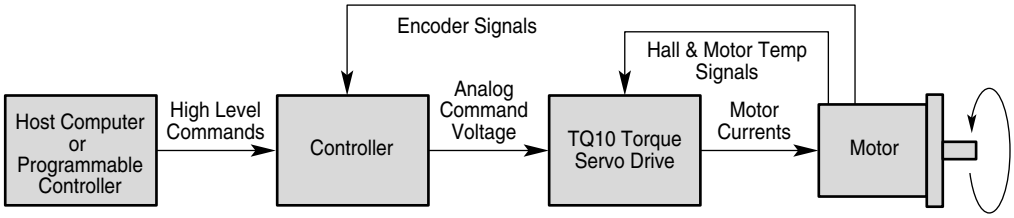
TQ10 – In this manual, when we use the name **TQ10**, it will apply to both products. Because most features are identical for both products, this will usually be the case.

TQ10SD – If we need to point out differences between the two products, for features that are not identical, we will specifically call the product by its full name—**TQ10 Torque Drive**, or **TQ10SD Step & Direction Drive**.

TQ10 Torque Drive – Description & Block Diagram

The TQ10 Torque Drive is a servo drive designed to run three phase brushless DC servo motors equipped with Hall effect sensors, using trapazoidal commutation. It can also operate brushed DC servo motors.

The block diagram for a typical system is shown below.



Block Diagram – TQ10 Torque Drive

The host computer or programmable controller may or may not be necessary, depending upon the motion controller's capabilities.

The analog command voltage is a *torque command* that represents commanded current. It can range from -10VDC to +10VDC. For each volt of command input, the TQ10 will produce 1.0 A of output current to the motor.

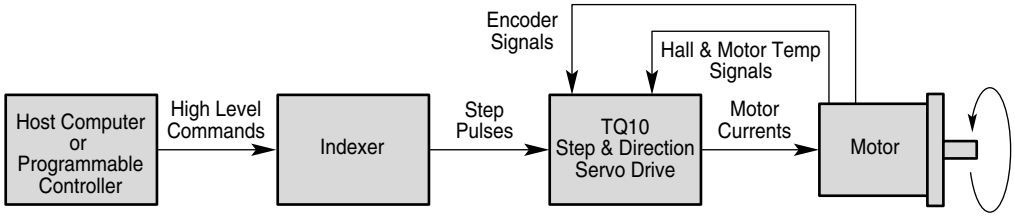
Inside the TQ10 the torque command goes into one of the inputs of a summing node. A feedback signal representing actual motor current goes into the other input. When actual current is subtracted from commanded current at the summing node, the difference is *current error*.

The resulting error signal goes through an error amplifier whose output controls a pulse width modulation (PWM) circuit. If actual current is too low, the PWM circuit will send longer pulses to the drive's power stage. These pulses keep the stage turned on longer, which results in more motor current. If actual current is too high, the PWM circuit sends shorter pulses, resulting in less motor current.

TQ10 Step & Direction Drive – Description & Block Diagram

The TQ10SD Step & Direction Drive is a servo drive designed to run three phase brushless DC servo motors equipped with Hall effect sensors. It can also operate brushed DC servo motors.

The block diagram for a typical system is shown below.



TQ10SD Step & Direction Drive – Block Diagram

The host computer or programmable controller may or may not be necessary, depending upon the motion controller's capabilities.

There are two circuit boards inside the TQ10SD—a *control board* and a *torque drive board*. The control board takes in control signals, and transforms them into a torque command. The drive board takes the torque command, and produces motor current in an amount proportional to the command.

The TQ10SD generates a move profile based upon step and direction signals from the indexer. For each step pulse received, the drive will make the motor turn one encoder count. Incoming step pulses represent *commanded position*, and go into one of the inputs of a summing node. Incoming encoder counts represent *actual position*, and go into the other input of the summing node. During a typical move, actual position will differ from commanded position by at least a few encoder counts. Actual position is subtracted from commanded position at the summing node—the result is *position error*. The TQ10SD produces an error signal, an analog voltage proportional to the error. The error signal is modified by the PID control loop, then continues to the torque drive circuit board as a *torque command*. The torque drive board is the same board that is used in the TQ10 Torque Drive; for a description of how the torque command is transformed into motor current, see the previous section describing the TQ10 Torque Drive.

Other Features – TQ10 & TQ10SD

Dip Switches

The TQ10 Drive (the name TQ10 now refers to both drives) has 12 DIP switches on the top and three DIP switches on the bottom. You can set these switches to configure the drive for your particular application.

Inputs and Outputs

All input and output signal connections are made on the front panel of the drive, through removable screw terminal connectors.

Cooling Options

The drive has a heatplate design. If you mount the drive to a surface that provides sufficient heatsinking capabilities, you may not need a separate heatsink.

An external heatsink/fan unit is available from Compumotor as an option.

The drive is open on the top and bottom. You can purchase optional covers from Compumotor. If you install the covers, you may also need to install the heatsink/fan unit, to help keep the drive within its temperature limits.

You can purchase TQ10 or TQ10SD drives from Compumotor that have the heatsink/fan unit and the covers installed at the factory. Part numbers for these drives are TQ10-EHS and TQ10SD-EHS. (The suffix -EHS is an acronym for *Enclosure/Heat Sink*.)

Compumotor SM and NeoMetric Series Brushless Servo Motors

Compumotor manufactures SM and NeoMetric Series servo motors; you can use these motors with the TQ10 Drive. Each motor is equipped with Hall effect sensors, an encoder, and a thermostat. The motor cables are color coded, which makes connecting the motor to the drive a straightforward procedure.

Compumotor Family of Products

The TQ10 Drive is completely compatible with Compumotor's broad range of single-axis and multi-axis motion control products.

CHAPTER TWO

2 Installation

IN THIS CHAPTER

- Product Ship Kit List
- Installation Procedure
- Tuning

What You Should Have *(ship kit)*

If you ordered a TQ10 or TQ10SD, you should have

Part	Part Number
TQ10 Drive	TQ10 or TQ10SD
includes 10-pin plug (two with TQ10, four with TQ10SD)	43-013891-01
includes 7-pin plug (one included)	43-013575-01
Power Cable – 6 feet (1.8 m) in length	44-000054-01
Thermally Conductive Strip	58-014871-01
TQ10/TQ10SD Servo Drive User Guide	88-015115-02
Accessories	
External Heatsink/Fan Unit	TQ-HS3
Top & Bottom Covers (to enclose drive)	TQ-ENCL

NOTE: If you ordered a TQ10-EHS or a TQ10SD-EHS, the External Fan/Heatsink Unit and the Top & Bottom Covers are installed at the factory.

SM Motor Information

SM with 500 Line Encoder	SM with 1000 Line Encoder	SM Motor Cables
SM161AD-N10N	SM161AE-N10N	23TQ Cable-10
SM162AD-N10N	SM162AE-N10N	(1 set/10' cables)
SM161AD-NTQN	SM161AE-NTQN	23TQ Cable-25
SM162AD-NTQN	SM162AE-NTQN	(1 set/25' cables)
SM231AD-NTQN	SM231AE-NTQN	Above cables are for
SM232AD-NTQN	SM232AE-NTQN	Size 16 and 23 motors
SM232BD-NTQN	SM232BE-NTQN	
SM233AD-NTQN	SM233AE-NTQN	
SM233BD-NTQN	SM233BE-NTQN	

NeoMetric Motor Information

NeoMetric with 500 Line Encoder	NeoMetric with 1000 Line Encoder	NeoMetric Motor Cables
N0701DD-NTQN	N0701DE-NTQN	70TQ Cable-10
N0701FD-NTQN	N0701FE-NTQN	(1 set/10' cables)
N0702ED-NTQN	N0702EE-NTQN	70TQ Cable-25
N0702FD-NTQN	N0702FE-NTQN	(1 set/25' cables)
N0703FD-NTQN	N0703FE-NTQN	92MS Cable-10
N0703GD-NTQN	N0703GE-NTQN	(1 set/10' cables)
N0704FD-NTQN	N0704FE-NTQN	92MS Cable-25
N0704GD-NTQN	N0704GE-NTQN	(1 set/25' cables)
	N0921FE-NMSN	
	N0921GE-NMSN	
	N0922GE-NMSN	

Precautions

The TQ10 Drive has an open-frame style of construction. The top and bottom of the sheet metal enclosure is open, and internal components are exposed. Hazardous voltages are present inside the drive and on many of its terminals. Therefore, observe the following precautions:

- Do not reach inside the drive
- Do not probe inside the drive
- Do not touch the drive's motor terminals while power is applied to the drive
- Do not touch **MOTOR TEMP+** or **MOTOR TEMP-** while power is applied to the drive
- Configure the drive's DIP switches for your application before you apply power to the drive
- Covers are available if desired

Installation Overview

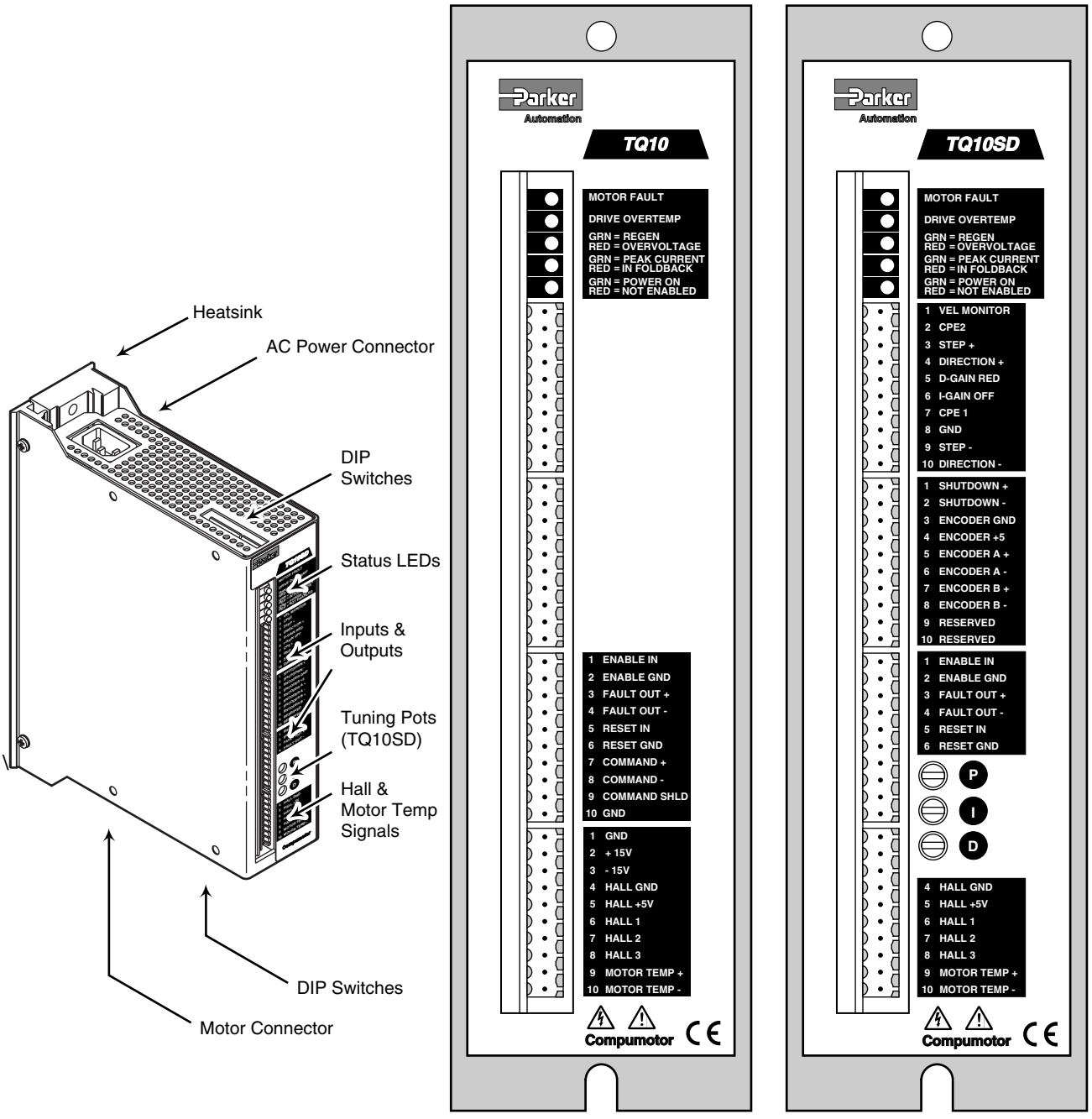
The order of topics in the installation procedure is:

- Quick Test
- DIP Switch Configuration
- Drive Mounting & Heatsinking
- Motor Mounting
- Connecting the Motor to the Drive
- Connecting a Controller
- Connecting AC Power
- Testing the System Installation
- Connecting the Motor to the Load
- Tuning

Installation Procedure

Topics in this chapter are arranged to lead you through the installation process in a step-by-step manner. Complete each step before proceeding to the next.

The next drawing shows locations and names of the various connectors, switches, and components that you will encounter during the installation procedure.



TQ10 Torque Servo Drive

TQ10SD Step & Direction Servo Drive

TQ10 & TQ10SD – Component Locations

Quick Test

The following installation procedure leads you through steps to permanently install your drive. However, if you wish to familiarize yourself with the drive before you install it, you can perform a bench top *quick test*. To do so, complete the following sections, in the order given below:

Set configuration DIP switches (on top of drive). For bench top operation, set peak current at or below the motor's continuous current rating.

Set compensation DIP switches (on bottom of drive)

Connect a Controller (TQ10) or Indexer (TQ10SD)

- TQ10 Torque Drive – Connect Command Input signals
- TQ10SD Step & Direction Drive – Connect Step and Direction Inputs

Connect the Motor to the Drive

Connect AC Power

Test your system

During your permanent installation, complete the other sections in this chapter—drive and motor mounting, connecting the load, and tuning.

Installation

The following procedures will lead you through the steps required to permanently install your TQ10 Drive and motor.

1. Set DIP Switches (Top of Drive)

Configure the TQ10 Drive's DIP switches for your motor and application. Two 6-position DIP switches—Switch 1 (SW1) and Switch 2 (SW2)—are located on top of the drive. The table below summarizes their settings. A 3-position DIP switch—Switch 3 (SW3)—is located on the bottom of the drive. See the section after this for instructions on setting SW3.

Default Settings

The factory default position is *off* for all switches. You must set these switches appropriately for your application.

Peak Current

Set DIP switches SW1-#1 — SW1-#3 for the *peak current* that you want your drive to produce. If you use a high performance motor (peak current rating greater than three times the continuous current rating), such as Compumotor's SM Series servo motors, see the caution note below.

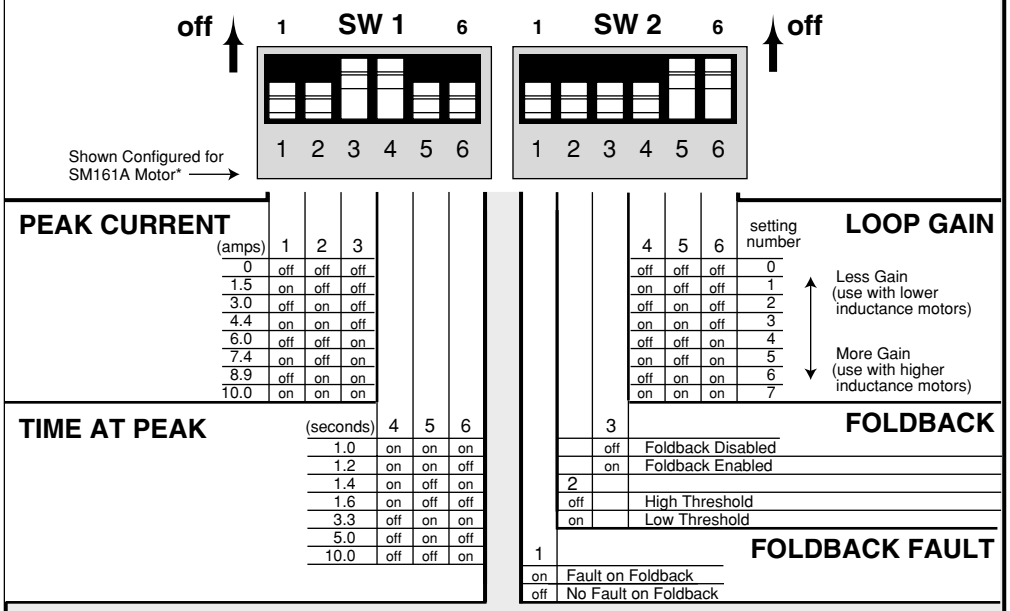
CAUTION

Peak current settings for initial drive tuning with SM and NeoMetric Motors: Set peak current at twice the motor's continuous rated current, or less. Otherwise, motor damage due to excessive heating may result from high peak currents and improper tuning values. See *Tuning* in this chapter for a procedure to iteratively raise peak current during tuning.

Time at Peak Current

Set DIP switches SW1-#4 — SW1-#6 to control the length of time the drive can produce peak current, before it goes into current foldback.

TQ10 DIP SWITCH SETTINGS



PEAK CURRENT

(amps)	1	2	3
0	off	off	off
1.5	on	off	off
3.0	off	on	off
4.4	on	on	off
6.0	off	off	on
7.4	on	off	on
8.9	off	on	on
10.0	on	on	on

TIME AT PEAK

(seconds)	4	5	6
1.0	on	on	on
1.2	on	on	off
1.4	on	off	on
1.6	on	off	off
3.3	off	on	on
5.0	off	on	off
10.0	off	off	on

LOOP GAIN

setting number	4	5	6
0	off	off	off
1	on	off	off
2	off	on	off
3	on	on	off
4	off	off	on
5	on	off	on
6	off	on	on
7	on	on	on

Less Gain (use with lower inductance motors)

More Gain (use with higher inductance motors)

FOLDBACK

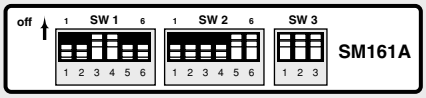
3	
off	Foldback Disabled
on	Foldback Enabled

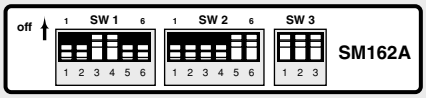
2	
off	High Threshold
on	Low Threshold

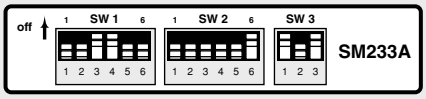
FOLDBACK FAULT

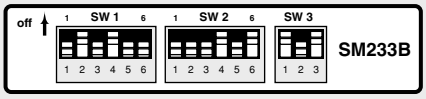
1	
on	Fault on Foldback
off	No Fault on Foldback

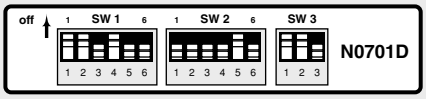
DIP Switch Settings for Compumotor SM and NeoMetric Motors* (with foldback enabled)

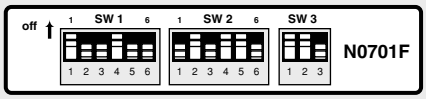


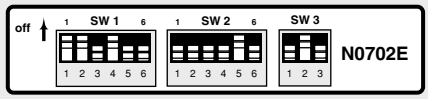


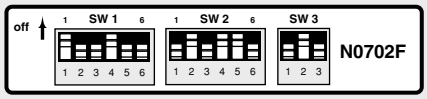


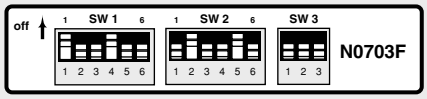


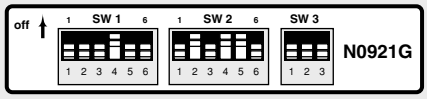


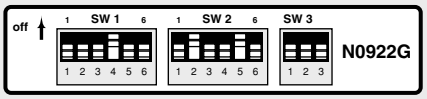












*Switches shown configured for initial tuning, with peak current approx. twice motor's continous current rating. See Tuning for procedure to raise current. For SW 3 settings, see next page.

Foldback Fault Enable

If DIP switch SW2–#1 is in the *off* position, the drive can go in and out of current foldback without affecting the fault output. If DIP switch SW2-#1 is in the *on* position, then going into foldback will cause a latched fault condition; this setting can aid in troubleshooting your system.

Foldback Threshold

DIP switch SW2-2 sets the current threshold for the foldback circuit. This switch should be ON (low threshold) for "A" winding SM motors. It should be OFF (high threshold) for "B" winding motors, NeoMetric (70mm and 92mm) motors, and for most motors with continuous current ratings above 4 amps.

Foldback Enable

DIP switch SW2-3 enables foldback. When this switch is ON (the default) foldback is enabled.

Loop Gain

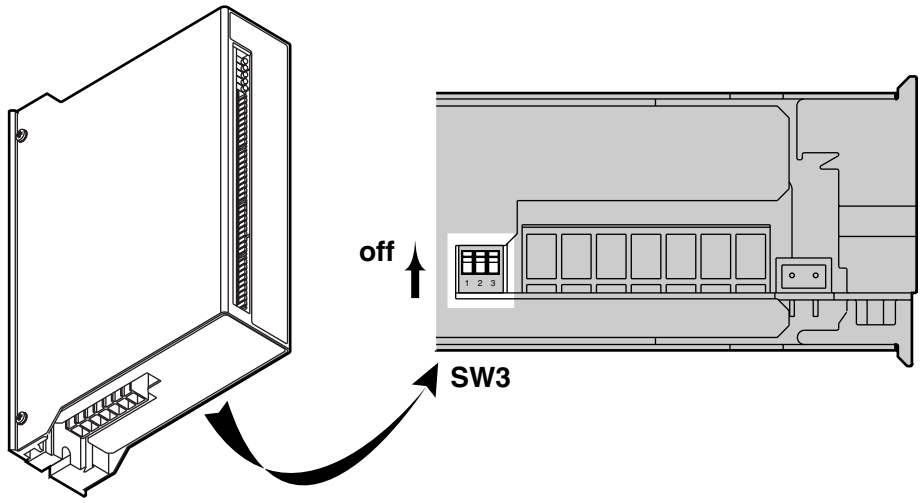
Set DIP switches SW2-#4 — SW2-#6 to control the gain of the drive's internal current control loop. Properly setting this switch will match the drive to your motor's parameters (inductance and resistance). The suggested settings provide wide current-loop bandwidth. In some applications, lower bandwidth may allow easier position-loop tuning. To reduce bandwidth, set the loop gain DIP switch for lower gain by one or two settings. ***Do not set loop gain higher than the suggested setting.***

DIP Switch Settings for SM and NeoMetric Motors

DIP switch settings for Compumotor SM and NeoMetric motors are shown on the previous page. If you use a non-Compumotor motor, see the *Appendix* at the end of this User Guide for information about setting DIP switches for your motor.

2. Set DIP Switches (Bottom of Drive)

Switch 3 (SW3) is a 3-position DIP switch located on the bottom of the drive, near the motor connector.

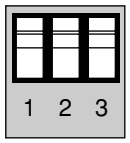


DIP Switch 3 – Location

Set it to control the drive's motor pole compensation, based upon your motor's electrical time constant. The following table shows switch settings for Compumotor SM and NeoMetric Series servo motors.

TQ10 DIP SWITCH #3*

*Located on Bottom of Drive



MOTOR POLE COMPENSATION

	1	2	3
SM161A, SM162A	off	off	off
Reserved	on	off	off
SM231A, SM232A+B, SM233A+B	off	on	off
Reserved	on	on	off
N0701D, N0701F	off	off	on
N0702E, N0702F	on	off	on
Reserved	off	on	on
N0703F, N0703G, N0704F, N0704G, N0921F, N0921G, N0922G	on	on	on

If you use a non-Compumotor motor, see the *Appendix* at the end of this User Guide for information about setting DIP switches for your motor.

Offset Potentiometer—Do Not Adjust

Located next to DIP SW3 is a small potentiometer that controls the drive's offset. It was adjusted at the factory, and requires no further adjustment.

WARNING

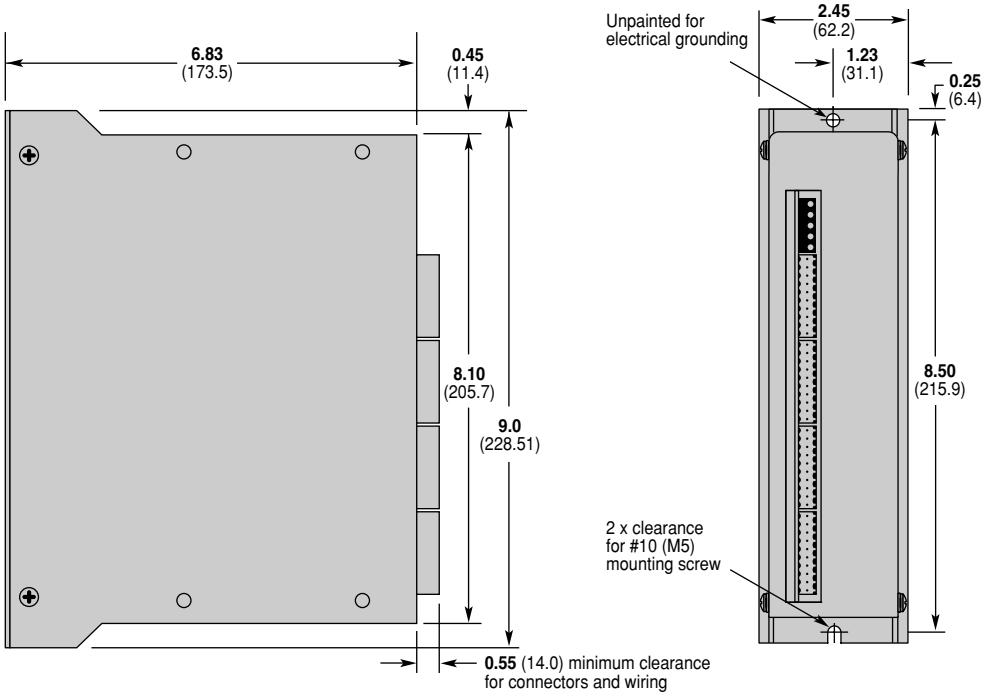
Do not adjust the offset potentiometer. Lethal voltages are present inside the drive. Adjusting the potentiometer with AC power applied can be hazardous to personnel.

3. Mount the Drive

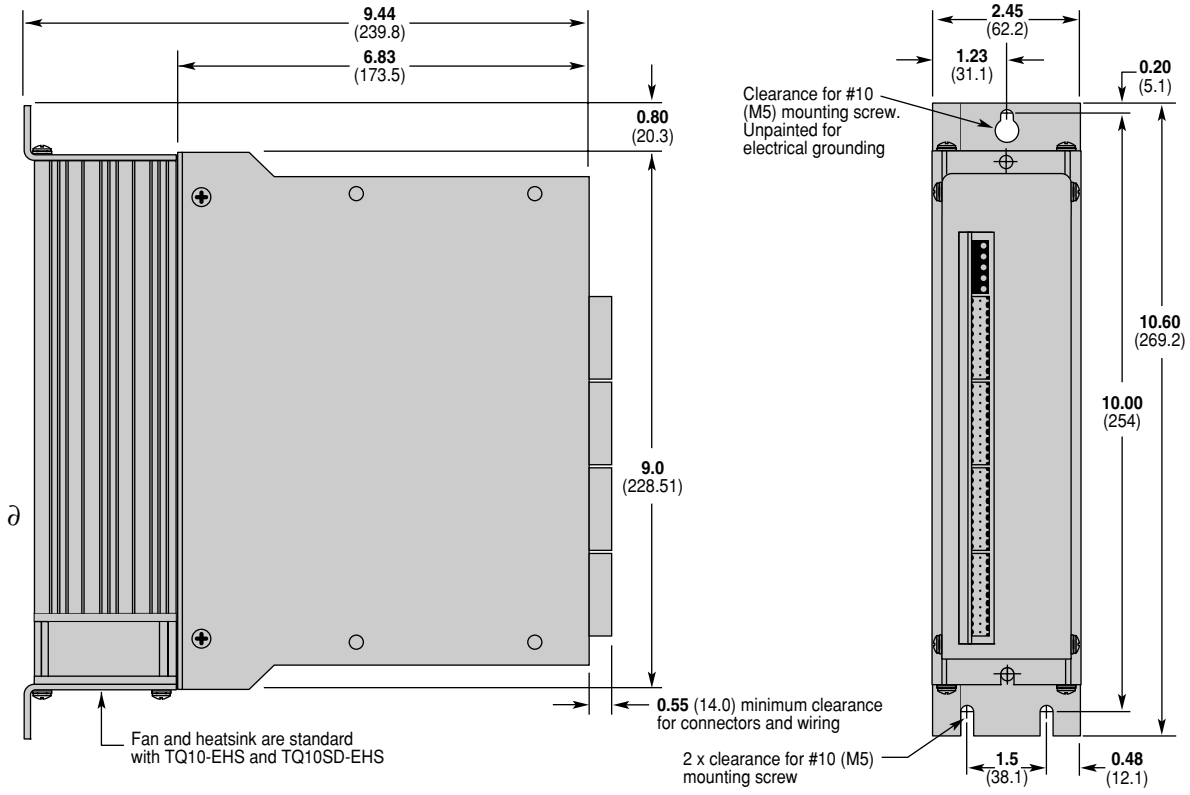
TQ10 and TQ10SD drives have “open frame” enclosures—sheet metal encloses the front and sides, but the top and bottom are open. TQ10-EHS and TQ10SD-EHS drives have top and bottom covers, and an attached heatsink and fan. You can also purchase the heatsink or covers separately, and install them on your TQ10 or TQ10SD drive.

Dimensions for each version of the drive are shown below.

Drive Dimensions



Dimensions — TQ10 Torque and TQ10SD Step & Direction Servo Drives



Dimensions — TQ10 and TQ10SD With Heatsink Attached

Environmental Considerations

Temperature Specifications

Maximum Ambient Temperature:	50°C (122°F)
Minimum Ambient Temperature:	0°C (32°F)
Maximum Temperature of Mounting Surface:	45°C (113°F) (for non -EHS version)

Humidity Keep the relative humidity below 95%, non-condensing.

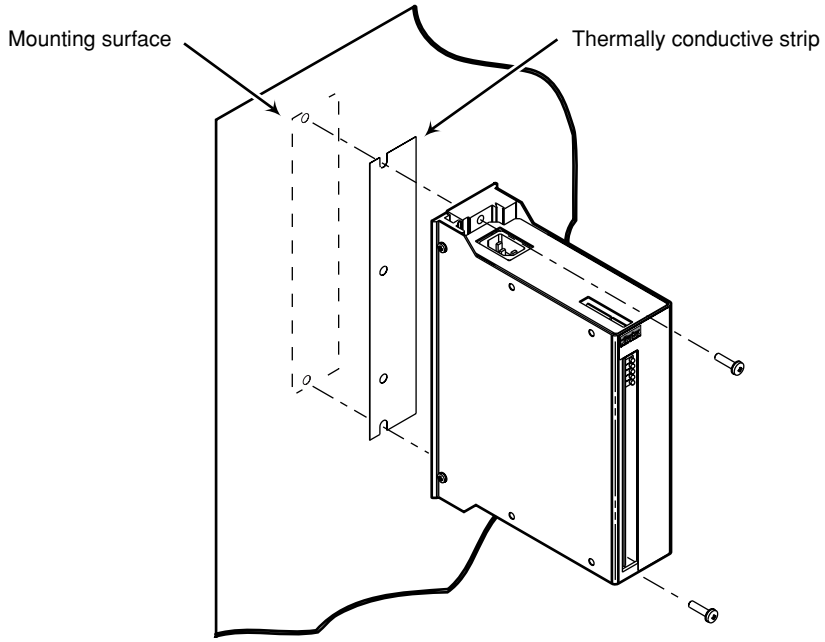
Liquids Do not allow liquids or fluids to come into contact with the TQ10 Drive or its cables.

Airborne Contaminants Particulate contaminants, especially electrically conductive material such as metal shavings or grinding dust, can damage the TQ10 drive and motor. Do not allow contaminants to come into contact with the drive or motor.

Mounting the Drive to a Heat Sinking Surface

Move profiles and loads affect the amount of heat dissipated by the TQ10 Drive. If yours is a low power application with moderate ambient temperature, the drive may not need a large heatsink. The mounting surface may be adequate as a heatsink, provided it has sufficient mass and surface area.

The mounting plate at the rear of the drive is a *heatplate*—it is a thermal pathway through which the drive can dissipate its excess heat. Mount the drive to a suitable heat sinking surface. A thermally conductive strip is provided with the drive. When you mount the drive, install the strip between the drive's heatplate and the mounting surface, as the next drawing shows. Do not fold or wrinkle the strip.



Mounting with Thermally Conductive Strip

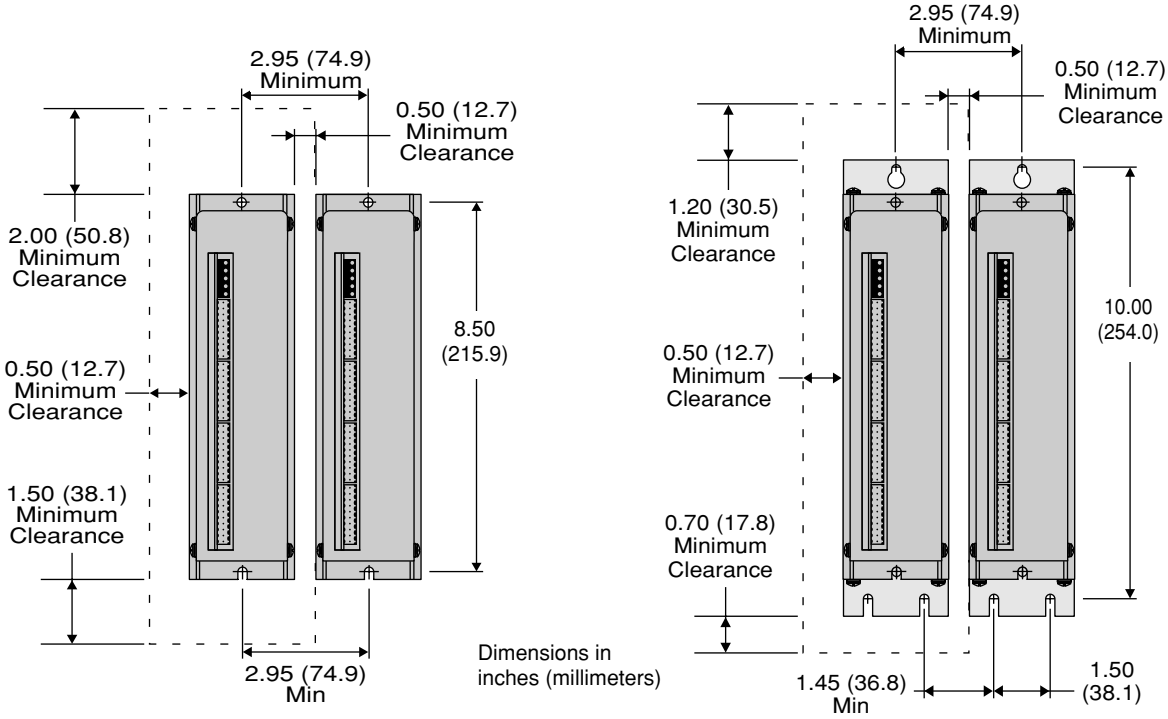
While the drive is operating, ensure that the temperature of the mounting surface is no higher than 45°C (113°F), and that the temperature of the ambient air is no higher than 50°C (122°F).

Do not mount equipment that produces substantial heat below the drive. Avoid mounting heat sensitive equipment directly above the drive.

Panel Layout

High power applications may require a heatsink. A heatsink/fan unit for the TQ10 drive is available from Compumotor (part number TQ-HS3). If you purchased a TQ10-EHS or TQ10SD-EHS Drive, the heatsink/fan unit was installed at the factory.

The next drawing shows minimum spacing and clearance requirements you should follow when you mount TQ10 Drives. Dimensions are shown with and without heatsink/fan units attached to the drive.



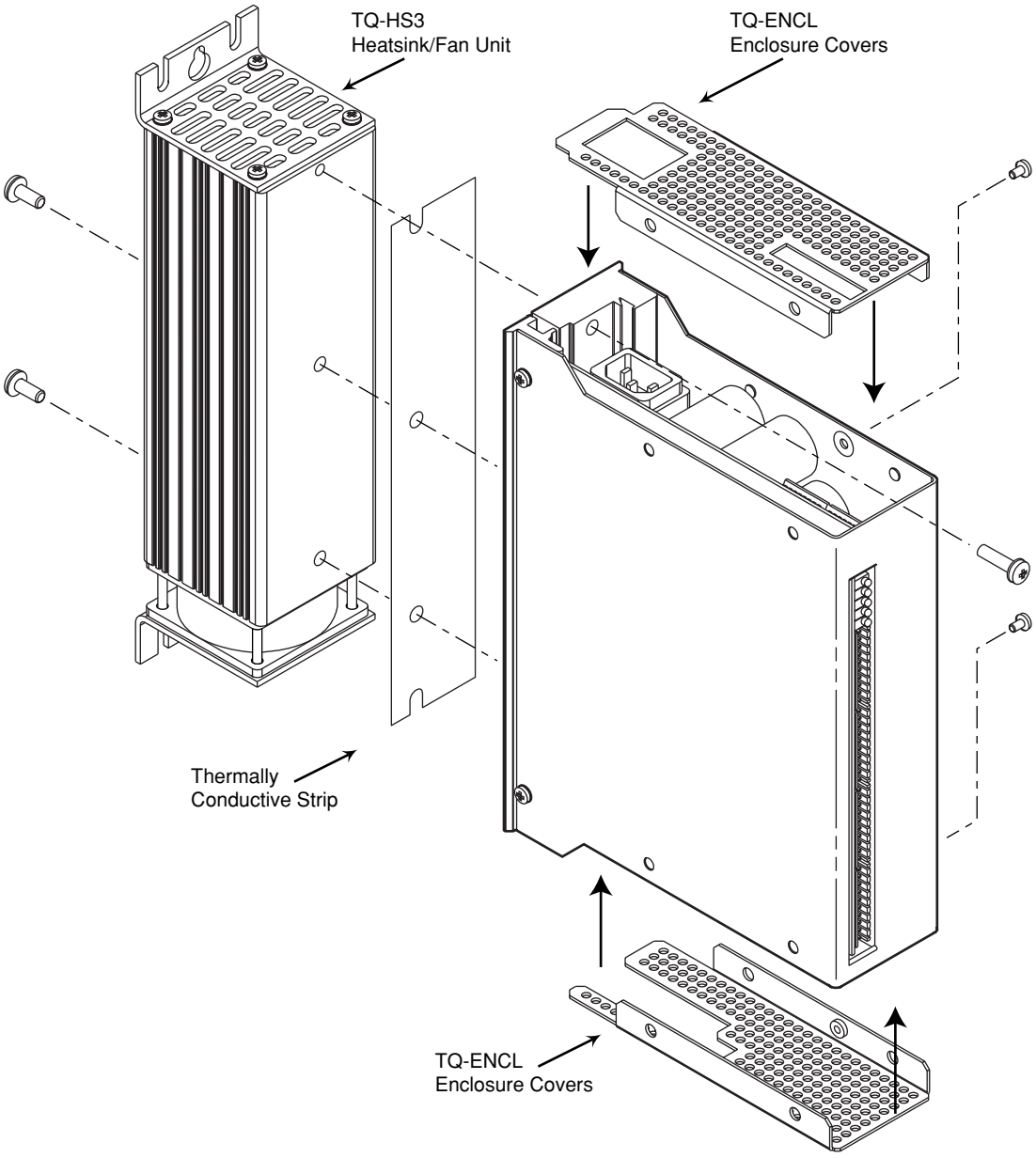
Dimensions without Heatsink/Fan Unit attached

Dimensions with Heatsink/Fan Unit attached

Panel Layout Dimensions

Attaching Heatsink/Fan Unit and Enclosure Covers

The next drawing shows how to attach Compumotor's optional TQ-HS3 Heatsink/Fan Unit to your TQ10 Drive.

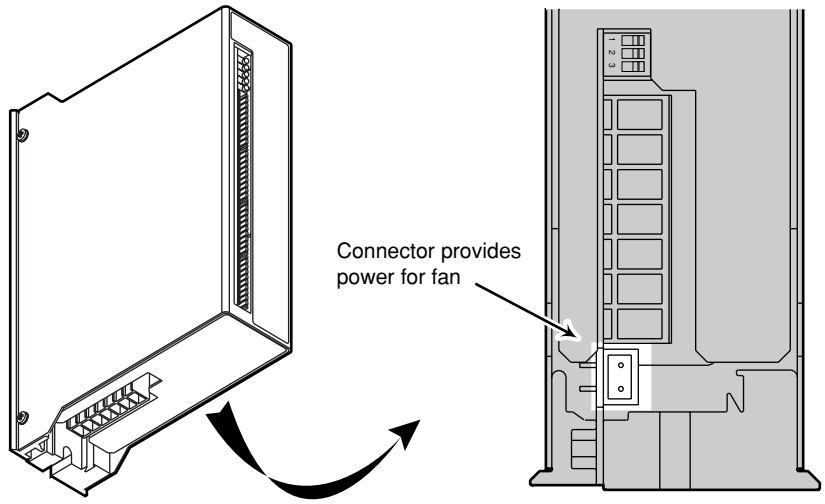


Heatsink/Fan Unit and Covers – Attaching to Drive

Perforated sheet metal covers that enclose the top and bottom of the drive are available from Compumotor (part number TQ-ENCL). The drawing above shows how to attach these optional parts to your TQ10 Drive.

Because the covers will reduce convection available for cooling internal components, drive temperature may increase. You may need to reduce ambient temperature or provide forced air cooling to cool the drive. You may also need to install an external regeneration resistor (power dump), if regenerated energy causes drive overheating with the covers installed.

The heatsink/fan unit has a cable with connector attached. Plug the connector into the TQ10's fan power connector, shown below.

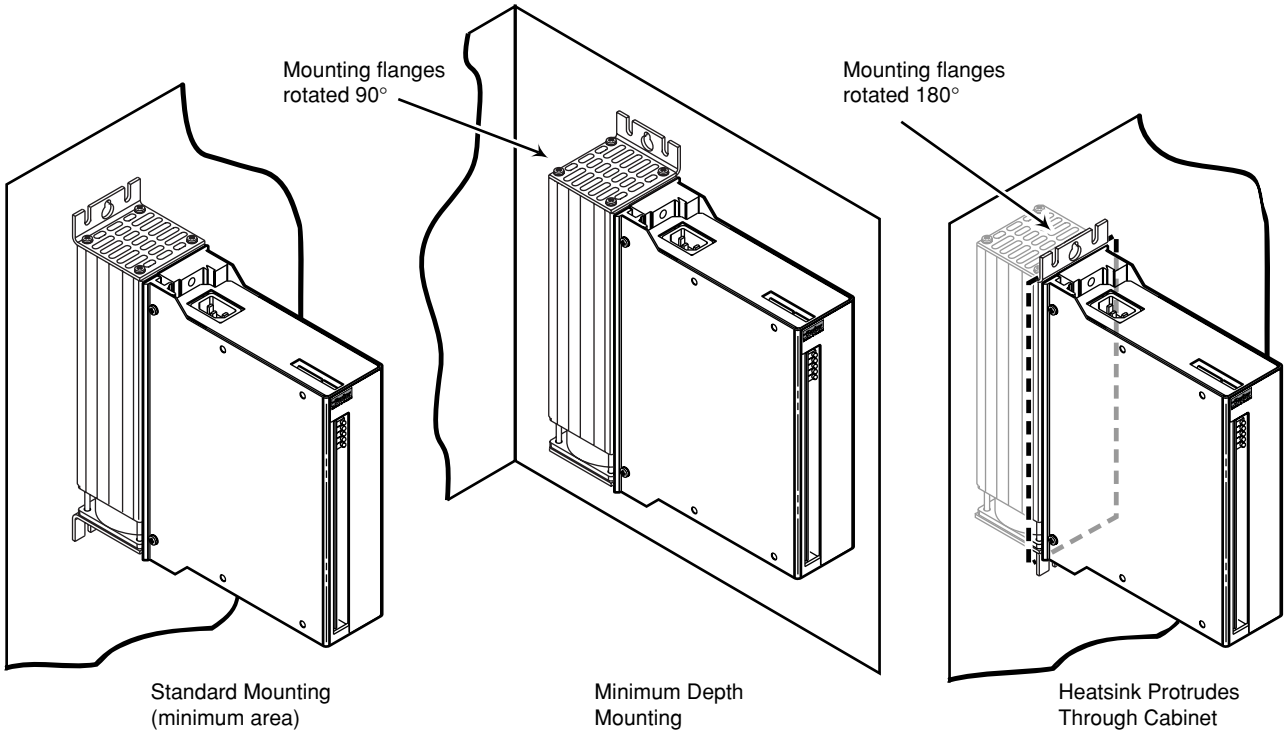


Fan Power Connector

Mounting Options with Heatsink/Fan Unit

If your drive has a TQ-HS3 Heatsink/Fan Unit attached, you have several options for mounting the drive, as the next drawing shows.

You can mount the drive in a "minimum area" configuration, as shown on the left, below. Or, you can mount the drive in a "minimum depth" configuration by rotating the mounting flanges 90° (located at the top and bottom of the heatsink), as shown in the center. If you rotate the mounting flanges 180°, as shown on the right, you can mount the drive with the heatsink protruding through an opening in your equipment cabinet. This configuration may help to remove heat from the interior of your cabinet.



Mounting Options

4. Mount the Motor

The following guidelines present important points about motor mounting and its effect on performance.

For mechanical drawings of SM and NeoMetric Series servo motors, see *Chapter* 3—*Specifications.*

WARNING
Improper motor mounting can limit system performance and jeopardize safety of personnel.

Servo motors should be mounted by bolting the motor's face flange to a suitable support. Foot mount or cradle configurations are not recommended because the motor's torque is not evenly distributed around the motor case. Any radial load on the motor shaft is multiplied by a much longer lever arm when a foot mount is used rather than a face flange.

Servo motors used with the TQ10 can produce large torques and high accelerations. These forces can shear shafts and mounting hardware if the mounting is not adequate. High accelerations can produce shocks and vibrations that require much heavier hardware than would be expected for static loads of the same magnitude.

Under certain move profiles, the motor can produce low-frequency vibrations in the mounting structure. If harmonic resonances are induced by the move profiles you are using, these vibrations can cause metal fatigue in structural members. A mechanical engineer should check the machine design to ensure that the mounting structure is adequate.

CAUTION
Modifying or machining the motor shaft will void the motor warranty. Call Compumotor's Application Engineers (800-358-9070) about shaft modifications as a custom product.

Motor Heatsinking

Performance of a servo motor is limited by the amount of current that can flow in the motor's coils without causing the motor to overheat. Most of the heat in a brushless servo motor is dissipated in the stator—the outer shell of the motor. Performance specifications usually state the maximum allowable winding or case temperature. Exceeding this temperature can permanently damage the motor. The maximum case temperature for Compumotor SM and NeoMetric servo motors is 70°C (158°F).

If yours is a demanding application, your motor may become quite hot. The primary pathway through which you can remove the heat is through the motor's mounting flange. Therefore, mount the motor with its flange in contact with a suitable heatsink.

CAUTION
In temporary "bench top" setups, often used for prototyping or demonstrations, motors are very vulnerable to overheating if they are not mounted to a heatsink. Limit peak current to the motor's continuous current rating if you operate your motor without a heatsink.

Specifications for Compumotor SM and NeoMetric Series servo motors apply when the motor is mounted to a ten inch by ten inch aluminum plate, $\frac{1}{4}$ inch thick. To get rated performance in your application, you must mount the motor to a heatsink of at least the same thermal capability. Mounting the motor to a smaller heatsink may result in decreased performance and a shorter service life. Conversely, mounting the motor to a larger heatsink can result in enhanced performance.

5. Connect the Motor to the Drive

The TQ10 Drive works with three-phase brushless motors equipped with Hall effect sensors. The typical motor has a permanent-magnet rotor with four poles (two pole pairs). Higher pole-count motors may also be used.

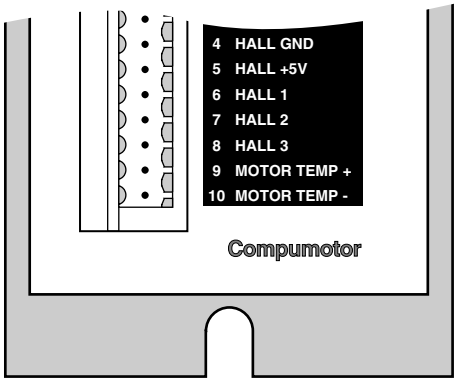
In the following installation procedure, we assume you are using a Compumotor SM or NeoMetric Series Motor with your TQ10 Drive. If you are using a non-Compumotor motor, consult the *Appendix* at the end of this User Guide for information you may need during the following installation steps.

Connect Hall Effect Wires

The TQ10 Drive is designed to be used with motors that have single-ended, open collector Hall outputs. Internally, the drive pulls these signals up to +15V.

For best performance and reliability, the drive should be used with motors having no more than six electrical degrees of commutation error in either direction. Motors with greater commutation error may cause increased torque ripple and motor heating, reduced average torque, and greater stresses on the drive output stage.

Connect your motor's Hall effect wires to the 10-pin screw terminal on the front of the TQ10. Each terminal is labeled with the name of the wire you should connect.



Hall Effect and Motor Temperature Connections – Front of Drive

14 AWG (2.5 mm^2) is the maximum wire size that can fit in the connector.

Connect Motor Thermostat Wires

Connect your motor's thermostat wires to **MOTOR TEMP+** and **MOTOR TEMP-**.

If your motor does not have a thermostat, short **MOTOR TEMP+** and **MOTOR TEMP-** together by connecting an insulated jumper wire between them. The drive will experience a motor fault if neither a thermostat nor a jumper wire is attached to the **MOTOR TEMP** terminals.

WARNING

Hazardous voltages are present on **MOTOR TEMP+** and **MOTOR TEMP–** when the drive is powered up. Use insulated wires for connections. Protect personnel from contacting these terminals or any attached wires. Do not short these terminals to earth ground.

The TQ10's motor overtemperature fault can, in many cases, protect the motor against overheating. Through its **MOTOR TEMP+** and **MOTOR TEMP-** terminals, the drive checks for electrical continuity provided by a normally-closed thermostat mounted on the motor. If the motor overheats and the thermostat opens, the loss of continuity triggers protection circuitry in the TQ10. It will turn off power output to the motor, and illuminate the LED labeled **MOTOR FAULT**.

This is a latched fault. Wait for the motor to cool, then cycle power to resume operations (with the TQ10 Torque Drive, you can also toggle the reset input to resume operations). A motor overtemperature fault indicates improper motor sizing, or improper installation of your application.

This circuit may not protect the motor in every possible application. It works best in cases where the temperature rise occurs slowly over a long period of time. In this situation, the thermal sensor and motor windings will be at the same temperature. When the sensor and windings reach the sensor's threshold temperature, the sensor can trigger the overtemperature circuit.

In cases where the temperature rise is caused by continuous peak current flowing—such as a mechanical jam— the winding temperature may rise much more quickly than the sensor temperature does. In this situation, the windings may be damaged from overheating *before* the sensor can trigger the overtemperature circuit.

Be careful not to overheat your motor during system tuning. Allow the motor to cool for several seconds between test moves. Instability while tuning can cause rapid motor heating and possible motor damage. A thermal switch may not protect the motor if the motor heats up too quickly. Do not allow instability to persist longer than a few seconds. After each incident of instability, allow the motor to cool for several minutes.

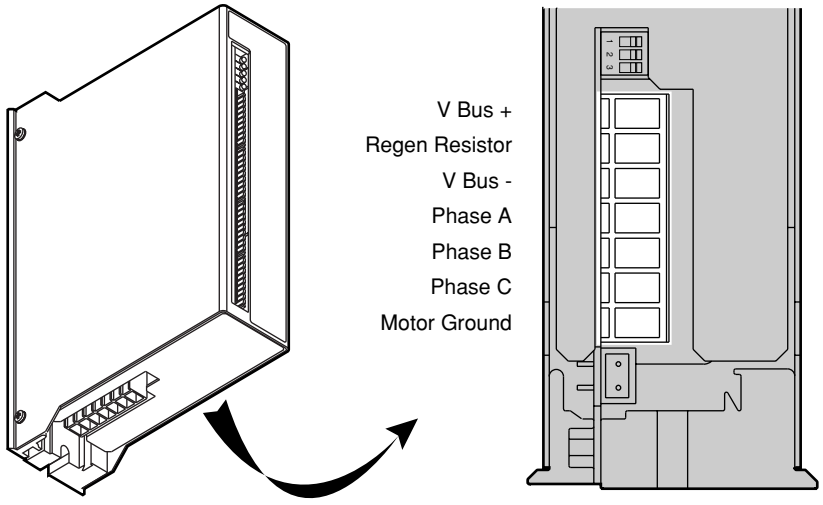
Connect Motor Phase Wires

Connect your motor's phase wires and ground wire to the removable 7-pin **MOTOR** connector located on the bottom of the drive. The next drawing shows the location of each terminal.

WARNING

Potentially hazardous voltages are present on motor connector terminals when power is applied to the drive.

Ensure the connector is aligned correctly when inserted—and not misaligned by one position.



Motor Connector

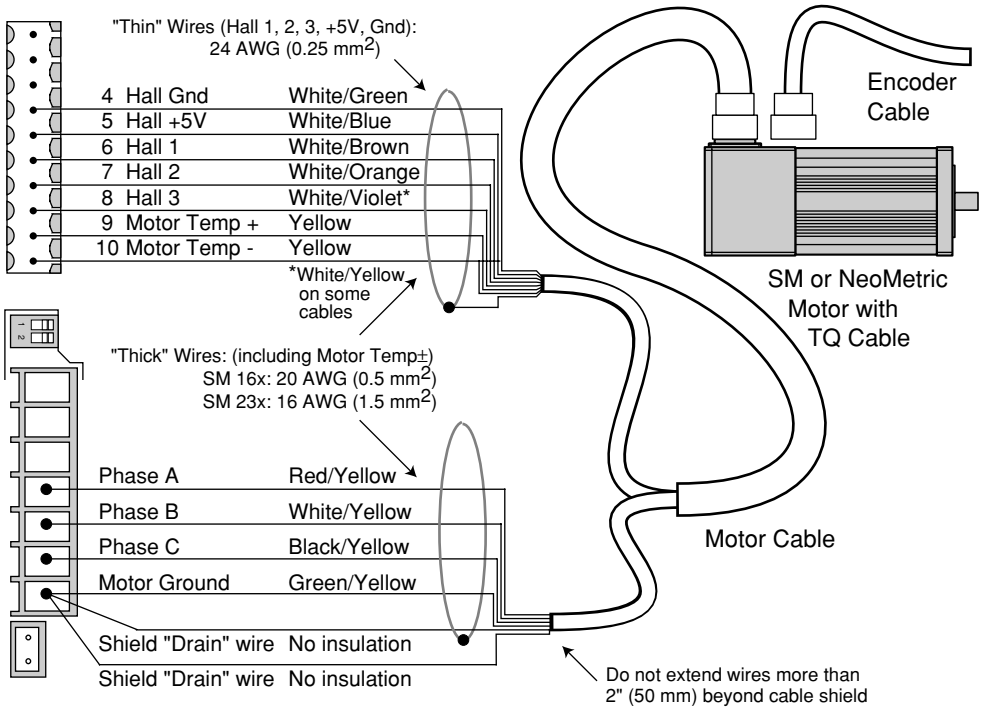
The terminal labeled **MOTOR GROUND** is connected internally to the **EARTH** terminal on the drive's AC power connector.

WARNING

DO NOT OMIT the **Motor Ground** connection. Internal failure of motor insulation can place the motor frame at deadly potential if it is not properly grounded.

Connecting Compumotor SM or NeoMetric Series Motors

To connect a Compumotor SM or NeoMetric Series servo motor to the TQ10, follow the color code shown in the next drawing.



Motor Cable Connections for SM and NeoMetric Series Motors

Inside the motor cable, there are two sets of wires. One contains Hall effect and motor thermostat wires; the other contains motor phase wires. Each set of wires has its own shield and shield drain wire. As shown in the drawing, you should connect both drain wires and the green/yellow ground wire to the **MOTOR GROUND** connector.

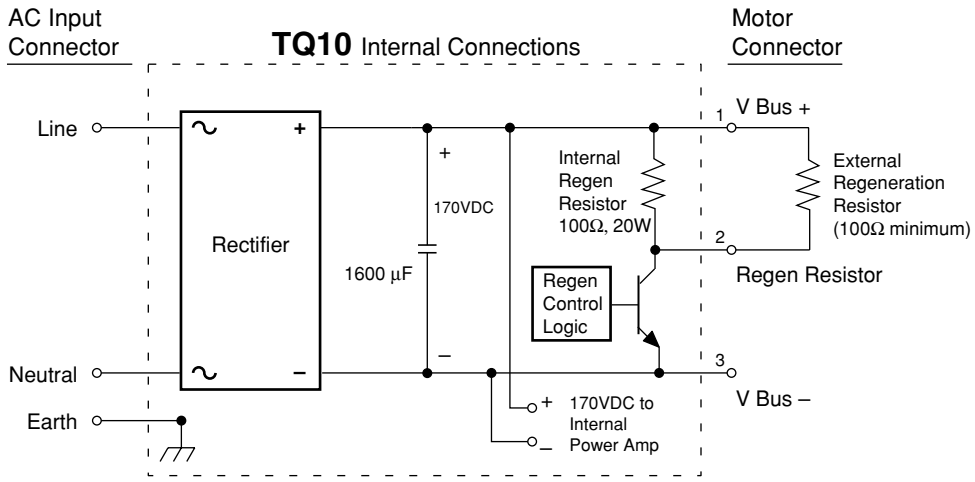
Optional – Connect an External Regeneration Resistor

The TQ10 Drive can dissipate regenerated energy in its internal *regeneration resistor*. If your system regenerates more energy than the internal resistor can dissipate, you can connect an external resistor between two terminals called **V Bus+** and **Regen Resistor**, located on the motor connector. The external resistor doubles the TQ10's dissipation capabilities.

WARNING

Potentially hazardous voltages are present on **V Bus+** and **Regen Resistor** terminals when power is applied to the drive.

The next drawing shows the internal regeneration resistor, terminals for an external regeneration resistor, and the DC power bus.



Regeneration Circuit

The TQ10's regeneration circuit works automatically—there are no adjustments to make. The circuit monitors the voltage on the power bus. If regenerated energy from the motor causes the bus voltage to rise above a threshold value, the circuit closes a switch, thus connecting the regeneration resistor between the positive and negative sides of the power bus, **V Bus+** and **V Bus–**. The energy is then dissipated in the resistor—its power capacity is 1KW for one second, or 10 watts on a continuous basis. During the regeneration event, the bicolor LED labeled **REGEN/OVERVOLTAGE** will be illuminated *green*.

The TQ10 also has an *overvoltage* circuit; it protects the drive from excessive regeneration. If the motor regenerates more energy than the internal resistor can dissipate, voltage on the power bus will rise and trigger an overvoltage fault. The drive will shut down power output to the motor. The bicolor LED labeled **REGEN/OVERVOLTAGE** will be illuminated *red*. This is a latched fault—cycle power to resume operations (with the TQ10 Torque Drive, you can also toggle the reset input to resume operations).

If excessive regeneration causes overvoltage faults in your system, you can install an external regeneration resistor. Ensure that the external resistor is adequately mounted and cooled. Excessive heating can cause the resistor to fail.

CAUTION

Adequately cool the external resistor. Forced air cooling may be required. Maintain resistor temperature below its rated temperature limit.

The internal resistor is a 100 Ω, 10 watt, 10% non-inductive resistor. For an external resistor, we suggest:

- Manufacturer Name: Dale
- Manufacturer Part Number: NHL-55-16N-100Ω (5% – 20% is suitable)

This resistor has "faston" mounting tabs, and can be mounted with two screws. You can order this resistor, with two 18 inch (457 mm) cables, as a kit from Compumotor. The part number is:

TQ-REGEN-KIT

Or, you may use an equivalently rated 100Ω *non-inductive* resistor for your external resistor.

To connect the external resistor, follow these steps:

① Connect the resistor's two terminals to **V BUS+** and **REGEN RESISTOR**, located on the motor connector.

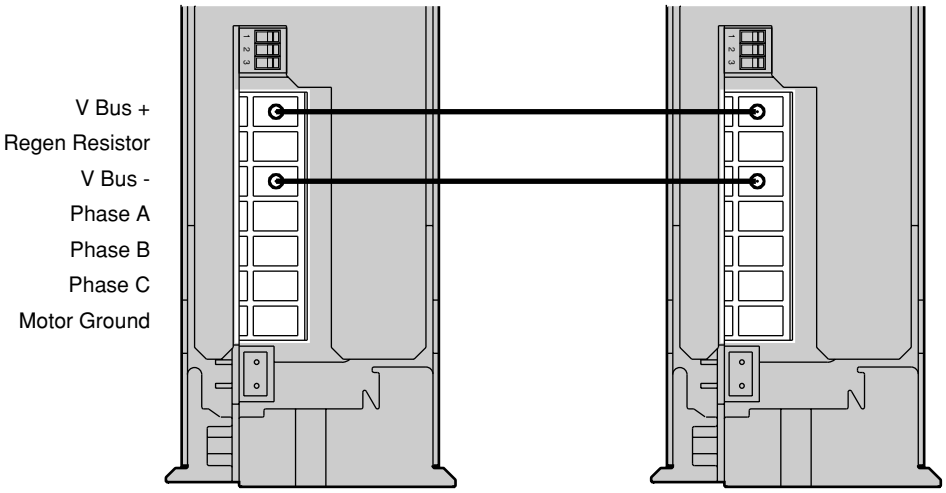
② Keep wires as short as possible, and twist them together.

The circuit will automatically dissipate half the regenerated energy in the external resistor. Total dissipation with the external resistor installed is 2KW peak, 20W continuous.

Optional – Sharing the Power Bus

In some applications with multiple drives, one or more drives may continuously receive regenerated power from their loads. For example, in a tensioning application, two TQ10s apply tension (opposite torques) to a single moving load. In this situation, one TQ10 could receive substantial regenerated power from its motor.

In such applications, you can connect the power buses for the TQ10s in parallel, through the **V BUS+** and **V BUS-** terminals located on the motor connector, as shown below. (See the previous drawing, *Regeneration Circuit*, for an internal schematic.)



Sharing the Power Bus

With the buses connected in parallel, the regenerated power from one TQ10 is dissipated by the power consumption of the other.

In standard multi-axis applications, where regeneration occurs when one axis decelerates, the energy can be used by other axes if the power bus is shared. This improves system efficiency by using energy that would otherwise be wasted.

Connecting Motors from Other Vendors

Before connecting a motor from another vendor, you must determine which motor phase wires correspond to Phase A, Phase B, and Phase C inputs on the TQ10. Similarly, you must determine which Hall effect wires correspond to Hall 1, Hall 2, and Hall 3.

Connect each wire to its appropriate terminal on the TQ10. Ensure that the Hall effect sensors accurately transmit information about rotor position, and that motor current is commutated to the correct motor phases. See the *Appendix* at the end of this User Guide for more information about using a motor from a vendor other than Compumotor.

Connecting a Brushed DC Servo Motor

You can use the TQ10 as a drive for brushed DC servo motors. To do this, follow these steps:

① Connect drive terminals **HALL 1** and **HALL 2** to **HALL GND**
② Make no connections to drive terminal **HALL 3**
③ Connect the drive's **Phase A** to your motor's positive input.
④ Connect the drive's **Phase C** to your motor's negative input.

Under these conditions (**HALL 1** and **HALL 2** connected to ground; **HALL 3** unconnected), the drive's internal logic determines that a brushed motor is connected. The drive will send DC current out of Phase A, through the motor, and back into the drive through Phase C. The amount and polarity of the current will be determined by the command input signal.

Shielded Motor Cables

Keep electrical noise from interfering with the signals that the Hall effect sensors send to the drive. Position the motor as close as possible to the drive. If you need to connect a long cable between the drive and motor, we recommend you use a shielded cable for the Hall wires (Hall 1, Hall 2, Hall 3, Hall +5V, Hall Gnd). Run the power wires (phase A, B, and C) separately from the Hall wires.

Motor Grounding

For safety reasons, the motor case should be grounded. Often, the motor can be grounded through the equipment to which it is mounted. This requires a good electrical connection between the motor's mounting flange and the equipment, and that the equipment be connected to ground. Check with the National Electrical Code (NEC) and your local electrical code to ensure you use proper grounding methods.

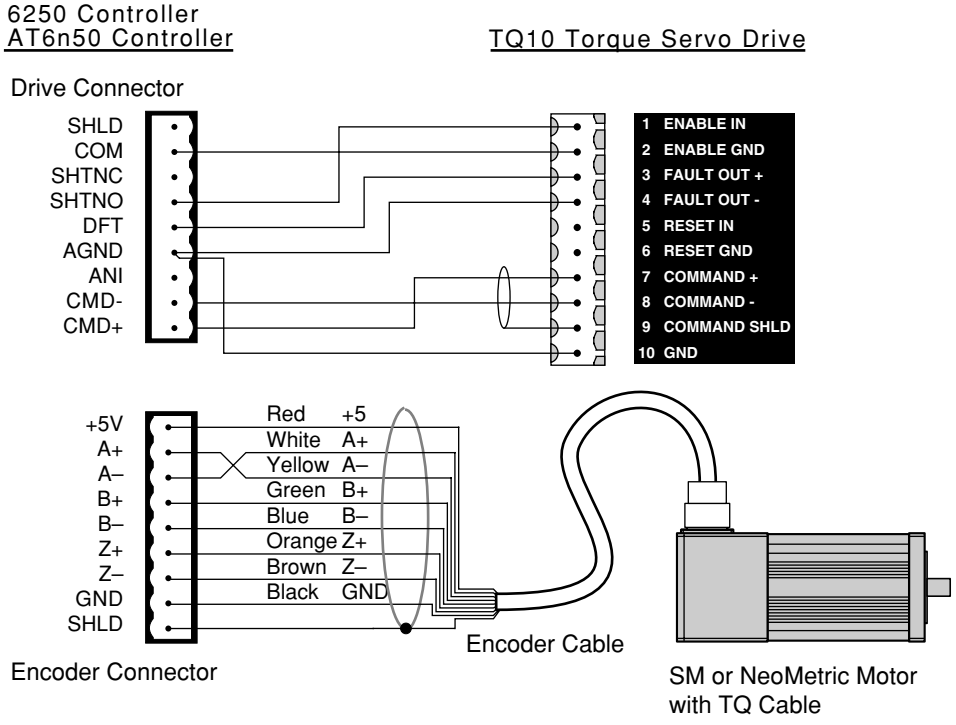
Proper grounding can also reduce electrical noise.

GROUND THE MOTOR CASE!

The motor case must be grounded, to reduce electrical noise. An ungrounded motor can cause electrical noise problems throughout the system, particularly in encoder wiring and circuitry. This noise may cause the encoder to output erroneous information, such as missing encoder pulses. To avoid electrical noise problems, ground the motor case.

6A. Connect a Controller or Indexer (TQ10 and TQ10SD)

The next drawing shows how to connect a Compumotor 6250 Servo Controller to your TQ10 Torque Servo Drive. The drawing also shows the color code for Compumotor SM or NeoMetric Series servo motors equipped with TQ cables.



Connections to Compumotor 6250 Servo Controller

The TQ10 Torque drive and the TQ10SD Step & Direction drive have **ENABLE IN** and **FAULT OUT** terminals on their front panels. Connect your controller to these terminals on the TQ10 Torque drive; or, connect your indexer to these terminals on the TQ10SD Step & Direction drive. Instructions are given below.

Enable Input

To enable the drive, you must connect the enable input to ground. (TQ10SD Step & Direction Drive: this connection must be made *before* applying power to the drive.)

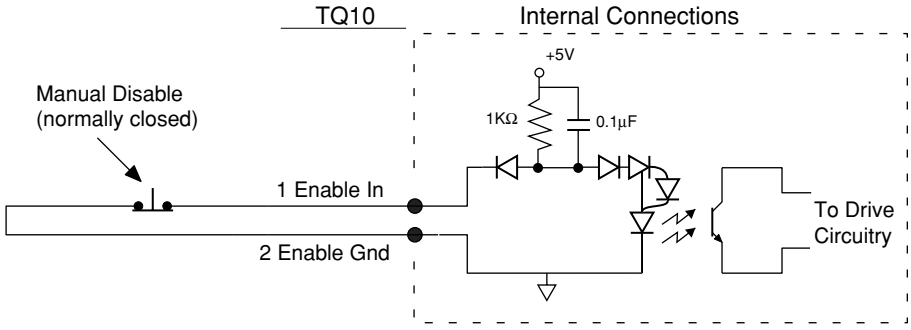
If you break the connection to ground while the drive is on, the TQ10's fault circuitry will activate, with the following results:

- The drive will shut down power output to the motor.
- The motor will freewheel (it may not stop immediately).
- The bicolor LED labeled **GRN = POWER ON, RED = NOT ENABLED** will be illuminated red.
- The fault output will become active (no current will flow through it).

To re-enable the drive, establish the connection between enable and ground. (TQ10SD Step & Direction Drive: you must cycle power to re-enable the drive, and clear fault conditions.)

In most applications, you can permanently wire the enable input to ground. This input is internally pulled up to +5V. If your equipment requires, you can connect the input to an external voltage as high as +24V. You can also connect it to a dry contact closure to ground.

If you need to disable the drive in an emergency, use the enable input. Connect a *manual disable* switch to the enable input, as the next drawing shows. The switch is normally closed. When it is opened, the drive will be disabled. The load can freewheel—therefore, you should use a brake to stop the motor immediately in applications where a freewheeling motor can cause injury or damage.



Enable Input Connected to a Switch

WARNING

Do not use the ENABLE INPUT by itself as an emergency stop. The motor can freewheel when the drive is disabled and may not stop immediately. Use a mechanical brake or some other method to stop the motor quickly.

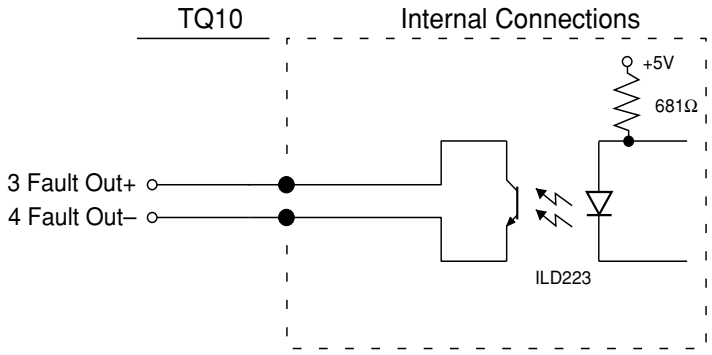
If you need to disable the TQ10SD Step & Direction drive during *normal operations*, you should use the shutdown input—it allows you to re-enable the drive from the indexer without cycling power. The shutdown input is described later in this section.

If you need to disable the TQ10SD Step & Direction drive in an *emergency*, use the enable input as described above—*not* the shutdown input.

The TQ10 Torque drive has no shutdown input.

Fault Output (Optional)

When the TQ10 is operating normally, its fault output's internal transistor is in the "on" state, and conducts current. If the TQ10 detects a fault, it turns off the transistor, and current stops flowing.



Fault Output

Specifications

Maximum Applied Voltage	50 V
Maximum Current	10 mA
Active Level	No Fault: Transistor *on*, current flows Fault: Transistor *off*, no current flows

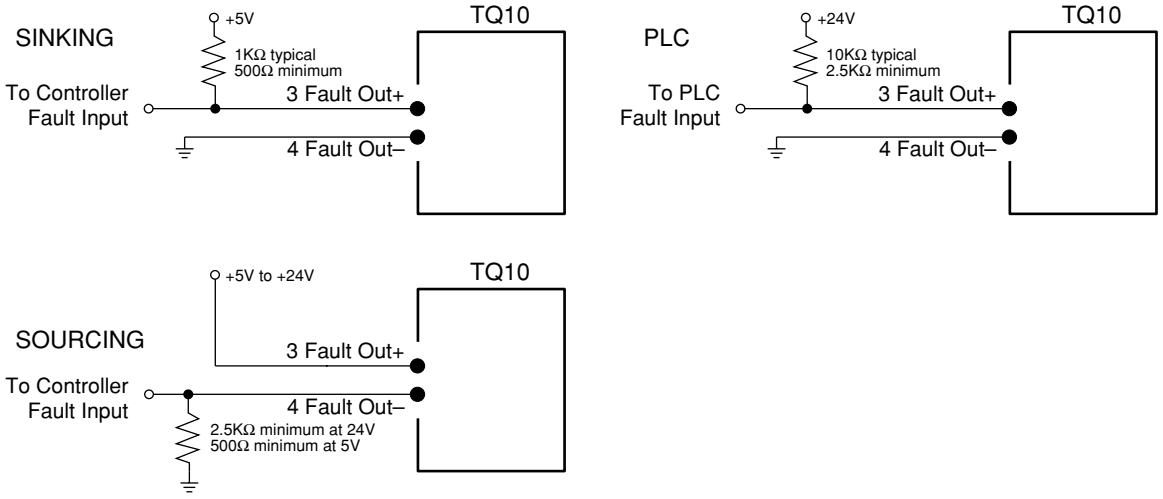
The following conditions will activate the fault output.

Fault Condition

Drive Not Enabled	
Over Temperature	*latched*
Overvoltage	*latched*
Undervoltage	*not latched*
Excess Position Error	*latched (TQ10SD only)*
Short Circuit	*latched*
Power Supply Fault	*latched*
Foldback	*foldback causes fault if DIP SW2, Position#1 is set to ON*

Latched means you must cycle power before the drive will operate again (or, with the TQ10 Torque Drive, you can also use the reset input to reset the drive).

You can use the TQ10's fault output as a signal to a controller or PLC that a fault has occurred. The following drawing shows several ways to connect external devices to the TQ10's fault output.



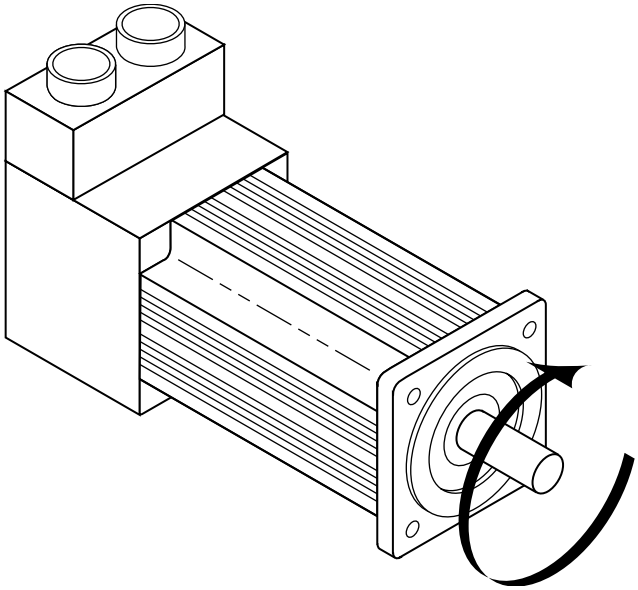
Fault Output – Typical Applications.

6B. TQ10 Torque Drive Only – Connect Command & Reset Inputs

The TQ10 Torque Drive monitors an analog voltage signal, called *command input*, at its input terminals (**COMMAND+** and **COMMAND-**). It sends an output current to the motor that is proportional to the command input voltage. Your controller's command voltage can range from -10VDC to +10VDC.

The TQ10 will produce 1.0 amp for each volt present at its input terminals. A 10 volt command input will result in peak current flowing to the motor. Smaller voltages result in proportionally less current, with a zero volt command input resulting in no current to the motor.

Positive voltages cause the TQ10 to produce currents that turn the motor's shaft clockwise. Negative voltages cause currents that turn the shaft counterclockwise. As the next drawing shows, shaft rotation is defined as the direction the shaft rotates, as viewed from the mounting flange end of the motor.



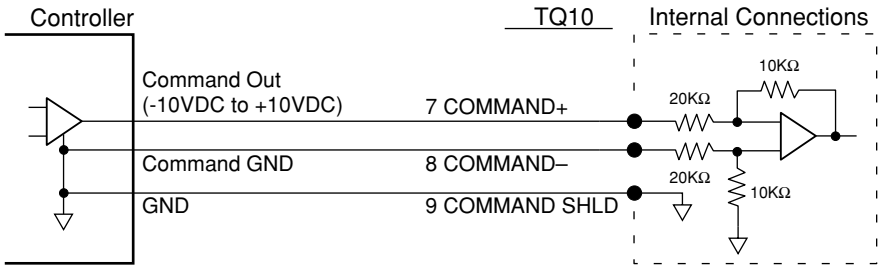
Clockwise Shaft Rotation

Connect your controller's command output signal to the TQ10's command input terminals. The following sections describe how to connect different types of controller outputs to the TQ10's command input terminals.

Controller with Single-ended Output

If your controller uses a single-ended output—a single terminal that produces a voltage that ranges from -10VDC to +10VDC—connect that output to **COMMAND+** on the TQ10.

Connect wires from the TQ10's **COMMAND-** and **COMMAND SHLD** terminals to the controller's ground terminal. If you connect the wires as shown in the next drawing, you will minimize electrical noise in the circuit. You should use shielded, twisted-pair wire for your connections.



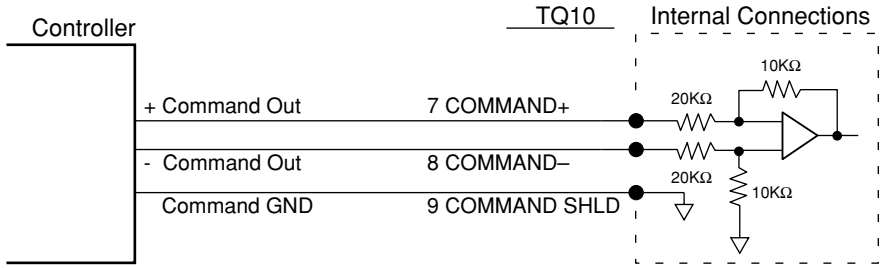
Controller – Single-Ended Output Connections

Bring both wires from the TQ10, and connect them both to the controller. This will ensure that the TQ10's **COMMAND-** input and **COMMAND SHLD** input are both referenced to the controller's ground terminal.

Controller with Differential Output

If your controller has a differential output, then it has two command signals. One is a signal that ranges from -5VDC to +5VDC. The other signal ranges from +5VDC to -5VDC. The two signals mirror each other—their magnitudes are equal, but they have opposite signs.

Your controller should also have a ground terminal to use as a reference for the positive and negative command outputs.



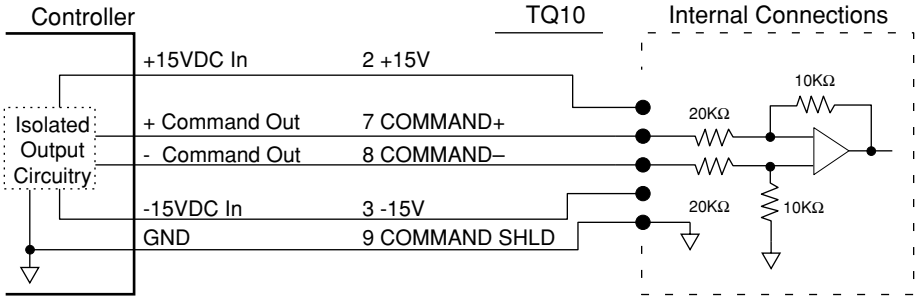
Controller—Differential Output Connections

The figure above shows how to connect these three outputs to the TQ10.

Controller with Isolated Output

Some controllers have isolated command outputs, and may require a voltage source to power their outputs. The TQ10 has three pins available to power isolated outputs on a controller. These pins provide +15VDC, -15VDC, and ground.

The next figure shows a typical controller with isolated differential outputs, and illustrates how you can connect it to the TQ10.

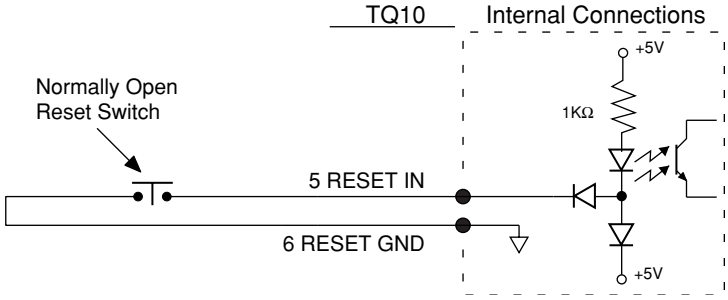


Controller—Isolated Output Connections

If your controller has an isolated single-ended output, connect the ±15VDC outputs as shown in this figure. Connect the command and ground signals as shown earlier in the section on single-ended outputs.

Reset Input (Optional)

You can use the reset input to reset the drive. The effect of a reset is identical to cycling power. The reset input is internally pulled up to +5V. If your equipment requires, you can connect the input to an external voltage as high as +24V. You can also connect it to a dry contact closure to ground.



Reset Input

Specifications

Maximum Applied Voltage	30 V
Maximum Current	5 mA
Active Level	Low to reset

6C. TQ10SD Only – Connect Inputs & Outputs

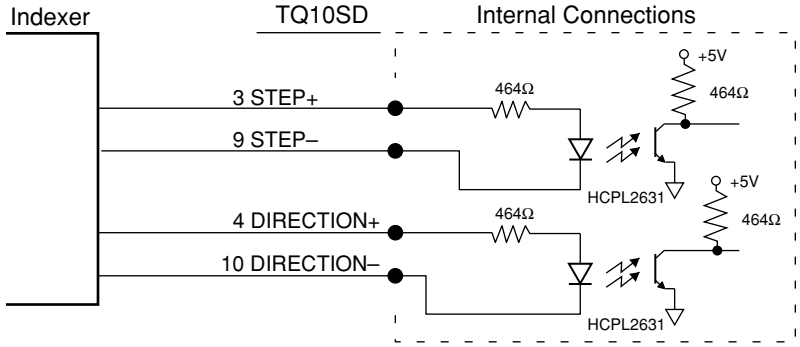
You must connect step and direction, enable, and encoder signals to the TQ10SD Step & Direction Drive for it to work. Use the drive's other inputs and outputs for your application's specific requirements.

Unlike a step motor system, which operates *open loop*, the TQ10SD is a *closed loop* servo system. It requires feedback from the encoder for stability. For each step pulse received while **Direction+** is positive, the drive will make the motor turn in the positive direction a distance of one positive encoder count.

For stability, it is important that you connect your system so that a positive step command causes the encoder position to increment, not decrement. If the system is connected incorrectly, each step pulse will cause the encoder to move in the wrong direction, causing increasing position errors. This could lead to instability and a *motor runaway*, in which the motor spins faster and faster, eventually going out of control.

Step & Direction Inputs

Connect your indexer to the step and direction inputs, as shown in the next drawing. These inputs are optically isolated. For best performance, your indexer should drive the inputs differentially. Single-ended operation is also possible, especially at lower step frequencies (where the switching speed of the internal diode is not as critical).



Step & Direction Inputs

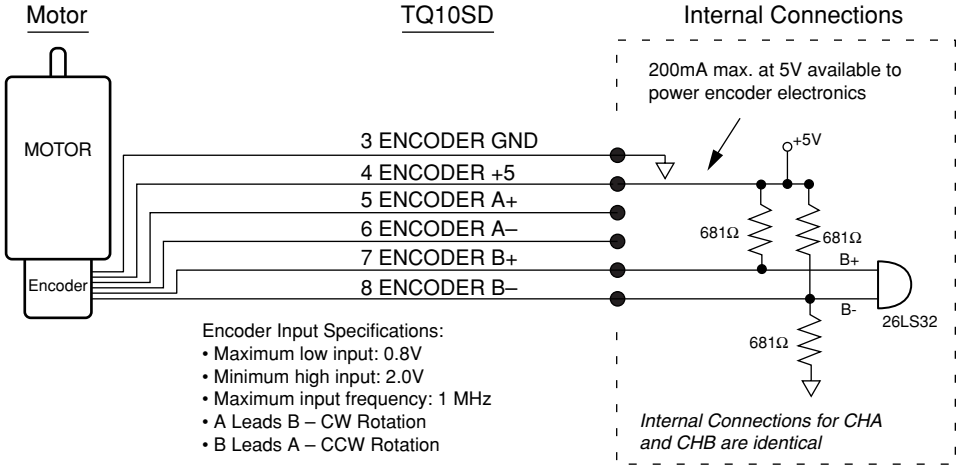
Specifications for the step and direction inputs are as follows:

Specifications	Step+/Step– Dir+/Dir–
Applied Voltage	5 V maximum
Input Current	12 mA maximum 6.3 mA minimum
Step Pulse	500 nsec minimum pulse width
Setup Time	Direction input may change polarity coincident with the last step pulse. The direction input must be stable for 500 nsec before the drive receives the first step pulse.

You can use an input voltage higher than 5V if you install a resistor in series with the input, to limit current to the range specified above.

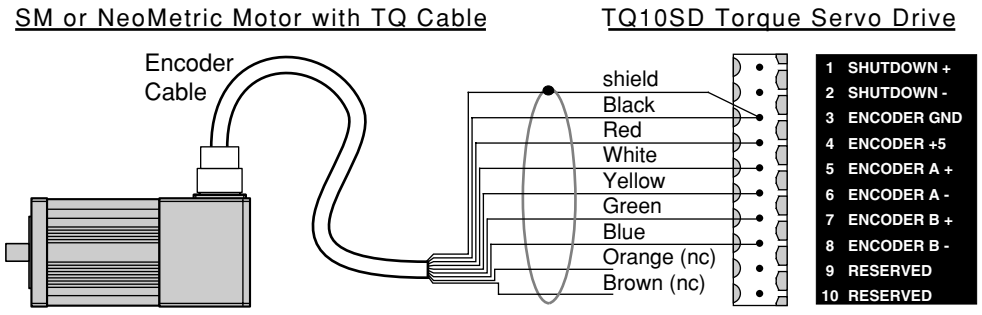
Encoder Input Connections

You must connect an encoder to the TQ10SD's encoder inputs. These are differential inputs; therefore, your encoder should have differential outputs. Single-ended operation is possible, but is more susceptible to electrical noise and is not recommended. Up to 200 mA at 5 volts is available from the TQ10SD to power encoder electronics.



Encoder Input

The color code for encoder wires is shown in the next drawing for Compumotor SM and NeoMetric Series servo motors.

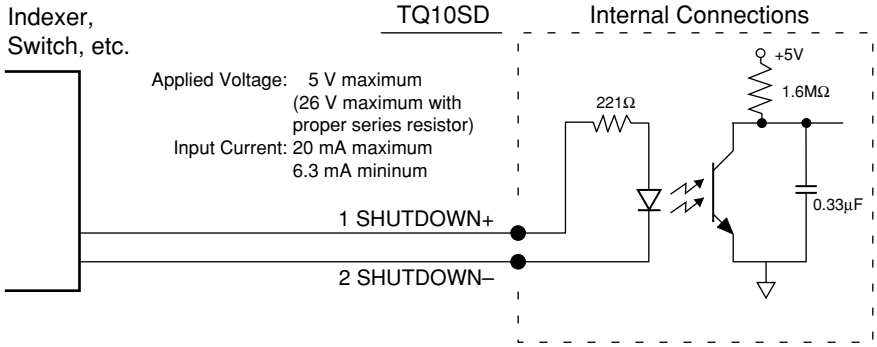


Connecting Encoder Input to SM or NeoMetric Motor Encoder Cable

The orange and brown wires connect to **INDEX+** and **INDEX-** on the encoder, which the TQ10SD does not use. Do not connect these two wires to the drive.

Shutdown Input *(Optional)*

Use the shutdown input if you need to temporarily disable the drive during normal operations. You may wish to do this, for example, to manually move the load to a desired position. Make connections according to the following diagram. The inputs are designed for 5V operation. For 24V operation, install an external 2KΩ resistor in series with **Shutdown+** to limit the input current.



Shutdown Input

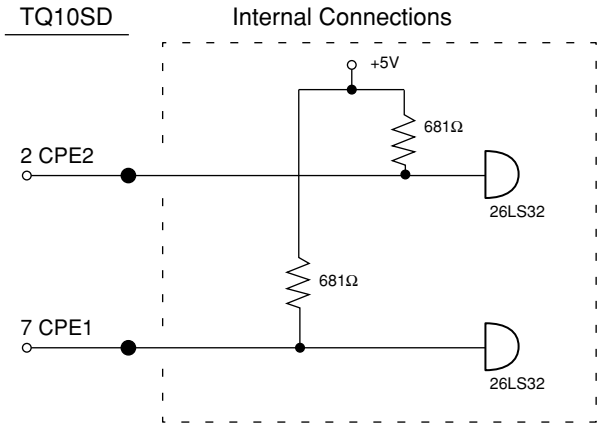
When +5V is applied to the **Shutdown+** input, the TQ10SD's power output stage remains active, but its internal controller commands zero torque. You can then manually position the motor shaft. The controller will ignore encoder counts and position error as the shaft turns. Approximately one second after you release the shutdown input, the internal controller accepts the new position as the commanded position, and reestablishes servo action.

While the TQ10SD is in shutdown, it's small internal offset torque will be applied to the load. This torque is usually too low to overcome friction and cause motion. In some applications, however, the shaft may need to be held in the desired position during shutdown.

Note that shutdown in the TQ10SD functions differently than shutdown in a step motor drive. When a step motor drive is shut down, it actually shuts down its power output stage. When it comes out of shutdown, the step motor drive will command phase currents that immediately apply torque to the shaft, which holds it in some position between the poles.

CPE1 and CPE2 – Position Error Inputs

You can *configure position error* (CPE) with two position error inputs, **CPE1** and **CPE2**. Position error faults provide warnings of impending problems such as increased friction, or of immediate problems such as a mechanical jam. Position error is measured in post-quadrature encoder counts. Four settings are available, as the next table shows.



CPE 1 and CPE 2 – Position Error Inputs

Position Error Settings			Number of Revolutions 500 Line Encoder	1000 Line Encoder
CPE1	CPE2	Error*		
low	low	2047	1.024	0.512
high	low	4095	2.048	1.024
low	high	8191	4.096	2.048
high	high	16383 *(default)*	8.196	4.096

high = not connected
low = connected to ground

*error is measured in post-quadrature encoder counts

When the TQ10SD ships from the factory, neither **CPE1** nor **CPE2** is connected to ground. This is the default setting; it selects the widest position error range. You might begin with this setting when you start configuring your system. This will give you the widest range of motion. Once your system is tuned and performing properly, you can select one of the other three settings by connecting either or both of the inputs to ground.

The position error feature works as follows. Internally, the drive generates a control voltage proportional to error counts—the difference between the number of step pulses received and the number of post-quadrature encoder counts received. The first 2047 counts in each direction produce an increasing control voltage. This causes an increasing torque to move the load towards the commanded position. After the first 2047 counts, maximum torque is being commanded. Additional error counts have no immediate effect on torque, but they are accumulated until the error is reduced by shaft motion, or the CPE limit is reached. Reaching the limit causes a fault that disables the drive and illuminates the red LED labeled **NOT ENABLED**.

To clear the position error fault, cycle power.

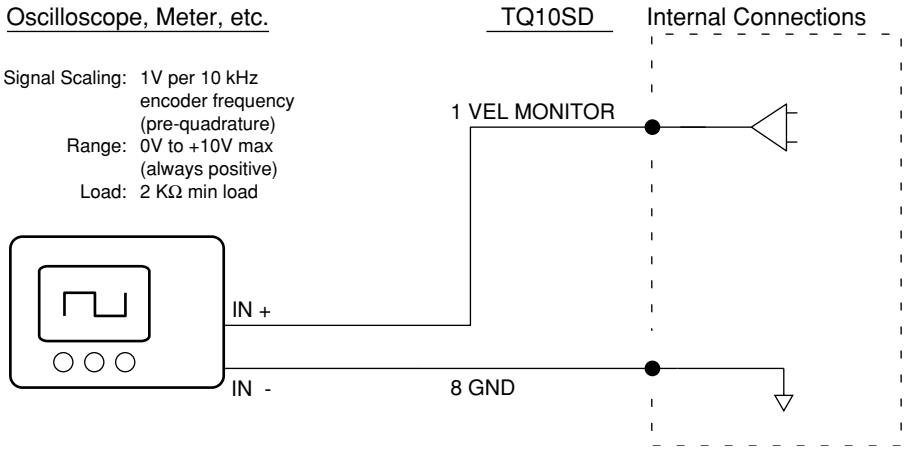
Velocity Monitor Output *(Optional)*

The TQ10SD's velocity monitor output is a voltage signal proportional to encoder speed. You can connect a voltmeter to this output to measure velocity, or you can connect an oscilloscope to help you tune your system. See the *Tuning* section at the end of this chapter for more information.

The signal is always positive, regardless of the direction of encoder rotation. It is scaled so that a pre-quadrature encoder count frequency of 10 kHz produces an output of one volt. The maximum output is +10V. (For example, a 1000 line encoder rotating at 100 rps (100 kHz) will produce the maximum signal of +10V. The same encoder at 10 rps will produce a signal of +1V.)

Encoder counts come slowly at low velocities, which can cause the velocity monitor to show ripple at four times the line frequency, resulting in a "fat" trace on the oscilloscope.

The next drawing shows typical connections to the velocity monitor. Use any of the terminals labeled **GND** as a ground reference for your signal.



Velocity Monitor Output Connections

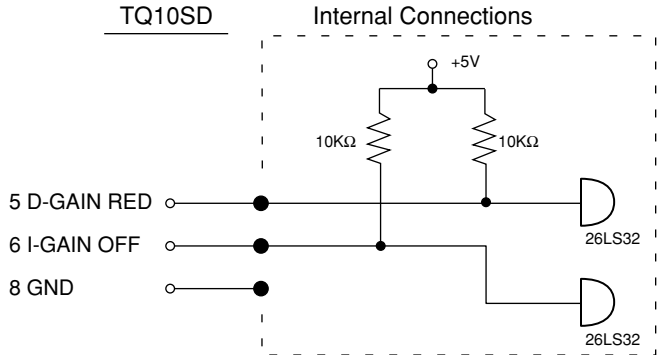
Derivative Gain Reduction—Input *(Optional)*

This input, labeled **D-GAIN RED**, can reduce the derivative gain in the TQ10SD's internal feedback loop. If no connections are made to the input, the gain does not change. If the input is connected to ground, the drive gradually reduces derivative gain to a low value whenever motion stops. When motion is commanded again, or if the motor shaft moves, the drive instantly increases derivative gain to the value set by the derivative tuning pot. See the *Tuning* section at the end of this chapter for more information. The internal schematic for the input is shown in the next drawing.

Integral Gain Disable—Input *(Optional)*

This input, labeled **I-GAIN OFF**, can disable the integral gain in the TQ10SD's internal feedback loop. If this input is grounded, integral gain is disabled. If it is not grounded, integral gain is determined by the tuning pot setting. (However, the tuning pot cannot reduce integral gain to zero; you must ground **I-GAIN OFF** to set integral gain to zero.)

As an initial setting to simplify tuning, we recommend disabling integral gain by grounding **I-GAIN OFF**. You can add integral gain later, if necessary. The internal schematic for the input is shown in the next drawing. See *Tuning* at the end of this chapter for more information.



Derivative Gain Reduction & Integral Gain Disable Inputs

7. Connect AC Power

At this point in your installation procedure, you should have mounted your drive and motor, and connected motor cables and controller cables (or indexer cables) to the drive.

The TQ10 does not have an *on/off* switch. When you plug the power cord into the drive, the system will turn on. Therefore, before you apply power to the TQ10, verify the following:

- Motor should be properly secured
- Load should not yet be connected to motor shaft
- Motor cable should be connected to drive
- Drive should be properly mounted
- Controller/Indexer cable should be connected to drive
- Controller/Indexer cable should not be located close to motor cable

Apply Power

To apply power to the TQ10, plug one end of the power cord into the drive's AC Power connector (cord length is 6 feet/1.8 m). Plug the other end of the cord into an AC power source that meet these specifications:

Specifications – AC Power Input

Input Power:	120VAC nominal
	95VAC minimum
	132VAC maximum
	50 – 60 Hz
Fuses:	No user serviceable fuses
Grounding:	You must provide a proper AC power ground

WARNING
The motor case and drive are grounded through the AC power connector ground pin. You must provide a proper AC power ground for safety purposes.

Peak Power Ratings

The amount of power the TQ10 draws from your AC power source depends upon the motor you use and upon your specific application. For high power applications, we suggest you use a dedicated 20 amp service for the TQ10. Even applications that use low *average* power may require 20 amp service if the *peak* power is high. Inadequate AC power can cause various problems that are difficult to diagnose.

8. Test Your System

Except for connecting the motor to the load, system installation should be complete at this point. Perform the test procedure below to verify that your system is functioning properly.

In the test procedure, you will command single revolution moves in the clockwise and counterclockwise direction. If your mechanics do not permit such moves, choose a move that allows you to easily verify correct system response.

CAUTION
If you have an SM or NeoMetric Motor, use the drive's DIP switches to set the peak current at twice the motor's continuous current rating, or less. Motor damage due to excessive heating may result from the combination of high peak current and improper tuning values.

Test Procedure

① Apply 120VAC power. The bicolor LED labeled **GRN = POWER ON** should be illuminated green.

② Command a slow move of one revolution in the clockwise direction. Verify that the motor turns as commanded.

③ Command a slow move of one revolution in the counterclockwise direction. Verify that the motor turns as commanded.

④ Test any of the optional inputs and outputs that you have connected.

You may need to tune your system before you can obtain motion from the motor. We give tuning instructions later in this chapter.

Successful completion of this procedure will verify that your controller and motor are correctly connected to the TQ10, and that the drive is functioning properly.

If the test was unsuccessful, observe the LEDs on the front panel of the TQ10 while you try the test procedure—they may indicate the cause of the problem. (*Chapter 4, Troubleshooting* has a complete description of LED functions.) Review earlier sections of this user guide, verify that you have completed each step, and try this test procedure again.

If the test is still unsuccessful, proceed to *Chapter 4, Troubleshooting* for problem identification and solution procedures.

9. Connect the Motor to the Load—Couplers

Your mechanical system should be as stiff as possible. Because of the high torques and accelerations of servo systems, the ideal coupling between a motor and load would be completely rigid. Rigid couplings require perfect alignment, however, which can be difficult or impossible to achieve. In real systems, some misalignment is inevitable. Therefore, a certain amount of flexibility may be required in the system. Too much flexibility can cause resonance problems, however.

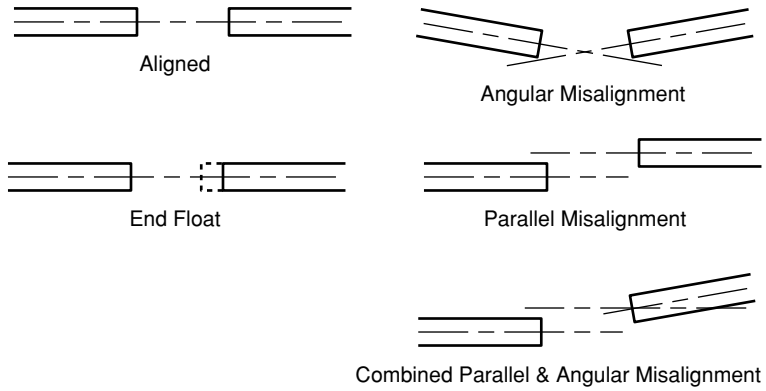
These conflicting requirements are summarized below.

- Maximum Stiffness (in the mechanical system)
- Flexibility (to accommodate misalignments)
- Minimum Resonance (to avoid oscillations)

The best design may be a compromise between these requirements.

Misalignment & Couplers

Align the motor shaft and load as accurately as possible. In most applications, some misalignment is unavoidable, due to tolerance variations in components. However, excessive misalignment may degrade your system's performance. The three misalignment conditions, which can exist in any combination, are illustrated and described below.



Misalignment Conditions

- Angular Misalignment: The center lines of two shafts intersect at an angle other than zero degrees.
- Parallel Misalignment: The offset of two mating shaft center lines, although the center lines remain parallel to each other.
- End Float: A change in the relative distance between the ends of two shafts.

The type of misalignment in your system will affect your choice of coupler.

Single-Flex Coupling

Use a single-flex coupling when you have angular misalignment only. Because a single-flex coupling is like a hinge, one and only one of the shafts must be free to move in the radial direction without constraint. ***Do not use a double-flex coupling in this situation***: it will allow too much freedom and the shaft will rotate eccentrically, which will cause large vibrations and catastrophic failure. ***Do not use a single-flex coupling with a parallel misalignment***: this will bend the shafts, causing excessive bearing loads and premature failure.

Double-Flex Coupling

Use a double-flex coupling whenever two shafts are joined with parallel misalignment, or a combination of angular and parallel misalignment (the most common situation).

Single-flex and double-flex couplings may or may not accept end play, depending on their design.

Rigid Coupling

Rigid couplings are generally not recommended, because they cannot compensate for *any* misalignment. They should be used only if the motor or load is on some form of floating mounts that allow for alignment compensation. Rigid couplings can also be used when the load is supported entirely by the motor's bearings. A small mirror connected to a motor shaft is an example of such an application.

Coupling Manufacturers

HUCO
70 Mitchell Blvd, Suite 201
San Rafael, CA 94903
(415) 492-0278

ROCOM CORP.
5957 Engineer Drive
Huntington Beach, CA 92649
(714) 891-9922

HELI-CAL
P.O. Box1460
Santa Maria, CA 93456
(805) 928-3851

Resonance Issues

A coupler that is too flexible may cause a motor to overshoot its commanded position. When the encoder sends a position feedback signal, the controller will command a correction move in the opposite direction. If the resonant frequency of the system is too low (too flexible), the motor may overshoot again and again. In extreme cases, the system could become an oscillator.

To solve resonance problems, increase the mechanical stiffness of the system to raise the resonant frequency so that it no longer causes a problem.

If you use a servo as a direct replacement for a step motor, you may need to modify your mechanical coupling system to reduce resonance. For example, we recommend using a bellows-style coupler with servo motors, rather than the helical-style coupler that is often used with step motors. Helical couplers are often too flexible, with resonant frequencies that can cause problems. Bellows couplers are stiffer, and perform better in servo systems.

Tuning – TQ10 Torque Drive

The TQ10 Torque Drive requires no tuning adjustments. See your controller's User Guide for instructions on controller tuning adjustments.

If you use a high performance motor (peak current rating greater than three times the continuous current rating), such as Compumotor's SM and NeoMetric Series servo motors, see the *Special Considerations* section below.

Special Considerations when Tuning with SM and N Series Motors

When using a Compumotor SM or NeoMetric Series motor, or other high performance servo motor, be careful not to overheat the motor while tuning your system. If you accidentally choose tuning gains that cause motor oscillations or instability, excess motor current can quickly overheat and damage the motor—even before the thermostat can trigger the motor overtemperature circuit.

CAUTION

For initial tuning with an SM or NeoMetric motor, set peak current DIP switches at twice the motor's continuous rated current, or less. Otherwise, high peak currents during instability may cause motor overheating and damage.

To avoid damage, we recommend a tuning procedure that may differ from methods you have used before. Instability sometimes *does occur* during tuning; to avoid the damaging currents that instability can cause, reduce the peak current *before* you begin the tuning process. Then, as you refine your tuning values, you can gradually increase peak current. Details of this procedure are listed below.

Because you will start with reduced peak current, at first the motor may not be able to make the move called for in your application. The best way to test the system's response under this reduced current condition is to command a short test move, and observe the results.

After you change current settings, adjust tuning gains, or command a move, closely monitor the motor. If there is any sign of uncontrolled instability, quickly disable the drive to avoid motor damage. The fastest, most reliable way to disable the drive is with a normally-closed switch connected in series with the **ENABLE IN** input.

Tuning Procedure with SM and NeoMetric Motors:

① **Heatsink Your Motor:** This is especially important in temporary "bench top" procedures. SM and NeoMetric Motors dissipate excess heat through their faceplate; to ensure proper motor cooling, the faceplate must be mounted to a heatsink.

② **Reduce Peak Current:** Using the drive's DIP switches, set the peak current at a level that is less than twice the motor's continuous current rating: Following the dipswitch settings illustrated on the back cover will do this.

- 4.4 amps for SM motors with **-A** windings
- 7.4 amps for SM motors with **-B** windings, N0921F
- 6.0 amps for N0701D and N0702E motors
- 8.9 amps for N0702F, N0701F, N0703F, N0704F
- 10.0 amps for N0703G, N0704G, N0921G, N0922G

③ **Select Tuning Gains:** Starting with low tuning gains (proportional gain at zero, or very low), test your system's response. Adjust the gains until you achieve a satisfactory response and settling time. Use aggressive gains only when necessary; they are likely to cause the system to become unstable. Before proceeding to the next step, ensure that the system is stable.

④ **Try Your Application's Move:** To see if current and gain settings are adequate for your system, try your actual move (rather than the test move). If the move is successful and your motion requirements are satisfied, you do not need to increase peak current any higher—tuning is complete. Proceed to *Step 7* below.

If the move is not successful, proceed to *Step 5*.

⑤ **Increase Peak Current:** Using the DIP switches, increase peak current to: 6.0 amps for SM motors with A windings; 10.0 amps for all other motors. Do not exceed your motor's peak current rating, or three times its continuous current rating, whichever is lower.

⑥ **Repeat Steps 3, 4:** Continue repeating *Steps 3 – 4* until you achieve performance satisfactory for your application. Use only enough peak current to satisfy your motion requirements—not every application requires maximum peak current.

⑦ **Verify Thermal Stability:** Run your application for at least four thermal time constants to ensure that the motor stabilizes at an acceptable temperature.

Example: An SM232A motor's current ratings are 2.1A continuous, 6.3A peak; its thermal time constant is 35 minutes. The motor is to be used in an application that requires 95% peak torque; required peak current is therefore (6.3A • 0.95) = 6A.

Step 1: Start with peak current DIP switches set for 4.4A. Determine a set of initial tuning gains that is stable. If at any time the system becomes unstable, disable the drive immediately.

Step 2: Try the application's move. If the application's motion requirements are satisfied, go to *Step 4*, below

Step 3: If necessary, increase peak current to 6.0A and determine the final set of tuning gains. Verify that the application's motion requirements are satisfied.

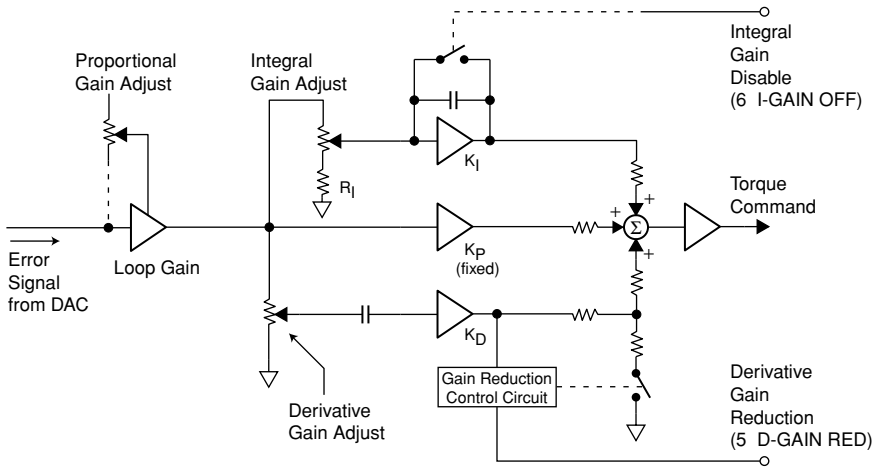
Step 4: Run the application for at least 4 thermal time constants (140 minutes) to ensure that the motor stabilizes at an acceptable temperature.

Tuning – TQ10SD Step & Direction Drive

You must tune the TQ10SD's internal *Proportional Integral Derivative* (PID) servo control loop for optimum system performance. A properly tuned system will exhibit smooth motor rotation, accurate tracking, and fast settling time.

Tuning Theory

The TQ10SD generates a move profile based upon step and direction signals from the indexer. Incoming steps represent *commanded position*, and go to a summing node. Incoming encoder counts represent *actual position*, and also go to the summing node. During a typical move, actual position will differ from commanded position by at least a few encoder counts. At the summing node, actual position is subtracted from commanded position—the resulting difference is the *position error*, which is converted into an analog voltage. This analog error signal is the input to the PID control loop, whose block diagram is shown below.



PID Control Loop – Block Diagram

You can adjust three potentiometers to tune the PID loop. These potentiometers control the settings for proportional gain, integral gain, and derivative gain. You can also make two other adjustments: you can connect the terminal labeled **D-GAIN RED** to ground, to reduce derivative gain; and you can connect the terminal labeled **I-GAIN OFF** to ground, to disable integral gain.

These five tuning parameters are described in the next sections.

Proportional Gain

Proportional gain provides a torque that is directly proportional to the *magnitude* of the error signal. Proportional gain is similar to a spring—the larger the error, the larger the restoring force. It determines the stiffness of the system and affects the following error. High proportional gain gives a stiff, responsive system, but can result in overshoot and oscillation. Damping—provided by derivative gain—can reduce this overshoot and oscillation.

Notice from the block diagram that adjusting proportional gain affects the loop gain. This means that integral gain and derivative gain are both affected by changes in the proportional gain tuning potentiometer. This arrangement simplifies tuning; once you set the integral and derivative gains in the correct ratio to proportional gain, you only need to adjust proportional gain—integral and derivative gain will follow.

Derivative Gain

Derivative gain provides a torque that is directly proportional to the *rate of change* of the error signal. When the error's instantaneous rate of change, or *derivative*, increases, derivative gain also increases. Derivative gain opposes rapid changes in velocity. It will dampen the resonance effects of proportional gain. With higher derivative gain, you can use higher proportional gain.

Derivative Gain Reduction

Many applications require high derivative gain for proper performance. High derivative gain, however, can cause jitter and audible noise at the shaft when the motor is at rest. Many applications have enough "stiction" so that high derivative gain is not necessary for stability when the system is at rest. If your application must hold position with minimum jitter or noise, connect a wire from the terminal labeled **D-GAIN RED** to ground (see the *Inputs and Outputs* section earlier in this chapter). With this terminal grounded, the drive will gradually reduce derivative gain to a low value whenever motion stops. When motion starts again, or if the motor shaft moves, the drive will instantly increase derivative gain to the value set by the tuning potentiometer.

Integral Gain

Integral gain provides a torque that is directly proportional to the sum, over time, of the error signal—the *integral* of the error. If the error persists, integral gain provides a restoring force that grows larger with time. Integral gain can remove steady state errors that are due to gravity or a constant static torque. It can also correct velocity lag and following error in a constant velocity system.

Too much integral gain can cause overshoot during acceleration and deceleration; this overshoot will increase settling time. You should use only as much integral gain as your application requires. If your application does not need any, you should disable it (see below).

Integral Gain Disable

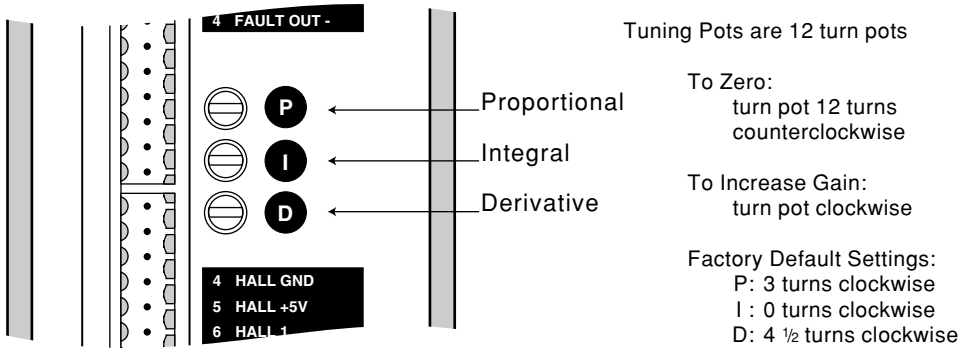
You can *permanently* disable integral gain by connecting a wire from the terminal labeled **I-GAIN OFF** to ground. Notice on the block diagram that even if you zero the integral gain potentiometer, integral gain is not reduced to zero, just to a lower value. There will still be integral gain in the system (because of voltage on resistor R_I). The only way you can eliminate integral gain is to ground **I-GAIN OFF**.

You can use a control signal to *temporarily* disable integral gain, by connecting **I-GAIN OFF** to ground only during acceleration and deceleration. This will disable integral gain during those parts of the move, which should decrease overshoot and settling time. When the system reaches constant velocity or comes to rest, use your control signal to break the ground connection, which will re-enable integral gain.

Tuning Procedure

In the procedure given below, you will systematically vary the tuning potentiometers until you achieve a move that meets your requirements for accuracy and response time.

You can adjust the potentiometers through three holes in the drive's front cover. Use the plastic adjustment tool supplied with the TQ10SD to make adjustments. Turn the potentiometers clockwise to increase the gains.



Tuning Potentiometer Locations

Special Considerations when Tuning with SM and NeoMetric Motors

If you use a high performance motor (peak current rating greater than three times the continuous current rating), such as a Compumotor SM or NeoMetric Series motor, be careful not to overheat the motor while tuning your system. If you accidentally choose tuning gains that cause motor instability, excess motor current can quickly overheat and damage the motor—even before the thermostat can trigger the motor overtemperature circuit.

CAUTION

For initial tuning with an SM or NeoMetric motor, set peak current DIP switches at twice the motor's continuous rated current, or less. Otherwise, high peak currents during instability may cause motor overheating and damage.

To avoid damage, we recommend a tuning procedure that may differ from methods you have used before. Instability sometimes *does occur* during tuning; to avoid the damaging currents that instability can cause, reduce the peak current *before* you begin the tuning process. Then, as you refine your tuning values, you can gradually increase peak current. These steps are included in the tuning procedure described below.

Preparing the System for Tuning

Before applying power and tuning the drive, complete the following steps.

Setup Procedure:

① **Heatsink your motor**: This is especially important in temporary "bench top" procedures. SM Motors dissipate excess heat through their faceplate; to ensure proper motor cooling, the faceplate must be mounted to a heatsink.

② **Disable Integral Gain *(optional)*:** If you do not need integral gain in your application, connect a wire from **I-GAIN OFF** to ground; this will permanently disable integral gain. If you intend to use integral gain, tuning will be simplified if you disable it now, and re-enable it in *Step 6* of the tuning procedure.

③ **Set up the Velocity Monitor *(optional)*:** Connect an oscilloscope to the velocity monitor output, as described earlier in the *Inputs and Outputs* section. Its use is optional—however, because the velocity monitor clearly shows your system's response when you adjust the potentiometers, we recommend using it.

④ **Set Potentiometers to their Default Values:** The tuning potentiometers were set at default values when the TQ10SD shipped from the factory. If yours is a new unit, skip this step and proceed to Step 5. Otherwise, follow this procedure to return the settings to their default values:

1. Turn each potentiometer 12 turns counterclockwise to zero it.
2. Turn the proportional gain potentiometer 3 turns clockwise.
3. Leave the integral gain potentiometer at zero.
4. Turn the derivative gain potentiometer 4½ turns clockwise.

These settings will provide a stable but "mushy" response with most motors and light loads.

⑤ **Reduce peak current**: Using the drive's DIP switches, set the peak current at a level that is less than twice the motor's continuous current rating.

- 4.4 amps for SM motors with **-A** windings
- 7.4 amps for SM motors with **-B** windings, N0921F
- 6.0 amps for N0701D and N0702E motors
- 8.9 amps for N0702F, N0701F, N0703F, N0704F
- 10.0 amps for N0703G, N0704G, N0921G, N0922G

Tuning the System

You will test your system's response as you vary the tuning gains in the procedure below. Because you will start with reduced peak current, the motor may not be able to make the move called for in your application. The best way to test the system's response under this reduced current condition is to command a short test move, and observe the results.

After you change current settings, adjust a potentiometer, or command a move, closely monitor the motor. If there is any sign of uncontrolled instability, quickly disable the drive to avoid motor damage. The fastest, most reliable way to disable the drive is with a normally-closed switch connected in series with the **ENABLE IN** input.

Tuning Procedure:

① **Increase Proportional Gain:** Apply power to the drive. Slowly increase proportional gain by turning the potentiometer clockwise, as you test your system's response with short test moves. As soon as you notice instability in the motor (as evidenced by ringing, excessive overshoot, jitter or audible noise), immediately **decrease** the gain until the system returns to stability (at least $\frac{1}{2}$ turn counterclockwise).

② **Increase Derivative Gain:** As you continue to test your system's response, slowly increase derivative gain by turning the potentiometer clockwise. With increased derivative gain, you should see an improvement in settling time. As soon as you notice instability in the motor (as evidenced by ringing, excessive overshoot, jitter or audible noise), immediately **decrease** the gain until the system returns to stability (at least $\frac{1}{2}$ turn counterclockwise).

With the damping provided from higher derivative gain, you can now return to Step 1 and increase proportional gain. After doing so, proceed to *Step 3*.

③ **Try Your Application's Move**: To see if current and gain settings are adequate for your system, try your actual move. If the move is successful and your motion requirements are satisfied, you do not need to increase peak current any higher—you may proceed to *Step 6*.

If the move is not successful, proceed to *Step 4*, in which you will increase peak current.

④ **Increase peak current**: Using the DIP switches, increase peak current to: 6.0 amps for SM motors with A windings; 10.0 amps for all other motors. Do not exceed your motor's peak current rating, or three times its continuous current rating, whichever is lower. Closely monitor the motor immediately after you increase peak current. Be prepared to disable the drive, or quickly reduce proportional gain, should the motor exhibit any signs of instability.

You can change the DIP switches with power applied—the drive will immediately sense the new current setting. For safety reasons, however, we recommend removing power from the drive before changing the DIP switches.

⑤ **Repeat *Steps 1 – 3***: With higher peak current, you can now increase the proportional and derivative gain settings. Continue repeating *Steps 1 – 3* until you achieve satisfactory performance.

Note: you may not need to readjust derivative gain (see *Step 2*); adjusting proportional gain may be sufficient. Because of the drive design, the derivative setting will automatically track the proportional setting.

⑥ **Adjust Integral Gain:** If you intend to use integral gain, adjust it now. Set it to the lowest value that will correct following errors and static position errors, but not increase overshoot or settling time. Adjusting integral gain may require you to readjust the derivative and integral gain potentiometers. In a system without static torque loading, you may wish to disable integral gain entirely. This is done by grounding the intergral gain disable pin.

⑦ **Verify Thermal Stability**: Run your application for at least 4 thermal time constants to ensure that the motor stabilizes at an acceptable temperature.

This completes the tuning procedure.

CHAPTER THREE

3 Specifications

IN THIS CHAPTER

- Drive Specifications
- SM and NeoMetric Motor Specifications
- SM and NeoMetric Motor Speed/Torque Curves
- SM and NeoMetric Motor Dimensions
- SM and NeoMetric Encoder Specifications
- SM and NeoMetric Motor Part Numbering System

Drive Specifications – TQ10 & TQ10SD

Parameter	Value	
Performance		
Accuracy	±2 arc minute, encoder dependent	
Resolution	2000 or 4000 post-quadrature counts	
Drive Input Power		
Voltage	95–132 VAC	
Frequency	50/60 Hz	
Recommended Service	20 Amp RMS dedicated	
Drive Output Power		
Voltage	170VDC	
Switching Frequency	20 kHz	
Continuous Current	5 Amps with TQ-HS3 or mounted to heatsink at or below 45°C	
Peak Current	10 Amps with approximately 10 seconds maximum duration at 45°C	
Bandwidth	2 kHz typical (motor dependent)	
Commutation	6 state commutation; 120° open-collector Hall sensors, 6° (elec.) max. commutation error	
Inputs	**TQ10**	**TQ10SD**
Command	±10V 20K ohms input impedance	
Enable	Must be low or grounded to enable. 5-24 VDC to disable. Optically coupled with internal pull-up.	Must be low or grounded to enable. 5-24 VDC to disable. Optically coupled with internal pull-up.
Reset	Must be 5–24V or unconnected for normal operation. Ground to reset. Optically coupled with internal pull-up.	
Step		5V maximum input. Current 12 mA max. 6.3 mA min. 500 nS min. pulse width.
Direction		5V maximum input. Current 12 mA max., 6.3 mA min. 500 nS set up time. Positive voltage = CW motor rotation.
Shutdown		5V maximum input (24V with series resistor). Current 20 mA max., 6.3 mA min. +5V at SHUTDOWN+ input commands zero torque. Power stage still active.
Protection		
Short Circuit	Phase-to-phase, phase-to-earth	
Brownout	Below 80VAC	
Over temperature	Motor 90°C (194°F); Drive 65°C (150°F)	
Outputs	**TQ10**	**TQ10SD**
Reference	±15V, 10 mA available	
Encoder Power		+5VDC @ 200mA max
Fault+ Fault-	5-24VDC, 20mA max current. Pull-up resistor needed. No fault, transistor on, current flows. Output turns off under fault condition	5-24VDC, 20mA max current. Pull-up resistor needed. No fault, transistor on, current flows. Output turns off under fault condition
Velocity Monitor		0–10VDC signal. 1VDC per 40 kHz post quadrature. 2 K ohms min load.
Motor-Mounted Encoder	SM and NeoMetric Motors use two-phase differential encoder outputs with line drivers. 20 mA sink or source. Max of 100 kHz pre-quadrature operating frequency.	
Physical		
Connections	10-pin removable screw terminal (all signal connection points)	
Motor	7-pin removable screw terminal	
Power	Standard 3-pin AC connection, molded plug	
Environment		
Drive Temperature – ambient	32°F to 122°F (0° to 50°C)	
Storage Temperature	-40°F to 185°F (-40°C to 85°C)	
Humidity	0 to 95% non-condensing	
Diagnostics	**LED Name**	**Indication**
LEDs	Enable (Bicolor)	Green = enabled Red = power on, not enabled
	Drive Temp	Red = drive overtemp
	Motor Fault	Red = fault (short circuit, motor overtemp, etc.)
	Peak Current/Foldback (Bicolor)	Green = current is near peak (over ~90%) Red = in foldback (peak current time exceeded)
	Regen (Bicolor)	Green = regen active Red = overvoltage fault
Faults (Hardware)	Short Circuit (phase-phase, phase-ground) Under voltage lock out (input <80 VAC) (no LED indication for this) Drive temperature	

Motor Specifications—Compumotor SM Series Servo Motors

	Symbol	Units	SM161A	SM162A	SM231A	SM232A	SM232B	SM233A	SM233B
Continuous Stall Torque[1]	T_{CS}	oz-in	24	44	46	92	92	140	140
		N-m	0.17	0.31	0.32	0.65	0.65	0.99	0.99
Continuous Stall Current[1]	I_{CS}	amps-rms	2.1	2.1	2.1	2.1	4.1	2.1	4.1
Rated Speed[2]	ω_T	rpm	7,500	7,500	7,500	4,500	7,500	2,800	7,500
		rps	125	125	125	75	125	47	125
Peak Torque[1]	T_{pk}	oz-in	72	132	138	276	276	420	420
		N-m	0.51	0.83	0.97	1.95	1.95	2.97	2.97
Peak Current, rms[1]	I_{pk}	amperes	6.3	6.3	6.3	6.3	12.3	6.3	12.3
Torque @ Rated Speed[1]	T_C	oz-in	20	41	38	78	84	134	114
		N-m	0.14	0.29	0.27	0.55	0.59	0.95	0.81
Rated Power-Output Shaft[1]	Po	Watts	110	222	205	260	362	277	505
Resistance[4]	Ω	ohms	4.53	6.50	5.22	7.50	2.01	9.65	2.58
Inductance[3]	L	millihenries	0.808	1.39	1.64	2.9	0.78	4.08	1.06
Thermal Resistance[1]	R_{th}	°C/watt	2.75	2.00	2.23	1.58	1.50	1.25	1.26
Thermal Time Constant	T_{th}	minutes	30	30	30	35	35	40	40
Electrical Time Constant	T_{te}	milliseconds	0.178	0.21	0.31	0.39	0.39	0.42	0.41
Mechanical Time Constant	T_m	milliseconds	9.2	5.0	13.7	8.6	8.8	5.4	7.0
Rotor Inertia	J	lb-in-sec^2	0.000094	0.00016	0.00046	0.00082	0.00082	0.00117	0.00117
		oz-in^2 (mass)	0.58	0.99	2.84	5.07	5.07	7.23	7.23
		kg-m^2 x 10^{-6}	10.62	18.07	51.97	92.65	92.65	132.19	132.19
Weight	#	pounds (kg)	1.1 (0.5)	1.6 (0.7)	2.6 (1.2)	3.5 (1.6)	3.5 (1.6)	4.4 (2.0)	4.4 (2.0)

Data listed is for SM motors alone. Drive specifications may change some values.

[1] @25°C ambient with 10 x 10 x 0.25 in. mounting plate, 90°C winding temperature. For 40°C ambient operation, reduce values by 12%.

[2] With 500 ppr encoders. For 1,000 ppr encoders, derate to 6000 rpm.

[3] ±30%, line-to-line, inductance bridge measurement method @ 1 kHz

[4] ±10%, line-to-line, at 25°C

Motor Specifications—
Compumotor NeoMetric Series Servo Motors (70mm)

Parameter	Symbol	Units	N0701D N0341D	N0701F N0341F	N0702E N0342E	N0702F N0342F	N0703F N0343F	N0703G N0343G	N0704F N0343F	N0704G N0344G
Stall Torque Continuous[1,4]	T_{CS}	lb-in	5.8	5.8	10.6	10.6	16.2	16.2	20.0	20.0
		N-m	0.65	0.65	1.19	1.19	1.83	1.83	2.26	2.26
Stall Current Continuous[1,2]	I_{CS}	amps-rms	2.92	4.56	3.36	4.67	4.59	6.38	4.73	6.57
Rated Speed	ω_r	rpm	4850	7500	3025	4380	2825	4050	2365	3390
		rps	80.8	125	50.4	73	47.1	67.5	39.4	56.5
Peak Torque[1]	T_{pk}	lb-in	17.3	17.3	32.0	32.0	48.6	48.6	60.0	60.0
		N-m	1.95	1.95	3.62	3.62	5.49	5.49	6.78	6.78
Peak Current, rms[1,6]	I_{pk}	amperes	8.8	13.7	10.0	14.0	13.7	19.1	14.2	19.7
Torque @ Rated Speed[1]	T_C	lb-in	4.6	4.6	8.6	8.6	13.0	13.0	15.8	15.8
		N-m	0.52	0.52	0.97	0.97	1.47	1.47	1.79	1.79
Rated Power-Output Shaft[1]	Po	watts	265	415	309	447	435	624	442	634
Voltage Constant[3,4]	K_b	volts/radian/sec	0.221	0.14	0.353	0.253	0.392	0.282	0.468	0.338
Voltage Constant[3,4]	K_e	volts/KRPM	23.11	14.67	36.97	26.52	40.99	29.54	49.02	35.36
Torque Constant[3,4]	K_t	lb-in/amp rms	1.95	1.24	3.12	2.24	3.46	2.50	4.14	2.99
Resistance[3]	R	ohms	5.52	2.27	5.22	2.7	3.36	1.74	3.47	1.80
Inductance[5]	L	millihenries	12.98	5.23	15.86	8.16	12.13	6.30	14.50	7.55
Thermal Resistance[1]	R_{th}	°C/watt	1.44	1.44	1.15	1.15	0.96	0.96	0.87	0.87
Motor Constant	K_m	lb-in/√watt	0.83	0.83	1.37	1.36	1.89	1.89	2.23	2.23
Viscous Damping	B	lb-in/Krpm	0.044	0.044	0.05	0.05	0.0563	0.0563	0.0625	0.0625
Torque-Static Friction	T_f	oz. in.	1.4	1.4	2.1	2.1	2.8	2.8	3.5	3.5
Thermal Time Constant	τ_{th}	minutes	45	45	45	45	45	45	45	45
Electrical Time Constant	τ_e	milliseconds	2.35	2.35	3.03	3.03	3.61	3.61	4.19	4.19
Mechanical Time Constant	τ_m	milliseconds	1.3	1.3	0.77	0.77	0.54	0.54	0.52	0.52
Rotor Inertia	J	lb-in-sec^2	0.000106	0.000106	0.000173	0.000173	0.000240	0.000240	0.000307	0.000307
Weight	#	pounds	3.54	3.54	4.53	4.53	6.04	6.04	7.28	7.28
Winding Class			H	H	H	H	H	H	H	H

[1] @25°C ambient with 10 x 10 x 0.25 in. mounting plate, 90°C encoder temperature.
[2] RMS current, line-to-line, six state commutation.
[3] +/- 10% line-to-line.
[4] Peak value.
[5] +/- 30% line-to-line, inductance bridge measurement @ 1KHz.
[6] Peak current for 2 seconds maximum with initial winding temperature of 40°C.
All specifications are subject to engineering change.

Motor Specifications—
Compumotor NeoMetric Series Servo Motors (92mm)

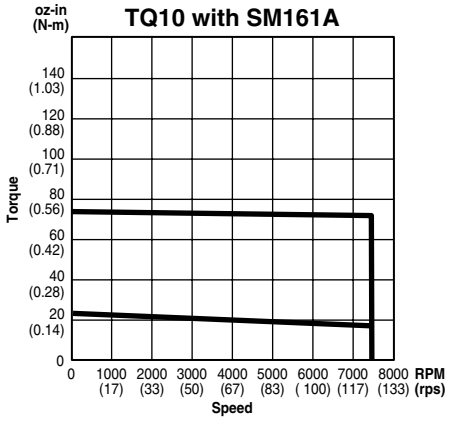
Parameter	Symbol	Units	N0921F	N0921G	N0922G
Stall Torque Continuous[1,4]	T_{CS}	lb-in	16	16	31
		N-m	1.81	1.81	3.50
Stall Current Continuous[1,2]	I_{CS}	amps-rms	4.16	5.76	6.17
Rated Speed	ω_r	rpm	2500	3575	1975
		rps	41.7	59.6	32.9
Peak Torque[1]	T_{pk}	lb-in	48	48	93
		N-m	5.42	5.42	10.51
Peak Current, rms[1,6]	I_{pk}	amperes	12.5	17.3	18.5
Torque @ Rated Speed[1]	T_C	lb-in	12.9	12.9	24.6
		N-m	1.46	1.46	2.78
Rated Power-Output Shaft[1]	Po	watts	383	548	578
Voltage Constant[3,4]	K_b	volts/radian/sec	0.427	0.309	0.556
Voltage Constant[3,4]	K_e	volts/KRPM	44.66	32.37	58.18
Torque Constant[3,4]	K_t	lb-in/amp rms	3.84	2.78	5.0
Resistance[3]	R	ohms	3.72	1.94	2.32
Inductance[5]	L	millihenries	17.11	8.99	14.72
Thermal Resistance[1]	R_{th}	°C/watt	1.06	1.06	0.77
Motor Constant	K_m	lb-in/√watt	1.96	2.00	3.29
Viscous Damping	B	lb-in/Krpm	0.075	0.075	0.0875
Torque-Static Friction	T_f	oz. in.	4	4	6
Thermal Time Constant	τ_{th}	minutes	60	60	60
Electrical Time Constant	τ_e	milliseconds	4.6	4.6	6.4
Mechanical Time Constant	τ_m	milliseconds	1.13	1.13	0.64
Rotor Inertia	J	lb-in-sec^2	0.000363	0.000363	0.000623
Weight	#	pounds	8.1	8.1	11.7
Winding Class			H	H	H

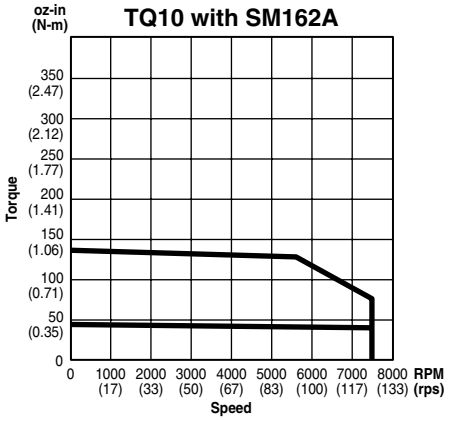
[1] @25°C ambient with 10 x 10 x 0.25 in. mounting plate, 90°C encoder temperature.
[2] RMS current, line-to-line, six state commutation.
[3] +/- 10% line-to-line.
[4] Peak value.
[5] +/- 30% line-to-line, inductance bridge measurement @ 1KHz.
[6] Peak current for 2 seconds maximum with initial winding temperature of 40°C.

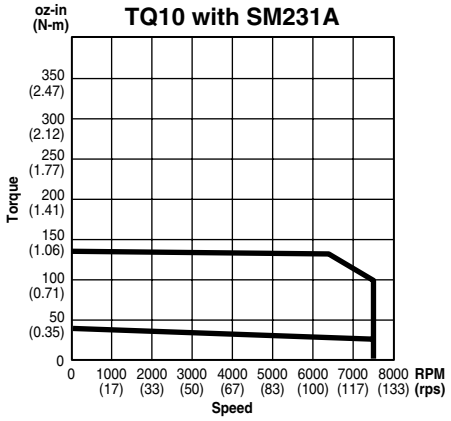
All specifications are subject to engineering change.

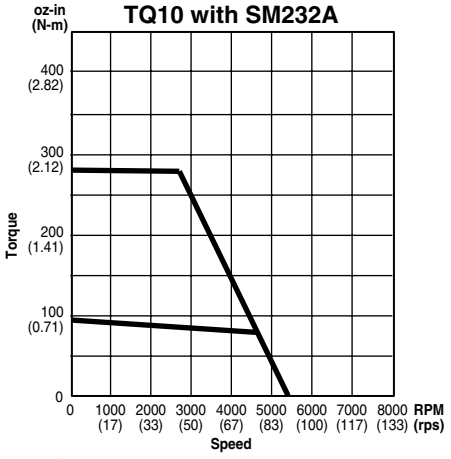
Speed/Torque Curves

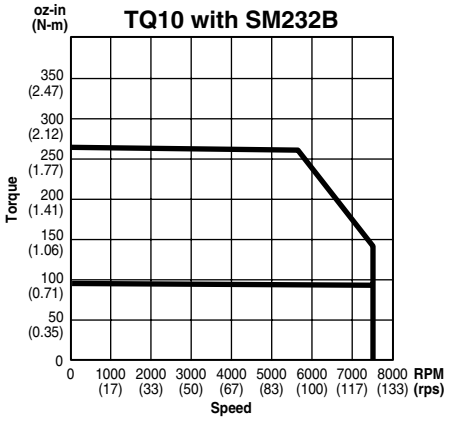
Note: Curves are based on 120VAC line, nominal motor K_t, and K_e. Actual values may vary ±10%. Line voltage directly limits maximum speed.

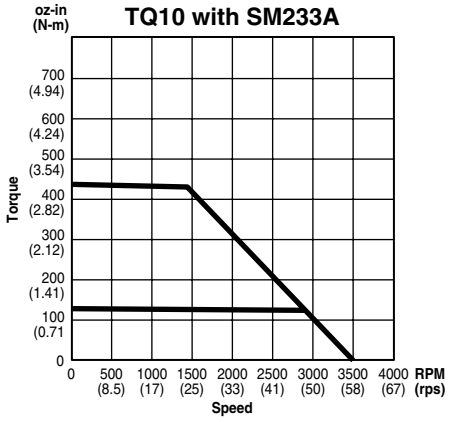


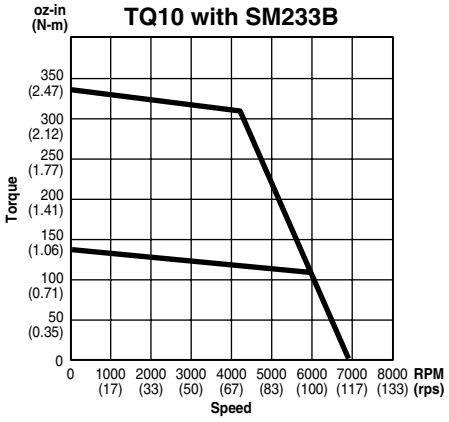






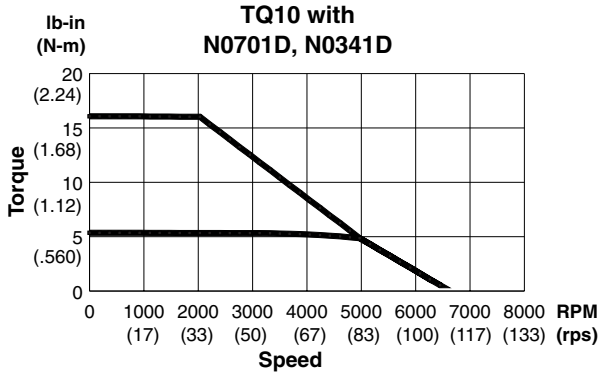


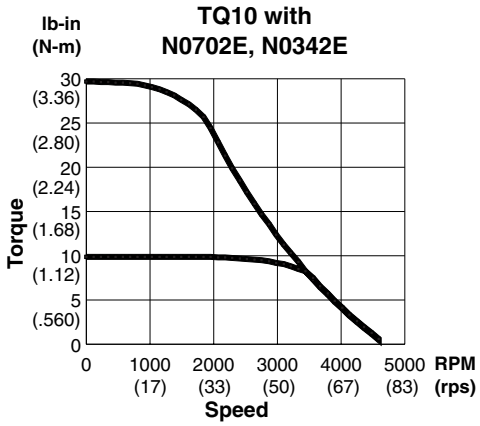


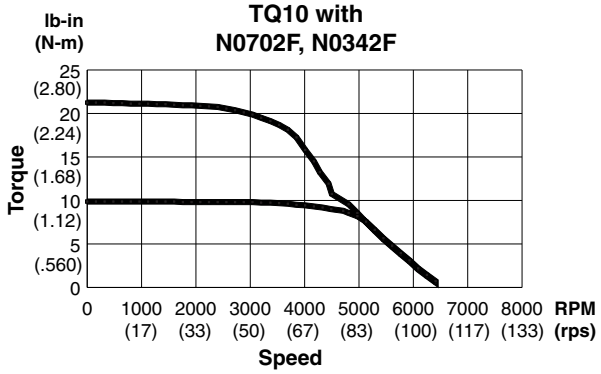


Speed/Torque Curves

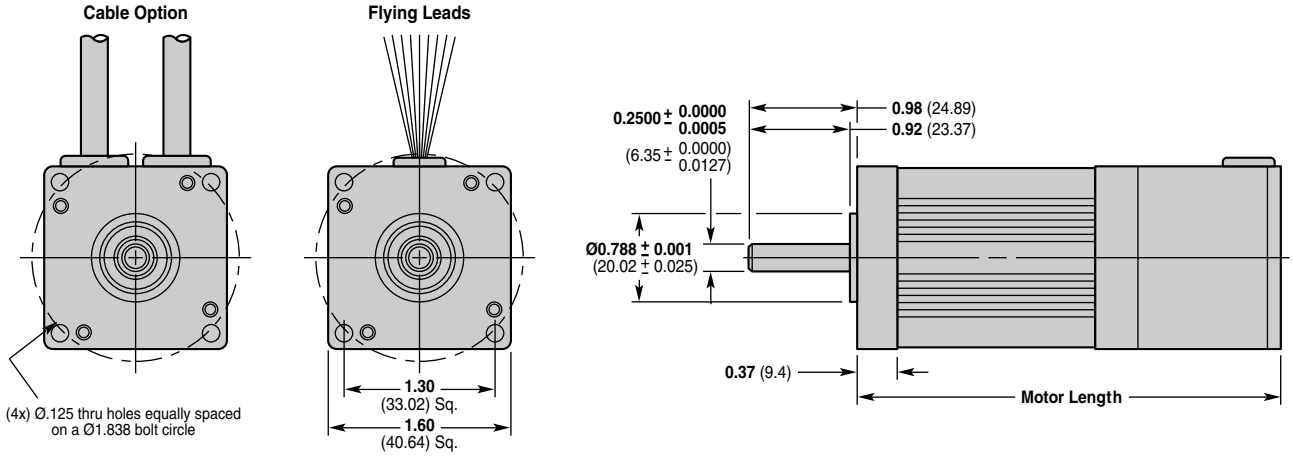
Note: Curves are based on 120VAC line, nominal motor K_t, and K_e. Actual values may vary ±10%. Line voltage directly limits maximum speed.







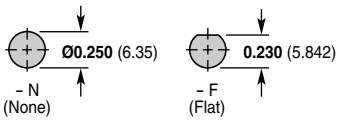
Motor Dimensions—Compumotor SM Series, Size 16



Cable Options	
Part #	Description
– FL	18" Flying Leads
– 10	10 ft. Cable

Longer lengths available
Consult Compumotor for information

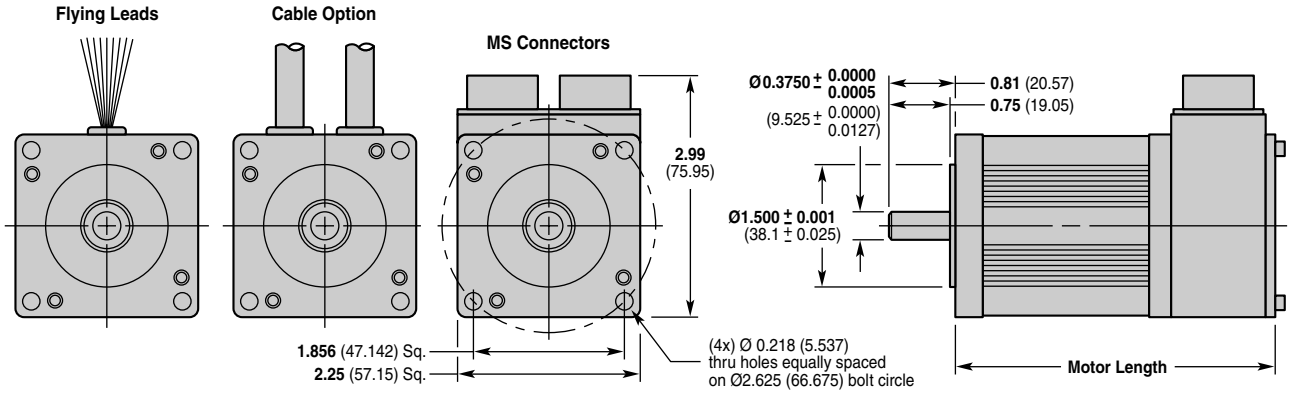
Shaft Options



Dimensions in inches
(millimeters)

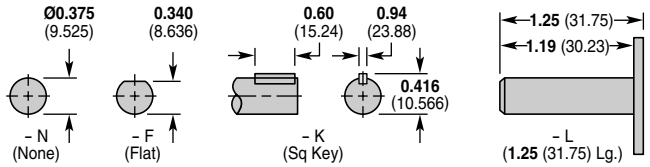
Motor Sizes	
Motor Length	Model
4.79 (121.66)	162 Motor
3.79 (96.27)	161 Motor

Motor Dimensions—Compumotor SM Series, Size 23



Dimensions in inches
(millimeters)

Shaft Options

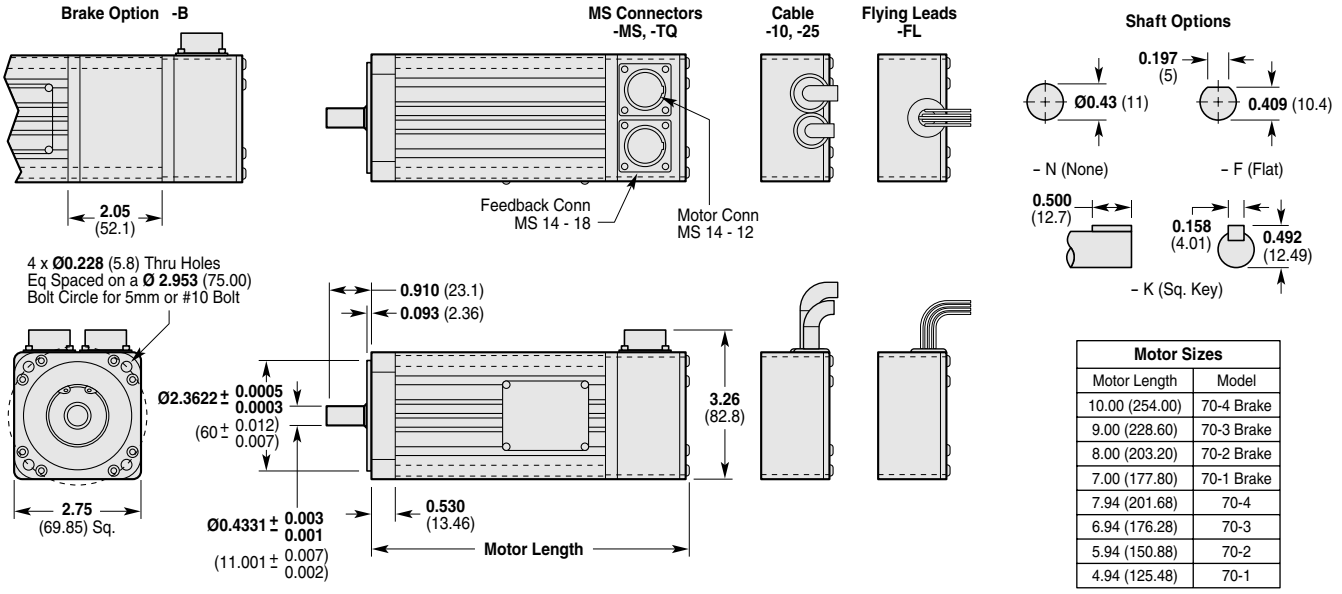


Cable Options	
Part #	Description
– FL	18" Flying Leads
– 10	10 ft. Cable

Longer lengths available
Consult Compumotor for information

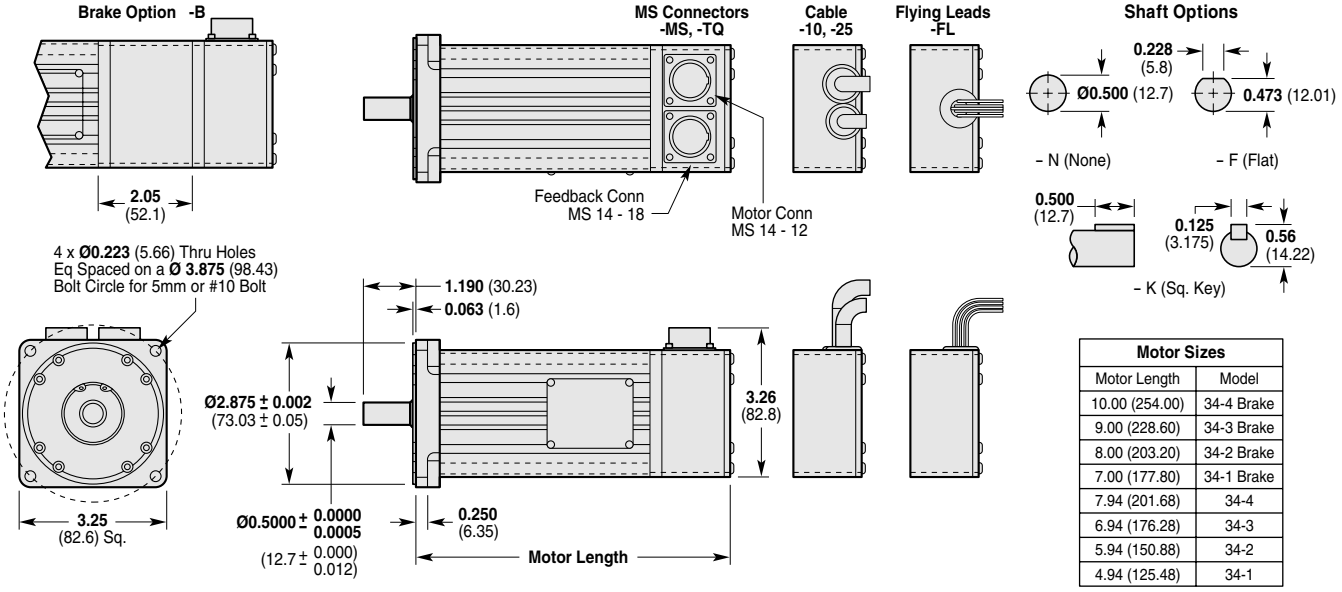
Motor Sizes	
Motor Length	Model
5.98 (151.89)	233 Motor
4.98 (126.49)	232 Motor
3.98 (101.09)	231 Motor

Motor Dimensions—Compumotor NeoMetric Series, Size 70



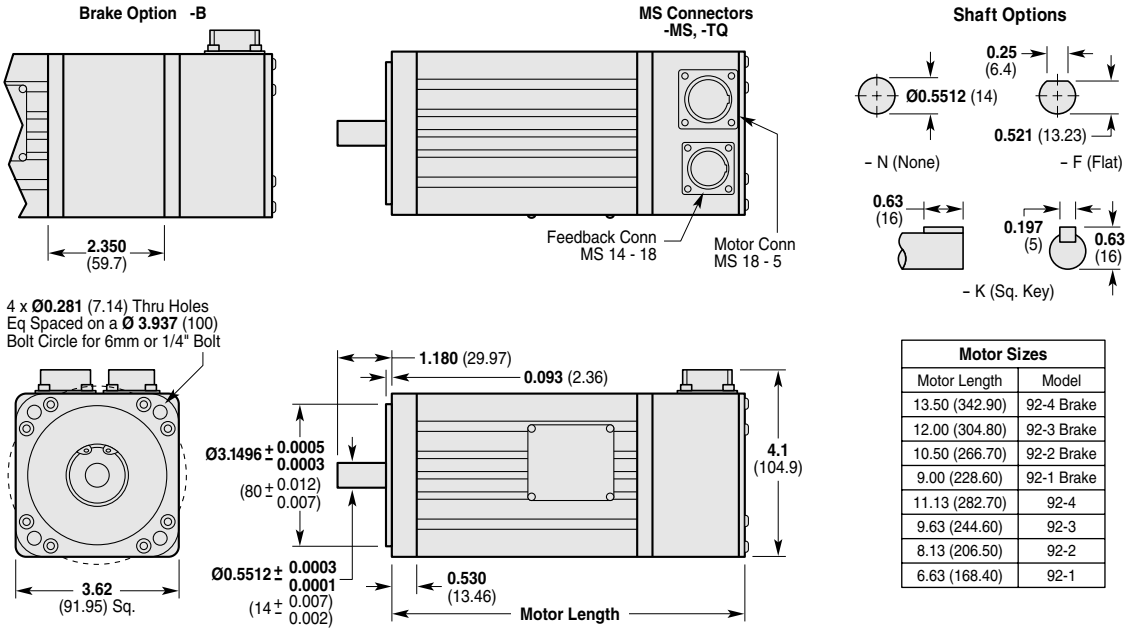
Motor Sizes	
Motor Length	Model
10.00 (254.00)	70-4 Brake
9.00 (228.60)	70-3 Brake
8.00 (203.20)	70-2 Brake
7.00 (177.80)	70-1 Brake
7.94 (201.68)	70-4
6.94 (176.28)	70-3
5.94 (150.88)	70-2
4.94 (125.48)	70-1

Motor Dimensions—Compumotor NeoMetric Series, Size 34



Motor Sizes	
Motor Length	Model
10.00 (254.00)	34-4 Brake
9.00 (228.60)	34-3 Brake
8.00 (203.20)	34-2 Brake
7.00 (177.80)	34-1 Brake
7.94 (201.68)	34-4
6.94 (176.28)	34-3
5.94 (150.88)	34-2
4.94 (125.48)	34-1

Motor Dimensions—Compumotor NeoMetric Series, Size 92



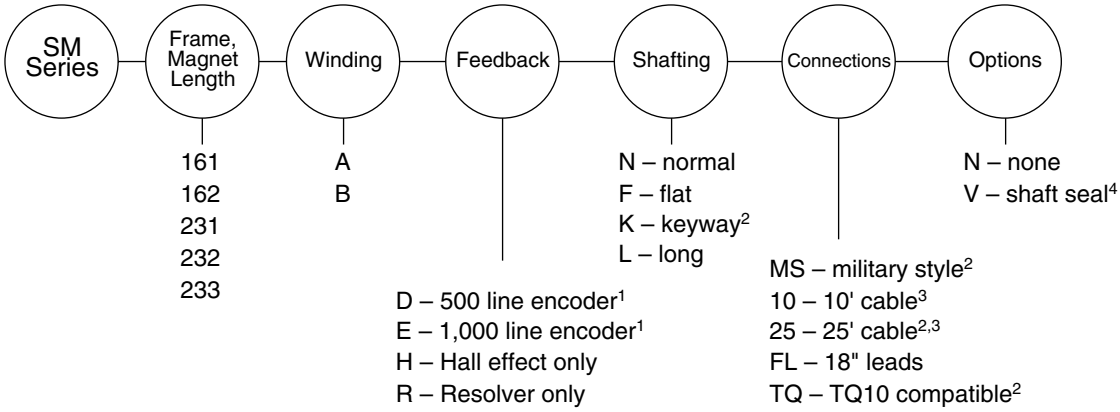
Motor Sizes	
Motor Length	Model
13.50 (342.90)	92-4 Brake
12.00 (304.80)	92-3 Brake
10.50 (266.70)	92-2 Brake
9.00 (228.60)	92-1 Brake
11.13 (282.70)	92-4
9.63 (244.60)	92-3
8.13 (206.50)	92-2
6.63 (168.40)	92-1

Encoder Specifications – Compumotor SM & NeoMetric Series Motors

Parameter	Value
Performance	
Accuracy	±2 min of arc
Electrical	
Input Power	5VDC ± 5% @ 135 mA
Operating Frequency	100 kHz maximum (pre-quadrature)
Output Device	26LS31
Sink/Source, nominal	20 mA
Suggested User Interface	26LS32

Motor Part Numbering System— Compumotor SM Servo Motor

The diagram below illustrates the part numbering system for Compumotor SM Series servo motors.

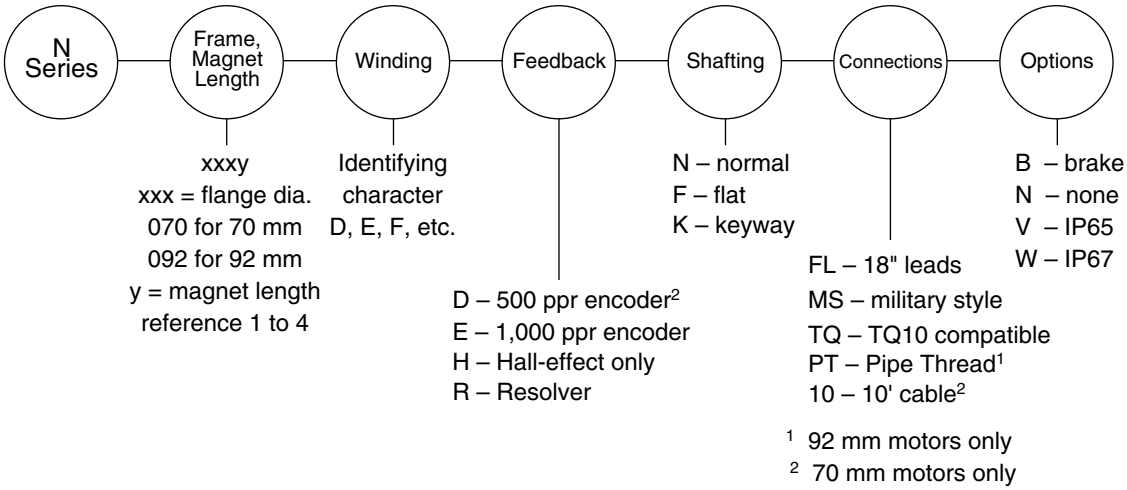


[1] includes Hall effect sensors
[2] not available on size 16 motors
[3] cable is hardwired to motor
[4] size 23 with MS or TQ connectors–IP65

Example: SM-231AE-NTQN = 23 Frame, 1" magnet, A winding, 1,000 line Encoder, Normal Shaft, TQ10 compatible, No options

Motor Part Numbering System— Compumotor NeoMetric Series Servo Motor

The diagram below illustrates the part numbering system for Compumotor NeoMetric Series servo motors.



[1] 92 mm motors only
[2] 70 mm motors only

Example: N0702EE-KMSN

CHAPTER FOUR

4 Troubleshooting

IN THIS CHAPTER

- Troubleshooting Basics
- Diagnostic LEDs
- Non-Drive Related Problems
- Protective Circuits
- Product Return Procedure

Troubleshooting Basics

When your system does not function properly (or as you expect it to operate), the first thing that you must do is identify and isolate the problem. When you have accomplished this, you can effectively begin to resolve the problem.

The first step is to isolate each system component and ensure that each component functions properly when it is run independently. You may have to dismantle your system and put it back together piece by piece to detect the problem. If you have additional units available, you may want to exchange them with existing components in your system to help identify the source of the problem.

Determine if the problem is mechanical, electrical, or software-related. Can you repeat or recreate the problem? Random events may appear to be related, but they are not necessarily contributing factors to your problem.

You may be experiencing more than one problem. You must isolate and solve one problem at a time. Log (document) all testing and problem isolation procedures. You may need to review and consult these notes later. This will also prevent you from duplicating your testing efforts.

Once you have isolated a problem, take the necessary steps to resolve it. Refer to the problem solutions contained in this chapter. If the problem persists, contact your local technical support resource.

Diagnostic LEDs

The TQ10 Drive has five LEDs on its front panel. The following summary of LED functions may help you isolate problems.

LED Name	Color	Function
MOTOR FAULT	Red	Indicates short circuit in motor or cabling; or, Indicates motor overtemperature; or, Indicates Hall miswiring, or damaged Hall sensor; or, Indicates foldback with fault-on-foldback set.
DRIVE OVERTEMP	Red	Indicates drive has exceeded temperature limit
REGEN/	Green	Illuminates green during regen event;
OVERVOLTAGE	Red	Illuminates red if regen causes overvoltage
PEAK CURRENT/	Green	Illuminates green during peak current output;
IN FOLDBACK	Red	Illuminates red while drive is in foldback
POWER ON/	Green	Illuminates green when AC power is applied;
NOT ENABLED	Red	Illuminates red when AC power is applied but drive is not enabled

Non-Drive Related Problems

When the drive is powered up, enabled, and operating properly:

- The **POWER ON** LED is illuminated green
- No LEDs are illuminated red
- The fault output is LOW

These conditions indicate that the TQ10 is probably not the source of the problem. The next table summarizes other possible sources of problems.

TROUBLESHOOTING TABLE

Possible Source of Problem	*SOLUTION*
CONTROLLER/ INDEXER	Cycle power to clear fault latch. Verify control voltage at TQ10 Torque Drive command input. Verify step/direction pulses at TQ10SD step/direction inputs.
MOTOR	Check for motor problems. Check motor coils for continuity, shorts, proper resistance. Check Hall and Phase wiring.
MECHANICAL SYSTEM	Check for jams, binds, increased friction, etc. Uncouple motor from load to test motor separately.
WIRING	Check motor wiring: phases, Hall effects. Check controller/indexer wiring, especially enable.
OVERHEATING	Verify that drive's heatplate has good thermal contact with heatsink. Check mounting screws. Provide sufficient ventilation.
AC POWER	Verify AC power mains supply delivers enough power during entire move without undervoltage, especially during acceleration.
MOVE PROBLEMS	Check speed/torque limitations. Check for excessive friction, regeneration, problems with gravity, transient undervoltage, etc.
ELECTRICAL NOISE	Check for problems caused by electrical noise. Consult the Compumotor sales guide for possible solutions. Check grounds.

Problems During Move

Some problems occur transiently during a move, or do not affect the LEDs. Others may be due to wiring mistakes, or failure of other components in the system (controller or indexer, encoder, motor, etc.). The sections below will help you identify such problems.

Speed/Torque Limitations

Make sure that you are not commanding a move that requires the motor to go faster than it can, or use more torque than it can produce. Check the motor's speed/torque curve for your operating conditions.

Acceleration

Some problems during acceleration can be caused by an undervoltage on the AC power line (this can be a transient event), an unrealistic move profile, or too much load inertia.

Deceleration

Some problems during deceleration can be caused by excessive regeneration, resulting in an overvoltage fault.

Excessive Friction

Too much friction in your system might cause move problems. Excessive friction can cause trouble when mechanical components in a system age. As friction increases, problems may occur in a system that had previously been working well.

Mechanical Problems

Check for binds, jams, increased friction, or other problems in the mechanical system. If a system was working properly, but then suddenly develops new problems, check for changes in the mechanical system that could be causing the problems—increased friction, lack of grease, worn bearings, etc.

Encoder Problems

Encoders that are miswired or malfunctioning can cause problems during a move. Check wiring from the encoder to the controller, or to the TQ10SD. To isolate a malfunctioning encoder, rotate the motor shaft a known distance, and check the encoder readout (the TQ10SD has no encoder readout). Verify that the encoder is properly coupled to the motor shaft, especially during rapid acceleration. Some symptoms of encoder problems are no motion, or motor runaway.

Electrical Noise Problems

Electrical noise can cause problems, depending on the application and the sensitivity of equipment in the system. For more information on identifying problems caused by electrical noise, and solutions to those problems, consult the technical section in Compumotor's current catalog.

Protective Circuits

The TQ10 Drive has several protective circuits, some of which can indicate fault conditions by illuminating one of the LEDs.

Drive Overtemperature Protection

To protect against damage from high temperatures, the TQ10 Drive has an internal temperature sensor. If the output stage overheats, the red **DRIVE OVERTEMP** LED will illuminate, and the drive will shut down. This is a latched fault. To restart the drive, first allow it to cool, then cycle power; or, with the TQ10 Torque drive, you can use the reset input. You can prevent overtemperature faults by heatsinking the drive properly (or adding the -HS3 Heatsink/Fan Unit option), and maintaining ambient temperature at or below 50°C (122°F).

Short Circuit Protection

The TQ10 Drive has short circuit protection. The drive monitors current in its motor output terminals. When the drive detects a short circuit in the motor or motor cabling, it illuminates the **MOTOR FAULT** LED, and stops producing motor current. This is a latched condition. To restart the drive, first fix the short in the motor or cable, then cycle power.

Regeneration

The TQ10 Drive has an internal regeneration resistor. If the motor *regenerates*—produces excess energy during deceleration—the drive will automatically dissipate the excess energy in its regeneration resistor. The power capacity of the resistor is 1KW for one second, or 10 watts on a continuous basis. If the motor regenerates more energy than can be dissipated in the regeneration resistor, the resulting voltage rise on the drive's motor output terminals can cause an overvoltage fault (see below).

If excessive regeneration repeatedly causes overvoltage faults, you may need to alter your move profile, change application conditions, or install an external regeneration resistor (see *Chapter 2, Installation* for instructions).

Vertical applications require careful sizing, and should use a mechanical brake to aid in deceleration.

Overvoltage

The TQ10 Drive monitors the voltage on the motor output terminals. If the voltage rises above a threshold level, the drive will shut down power output to the motor, and will illuminate *red* the bicolor LED labeled **RED = OVERVOLTAGE**. Excessive regeneration is the primary cause of an overvoltage fault.

This is a latched fault. To resume operations, cycle power; or, with the TQ10 Torque drive, you can use the reset input.

Undervoltage

The TQ10 Drive monitors the voltage on its AC power input terminals. If the voltage falls below 80VAC, the drive will shut down and activate its fault output. When you apply power to the drive, the power-up event is indistinguishable from an undervoltage; therefore, the undervoltage fault is not latched. Furthermore, an undervoltage fault will unlatch any other faults that may be present at the time of the undervoltage.

There is no LED indicator for an undervoltage fault.

Foldback

A mechanical jam in a servo system can cause the motor to overheat. In contrast to a stepper motor, which does not run hotter when jammed, a servo will apply full current (for full torque) while it attempts to move as commanded. Usually, this current will be *much* higher than the motor can withstand continuously. If it persists indefinitely, it may damage the motor's windings.

To help protect the motor from overheating, the TQ10 has a *current foldback* circuit. If high motor current persists for too long, the circuit can cause a fault, or reduce the current to a lower level that decreases the rate of motor heating.

Three of the DIP switches on top of the drive allow you to set the maximum current the drive will produce ("**PEAK CURRENT LIMIT**"). These switches should be set to a value no greater than three times the continuous current rating (Ics) of the motor used. This setting is used by the foldback circuitry to help protect the motor.

Six of the DIP switches configure the foldback circuitry. Three of them set the time that "high" current will be permitted before the foldback circuitry takes action. Settings range from 1 to 10 seconds. One switch defines what constitutes "high" current. This is set according to Ics. One switch will cause a latched fault to be generated when the selected time at high current is exceeded, otherwise current is reduced ("folded back") to 40% of the peak current limit setting. One switch allows foldback to be disabled entirely. See *Chapter 2—Installation* and *Chapter 4—Tuning* (Tuning Procedure) for instructions on setting the dip switches.

How Foldback Works

When actual current produced by the drive exceeds the threshold (relative to the peak current limit) set with SW2-2, the foldback circuit illuminates the **PEAK CURRENT** LED green, and starts a timer. If the current remains above this threshold for longer than the time set with the time-at-peak dipswitches, the foldback circuit activates, and the IN **FOLDBACK** LED illuminates red. The circuit can generate: A) A latched fault, if so configured, or B) reduce current to 40% of the peak current limit setting.

In case A (with **SW2-1 ON**), the fault will remain until power is cycled, or the **RESET** input is asserted. This fault condition will be indicated by a red **MOTOR FAULT** LED, and an active **FAULT OUT** signal. The **IN FOLDBACK** LED may go out when the **MOTOR FAULT** comes on, depending on the load. When faulted, the motor current will be reduced to zero.

In case B (with **SW2-1 OFF**), the current reduction will persist until the command input goes below the actual current, when the circuit will once again allow the full current permitted by the peak current limit setting. While foldback is limiting the current, the **IN FOLDBACK** LED will be red. When the command is reduced, the LED will go out. The **FAULT OUT** will not go active, since current foldback is not considered a fault.

Oscillating currents, such as are seen when a system goes unstable during tuning, will activate the foldback circuit if the current gets high enough, and the frequency of oscillation is greater than about 20 Hz. Systems in this power range typically have resonant frequencies much higher than this. The default settings suggested for each motor will result in a latched fault after about 3.3 seconds above threshold. This time can be selected with SW1-4,5,6. The sequence of events is: Current exceeds threshold, illuminating the **PEAK CURRENT** LED (green). If this continues for longer than 3.3 seconds, the **IN FOLDBACK** LED will illuminate red, and current will be reduced.

If **SW2-1** is **ON**, then the **MOTOR FAULT** LED (red) will illuminate. The **IN FOLDBACK** LED may go out when the **MOTOR FAULT** LED turns on, depending on the load. Current will be reduced to zero and the **FAULT OUT** will go active. This setting is recommended for nearly all applications, since it causes a motor fault to be indicated. In most applications, allowing the current to be reduced by foldback (without causing a fault) will result in the controller faulting from excess position error, masking the source of the problem, or in the production of defective product. The latched drive fault will lead the troubleshooter to the source of the problem more directly. A mechanical jam, or increased friction in the mechanical system are the common causes.

An exception to this would be an application where stopping the axis will lead to unacceptable consequences, and continued motion, even at a reduced rate, is preferable. An example of this would be a conveyor drive running product through an oven which is hot enough to melt the product eventually.

The default settings cause the timer to start when the current is approximately twice the motor's continuous rating (2 times Ics). The thermal switches in Parker servo motors will protect a properly mounted motor in its specified ambient temperature, up to at least twice Ics, at which point foldback takes over. If the peak current limit is set to three times Ics as recommended, foldback will reduce current to a level below twice Ics, reducing the rate of motor heating enough to give the thermal switch time to react, and protect the motor.

Note that foldback is not a substitute for proper sizing of the application, and does not enforce a lengthy cooling-off period. As soon as the command goes below the actual current, the circuit starts over. Applications with insufficient dwell time to allow the motor to cool between periods of peak current will not be successful.

Foldback is intended to be a secondary safety net. Primary protection of the motor during application problems should be provided by end-of-travel-limit switches, and by proper setting of position-error faults in the controller. These will provide quicker, more direct detection of end-stop or mechanical jamming problems in the application than foldback can. If these systems fail, foldback can generate a fault (which stops all motor current) or reduce the rate of motor heating to enable the thermal switch to operate.

Hall Miswiring

The drive will produce a motor fault and illuminate the red **MOTOR FAULT** LED if it detects an improper Hall state on its Hall effect inputs (all HIGH or all LOW), or if no motor is connected to the drive. A damaged Hall sensor can also activate the motor fault protection circuit.

To diagnose Hall miswiring or a damaged Hall sensor:

① **Remove AC power**

② **Disconnect I/O:** Disconnect all front panel inputs and outputs, except for enable input, motor temp±, and Hall signals (Hall 1 – 3, Hall +5, Hall Gnd).

③ **Apply AC power**: If the **MOTOR FAULT** LED is still illuminated, then one or more Hall sensors in the motor may be damaged.

④ This can be verified with a volt meter or oscilloscope. Monitor the three Hall inputs at the connector, relative to Hall ground. Slowly rotate the motor. A damaged, miswired, or disconnected Hall signal will cause the "all HIGH" or "all LOW" state to occur at some shaft position.

⑤ Note that "open-collector" Hall outputs must be used. Contact factory if you must use "differential" Hall-output motors.

Motor Overtemperature Protection

The TQ10 Drive has a circuit that can protect the motor against overheating. Through its **MOTOR TEMP+** and **MOTOR TEMP–** terminals, the drive checks for electrical continuity provided by a normally-closed thermostat mounted on the motor. If the motor overheats and the thermostat opens, the loss of continuity activates protection circuitry in the TQ10—it turns off power output to the motor, and illuminates the **MOTOR FAULT** LED.

This is a latched fault. To resume operations, let the motor cool, then cycle power; or, with the TQ10 Torque drive, you can use the reset input.

A motor overtemperature fault may be an indication that your motor is not sized properly for your application. It may also indicate that your motor is not installed properly (poor heatsinking, for example).

A thermostat cannot protect the motor in every situation! Bursts of peak current produce bursts of heat that are quickly absorbed in the motor windings, but slowly dissipated through the motor case and mounting flange. If the bursts are short and infrequent, winding temperature and thermostat temperature will be similar, and the thermostat can protect the motor. If full current flows continuously in the motor, however, the windings can exceed their rated temperature and be damaged, even before the thermostat temperature rises enough to trigger a motor fault.

Technical Support

If you cannot solve your system problems using this User Guide, contact your local Automation Technology Center (ATC) or distributor for assistance. If you need to talk to our in-house application engineers, contact Parker Compumotor's Applications Department at (800) 358-9070, from 6:00 AM to 5:00 PM Pacific time.

Product Return Procedure

If you must return your TQ10 Drive for repairs, use the following steps:

① Get the serial number and the model number of the defective unit, and a purchase order number to cover repair costs in the event the unit is determined to be out of warranty.

② Before you return the unit, have someone from your organization with a technical understanding of the TQ10 Drive and its application include answers to the following questions:

- What is the extent of the failure/reason for return?
- How long did the unit operate?
- Did any other items fail at the same time?
- What was happening when the unit failed (e.g., installing the unit, cycling power, starting other equipment, etc.)?
- How was the unit configured (in detail)?
- What, if any, cables were modified and how?
- With what equipment is the unit interfaced?
- What was the application?
- What was the system environment (temperature, enclosure, spacing, unit orientation, contaminants, etc.)?
- What upgrades, if any, are required (hardware, cables, user guide)?

③ In the USA, call your Automation Technology Center (ATC) for a Return Material Authorization (RMA) number. Returned products cannot be accepted without an RMA number. If you cannot obtain an RMA number from your ATC, call Parker Compumotor's Customer Service Department at (800) 722-2282.

Ship the unit to: Parker Hannifin Corporation
Compumotor Division
5500 Business Park Drive, Suite D
Rohnert Park, CA 94928
Attn: RMA # xxxxxxx

④ In Europe, call Parker Digiplan for a GRA (Goods Returned Authorization) number. *Returned products cannot be accepted without a GRA number.* The phone number for Parker Digiplan Repair Department is 0202-690911. The phone number for Parker Digiplan Service/Applications Department is 0202-699000.

Ship the unit to: Parker Digiplan Ltd.,
21, Balena Close,
Poole, Dorset,
England. BH17 7DX

⑤ Elsewhere: Contact the distributor who supplied the equipment.

APPENDIX A

A Using Non-Compumotor Motors

IN THIS APPENDIX

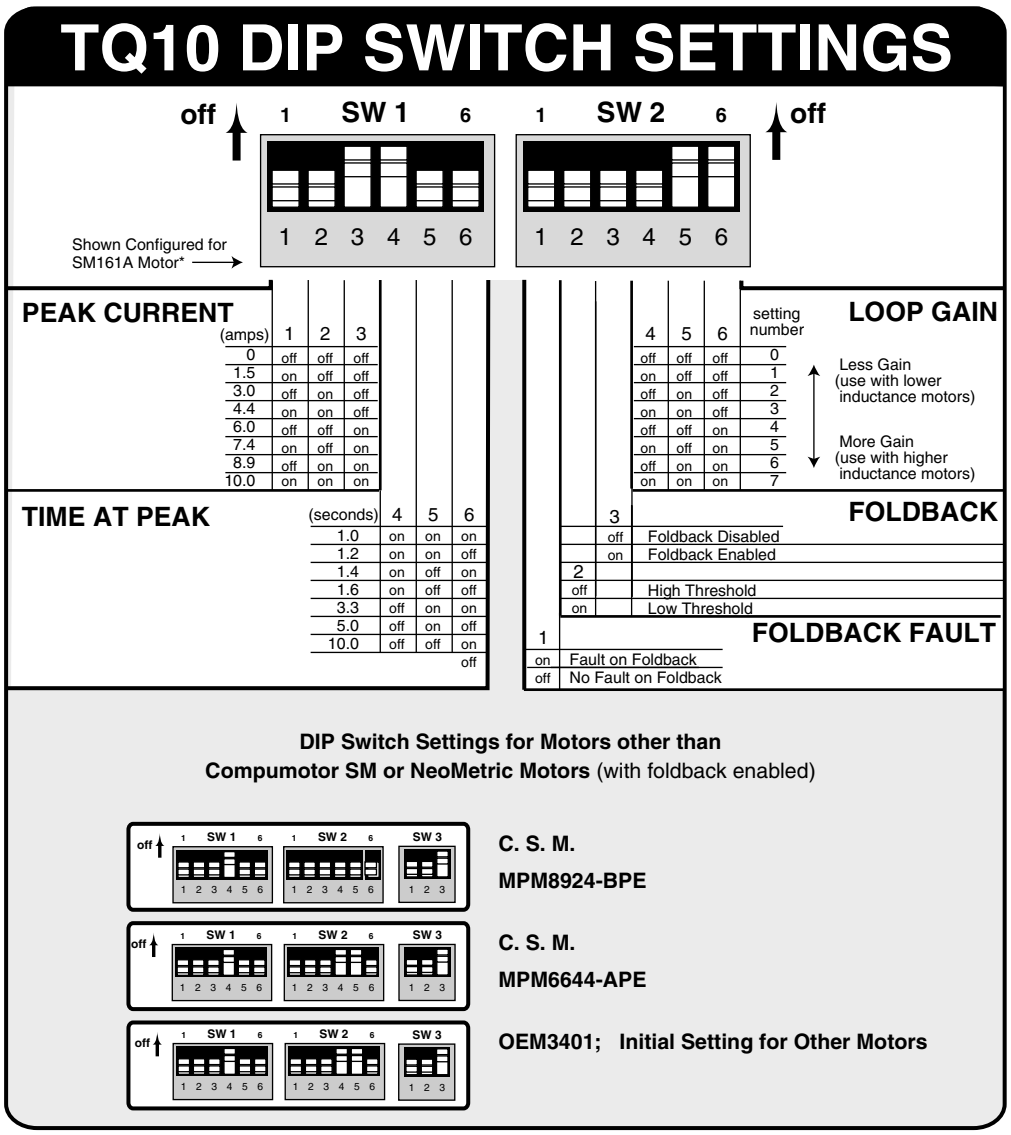
- Configuring DIP Switches
- Connecting Motor Phase Wires and Hall Effect Wires

Using Motors other than Compumotor SM or NeoMetric Series Motors

Test all motors carefully. Verify that the motor temperature in your application is within the system limitations. *The motor manufacturer's maximum allowable motor case temperature must not be exceeded.* You should test the motor over a 2-to-3 hour period. Motors tend to have a long thermal time constant, but can still overheat, which results in motor damage.

Configuring the TQ10 Drive's DIP Switches

Set the TQ10's 12 DIP switches located on top of the drive, and three DIP switches located on the bottom of the drive. The following drawing shows DIP switch settings for selected motors.



DIP Switch Settings – Non-Compumotor SM or NeoMetric Motors

If you are unsure of which settings to use for your motor, start with the setting shown above for the OEM3401 motor. If the motor gets hot when it is stopped, reduce the loop gain setting (DIP SW2 — #4, #5, #6).

The DIP switch settings shown above will enable foldback—after approximately three seconds at full current, the drive will fault due to foldback. These settings will help protect your motor while you prototype your system. To disable the foldback fault, to adjust time until foldback, or to disable foldback entirely, adjust the DIP switches.

If you have further questions, *first consult your motor vendor* to obtain a full and complete motor specification sheet. Consult your Automation Technology Center (ATC) if you have questions regarding the use of a non-Compumotor motor with Compumotor equipment. If you still need further information, call Compumotor's Application Engineering Department at (800) 358-9070.

Connecting Motor Phase Wires and Hall Effect Wires

If you use a motor from another vendor, obtain information from the motor's manufacturer about its phase wire color code, sequence of Hall states, commutation scheme, etc. Use the information below for guidance on how to connect your motor's phase and Hall wires to the TQ10.

Improper Wiring Can Result in Poor Performance

Assume that you arbitrarily connect your motor's three Hall wires to the TQ10's Hall inputs. For any particular Hall wiring pattern, there are six different ways you can connect wires to Phase A, Phase B, and Phase C.

Of these six possible phase wiring combinations, only one will work properly. Three will not work at all. The other two deserve particular attention: if the motor is wired in one of these two configurations, the motor will turn, but its performance will be severely impaired.

How can you tell if your motor is wired improperly? If it is in one of the two poor-performance configurations, its torque will be much lower than the torque level of a properly wired motor. Also, torque ripple will be very pronounced as the motor turns.

The best way to determine whether or not your motor is wired correctly is to find the three wiring configurations that enable the motor to turn. Compare the motor's torque in each configuration. The configuration with the most torque will be the proper configuration.

Trial and Error Method

WARNING
Motor shaft rotation may be opposite than you expect. Do not connect a load to the shaft until you first determine the direction of shaft rotation.

You can use a trial and error method to connect your motor to the TQ10. Follow these steps:

① Arbitrarily assign numbers to your motor's three Hall output wires, and connect them to **HALL 1**, **HALL 2**, and **HALL 3** on the TQ10.

② Connect **HALL +5V** and **HALL GND**.

③ Arbitrarily assign letters (A, B, C) to your motor's phase wires, and connect them to Phase A, Phase B, and Phase C on the TQ10.

④ If the motor turns, find the best phase wiring configuration:

- Move each phase wire over one position (A B C ➔ C A B). Compare torque and torque ripple.
- Move each phase wire one position further (C A B ➔ B C A). Compare torque and torque ripple.
- Use the wiring configuration that gives highest torque and lowest torque ripple.

⑤ If the motor does not turn, exchange two of the phase wires. The motor should now turn. Go to Step ④, compare the three wiring configurations that make the motor turn, and use the proper one.

⑥ If your motor turns in the opposite direction than you want, you can reverse it using one of several methods.

- Reverse the appropriate encoder connections.
- Exchange two Hall input wires, then follow steps 2 through 5 above.

APPENDIX B

LVD Installation Instructions

IN THIS APPENDIX

- LVD Installation Instructions

For more information about LVD, see 73/23/EEC and 93/68/EEC, published by the European Economic Community (EEC).

Environmental Conditions

Pollution Degree

TQ10 Drives are designed for pollution degree 2.

Installation Category

TQ10 Drives are designed for installation category II.

Electrical

Connecting and Disconnecting Power Mains

The TQ10 Drive's protective earth connection is provided through its make first/ break last earth terminal on the power mains connector. You must reliably earth the TQ10 Drive's protective earth connection.

Attach or remove the TQ10 Drive's power plug only while input power is OFF.

Using an Isolation Transformer

The TQ10 Drive's mains voltage is limited to 120 VAC nominal. If your mains voltage is higher, use an isolation transformer located between the power mains and the TQ10 Drive. Your isolation transformer should be insulated to ~2300V rms.

Do not interrupt the protective earth conductor between the source mains and the isolation transformer's secondary. The core of the isolation transformer and the drive's protective conductor terminal must *both* be connected to the main's protective earth conductor.

CAUTION

Do not use an autotransformer.

Line Fuses

Line fuses need to be added to protect the transformer and associated wiring. If the live wire cannot be readily identified, fuse both phase conductors. The value of fuse required is given by:

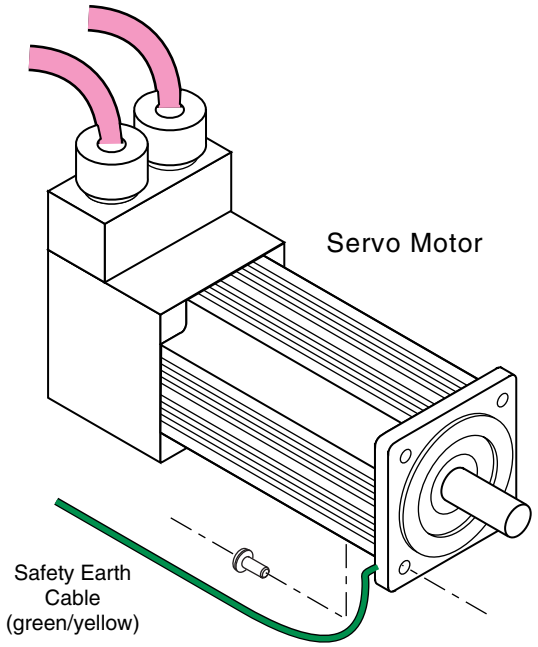
(1.5 x VA)/(supply volts) [amps]

Fuse types should be anti-surge HBC.

Providing a Protective Earth Connection for Motors

You must provide a connection from the motor to a reliable protective earth contact point. This connection provides a protective earth for the motor, and is *in addition* to the earth connection provided by the drain wire in the motor's power cable. The motor's protective earth connection is important for safety reasons, and *must not be omitted*.

Make connections according to the following instructions and diagram:



Providing Protective Earth Connection for Motor

① Use a spade lug in combination with a star washer and mounting bolt to make good contact with the bare metal surface of the motor's mounting flange.

② Use a green and yellow striped wire to make the connection between the motor and earth. Wire gauge must be no thinner than the current carrying wire in the motor's power cable.

③ Resistance between the motor and earth must be no greater than 0.1 ohm. Use thicker gauge wire if the resistance is too high.

Mechanical

Installing in an Enclosure

TQ10 Drives must be installed within an enclosure. The enclosure's interior must not be accessible to the machine operator. The enclosure should be opened only by skilled or trained service personnel.

Servicing the TQ10 Drive

Changing Firmware

Only skilled or trained personnel should change firmware.

Do Not Replace Fuses

The TQ10 Drive has no fuses designed to be replaced by the user. Fuse failure indicates that other components have also failed. Fuses and other components should only be replaced by Compumotor or its designated repair facilities.

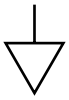
Thermal Safety

The Motor May Be Hot

The motor may reach high temperatures during normal operations, and may remain hot after power is removed.

Table of Graphic Symbols and Warnings

The following symbols may appear in this User Guide, and may be affixed to the products discussed in this user guide.

Symbol	Description
	Earth Terminal
	Protective Conductor Terminal
	Frame or ChassisTerminal
	Equipotentiality
	Caution, Risk of Electric Shock
	Caution, Refer to Accompanying Text
	Hot Surface

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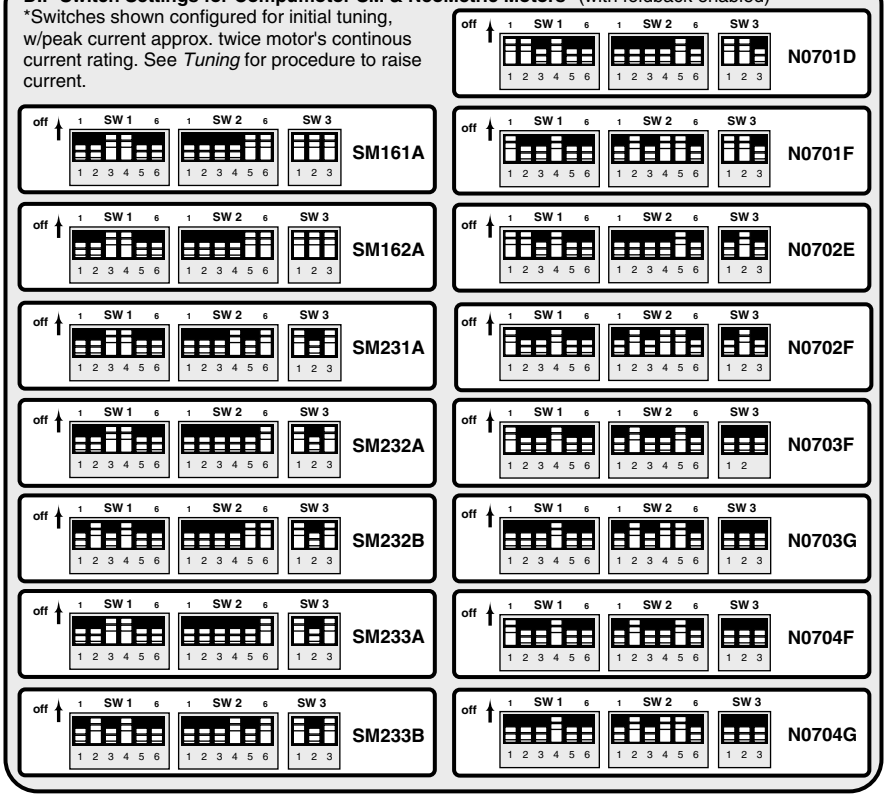
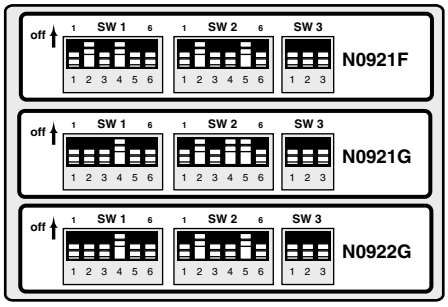
TQ10 Drive
Compumotor

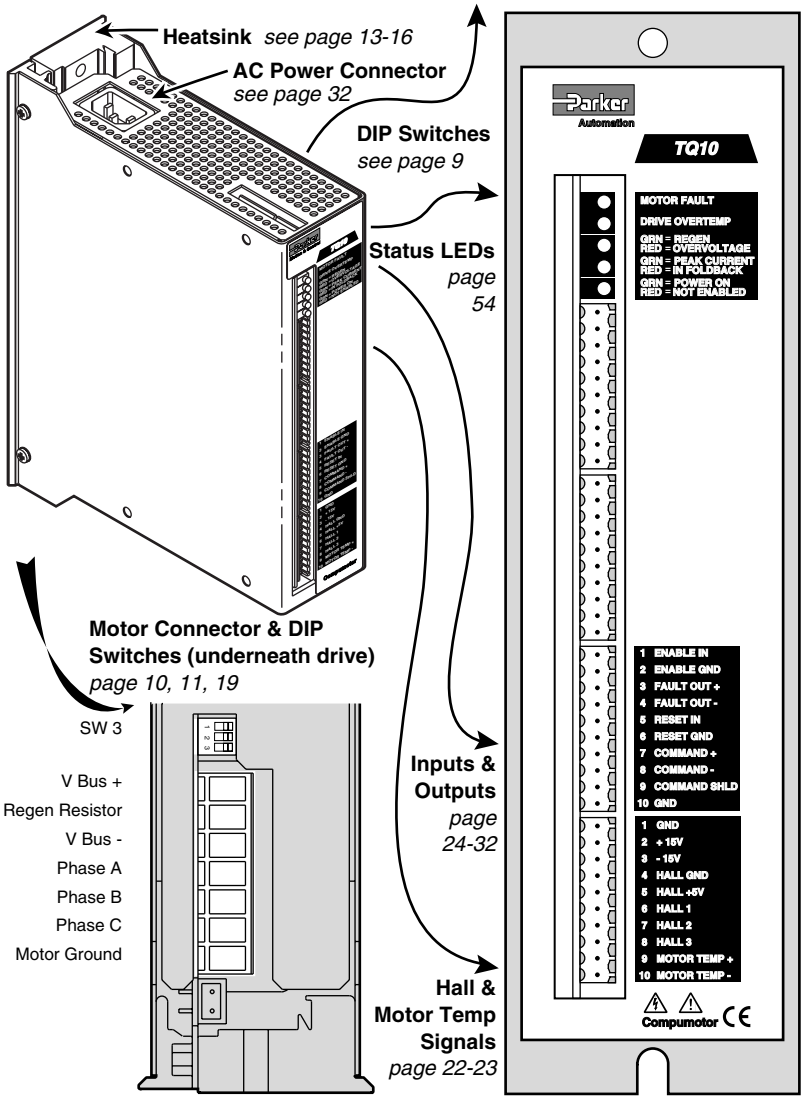
DIP Switch Settings for Compumotor SM & NeoMetric Motors* (with foldback enabled)
*Switches shown configured for initial tuning, w/peak current approx. twice motor's continous current rating. See *Tuning* for procedure to raise current.



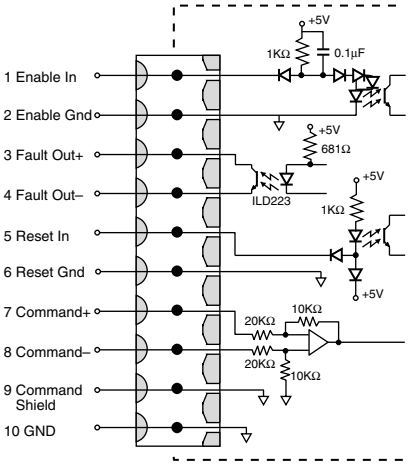
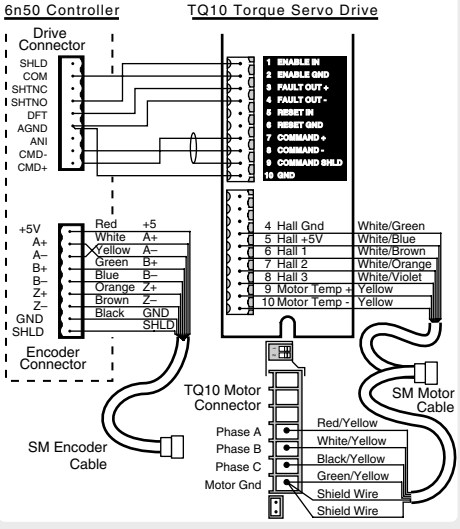


TQ10 Status LEDs *see page 54*

MOTOR FAULT	Red indicates short circuit in motor cabling, or indicates motor overtemperature.
DRIVE OVERTEMP	Red indicates drive has exceeded temperature limit.
REGEN/ OVERVOLTAGE	Illuminates green during regen event; illumates red if regen causes overvoltage.
PEAK CURRENT/ IN FOLDBACK	Illluminates green during peak current output; illuminates red while drive is in foldback.
POWER ON/ NOT ENABLED	Illuminates green when AC power is applied; illuminates red when AC power is applied but drive is not enabled.



TQ10 Torque Servo Drive – Inputs & Outputs
see page 24-32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