COMPUMOTOR CORPORATION

Q-SERIES

OPERATOR'S MANUAL

Motor # SM 365r-A-Ø-3-1-2
Brush # YPØØ373

P/N 88-004833-02

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Table of Contents

Manual 88-004833-02Y

INTRODUCTION

1. Description

The Q-Series is a complete DC Servo positioning sytem. Ready to run, the Q-Series system consists of a DC servomotor, brushless resolver feedback, and a microprocessor based closed loop drive amplifier. Digital electronics simplify operation and maintenance and improve performance.

The Q-Series drive accepts digital STEP and DIRECTION inputs to control position and velocity. The onboard microprocessor monitors both the pulse inputs and the resolver feedback, then determines the proper voltage levels to apply to the motor. The system offers speeds to 3600 RPM, and torques to 34 lb.-in. (540 oz.-in.) continuous and 100 lb.-in. (1600 oz.-in.) peak.

Closed-loop performance is simplified by microprocessor control and a sophisticated servo algorithm. All servo performance parameters are stored in non-volatile EEPROM memory, eliminating analog potentiometer adjustments required in conventional systems. Q-Series Motor/Drives are supplied as packaged systems, factory compensated for typical load and performance requirements.

Q-Series systems are readily installed and operated by personnel with little or no training in servo controls. In most applications, no adjustments will be required. A simple pushbutton adjustment is provided to alter factory set servo constants for special loads. In addition, an RS-232 interface is provided to access all servo parameters for the few cases where critical adjustment is required.

The power amplifier section of Q-Series drives utilizes a proprietary MOSFET hybrid power module for high frequency (20 kHz) pulse width modulation (PWM) current control. This innovative design improves efficiency, regulation and low speed smoothness, and results in virtually inaudible operation.

Features of the Q-Series Include:

* DC servomotor
* Brushless resolver feedback
* Speeds to 3600 RPM
* Torques to 100 lb.-in. (1600 oz.-in.)
* 4096 steps per revolution standard
* 6384 steps per revolution optional (35 RPS max speed)
* Microprocessor control; no drift, no analog pots to adjust
* Compact convection-cooled drive enclosure
* Inaudible 20 kHz PWM switching frequency
* Accepts digital STEP and DIRECTION inputs
* Servo parameters factory set and stored in non-volatile EEPROM memory
* High noise immunity due to optical isolation and brushless resolver technology
* Simple pushbutton adjustment of servo compensation

3. Pre Installation

Please read this entire manual carefully before attempting to install or operate the Q-Series system. If any questions should arise which are not covered to your satisfaction in this manual, please call Compumotor for assistance.

INSPECTION

Your Q-Series should be inspected upon receipt for obvious damage to its shipping container. Report any such damage to the shipping company as soon as possible, as Compumotor cannot be held responsible for damage incurred in shipment. The Q-Series should then be carefully unpacked and inspected for the following items to be present and in good condition.

1. Q-Drive unit
2. Motor
3. Motor cable (round MS connector one end, 4-pin screw terminal connector other end)
4. Resolver cable (round MS connector one end, 9 Pin D connector other end)
5. AC power connector with plastic interlock cover
6. Pushbutton tuning key
7. 2 ea. 6-32 x 0.75 inch screws
8. Drive Enable Connector
9. This manual

WARRANTY INFORMATION

Your Q-Drive is warranted against manufacturing defects for one year from the date of purchase. Should you have questions about operating the Q-Drive, your Compumotor representatives and distributors stand ready to support your individual needs. Call Compumotor Corporation at the number listed below to get the name, address and phone number of the Compumotor representative nearest you.

Should return of your Motor Controller be required to effect repairs or upgrades, do the following:

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 by Compumotor upon inspection.

2. Call Compumotor for a Return Material Authorization Number (RMA) at 800-358-9068 except in California. In California, call collect at 707-778-1244.

3. Ship the unit to: Compumotor Corporation
   1179 N. McDowell Blvd.
   Petaluma, CA 94952
   Attn: RMA# xxxxxxxx

INSTALLATION AND HOOKUP

1. General

Safety is of primary importance when installing a motion control system. This section outlines installation guidelines with the safety of the operator and the equipment in mind. The installer of this equipment should be familiar with this section and with local and national codes which pertain to installation of electrical equipment before attempting the installation.

2. System Installation Recommendations

Special attention should be given to the environment in which the equipment will be operated, the layout and mounting, and the wiring and grounding practices used, to ensure trouble free operation. These recommendations are intended to aid the user in easily and safely integrating Compumotor equipment in his manufacturing facility.

Industrial environments often contain conditions which may adversely affect solid state equipment. Electrical noise, atmoshpheric contamination, or excess heat may be generated by other equipment in use.

A. Electrical Noise

When a Q-Series system will be operated in an environment where there is an excess amount of electrical noise, special care must be taken to eliminate sources of possible noise interference. Potential sources of electrical noise include inductive devices such as solenoids, relays, motors, and motor starters when operated by a hard contact.

Noise suppression may be necessary when these types of devices are connected to the same AC power source or are in close proximity to electronic equipment. The illustration below shows some recommended suppression devices for most small loads. For best results these should be installed as close as possible to the inductive load.

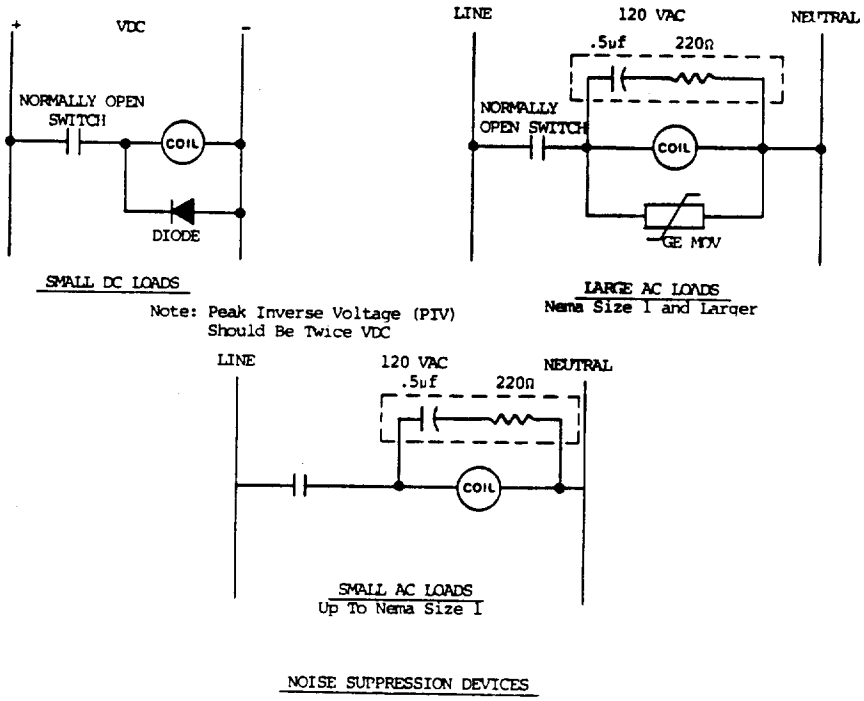


Figure 1. Recommended Supression For Small Inductive Loads

B. Enclosure Considerations

The Q-Drive should generally be installed in an enclosure to protect it against atmospheric contaminants such as oil, moisture, and dirt. The National Electrical Manufacturers Association has established standards which define the degree of protection provided by electrical enclosures. The enclosure should conform to NEMA Type 12 standards if the intended environment is industrial in nature and contains airborne contaminants. Proper layout of components is required to ensure sufficient cooling of equipment within the enclosure.

C. Grounding Information

Proper grounding of electrical equipment is essential to assure the safety of personnel. The affects of electrical noise due to electromagnetic interference (EMI) can also be reduced by grounding. All Compumotor equipment should be properly grounded. A good source of information on grounding requirements is the National Electrical Code published by the National Fire Protection Association of Boston, Massachussets. Grounding should also conform to applicable local codes and ordinances.

In general, all components and enclosures must be connected to earth ground through a grounding electrode conductor to provide a low-impedence path for ground fault or noise induced currents. All earth ground connections must be continuous and permanent.

Componenents and mounting surfaces should be prepared prior to installation so that good electrical contact is made between mounting surfaces of equipment and enclosure. Paint should be removed from equipment surfaces where they will be bolted to a panel and star washers should be used to assure a solid bare metal contact. An 8 guage or larger copper wire should be used to connect each component from a mounting stud to a central ground bus. Permanent ground connections should be made to only one mounting bracket on each piece of equipment. If this method is used, there should be no connection to the ground terminal of the AC Power connector.

For temporary installations, or when the grounding method described above cannot be implemented, the GROUND terminal on the AC power connector must be connected to earth ground.

3. Mounting

A. Panel Layout

A good panel layout is essential for trouble free operation of the Q-Drive. The Q-Drive relies on convection cooling to maintain the temperature within its operating range. Panel mounting requires consideration of this to allow sufficient space for unrestricted airflow over the heatsink. Because convection cooling draws air upward over the heatsink the air directly beneath the unit must not exceed the recommended maximum ambient temperature of 50 degrees C.

The Q-Drive should be mounted in an area that will allow air to circulate over its heat sink. Sufficient cooling may be derived from convection cooling at operation up to six amps of continuous motor current output, provided the Q-Drive is mounted in free air with its heat sink aligned vertically. In a normal factory environment this will seldom be a problem. The Q-Drive is designed to operate in an environment ranging from 0°F to 122°F (0 to 50°C). In a confined environment the Q-Drive may require forced air cooling. The limiting factor is the heatsink temperature, which must be no greater than 65°C. If cooling is necessary, a fan kit is available from Compumotor which mounts directly on the heatsink.

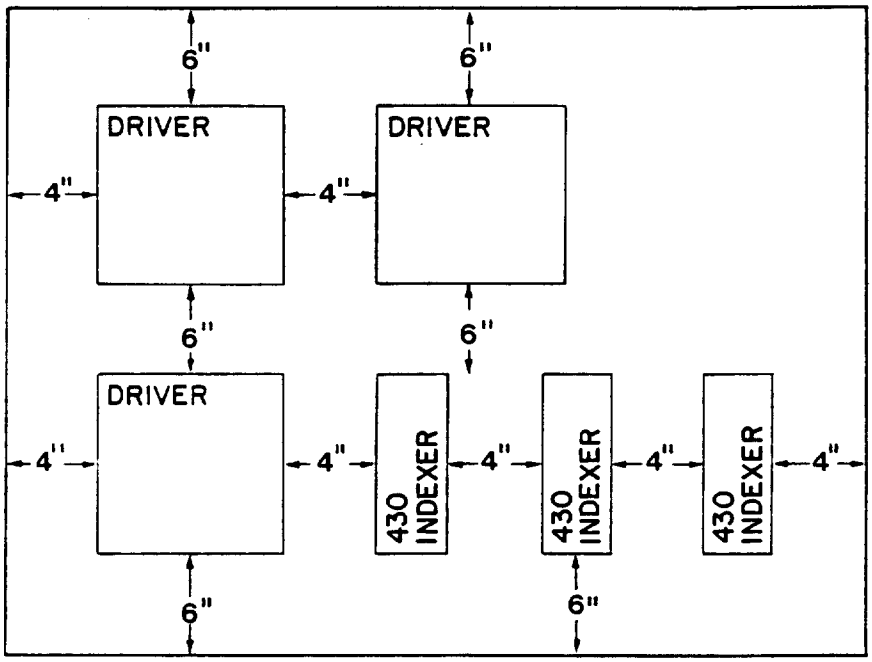
The following rules should be observed when mounting Q-Series drives in an enclosure:

1. The vertical distance between the Q-Drive and other equipment or the top and bottom of the enclosure should be no less than 6 inches.

2. The horizontal distance between the Q-Drive and other equipment or the side walls of the enclosure should be no less than 4 inches.

3. Because motor/drive products produce more heat than indexers, drives should not be mounted directly below indexers if possible.

4. Large heat producing equipment should not be mounted directly beneath the Q-Drive.



PANEL LAYOUT RECOMMENDATIONS

Figure 2. Recommended Panel Layout Guidelines

B. Panel Mounting

The Q-Drive has "L" shaped mounting brackets, notched to accept screws on either end to facilitate mounting to flat panel surfaces. The unit should be securely mounted to prevent it from moving unexpectedly, as this could cause an unsafe condition to occur, and could lead to damage of the Q-Drive.

CAUTION

The high voltage connections--both 120 VAC line power and motor drive power--have voltages present on them which are hazardous to personnel and could damage other electrical equipment. **Caution** should be used in the installation and operation of the Q-Drive so that this danger is minimized. The Q-Drive has been provided with a safety-interlock cover which prevents opening the enclosure with power applied. It is recommended that the safety-interlock cover be used in all installations of the Q-Drive.

C. Motor Mounting

When mounting a servo motor, several factors require important consideration to ensure long life and trouble free operation. this section provides usefull information intended to help in the proper installation of the Q- Series motor.

Shaft Misalignments -- Drive line component tolerances will always cause misalignments between the ends of coupled shafts. The misalignments that can occur include parallel, angular and end float. They can and will exist in any combination.

Parallel misalignment is the offset of two mating shaft centerlines although the centerlines remain parallel to each other. Angular misalignment is when two shaft centerlines intersect at some angle other than zero degrees. End float is a change in the relative distance between the ends of the two shafts.

Flexible couplings are used to accommodate these misalignments and to transmit the desired torque. The coupling manufacturer should be consulted to assure that the coupling is being used within its ratings; both for torque capacity and misalignment capabilities.

Coupling Types -- Shaft couplings may be divided into three types; single-flex, double flex and rigid. Like a hinge, a single flex coupling accepts angular misalignment only. A double-flex coupling accepts both angular and parallel misalignments. Both types, depending on thier design, may or may not accept end play. A rigid coupling cannot compensate for any misalignment.

Whenever two shafts are joined that are fixed in the radial and angular direction, a double-flex coupling should be used. A single-flex coupling should not be used because it does not permit any parallel misalignment and the only compensation for parallel misalignment will be by bending the shafts, which will cause excessive bearing loads and premature failure.

When a single-flex coupling is used, one and only one of the shafts must be free to move in the radial direction without constraint. A double -flex coupling should not be used in this situation because it will allow too much freedom and rotate eccentrically, which will cause large vibrations and immediate failure.

For situations other than those described here or if you have any questions regarding proper motor installation, please contact Compumotor for assistance.

4. Wiring

WARNING

Be certain that all AC power is disconnected before attempting to do any wiring. The wiring between the motor and Q-Drive should be done with AC power disconnected as there are life threatening voltages on the motor when energized.

A. Motor Connections

The Q-Drive is supplied with a preassembled motor cable with an MS type connector on the motor end and a 7-Pin screw terminal connector on the drive end. This cable should be attached to both the motor and the drive before the AC power. The motor connector on the Q-Series drive is a 4-pin removable screw terminal block. The screw terminal on the motor cable plugs into a receptacle on the Q-Drive. This connector should be installed prior to installing the AC power connector and interlocking cover.

The standard cable supplied with the Q-Drive is 25 feet in length. If you need a longer length cable it may be purchased from Compumotor in lengths up to 100 feet. If you wish to make up your own cable, 14 guage or larger wire should be used for lengths up to 100 feet. Lengths above 100 feet are not recommended.

Contact Compumotor for further details about configuring the Q-Drive for situations other than those provided for at the factory.

B. Resolver Connections

A preassembled 25 foot cable is supplied for connecting the resolver to the Q-Drive. This cable has an MS style connector on the motor/resolver end and a 9-pin D type connector on the drive end.

The MS type connector should be connected to the motor mounted resolver connector and securely tightened. The 9-pin D connector should be connected to the mating resolver connector on the Q-Drive and secured with the two captive mounting screws.

C. Line Power Connections

AC power is connected via the four terminal connector. The wires should be connected to the screw terminals as follows,
120 VAC single-phase power,

Terminal	Q-Drive	Wire color
1	120 VAC LINE	Black (blue)
2	120 VAC NEUT	White (brown)
3	n.c.	
4	GND	Green (green with yellow)

120 VAC three-phase power,

Terminal	Q-Drive	Function
1	120 VAC 1	120 VRMS, line 1
2	120 VAC 2	120 VRMS, line 2
3	120 VAC 3	120 VRMS, line 3
4	AC GND	Earth ground (green or green with yellow)

150 VDC power,

Terminal	Q-Drive	Function
1	Positive DC	+150 VDC (red)
2	Negative DC	DC return (black)
3	n.c.	
4	GND	Earth ground (green or green with yellow)

Note: See section 2.C for grounding recommendations.

Be careful to ensure that the leads do not short to one another and there are no loose strands that are not captured by the terminal connection for each lead.

The screw terminal connector and the plastic interlock cover supplied with the drive should be attatched to the Q-Drive following connection of the motor terminal block. The AC power terminal block plugs into a mating receptacle on the drive. The plastic cover should then be fastened to the drive with the two screws supplied. this cover prevents the motor cable from being disconnected with power applied and should always be used.

D. Indexer Connections

The Indexer connector on the Q-Drive is a 25-pin D connector which is compatible with Indexer to Motor/Drive cables supplied with all Compumotor Indexers shipped after 02/22/85. Simply connect the cable from the indexer you are using to the Indexer connector on the Q-Drive.

If you are using an indexer other than Compumotor, STEP+ and STEP- both must be connected to run the motor. DIRECTION+ and DIRECTION- need only be connected if the motor need be run bi-directionally. SHUTDOWN+ and SHUTDOWN- must be connected if the motor is to be shutdown remotely without powering down the drive. If a Compumotor indexer is used, a prefabricated indexer to Q-Drive cable is provided with the indexer. Refer to the Specifications sections for STEP and DIRECTION electrical characteristics.

E. Auxilliary Connector Connections

The Q-Drive has one signal available on the auxilliary connector, DRIVE ENABLE.

The DRIVE ENABLE input allows external devices to enable or disable the Q-Drive. This is typically where hardwired end of travel switches would be connected. This input must be connected to the PULLUP terminal for operation of the drive and is shipped from the factory with a temporary jumper installed. If you wish to use this input for end of travel inputs, you will need to connect from the DRIVE ENABLE input to PULLUP through normally closed contacts on your limit switches. After your switches have been connected the jumper should be removed.

Note: Motor will free wheel if this connection is broken.

F. RS-232 Connector

The RS-232 connector is a standard 25-pin D connector and is electrically commpatible with the IEEE specifications for RS-232C communications. The Q-Drive has a three wire implementation of this interface and provides RECIEVE DATA (pin 2), TRANSMIT DATA (pin 3), and GROUND (pin 7) signals on the connector.

The communication format is fixed at 1200 baud, 8 data bits, 2 stop bits, and no parity.

5. Fuses

The Q-Drive uses four fuses. Three for AC power (mounted internally), and one for internal circuit protection. Should the Q-Drive fail to function at all, check each of the 120 VAC LINE fuses.

CAUTION

Remove AC power before checking fuses or disassembling drive.

NOTE

Examining the AC power fuses will require partial disassembly of the Q-Drive enclosure. A continuity tester will be required to verify fuse integrity. Refer to Appendix C for more information.

OPERATION

1. General

The procedures outlined in this section are intended to help the user to quickly and safely begin operating the Q-Drive. Once you have completed the installation of the system, there should be little or no adjustment required for most applications.

2. Initial Start-up

A. Powering Up the System

To familiarize yourself with the operation of the system, you may wish to go through the start-up procedures before final installation of the motor to your load. If so, you should first attach the motor, resolver and indexer cables before applying AC power. Be careful to keep the motor shaft away from any cables or other loose objects which could get tangled when the shaft rotates. The motor should be firmly supported to prevent it from moving while it is running.

WARNING

> Do not grab hold of the motor shaft while it is turning, since there are sharp surfaces on the shaft. Also be sure that the shaft key is removed or securely fastened to the shaft because it could fly off when the motor is rotating.

Verify that all cables and wiring are properly connected, that the motor shaft is free from obstructions and then apply power to the system.

B. Visual Indicators

Once you have successfully completed all connections and turned on the AC or DC input power, you should check the LED indicators for their proper status before proceeding. The Q-Drive has three externally visble LED's which should appear as follows:

STATUS -- Green

FAULT -- Off

ERROR -- Off

If any of the LED indicators are not as described above, REMOVE POWER, inspect all electrical connections, and verify proper input voltages. If no problem is found and LED indicators are not correct when power is reapplied, refer to the Troubleshooting and Maintenance section of this manual.

C. Indexer Functions

Compumotor offers a variety of Indexers which are compatible with the Q-Drive. Performing a functional check using one of these indexers consists of the following steps:

1. Attach the motor/drive cable from the indexer to the Q-Drive.
2. Set up the Indexer in accordance with the Installation and Hookup section.
3. To verify that the Q-Drive is operating properly, apply power to the Q-Drive (115 VAC) and set the indexer to perform a 4096 step/second constant velocity move. This will cause a 4096 steps per revolution motor to rotate at the rate of one revolution per second.

By increasing the velocity setting of the indexer and issuing a new START command you will increase the rotational velocity of the motor. The motor should be able to accept frequencies up to 4096 (PPR) X the maximimum rated speed (RPS) of the motor you are using without stalling, provided the motor has not been accelerated too quickly.

The direction of the motor can be changed by stopping the motor, changing the DIRECTION switch on the indexer, and issuing a new START command.

If you wish to make this functional check with a square wave generator or some other pulse source, the positive or "hot" lead of the square-wave generator should be attached to the STEP+ input on Q-Drive. Refer to Appendix A for pin connections. Ground from the frequency generator should be attached to STEP-. The output of the square-wave generator should be set to 3 volts peak. There is an 220 ohm resistor and LED in series between the STEP+ and STEP- inputs. The current through these components should not exceed 20 mA for reliable operation.

D. Pushbutton Tuning

The Q-Series drive is supplied with a tuning "Key" which provides a simple pushbutton method of fine tuning the systems performance to a specific attatched load. This device plugs in to the D connector labled KEY on the end panel of the drive and is held in place by the two captive mounting screws. The Q-Series system is factory preset for typical user loads and for the individual motor supplied with the system. For most applications no adjustment is required by the user.

Once you have the system installed and the motor connected to its intended load, you can determine wether any fine tuning is required by observing the response of the system to commands from your indexer and by observing how "stiff" the system is when at rest.

Use CAUTION for the following steps.

With the motor at rest, try to deflect the shaft. You should not be able to easily turn the shaft away from its rest position. If it feels very soft, then the system gains probably need to be increased. This can be accomplished very easily using the tuning key.

There are four buttons on the key called UP, DOWN, ENTER and SAVE, also two test points, V (velocity) and G (ground). To begin tuning the system depress the UP button and while it is depressed also push the DOWN button. Let up on both buttons. The processor waits until all switches are released before performing any functions. This causes the Q-Drive to enter the tuning mode using the gain that were in effect prior to entering tuning. If the Q-Drive is being started for the first time these parameters will be the factory settings for a typical load and performance requirements. The ERROR LED indicator on the end panel of the Q-Drive should begin flashing at this time indicating that the processor is ready to accept tuning commands.

At this time depressing the UP button will increase the system gain a small amount each time it is pushed. Depressing the DOWN button will decrease the gain. If you push the UP button and feel the motor shaft, you should notice the stiffness increasing. If the shaft begins vibrating it means that you've increased the gain too far and the system is slightly unstable. If you get to this point depress the DOWN button several times to reduce the gain. When the motor feels reasonably stiff you can begin operating the system as required by your application. At any time during the tuning process the Q-Drive can be returned to the factory settings by depressing both the SAVE and DOWN buttons simultaneously.

The drive can be fine tuned while monitoring its performance as it is indexing. This can be done by watching to see if there is any overshoot or oscillation when it reaches position. Increase or decrease the gain until the motor smoothly accelerates and decelerates to position with little or no overshoot. If you have an

ocsilliscope available you can monitor the velocity for overshoot on test point V on the pushbutton panel. Connect your scope probe to test point V and probe ground to test point G. This test point should only be used to monitor relative performance, it is not a true indication of absolute velocity. The voltage will be between 0 and 12 VDC with 0 VDC representing maximum velocity CCW and 12 VDC equal to maximum velocity CW. When stopped the voltage should be approximately 6 VDC.

When the Q-Drive performance is satisfactory, depress the SAVE button to save the new servo parameters in the EEPROM memory. If you wish to exit the tuning mode and return to the gains that were in effect when you started tuning, depress the ENTER button. For a more detailed description of the pushbutton commands and other tuning methods, refer to the Set-up and Tuning section.

3. Visual Indicators

There are three LED (light emitting diode) indicators on the indexer connector end of the Q-Drive, STATUS, FAULT, and ERROR.

STATUS -- will be green if power is applied and the system is functioning properly. If power is missing the LED will be off and if there is a controller failure the LED will be red.

FAULT -- occurs any time the Q-Drive shuts itself down because of an internally sensed error condition in the amplifier section of the system or if a remote power shutdown is issued by the indexer. This is most likely to occur as a result of over heating (the Q-Drive has a built in temperature sensor), or as a result of a short circuit in the output wiring. A FAULT can be cleared by resetting the drive once the fault condition is removed.

ERROR -- occurs any time a "soft fault" is detected, such as excessive position error or exceeding the average current limit setting. This condition can be cleared by resetting the drive if the error condition is no longer present.

4. Indexer Inputs and Outputs

The indexer inputs provide the normal control signals for the Q-Drive. Following is a functional description of how each is used.

A. Step Input

The STEP input causes the motor position to be incremented one unit of feedback resolution. The resolver feedback used on Q-Drives is digitized to 4096 parts per revolution. By applying STEPs at various rates the motor is made to rotate at proportional velocities. STEP pulses applied first slowly, and then more quickly have the effect of accelerating the motor. Attempting to accelerate the motor too quickly can cause the motor to lag behind the commanded position. There is an adjustable user defined value for

maximum following error which will shut down the drive if exceeded.

B. Direction Input

The DIRECTION input controls the direction of rotation of the motor. When this signal is not activated the motor shaft rotates counter-clockwise as viewed from the flange end of the motor. The motor shaft rotates clockwise if the DIRECTION input is activated.

C. Remote Power Shutdown (RPS) Input

Activation of the REMOTE POWER SHUTDOWN (RPS) input causes the Q-Drive to stop putting current through the motor. This will allow the motor to freewheel and as such is intended to allow manual positioning of the load or to keep the Q-Drive from interfering with sensitive electronics in the immediate vicinity.

It is not intended to act as an emergency stop for the motor. If RPS is used in this fashion the motor will very likely move beyond its desired stopping position at the risk of **endangering property and life.**

D. Fault Reset Input

The FAULT RESET input will reset the microprocessor and clear an ERROR or DRIVE FAULT condition if the condition causing the fault has been removed.

E. Slip Fault Output

The SLIP FAULT output is activated whenever the actual position of the motor is outside the user defined deadband. This output will be turned off when the absolute value of the following error is less than the deadband.

F. Drive Fault Ouput

The DRIVE FAULT output is activated when the motor or Q-Drive is sensed as being in an over-temperature condition, over-current condition, or abnormal internal circuit operation condition. Once the condition causing the fault has been cleared and the drive reset, normal operation may resume.

5. Auxilliary Inputs and Outputs

A. Drive Enable Input

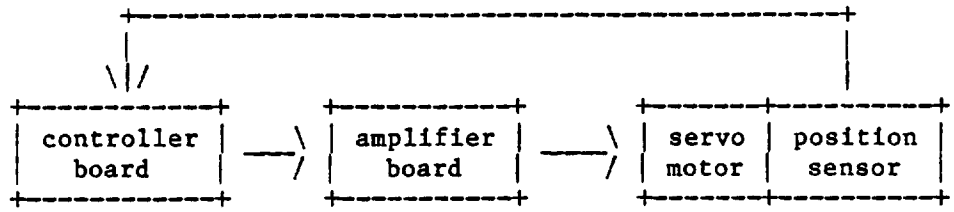
The DRIVE ENABLE input can be used to enable or disable operation of the Q-Drive. This input requires a normally closed connection from the input to the PULLUPS terminal.

6. Set-up and Tuning

A. Introduction

The Q-Drive controller board is the "main brain" behind the Q-drive's ability to position a servomotor. It performs ALL of the compensation necessary to stabilize a DC servomotor. No compensation is provided by the amplifier board. In fact, the amplifier board is a slave to the controller board; the amplifier board controls the voltage in the motor, the level of that voltage is commanded by the controller board.

A block diagram of the Q-Drive servo system appears below. The controller commands a "desired voltage" to the amplifier board, the amplifier board then attempts to generate that "desired voltage" in the motor's windings. The position of the motor's shaft is sensed by the controller via a position sensor attached to the motor. This positional information is used by the controller to generate the "desired voltage" command to the amplifier.



The generation of the voltage command to the amplifier by the controller is based on several quantities, not just the position of the servomotor's shaft; it is based on a desired position, which is generated by an indexer, and on previous voltage commands to the amplifiers. An indexer generates a stream of pulses which the controller collects with an up/down (ie.clockwise/counterclockwise) counter. The resultant pulse count, at any given instant of time, is the desired position. The controller subtracts the motor's actual position from this desired position to determine the positional error. The positional error is the difference between where we want the motor to be and where it actually is. This positional error is put into an equation, along with previous positional errors and previous commands to the amplifier, to generate the voltage command for the amplifier.

The equation used by the controller to calculate the voltage command

for the amplifier is known as a recursive equation. It is a mathematical equation, or function, that is evaluated at periodic time intervals. In the case of the Q-Drive controller the recursive equation is an approximation of an analog, continuous-time lead compensation network. The analog, continous-time lead compensation network is used quite often for the purpose of stabilizing conventional servo systems and consists of several potentiometers, resistors and capacitors. The Q-Drive's recursive equation is the discrete-time equivalent to a continuous-time lead compensation network. It is called a discrete-time lead compensation network because it operates on sampled data not on continuous data. The sampling-rate of the Q-Drive controller is the rate at which the recursive equation is evaluated and the rate at which the voltage command to the amplifier is changed. The sample-rate of the Q-Drive controller is faster than one millisecond. In general we would like the sampling rate to be as high as possible to get the best dynamic response.

B. TUNING THE Q-DRIVE SERVO SYSTEM

The most important aspect of a servo system is setting the controller's "gains". The controller in a conventional continuous-time servo system is an active or passive filter network, usually an op-amp with resistive and capacitive feedback. The values and configuration of the resistors and capacitors in the filter network are determined by the compensation necessary to stabilize the servo system. The values of the resistors and capacitors can be thought of as being the "gains" of the controller. To stabilize the servo system it is necessary to adjust the gains to match the system being controlled (the "system" being the motor, its load, and the amplifier). In the case of the Q-Drive the "gains" of the controller are the constant coefficients of the recursive equation. The form of the recursive equation determines how many of these "gains" must be adjusted in order to stabilize the system.

Fortunately, the equation is very simple and, better yet, it is not necessary to know its form to tune a Q-Drive servo system. To tune a Q-Drive servo system it is only necessary to adjust a single controller gain. The other gains are predefined and, in most cases, require no further adjustment by the user.

There are two methods available to adjust a Q-Drive's servo compensation network. The four switches on the separate pushbutton tuning key, and the RS-232 communications port. Tuning via the front panel switches will be described first followed by tuning through the RS-232 communications port. Following the tuning procedures, other commands not associated with tuning the Q-Drive are described.

B.1 Pushbutton Tuning

There are four switches on the Q-Drive tuning key labelled ENTER, SAVE, UP, and DOWN. This key is installed by inserting it in the 9-pin D connector labled KEY on the end panel of the drive and tightening the captive mounting screws.

On the end panel of the drive there are three LEDs:

The STATUS LED is bicolor and indicates the operating state of the Q-Series controller board. If it is green the controller is operating properly, if it is red the controller is not operating properly and the switches will not be functional.

The FAULT LED indicates "hard faults". If a hardware fault occurs in any of the amplifiers or the high voltage power supply this red LED will light. Additionally, the "hard fault" LED will light if the amplifiers are disabled.

The ERROR LED indicates "soft faults". "Soft faults" are various programmable fault conditions, such as excessive following error or exceeding the average voltage limit. The "soft fault" LED is used to indicate that we are in the tuning mode whenever the Q-Drive is tuned via the front panel switches .

Before beginning the tuning process check the three LEDs. The bicolor LED must be green and the two fault LEDs must be off. If any of the LEDs glows a continuous red the tuning process cannot be started. If the "soft fault" LED is a flashing red it means the Q-Drive currently thinks it is in the tuning mode.

To begin the tuning process depress the ENTER and SAVE buttons simultaneously. (It is not necessary to depress both buttons at precisely the same moment, you can hold down the ENTER button and then, while you are holding the ENTER button, depress the SAVE button.) When you release both buttons the tuning process will begin. (No action occurs until all switches that have been depressed are released.)

Entering the tuning mode takes about one second. When the gains have been initialized by the microprocessor the "soft fault" LED will begin to flash. If you feel the motor's shaft it should be relatively weak. To make the motor stiffer depress the UP button several times. Each time you depress either the UP or the DOWN button you should feel a change in the motor's stiffness. At this time or any time the Q-Drive is in the tuning mode you can return to the factory gain settings by depressing the SAVE and DOWN buttons simultaneously. If you depress the UP button enough times you should be able to make the motor go unstable. This will be readily apparent since the shaft will begin to shake and you will hear a loud buzzing or grinding noise! If the motor does become unstable depress the DOWN button several times until the shaft no longer shakes. It is advisable to not leave the gain just at the edge of instability since this results in a system with a limited margin of

stability, which means there is a small chance that the system could be upset into an unstable mode upon operation. Instability causes large commands to the amplifier and can cause the drive to overheat. Thus, bringing the gain back from the shaking point by depressing the DOWN button several times is best.

The ERROR LED will stop flashing and stay on if maximum or minimum gain is reached while in the tuning mode. For instance, during normal tuning the error LED flashes. If the gain is increased to its maximum value the error LED will stay on continuously. Decreasing the gain, by pushing the DOWN button, will cause the error LED to flash again, since we have moved away from the maximum gain value. The same holds true if the gain is decreased to its minimum value. When the minimum gain is reached the error LED will stop flashing and stay on continuously. Increasing the gain will cause the LED to flash again.

Once you have found a gain that is adequate you are ready to terminate the tuning process. To do this depress the SAVE switch. Depressing and releasing the SAVE switch will permanently save the new gains in the non-volatile EEPROM memory. Now, everytime the Q-Drive is turned on or reset the new gains will be used.

During the process of tuning it is not necessary to make the motor shake, or go unstable. If the desired stiffness is found before the motor begins to shake the tuning process may be stopped there by depressing and releasing the SAVE switch.

The tuning process can be performed while the motor is moving by attaching an indexer to the Q-Drive and commanding a move. If an oscilloscope is handy you can monitor the velocity of the motor via the test point labelled V. If you do monitor the velocity using this test point please keep in mind that the velocity output signal you are monitoring is synthesized and is not as accurate as a tachometer's output. The synthesized velocity output does not respond well to fast changes in the velocity and therefore it will never be possible to tune the motor such that the corners of the velocity profile are perfect. Some small overshoot is due to the synthesized velocity output. Large overshoots are real.

Sometimes you may wish to tune the motor, not from the default starting gain values, but from the gains that are currently in effect. This can be done by simultaneously depressing both the UP and DOWN buttons. Depressing both the UP and DOWN buttons simultaneously starts the tuning process (the soft error LED will flash) but does not change the gains in use. Depressing the ENTER and SAVE buttons to begin the tuning process modifies the gains in effect at that time and returns to the default values (very low gain). By depressing the UP and DOWN buttons individually, as described previously, you may adjust the gain of the system.

Depressing and releasing the SAVE button still has the effect of saving the new gains in the EEPROM and terminating the tuning process. If, during the tuning process, you wish to return to the

gains you had before you started the tuning process, depress and release the ENTER switch. This will cause you to exit the tuning mode and return to the gains that were in effect before the tuning process began. Depressing the SAVE and DOWN switches simultaneously, while you are in the tuning mode, will cause the Q-Drive to compute its "factory default settings". The gains the system selects after depressing these two switches are the gains that were installed in the system when it was shipped. For most applications the factory default settings are adequate and no further tuning is required.

B.1.1 SWITCH FUNCTION SUMMARY

Here is a summary of the functions available from the front panel switches. Not all of these functions have been described above.

NOTE:

Whenever a switch has been depressed the controller waits until ALL switches are released before performing any functions. In addition, it will remember all switches that were depressed while any other switch is depressed. For example, if one wants to depress the UP and DOWN buttons simultaneously do the following:

-- depress and hold down the UP button
-- depress and hold down the DOWN button
-- release the DOWN button
-- release the UP button

As far as the controller is concerned you have depressed the UP and DOWN buttons simultaneously. Two button commands are identified below with a plus sign.

If the Q-Drive is not in the tuning mode (the "soft fault" LED is not flashing):

ENTER + SAVE
Starts the tuning process from the default gain values. The "soft fault" LED will begin to flash. Entering the tuning process via the ENTER + SAVE buttons takes approximately one second.

UP + DOWN
Starts the tuning process from the gains currently in effect. The "soft fault" LED will begin to flash.

ENTER + DOWN
Disables the amplifiers. This is equivalent to shutting down the motor/driver (like remote power shutdown on the step motor drives).

ENTER + UP
Enables the amplifiers. This is the opposite of ENTER + DOWN. If an error condition exists or the remote power shutdown input on the indexer/driver interface is active this function will not work.

ENTER + SAVE + UP + DOWN
This is a software reset.

If the controller is in the tuning mode (the "soft fault" LED should be flashing):

ENTER
Terminates the tuning process and reinstates the gains that were in effect before the tuning process began.

SAVE
Terminates the tuning process and saves the new gains in the EEPROM. The gains that were in effect before the tuning process began are lost.

UP
Increases the gain of the system. Makes the system respond faster to a commanded position change.

DOWN
Decreases the gain of the system. Makes the system respond slower to a commanded position change.

SAVE + DOWN
Return to the factory default settings. This function will reinstate the gains that were in effect when the unit was shipped from the factory.

ENTER + DOWN
Disables the amplifiers. This is equivalent to shutting down the motor/driver (like remote power shutdown on the step motor drives).

ENTER + UP
Enables the amplifiers. This is the opposite of ENTER + UP. If an error condition exists or the remote power shutdown input on the indexer/driver interface is active this function will not work.

ENTER + SAVE + UP + DOWN
This is a software reset.

B.2 RS-232 Interface Commands

The tuning process described above for the front panel switches can be duplicated via the RS-232 communication port. In the interest of brevity the procedure is not repeated here but simply the description of the commands that may be issued via the RS-232 port to tune the motor/drive.

In order to tune the motor via the RS-232 port it is necessary to first enter the SETUP mode of operation. Initially the Q-Drive should be in the normal operating mode of operation, or the BASE mode. If the prompt that appears on your terminal is an asterisk (*) the Q-Drive is in the BASE mode. If an asterisk does not appear on the terminal try issuing a few carriage returns. If this does not work, something must be wrong!! It is possible that some RS-232 communication parameters on the terminal are set incorrectly. The Q-Drive has only one setting for its RS-232 parameters -- 1200 baud, no parity and two stop bits.

Once in the BASE mode the Q-Drive may be put in the SETUP mode so the tuning process may begin. This is done by issuing the two letter command ES (for Enter Setup mode) followed by a carriage return. A greater-than character should appear on the screen as your prompt (>) and the ERROR LED should begin to flash. The act of entering the SETUP mode is equivalent to depressing both front panel buttons simultaneously.

(Incidentally, when using either of the tuning processes, front panel or RS-232, you cannot use the other.) The commands available in the SETUP mode are single character commands and do not require a carriage return, they are acted upon immediately. The SETUP mode commands are summarized below.

U - Increases the gain of the system. Depressing the "U" key is equivalent to depressing the UP button on the front panel.

D - Decreases the gain of the system. Depressing the "D" key is equivalent to depressing the DOWN button on the front panel.

E - Enter the manual tuning process, initializes the controller's gains to some default starting values. This is equivalent to starting the tuning process via the ENTER + SAVE front panel switches.

F - Drive off

N - Drive on

S - Save the new gains. This is equivalent to depressing the SAVE switch on the front panel. The "S" key will cause the controller to save the gains as they are now adjusted and exit the tuning process, meaning the SETUP mode will be exited.

X - Exit the SETUP mode and return to the gains that were in effect before the entering the SETUP mode. This is equivalent to depressing the ENTER switch when we are in the process of tuning. Any changes that have been made to the controller's gains are forgotten and the gains in effect before the tuning process began are reinstated.

B.2.1 THE OTHER RS-232 COMMANDS

All other RS-232 commands are available in the BASE mode. The BASE mode is indicated by an asterisk prompt. If you are currently in the SETUP mode you can enter the BASE mode by issuing an "X" or "S" command (see the above command description).

All the commands which can be issued in the BASE mode are two letter commands. The controller will accept lower or upper case ASCII characters, it automatically converts all lower case characters to upper case when they are received. Spaces may be used in a command, since all spaces are ignored. All commands in BASE mode are terminated with a carriage return. To determine if you are in the BASE mode type several carriage returns and look at the prompts on the screen, they should be asterisks (*).

Many of the commands expect parameters. There are two types of parameters, numeric and boolean. A numeric parameter is an integer in the range of approximately minus two billion to plus two billion. Floating point numbers are not accepted (numbers with a decimal point). Boolean parameters are either an "ON" or an "OFF".

If you supply an invalid parameter to a command the command will not be performed and an error message will appear. Error messages are always preceded by two question marks (??).

Following are the commands available in the BASE mode or normal RS-232 mode of operation. They are listed in alphabetical order. Any changes made to parameters using these commands are NOT permanent. To make a change permanent the SAVE command (SV) must be issued. The SAVE command will save all changes that have been made into the EEPROM. Thus, if changes are made with these commands and then the machine is reset the changes are lost unless the SAVE command was issued before resetting the machine. (Issuing the "S" command in the SETUP mode is equivalent to issuing a SAVE command in the BASE mode.)

AC - Average Current definition/report.
Numeric parameter expected.
Range: 0 to 15000 mA
If no parameter is supplied "AC" will report the currently defined maximum allowed average current, in milliamps. If a parameter is supplied that number will be used as the new maximum average current. The controller continuously computes an average current command issued to the amplifiers. If the average current command exceeds the value defined by the "AC" command the controller will disable the amplifiers and indicate an error.

AF - Amp off

AN - Amp on

CF - Define/report the desired Crossover Frequency.
Numeric parameter expected.
Range: 1 to 200 Hz
This command allows one to change the crossover frequency which is used for defining the default controller gains when performing system tuning. If no parameters are supplied the desired crossover frequency (in Hertz) currently in use will be displayed. The crossover frequency is very close to the bandwidth of the system. When the system is shipped a default crossover frequency of 35 Hz has already been entered and saved into the system.

DB - DeadBand definition/report.
Numeric parameter expected.
Range: 0 to 32767
If no parameter is supplied "DB" will report the current value of the deadband, in motor steps. If a number is supplied that number becomes the new deadband. The slip fault line to the indexer is used to indicate when the absolute value of the following error is within the deadband region. It has no effect on the controller (the "position maintainer"). The slip fault line to the indexer will be on to indicate that the following error exceeds the deadband and off to indicate that the absolute value of the following error is within the deadband.

ES - Enter the SETUP mode.
No parameter expected.
This command allows the SETUP mode to be entered, which was described in preceding sections. The SETUP mode is used as an alternative to the front panel switches for tuning the servo system. To exit the setup mode type an "X" character. The setup mode is indicated by a ">" prompt.

FE - Define/report the maximum Following Error.
Numeric parameter expected
Range: 0 to 32767 Steps
If no parameter is supplied the maximum following error is displayed, in motor steps. Exceeding the maximum following error is an error condition that will cause the amplifier to be shutdown. A "0" will generate an error immediately. A 4096 step following error is defined when the motor is shipped.

MS - Motor Shutdown toggle/report.
Boolean parameter expected.
Range: On or Off
If no parameter is supplied the shutdown state of the motor is reported. "ON" will shutdown the motor and "OFF" will turn the shutdown off (or "unshutdown" the motor).

RE - Report any Error conditions.
No parameters expected.
If an error condition exists, such as excessive following error or an EEPROM failure, it will be reported. Errors are "soft errors" that are indicated with the "soft error" LED. To clear an error one must reset the machine.

RF - Return to Factory settings.
No parameters expected.
This command causes the controller to calculate gains for a system that has a load of one-half the rotor inertia attached to the motor. These new gains are not saved unless the SAVE command is issued.

RS - ReSet the driver system.
No parameters expected.
This command implements a software reset of the system. It is equivalent to depressing all four of the front panel switches simultaneously. A software reset is not identical to a hardware reset, it is as close as is possible. There is a button on the edge of the front control board available to perform a true hardware reset of the controller board. Any changes that have not been saved before issuing this command will be lost. It is a good idea to issue this command after changes have been made and saved.

RV - Software ReVision level reported.
No parameters expected.
This command is for determining the software revision level of the controller software. It will report the part number that is written on the label of the controller's EPROMs. Using this command means it is not necessary to open the Q-Drive amplifier's box in order to determine the revision level of the software!

Stream reports. No parameters expected.
Each of the following commands results in the controller continuously reporting the appropriate parameter to the display. When any of these commands are issued no other command may be issued until the stream report is terminated. To terminate a stream report send a carriage return to the controller. The position is reported in motor steps and the current is reported in milliamps.

SC - Stream Average Current.
Reports the average current which is the result of a sample of 256 data points. The report is updated every 43.7 milliseconds. The following formula is used:

$$\frac{255 \times \text{average} + \text{new sample}}{256} = \text{Average}$$

The report reflects the average current over the past 11.2 seconds.

SE - Stream Report Error in Position.
Report the difference between position commanded by the indexer and actual position of the resolver in motor steps. In effect it's the SS report minus the SP report. Maximum error is set by the FE command.

SP - Stream Actual Position
Reports the relative position of the motor with respect to power up, at which time SP = 0. It is also 0 when drive faults.
Values range 0 > 32767 > 0 (65534 motor steps).

SR - Stream Resolver Position
Report the absolute position of the resolver. It is dependent of drive status, ie: 0 is always at the same position.
Values range 0 > 2048 > (4096 motor steps).

SS - Stream Set Point
Reports the relative position commanded by the indexer with respect to the Q powering up at which time SS = 0.
Values range 0 > 32767 > 0 (65534 indexer steps).

SV - SaVe all EEPROM or permanent variables.
No parameters expected.
Issuing this command results in permanent saving of all EEPROM variables. All previous EEPROM variables are lost. After a SAVE is performed the controller will use these new variables whenever it is turned on or reset. This allows you to customize the system to your specific application without the necessity of custom software.

7. Motor Compatibility

The Q-Drive is designed to be compatible with at least the following motor sizes:

Model number
Q510
Q530

For motors other than those listed above consult Compumotor for information regarding available options.

8. Line Power Considerations

The 120 VAC input to the Q-Drive is not isolated by a transformer. To provide isolation or to step down from a 480 or 240 VAC supply, power to the Q-Drive should be routed through an isolation transformer with a power rating of 4500 VA.

An isolation transformer with line filtering capabilities will also insulate sensitive equipment on the same power line from the noise induced in the power line by the switchmode amplifiers in the Q-Drive.

MAINTENANCE AND TROUBLESHOOTING

1. Motor Maintenance

Brushes should be inspected every 500 hours of operation. If the environment is highly contaminated or if the motor is very lightly loaded, more frequent inspection may be necessary. Brushes should be able to move freely in their holders and brush springs should have equal tension. Replace the brushes when the length reaches 0.25 inches. Use only Compumotor approved brushes when replacing.

All mechanical parts of the motor should be inspected regularly to ensure that no bolts or couplings have worked loose during normal operation. This can prevent some minor problems from developing into anything more serious.

2. Diagnostic LED's

STATUS -- This is a bi-color LED which will be green under normal operating conditions. If this LED is red it indicates a microprocessor failure. Cycling power to the drive will clear this condition only if it is temporary. If the LED remains red the unit should be returned for repair. If the unit powers up and the LED is green, the Q-Drive should be ready for operation again. Intermittent occurances of a red STATUS LED can often signify electrical noise interference. See the System Installation Recommendations section of this manual for recommended noise suppression devices. If this LED is off it indicates a loss of the low voltage power supply. Check for correct input voltages and for fuses blown. If everything checks out and the drive is still not operating or if fuses blow when power is reapplied, send the unit back for repair.

FAULT -- This red LED will be off under normal operating conditions. It will be red if the amplifier section of the drive is shutdown. The amplifier will shutdown itself if an over-current, short-circuit or over-temperature condition exists. This LED will also be lit if the amplifier is shutdown by the Remote Power Shutdown input or by the microprocessor due to an error condition. If an error condition causes the FAULT LED to come on, the ERROR LED will also be on. If this LED comes on, first try disconnecting the indexer cable. If the LED goes off, it was probably caused by a Remote Power Shutdown. If it stays on, remove power and examine the connections to the motor to verify that no short circuits exist in the wiring or motor, winding to winding or winding to ground.

ERROR -- This LED is normally off and glows red when the microprocessor detects an error condition such as excess following error or exceeding the average current definition. The RE command can be issued to determine what condition(s) exist. The error condition can be cleared by resetting the drive, either by cycling power or through the FAULT RESET input on the indexer connector.

SPECIFICATIONS

System dependent:

DESCRIPTION	VALUE	UNITS
Repeatability	+/- 0.088	degrees, unloaded.
Accuracy	+/- 0.23	degrees, unloaded.
Relative Accuracy	+/- 0.088	degrees, any load.
Driver Operating Temperature	0 to +50	degrees Celsius.
Motor Case Temperature	125	degrees Celsius, max.
Storage Temperature	-40 to +85	degrees Celsius.
Humidity	0 to 95	percent, non-condensing.

Motor dependent:
(See Compumotor catalog for speed-torque curves)

DESCRIPTION	Q-510	Q-530	UNITS
Static Torque (cont.)	170	540	ounce-inches
Static Torque (peak)	680	1320	ounce-inches
Top Speed	60	30	revolutions/second
Rotor Inertia	0.024	0.367	ounce-inch-seconds^2
Maximum Radial Load	40	150	pounds
Motor Weight	7.4	33	pounds
Total Shipping Weight	22	47	pounds

Physical Description

Q-Drive Height: 4.75 inches (12.00 cm)
Q-Drive Length: 12.00 inches (30.48 cm)
Q-Drive Width: 8.00 inches (20.32 cm)

Q-Drive Weight: 10 lbs (4.5 kg) without motor
14 lbs (6.4 kg) without motor, with shipping container

Environmental

Operating temperature: 32°F to 122°F (0°C to 50°C) when passively cooled.
Humidity: 0-95%, non-condensing.

Electrical

Input power:

Configuration 1: Single phase power
- Voltage: 105-125 VAC, single phase.
- Frequency: 47-66 Hz.
- Current: 10 amps maximum continuous

Configuration 2: Three phase power
- Voltage: 105-125 VAC, three phase.
- Frequency: 47-66 Hz.
- Current: 10 amps maximum continuous

Configuration 3: DC power
- Voltage: 100 to 160 VDC
- Frequency: 0 Hz (DC)
- Current: 10 amps maximum continuous

Output power: (to motor)
- Voltage: 160 VDC peak
- Frequency: 20 kHZ PWM
- Current: 8.0 amps continuous.
  20.0 amps peak.

Inputs and Outputs

Motor: 4 connection screw terminal block.

1	**MOTOR +**	Output. Positive lead of motor.
2	**N.C.**	
3	**MOTOR -**	Output. Negative lead of motor.
4	**GND**	Output. Shield for motor wires. Motor case ground conductor.

Power: (All inputs) 4 connection screw terminal block.

120 VAC single-phase power,

	Q-Drive	Suggested Wire color
1	120 VAC LINE	Black (blue)
2	120 VAC NEUT	White (brown)
3	n.c.	
4	AC GND	Green (green with yellow)

120 VAC three-phase power,

	Q-Drive	Function
1	120 VAC 1	120 VRMS, line 1
2	120 VAC 2	120 VRMS, line 2
3	120 VAC 3	120 VRMS, line 3
4	GND	Earth ground

150 VDC power,

	Q-Drive	Function
1	Positive DC	+150 VDC
2	Negative DC	DC return
3	n.c.	
4	GND	Earth ground

Resolver: 9 pin D connector, female.

1	**S1**
2	**N.C.**
3	**S4**
4	**R1**
5	**SHIELD**
6	**S2**
7	**S3**
8	**N.C.**
9	**R2**

Indexer: 25 pin 'D' connector, female

1	**STEP+** Input. Optically isolated current loop input. 15 mA, 500 nS pulse, minimum; 1 MHZ maximum. Rising edge of current pulse causes one step.
14	**STEP-** Input. Return for Step+.
2	**DIRECTION+** Input. Optically isolated current loop input. 20 mA nominal. Must be held active at least 10 microseconds prior to rising current edge of STEP+.
15	**DIRECTION-** Input. Return for STEP+.

16 **RPS+** Input. Optically isolated current loop input. 20 mA nominal. Presence of current on RPS (Remote Power Shutdown) causes current to be removed from the motor phase outputs (ie: amp is shutdown). Removing current turns amp back on.

17 **RPS–** Input. Return for RPS+.

10 **SLIP FAULT+** Open collector output. Current sink indicates that the motor is not within the user definable deadband range.

22 **SLIP FAULT–** Output. Return for SLIP FAULT+.

9 **DRIVE FAULT+** Current sink indicates a drive fault condition (shorted outputs, overtempature, exceeded average current, etc.)

21 **DRIVE FAULT–** Output. Return for DRIVE FAULT+.

7 **FAULT RESET+** Input. Optically isolated current loop input. 20 mA maximum. Presence of current clears a DRIVE FAULT or an ERROR. Current must be removed for amp. to function.

19 **FAULT RESET–** Input. Return for FAULT RESET+.

12 **COMMON** Low voltage power supply common.

RS-232: 25 pin D connector

2 **RECEIVE DATA** Input. RS-232 characters are recieved on this input. Conforms to IEEE standards for RS-232 communication.

3 **TRANSMIT DATA** Output. Characters received are echoed on this output. Conforms to IEEE specifications for RS-232 communication.

7 **COMMON** Output. This is the signal common for TRANSMIT and RECEIVE signals.

APPENDIX A

CONNECTOR LISTING

MOTOR CONNECTOR 7 Connection screw terminal block.

1 -- MOTOR +
2 -- N.C.
3 -- MOTOR -
4 -- GND

POWER 3 Connection screw terminal block.

	Single phase	Three phase	DC
1 --	120 VAC LINE	120 VAC Line 1	+150 VDC
2 --	120 VAC NEUT	120 VAC Line 2	+150 VDC RETURN
3 --	n.c.	120 VAC Line 3	n.c.
4 --	AC GND	AC GND	Earth ground

RESOLVER 9 Pin D-connector, female.

1 -- S1
2 -- n.c.
3 -- S4
4 -- R1
5 -- SHIELD
6 -- S2
7 -- S3
8 -- n.c.
9 -- R2

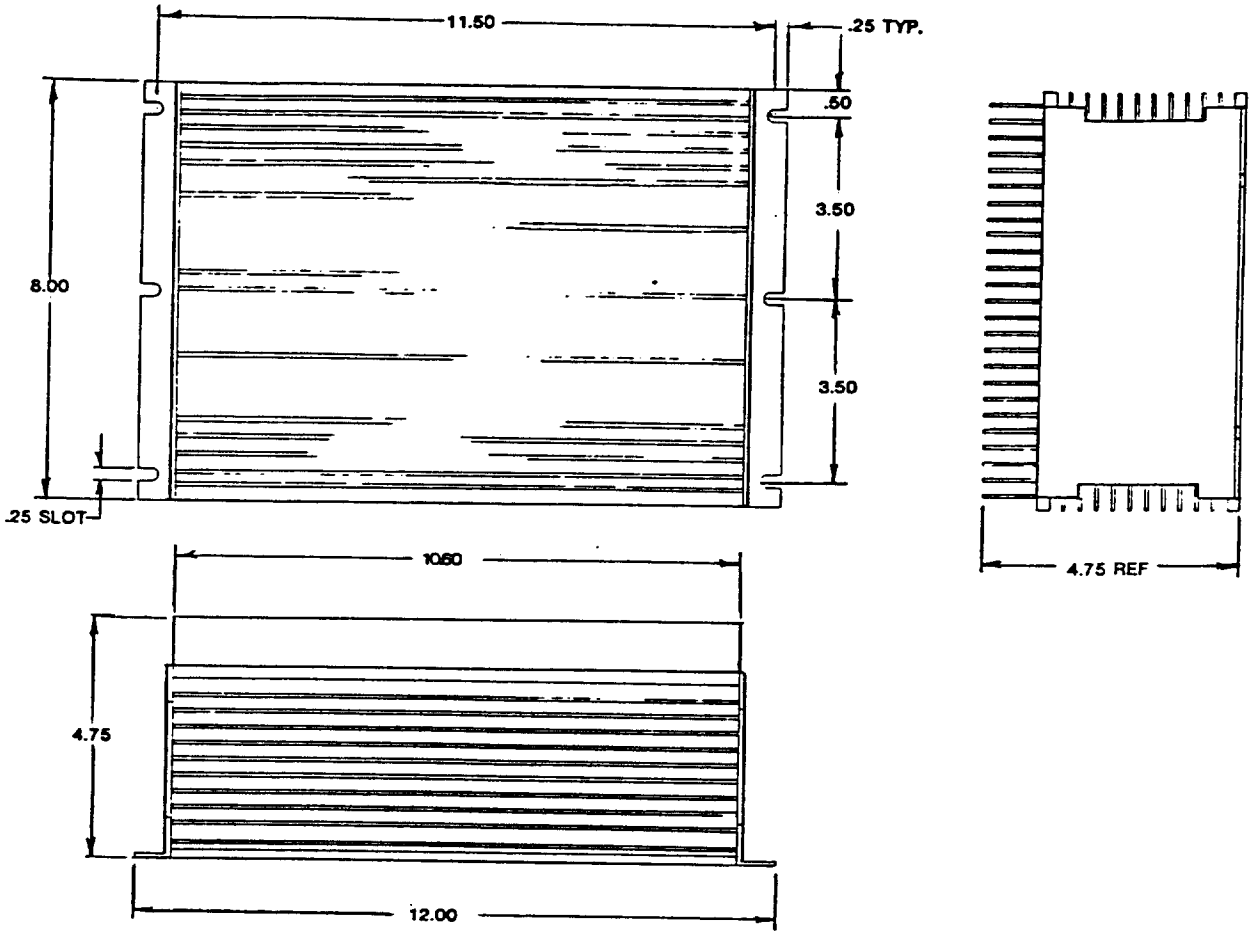
INDEXER 25-pin 'D' connector, female.

1 -- STEP+
2 -- DIRECTION+
3 -- n.c.
4 -- n.c.
5 -- SHIELD
6 -- n.c.
7 -- FAULT RESET+
8 -- n.c.
9 -- DRIVE FAULT+
10 -- SLIP FAULT+
11 -- n.c.
12 -- RESERVED
13 -- n.c.
14 -- STEP-
15 -- DIRECTION-
16 -- REMOTE POWER SHUTDOWN+
17 -- REMOTE POWER SHUTDOWN-
18 -- n.c.
19 -- FAULT RESET-
20 -- n.c.
21 -- DRIVE FAULT-
22 -- SLIP FAULT-
23 -- n.c.
24 -- n.c.
25 -- n.c.

RS-232 25-pin D connector, female.

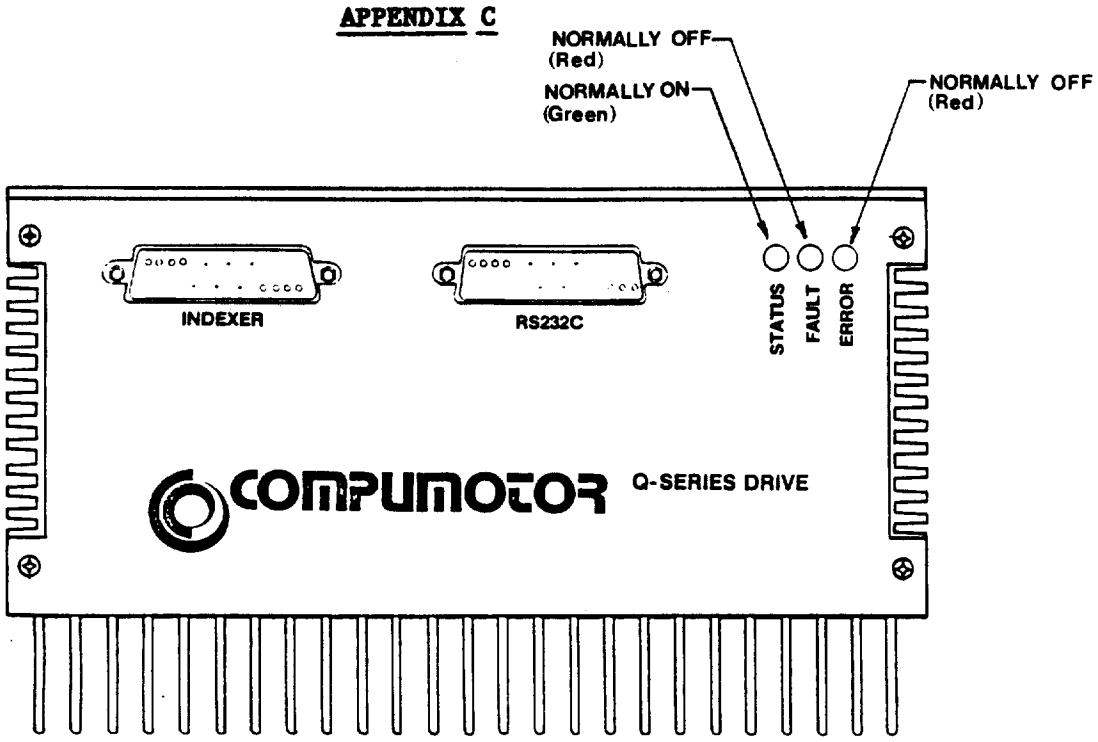
1 -- N.C.
2 -- RECEIVE
3 -- TRANSMIT
4 -- N.C.
5 -- N.C.
6 -- N.C.
7 -- GROUND
8 - 25 -- N.C.

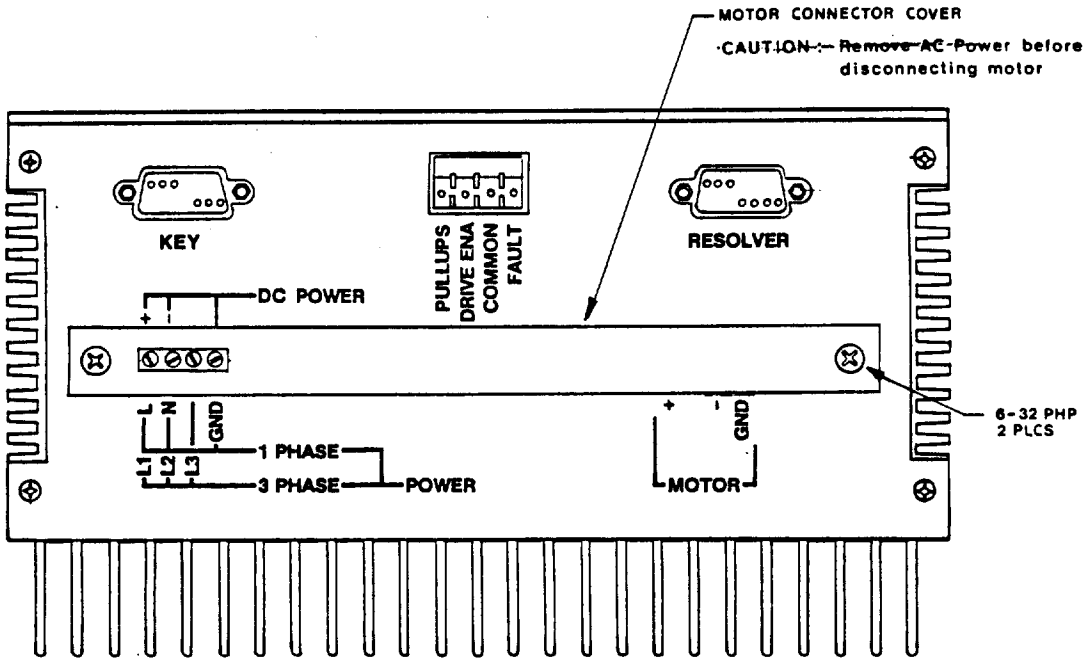
APPENDIX B



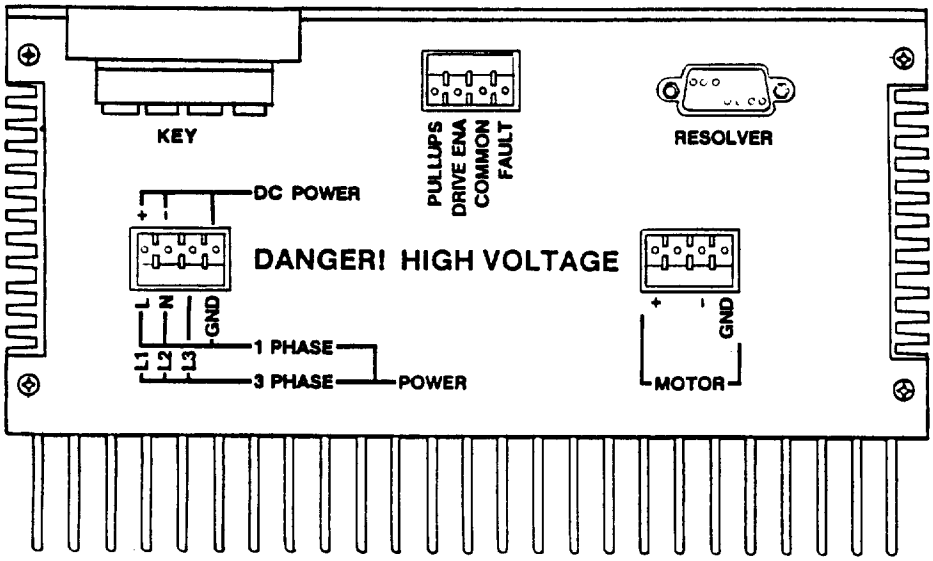
Q-Series DIMENSIONAL DRAWING

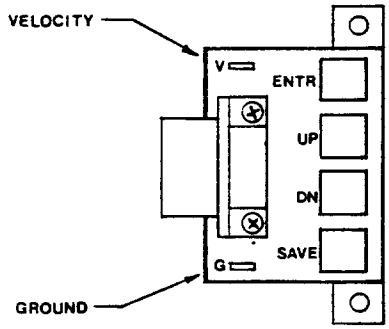
APPENDIX C





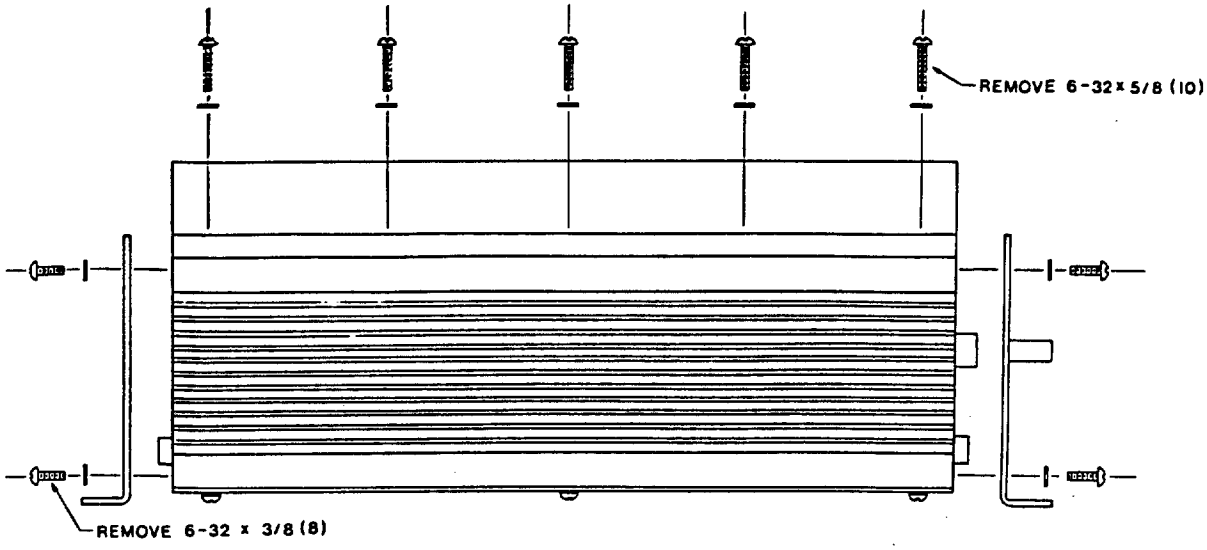
PANEL LAYOUT DRAWING



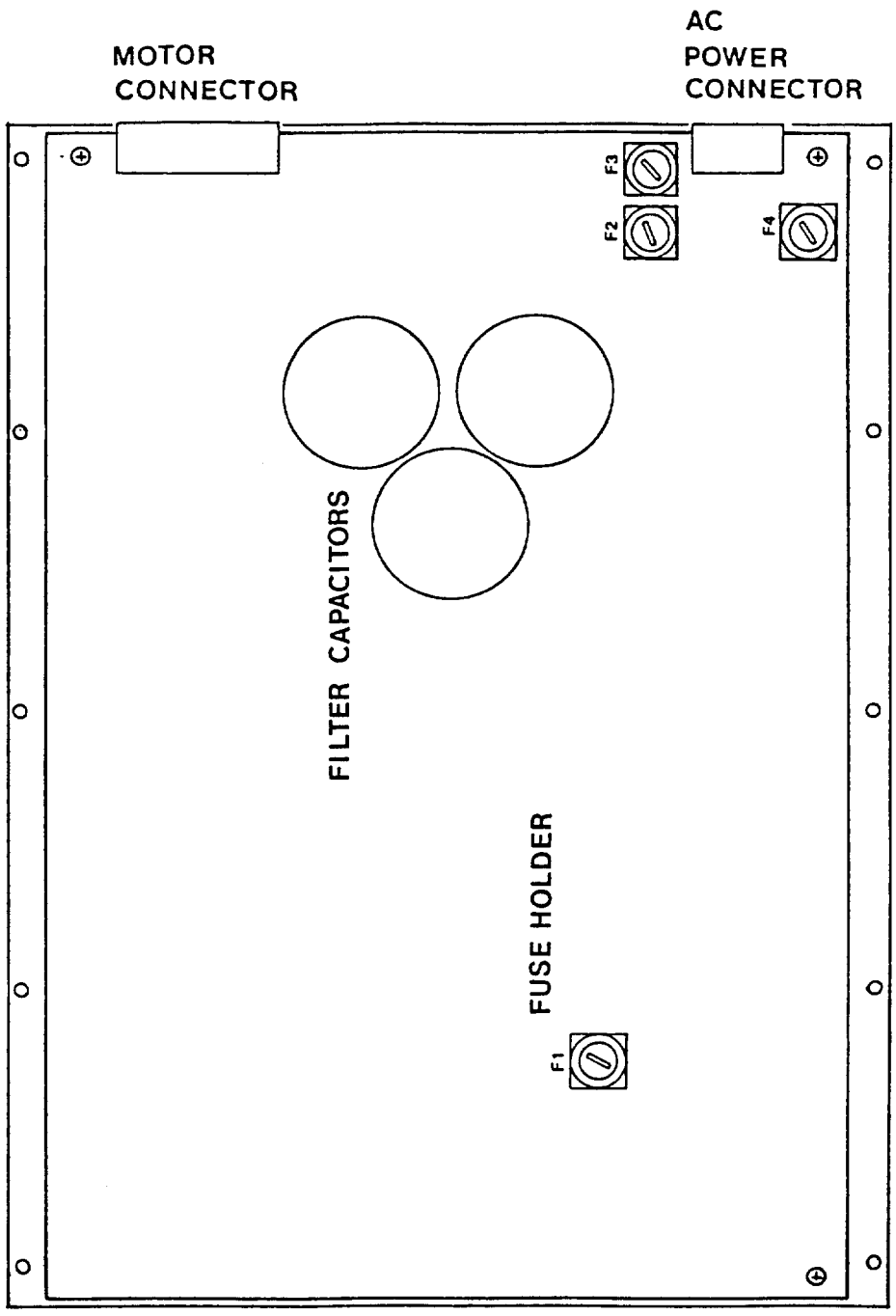


KEY DETAIL

PUSHBUTTON TUNING DRAWING



Q-DRIVE COVER REMOVAL DRAWING



FUSE LOCATION DRAWING

WARNING !

REMOVE AC POWER PRIOR TO DISCONNECTING

THE LINE POWER CONNECTOR

OR THE MOTOR CONNECTOR