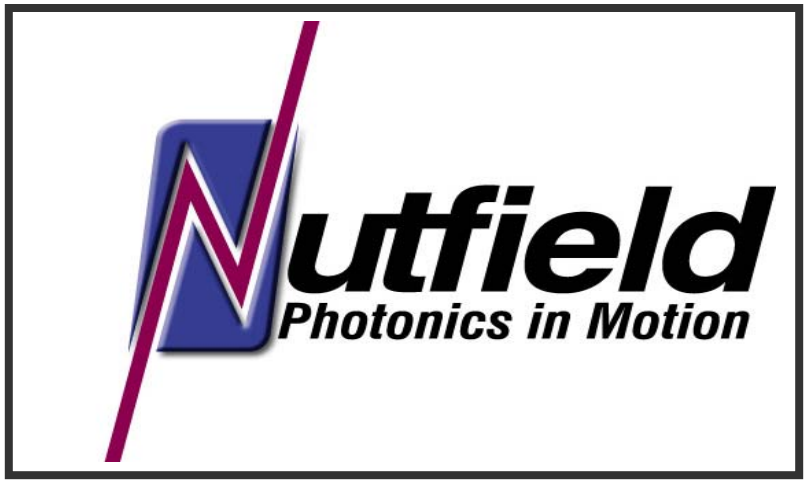

QuantumDrive-4000 Servo Drive Manual

Nutfield Technology, Inc.
49 Range Road
Windham New Hampshire 03087
USA

For QD-4000 Servo Drive Boards Only

 91-0027 Rev. C

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SAFETY AND WARNINGS

Nutfield Technology products are designed to provide maximum flexibility and ease of use. Such a design inherently requires the user to assure the overall safety of the configuration in use. Please follow carefully the requests for the different laser classes.

It is the user's responsibility to ensure that the following is understood:

1) Before installation or usage of a laser system you have to be aware about the regulations on laser safety.
2) During maintenance activities of laser systems the laser safety classes may change. In that case the customer has to take appropriate actions in advance.
3) Certified lasers contain features to assist in their safe usage. These protective features and the protective features within the Nutfield Technology products should not be defeated.

Prior to operating any configuration of the Nutfield Technology Scan Heads, you must make a thorough analysis of system safety. Key information for this purpose is contained in this manual. You must thoroughly familiarize yourself with all this information before proceeding.

The first consideration in a safety analysis is the laser mated to the Nutfield Technology product. The hazard level of the laser is roughly indicated by the Laser Class label that is on the device. A brief description of the radiation classes are shown in the following table.

Note that, besides radiation, lasers may present other hazards, e.g.; electric shock or creation of poisonous fumes.

Classes and Characteristics of Lasers

LASER CLASS	DESCRIPTION
Class I	Lasers are not considered to be hazardous.
Class IIa	Lasers are hazardous if viewed for periods greater than one thousand seconds.
Class II	Lasers are chronic viewing hazards.
Class IIIa	Lasers may represent acute, intrabeam viewing or chronic or acute viewing hazards when viewed with optical instruments.
Class IIIb	Lasers are an acute hazard to skin and eyes from direct radiation.
Class IV	Lasers are an acute hazard to skin and eyes from direct or scattered radiation.

Nutfield Technology Scanners provide you with the ability to aim the laser beam over a roughly pyramidal volume. The divergence of the focused beam beyond the focal point, which is a function of the lenses selected and their position, can cause radiation to exit the pyramid. When analyzing safety, you must consider all regions within this aiming pyramid, the divergent beam, and the effects of all focal possibilities in the zone of hazard. Reflections must also be considered.

Laser Shutter Installation

The laser attenuator (shutter) is not included with the scanners. Because each laser is unique, it is the user's responsibility to ensure that such a device is incorporated in the installation in conformance with CFR regulations (1040.10[f][6]), which reads as follows:

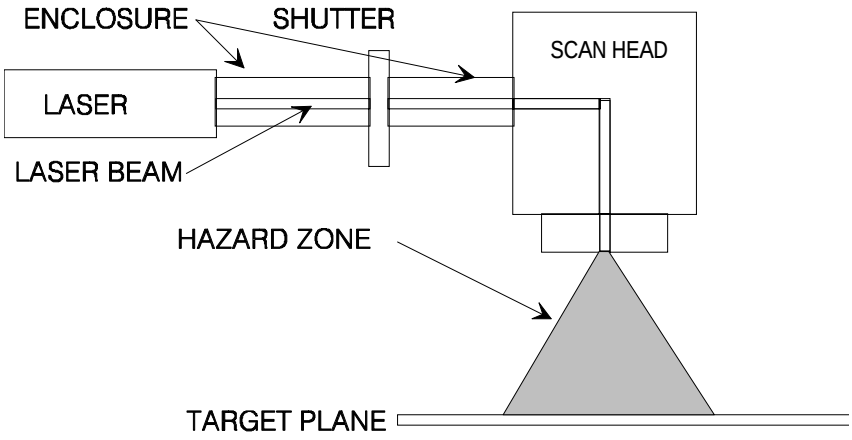
A beam attenuator is required on Class II, IIIa, IIIb, and IV laser systems. The beam attenuator is a mechanical or electrical device such as a shutter or attenuator that blocks emission. The beam attenuates or blocks bodily access to laser radiation above Class I limits without the need to turn off the laser. The beam attenuator must be available for use at all times during operation. Power switches and key controls do not satisfy the attenuator requirement.

The beam shutter should be installed between the laser head and the Scan Head. The following figure shows the recommended location of the shutter.

We strongly recommend that you specify a laser with a vendor-supplied shutter mechanism. If this is not possible, consult the laser vendor to design a proper safety shutter.

Laser Scanner Hazard Zones of a Scan Head

The figure shows the laser's internal and external optical path towards the target plane, specifically where the hazard zones are located as the optical beam passes through a Scan Head**.**



Installation Safety Requirements

Because of the possible hazard increase of scanning, stopping, or slowing to an unsafe velocity, it is required that the controller software shuts down the laser power (a scanning safeguard).

In all cases, we recommend that you fully enclose and interlock the zone of hazard for your application to prevent possible opening while the laser is energized. When laser radiation exceeding Class 1 levels may exit the enclosure, you must have suitable protection for eyes available.

At no time should you stare into the beam, place any parts of your body in the beam path, or expose yourself to reflections of powerful beams. You should use only a Class 1 HeNe Laser for alignment. If this is not possible, you should use the available laser's lowest power setting and remote beam sensing techniques.

Using optical instruments with this product increases eye hazard.

Safety Precautions During Usage

To maintain the necessary safety during usage of Nutfield Technology scanners please take following actions:

1) Please avoid any mechanical tension on the connection cables.
2) Protect the scanners from humidity, dust and aggressive steam to avoid damages to mirrors, objectives or electronics.
3) Always use proper lens cleaning cloth or cotton swabs to touch optical components.
4) Protect the scanners from electromagnetic fields and electrical discharges. This can severely damage interface and servo boards. Damage to the electronic circuits caused by electrical discharge may not be immediately apparent – but may result in malfunction at some later time thus affecting reliability of the product.
5) Please follow the maximum power handling capabilities of the mirrors.

1. Introduction

This manual covers the installation and use of the QuantumDrive-4000 for single axis and two axis applications.

The QuantumDrive-4000 (QD-4000) servo driver board is specifically designed to control a wide range of galvanometers and loads under a variety of command input conditions. The board incorporates the latest in servo technology along with system safety and status features.

The QD-4000 uses high quality components to achieve fast servo response with low noise and thermal drift. Generous output capacitors provide instantaneous current to the output drives, which improves performance and reduces power supply demands.

The QD-4000 is a class 1, Position, Integral, and Differential (PID) servo controller along with several other terms designed to maximize performance and allow for flexibility across a range of applications.

The board has several output signals available, which can be used as host inputs to monitor performance. One input allows for the remote control of Servo Enable. Two Status LEDs are on board as a quick status check for engineers and technicians. For your convenience, a set of mating connectors and pins for the Power, Command Input, and Diagnostic Output connectors ship with every driver board.

This manual contains all the information necessary to install and operate the servo driver along with a precision optical scanner. Servo drivers are typically factory tuned with a matched galvanometer and mirror. It is not advisable to attempt to adjust the servo driver in the field. Only factory trained service technicians should attempt to adjust any of the potentiometers on the board. If it becomes necessary to return a servo driver board to the factory, the matching galvanometer and mirror should be returned along with it. Any unauthorized attempt to retune the servo by an untrained individual could result in serious damage to the scanner, mirror and electronics.

2. READ THIS BEFORE CONNECTING

- When unpacking the servo driver board(s), caution should be used to protect against static electricity damage. Failure to use proper static protection may cause damage to the servo driver boards and void the manufacturer's warranty.
- For your convenience, three mating connectors and pins ship with every driver board; they are packaged separately.
- For proper operation of two servos drives, be sure to attach both servo grounds together as shown in the manual. Failure to do so could result in poor performance.
- If using a single ended command signal, Pin 1 is the positive (+) command input, Pin 2 is the ground, Pin 3 is also tied to ground. Be sure to attach the ground pin and the negative (-) command signal together at the servo drive command connector.
- Galvanometers packaged with servo drivers (and mirrors) are factory tuned as a set. Each galvanometer is tuned together with a servo driver and MUST stay together as a set. Servo driver boards have a copy of their mating scanner serial number on the bottom of them.
- Servo drivers must be properly attached to a heat sink. Refer to Section 9 on Heat Sink Requirements in the manual for proper heat sinking instructions. Failure to heat sink the servo driver could result in overheating of components, which could void the manufacturer's warranty.
- Every servo driver is tuned to accept an input voltage range based on customer-supplied information. Using input command voltages over the factory setting may cause the mirrors to collide. NTI will not be responsible for mirror damage as a result of command input voltages that exceed the factory setting.
- Be sure that you connect the proper power and ground to your servo driver before operation. The power supply should have sufficient voltage and current for your application. Noisy power supplies can result in poor scanner performance. Supplies are required to have <100mV of ripple at full load.
- Your optical scanners were carefully tested and inspected before packaging. Please report any damage to your shipping company immediately.

3. The Main and Personality Boards

The QD-4000 consists of two unique printed circuit boards: The Main Board, and the Personality Board. The Main Board, the larger of the two is the backbone of the system, hosts primarily the output power amplifiers, the majority of connections, and heat-generating devices. The Personality Board, the smaller of the two, hosts the control-loop, notch filter, and the diagnostic connector. A "Board Pair" MUST be used for the servo to operate.

4. Quick Connect Guide

Before connecting the servo drive(s) please read Section 2.

- Adjust your dual voltage supply within the proper range of +/- 15V to +/- 24V before connecting the power cables.
- After adjustment, turn off the power supply before making any connections to the servo drive(s).
- The servo drive(s) should be properly mounted to a sufficient heat sink.
- Galvanometers should be mounted properly to avoid mirror collisions.
- Connect the Position Detector Cable from the Galvanometer Position Detector Connector (white, 5 Pin) to the Servo Driver Board (J1). Repeat if there is more than one Galvanometer.
- Connect the Scanner Drive Coil Cable from the Galvanometer Drive Coil Connector (black, 3 Pin) to the Servo Driver Board (J6). Repeat if there is more than one Galvanometer.
- Connect the Power Cable(s) from the Power Supply to the Servo Driver Board(s) (J7).
- Connect the Command Input Cable(s) from the function generator or host system to the servo drive board(s) (J3). If using a single ended signal, be sure to attach the (-) negative and ground pins together at the servo drive command connector. If using a signal from a differential source, Pin 1 is the positive (+) command input, Pin 2 is the ground (-) command, and Pin 3 is the negative (-) command input.

Board Revisions

	Main Board PCB	Personality PCB
Release 1	31-1207 REV E	31-1208 REV F
Release 2	31-1210 REV A	31-1208 REV G

Power Connector – J7 (See Main Board Drawing)

Pin No.	Function
1	+ V Supply (+ 15 to 24V)
2	Ground
3	- V Supply (- 15 to 24V)

Input Command Connector – J3 (See Main Board Drawing)

Pin No.	Function
1	+ Command
2	Ground
3	- Command
4	Offset Adjust *
* Introduced in Release 2	

Diagnostic Output Connector – J12 (See Personality Board Drawing)

Pin No.	Function
1	Galvo Position Output
2	Galvo Error Output
3	AGC Monitor
4	Velocity Output
5	Ground
6	Slew Rate Output
7	Current Monitor
8	No Connect

Servo Enable Connector – J8 (See Main Board Drawing)

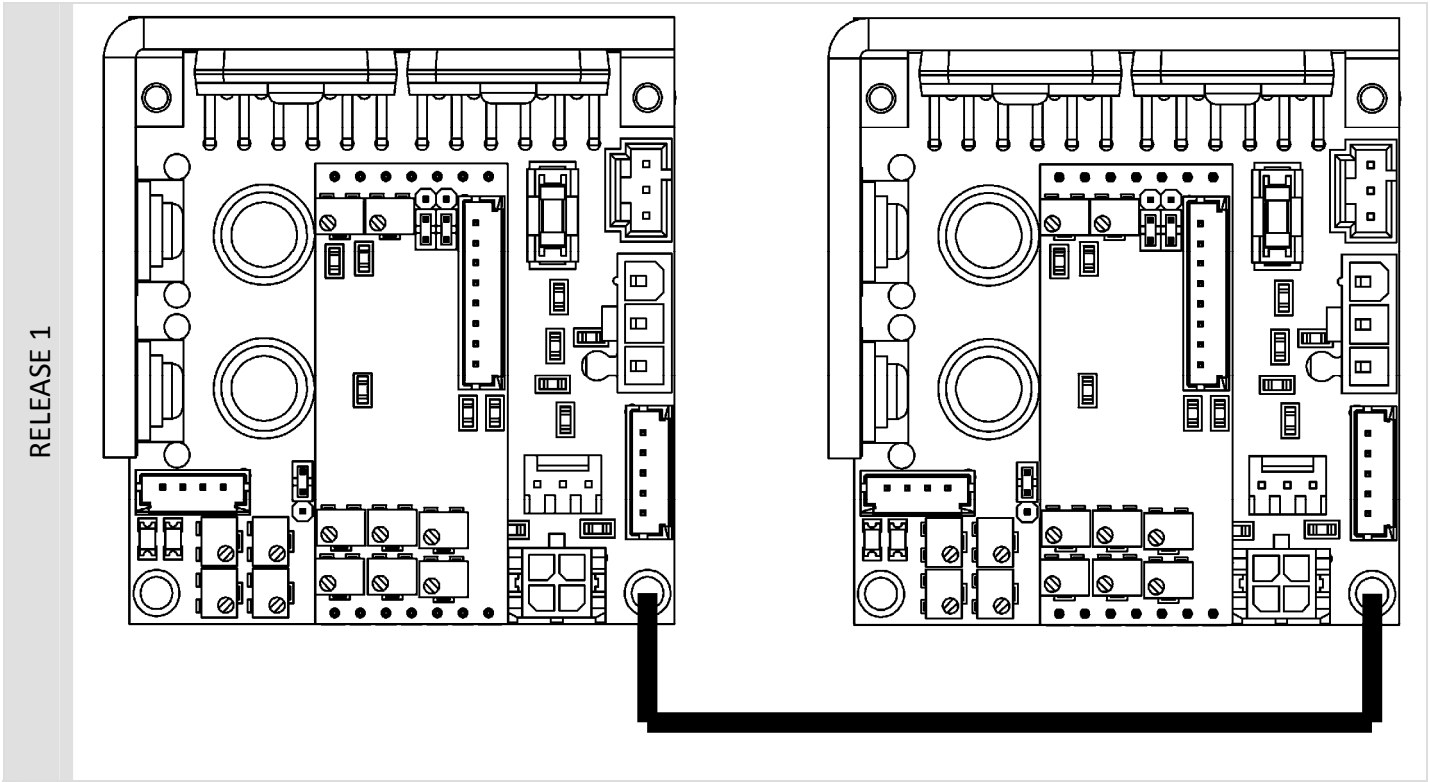
Pin No.	Function
1	Servo Ready High
2	Servo Ready Low
3	Servo Enable
4	Ground

Ground Connections

IMPORTANT! ***Proper grounding is required for good performance.***

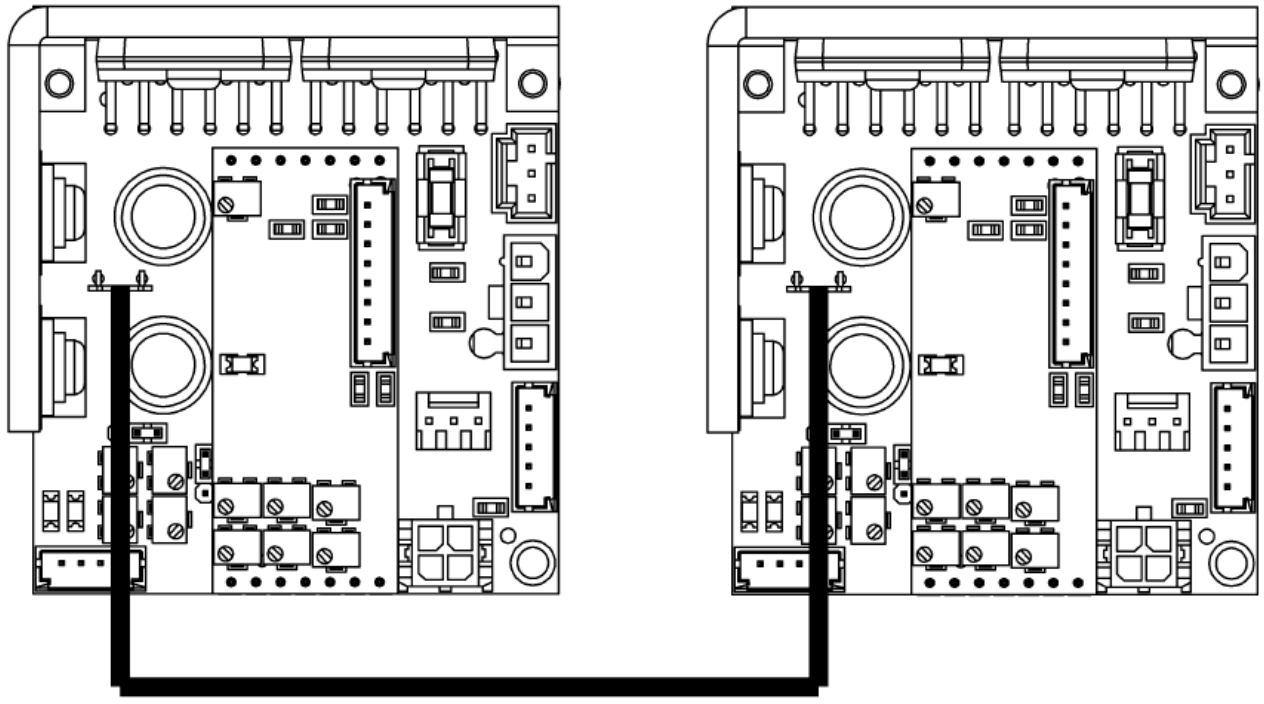
For the highest performance in two axis configurations, it is highly recommended that both servo drives have their grounds tied together as shown below. This will reduce cross talk between servo drives. Cross talk is a phenomenon that occurs when one servo drive demands a large amount of instantaneous current, causing the other drive to have a ground imbalance. The result is unintentional movement of the other galvanometer causing undesirable marking. Please follow the instructions below to eliminate this issue.

1) Attach a heavy gauge wire between both X and Y servo drives.
2) Confirm R97, the mounting hole ground connection is shorted on both boards.
3) Do not attach metal hardware to chassis through this hole or you will develop a ground loop.
4) If using the grounding hole for mounting, be sure to use plastic hardware to insulate the servo ground from chassis ground at this point.



5) Release 2 version alternately allows grounding with J2 quick fit terminal; in this case the mounting holes may be isolated from ground by removing solder from R97 pad.

RELEASE 2



5. Specifications

Servo Architecture

Class 1, PID, Single or Dual Push/Pull Outputs

Power Requirements

Input Voltage +/-15 to +/-24VDC, < 100mV Ripple, < 0.5% DC to 30MHz Noise
Maximum Drive Current Limit:
Peak: 10 Amperes per leg
RMS: 4 Amperes per leg (power supply, load, & heat sink dependent.)
Quiescent Current: 400mA per leg (Servo Enabled, Galvo Resting)

Inputs

+/- Command, Servo Enable
Command Input Range: +/-3, +/-5, or +/-10 volts (Factory Configured)
Command Input Scale Factor: Customer Specified +/- 3, 5 or 10V
For +/- 3V at +/- 20° = 0.15V/degree
For +/- 5V at +/- 20° = 0.25V/degree
For +/- 10V at +/- 20° = 0.5V/degree
Command Input Impedance: 20K ± 1% ohms (Differential)
10K ± 1% ohms (Single Ended)
Position Offset Range: ± 0.25V
Digital Position Input Range: 2^{16} DAC counts digital to +/-5 or +/-10 Volts
Non-Linearity of 16 Bit Digital Input: 0.006% of full scale, max

Outputs

Scanner Position, Error, AGC, Velocity, Slew Rate, and Current Monitor
Output Impedance: 1K ± 1% ohms (For all observation outputs)
Scanner Position Output Scale Factor: 0.25 volt/° @ +/-20º for +/- 5V Command In
Error Output Scale Factor: 0.25 volt/° @ +/-20º for +/- 5V Command In
Integration Output Scale Factor: 0.25 volt/° @ +/-20º for +/- 5V Command In
Velocity Output Scale Factor: Analog

Status LED's

Servo Power/Ready D8 (Green)
Fault D7 (Red)

Protection Circuits (Shut Down Conditions)

Power Fail, Under Voltage, Over Position, AGC Fail, Open Loop Condition

Start Up and Shut Down Protection: Soft Start, Soft Stop

Environmental

Operating Temperature:	0°C to +45°C (with appropriate cooling)
Storage Temperature:	-10°C to +60°C
Humidity:	Non-Condensing
Temperature Stability of Electronics:	10 PPM per °C Standard

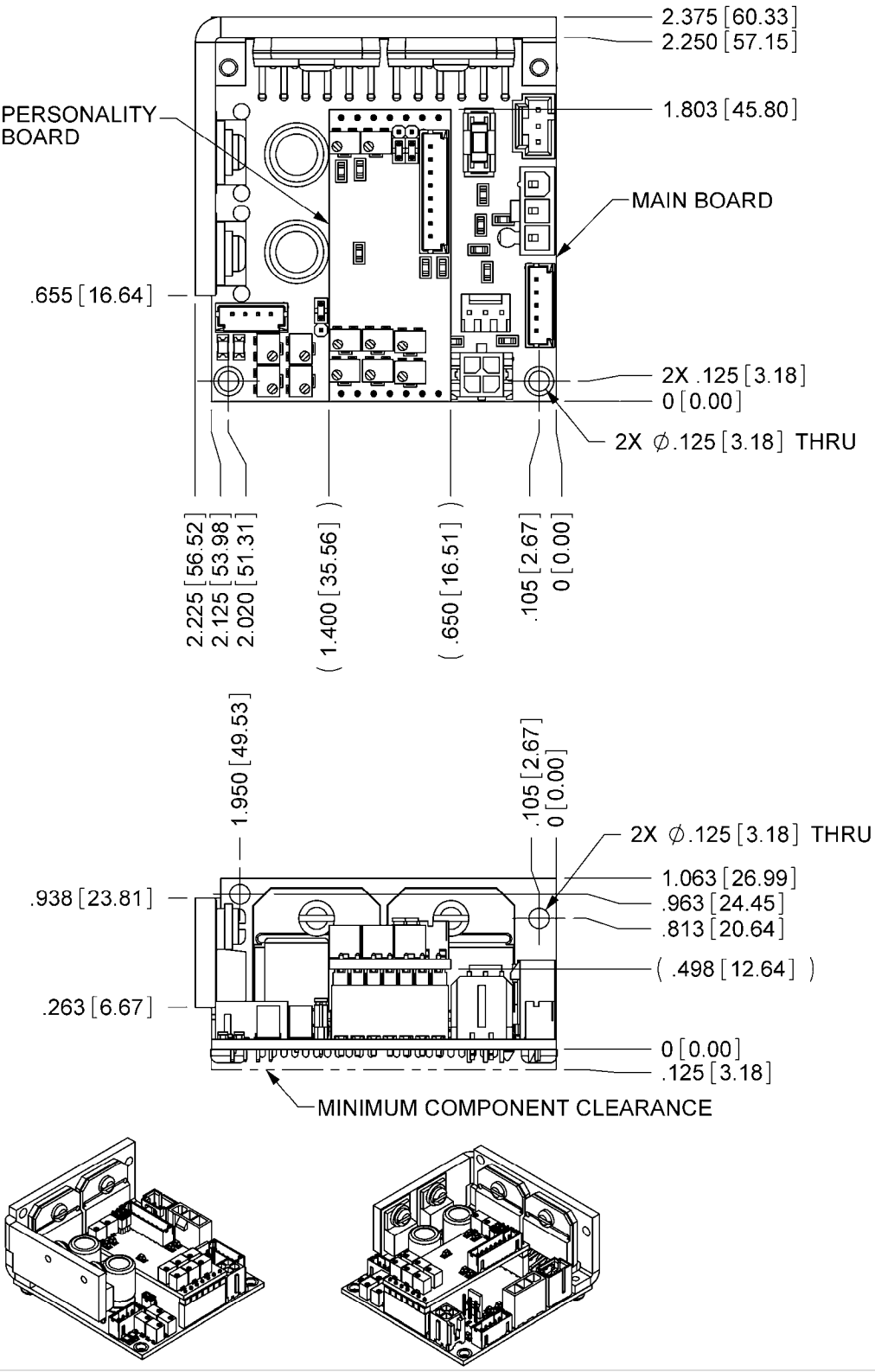
Size and Weight

61mm x 57mm x 28mm
2.6 ounces (74 grams)

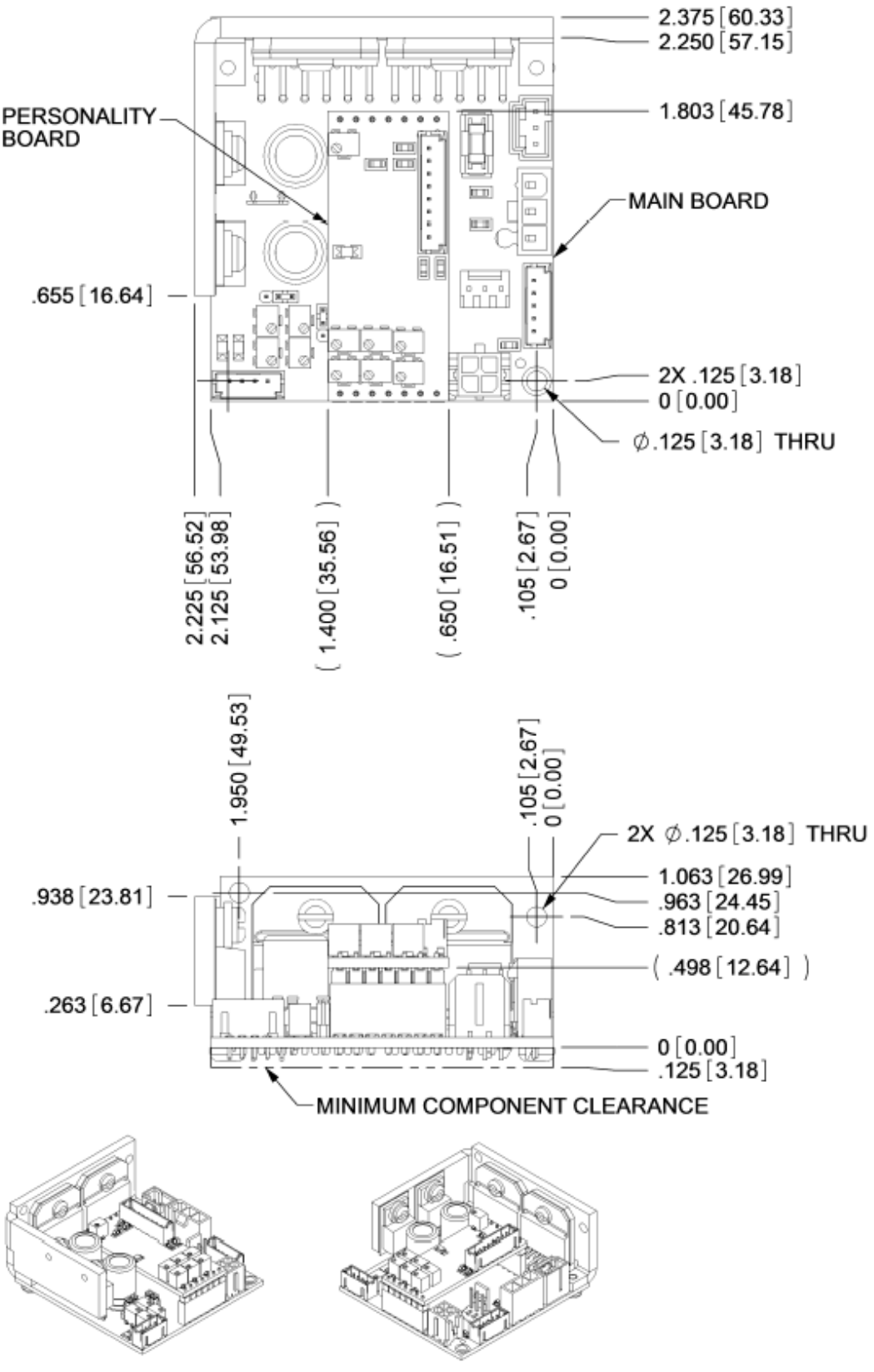
Specifications are in degrees optical (2 x mechanical degrees) after a two-minute warm up period.

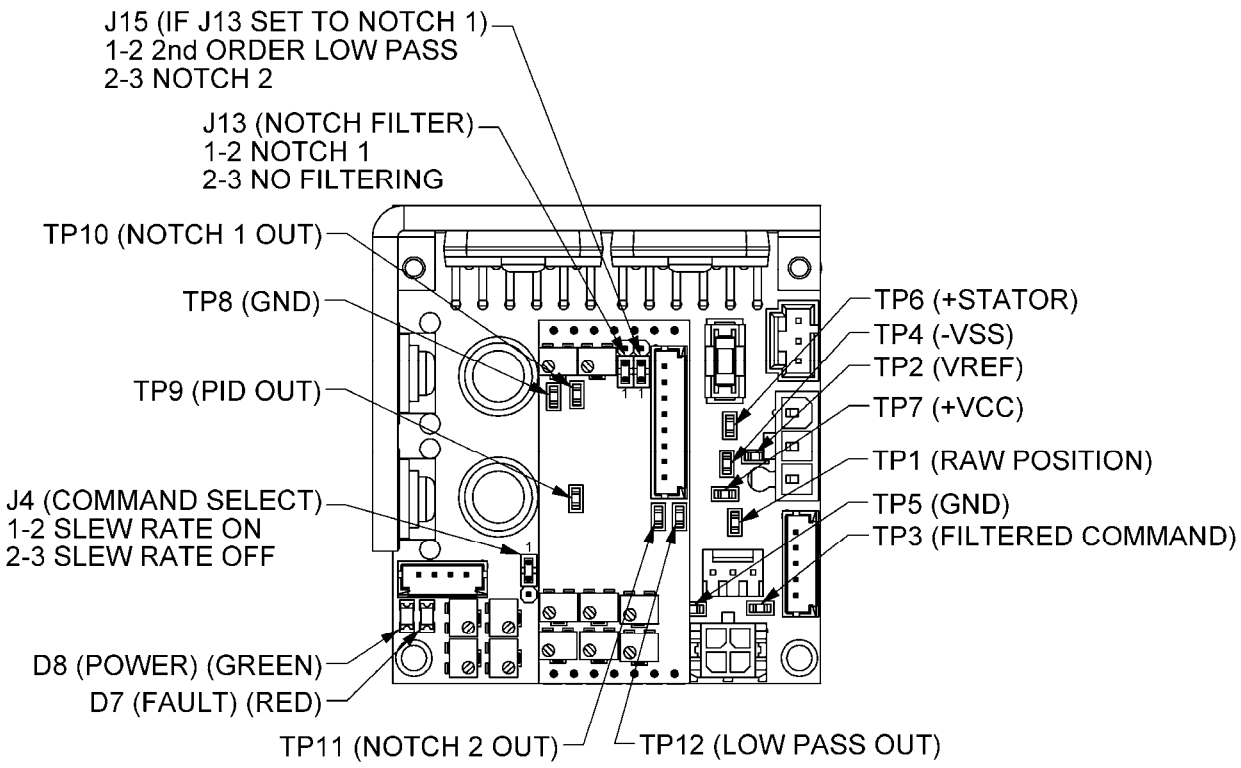
6. Outline Drawings

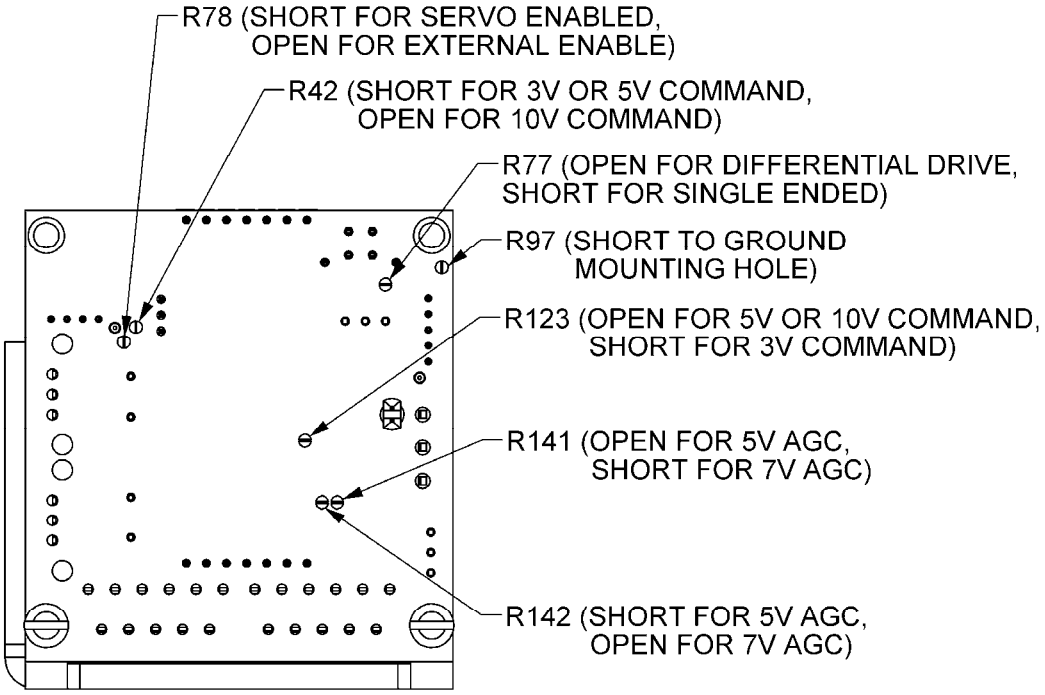
6.1 Mechanical Outline – Release 1



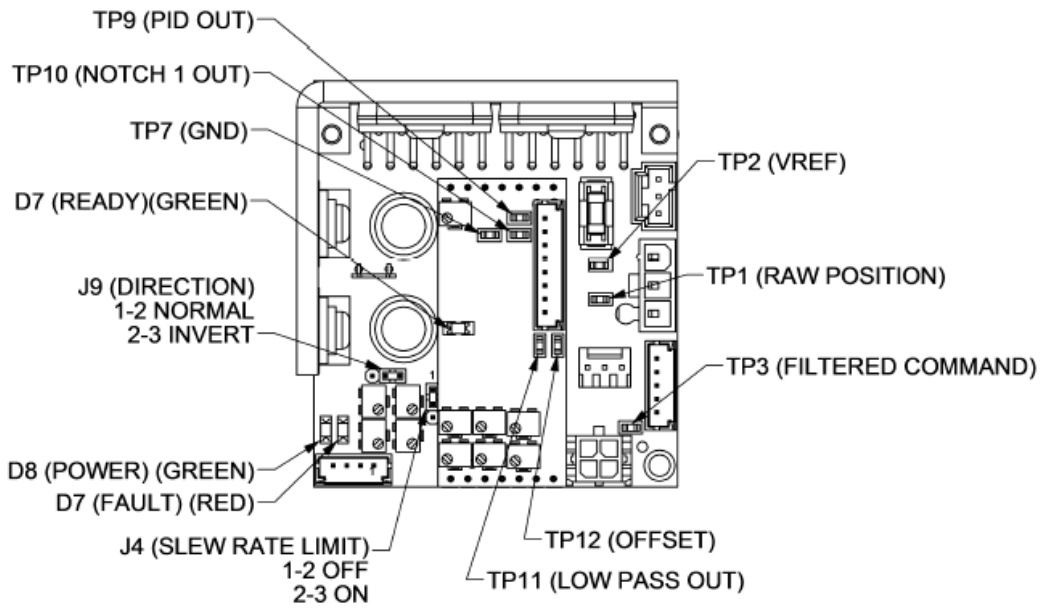
6.1 Mechanical Outline – Release 2





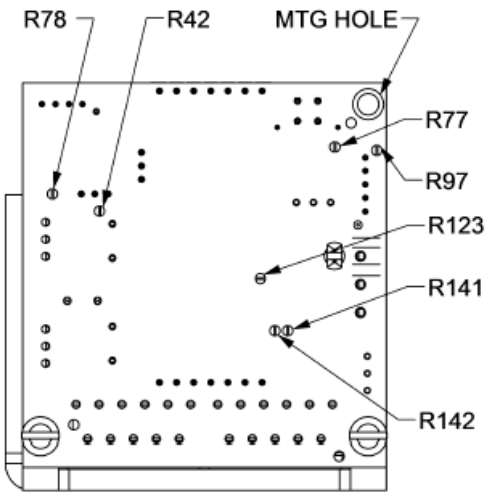


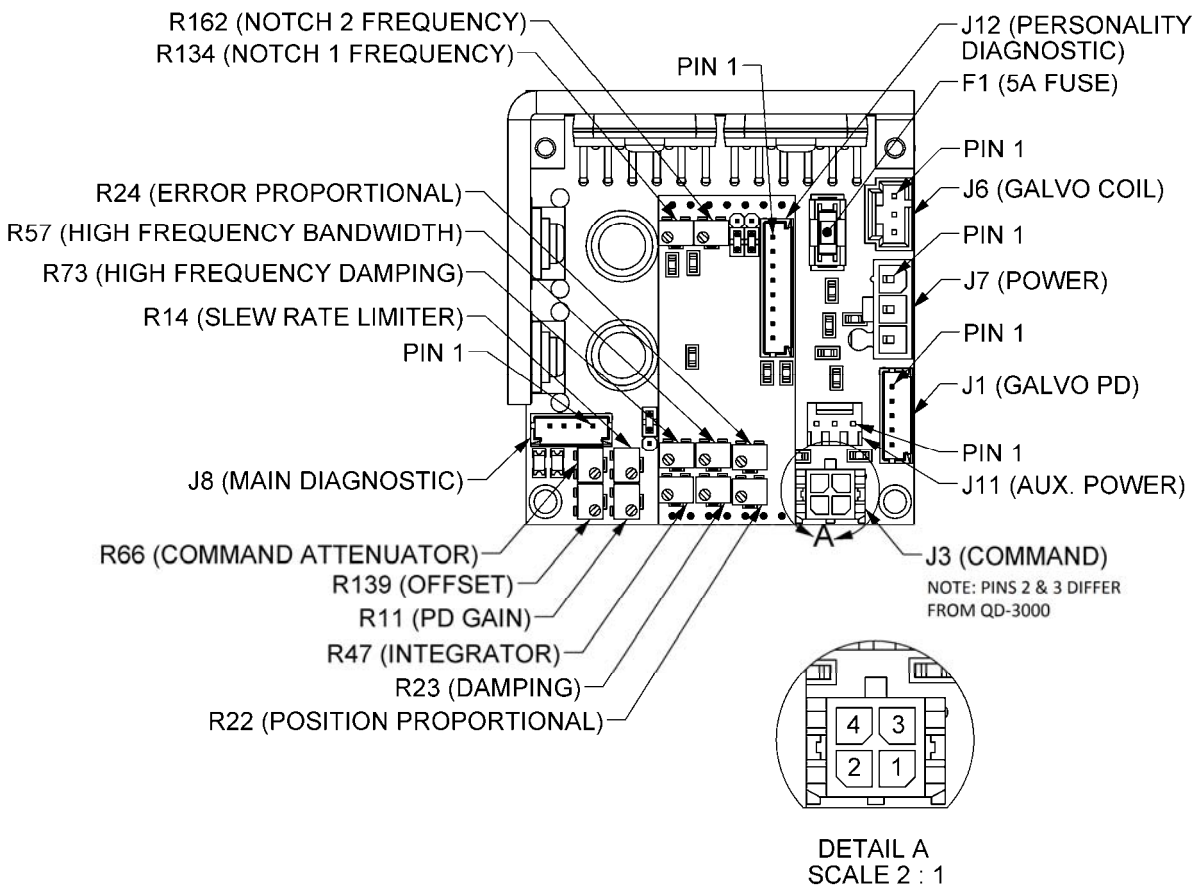
6.2 Jumpers, Test Points and LEDs– Release 2



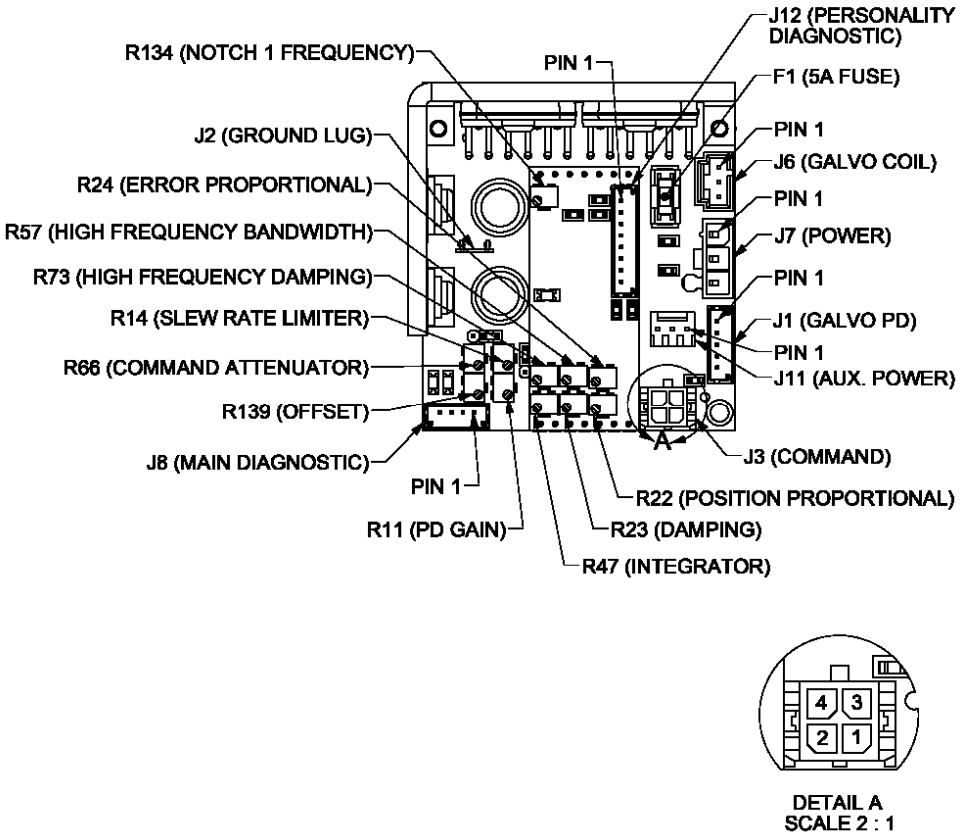
REF DES	OPEN	SHORT
R42	10V Command	3V & 5V Command
R77	Differential Command	Single Ended Command
R97	Floating Mounting Hole	Grounded Mounting Hole
R78	External Enable	Servo Enabled
R123	5V & 10V Command	3V Command
R141	QS-7, 10, 12 & LT	QS-30*
R142	QS-30*	QS-7, 10, 12 & LT

*Note: 5V or 10V Command Only.





6.3 Connectors and Potentiometers – Release 2



7. Connectors

For your convenience, a set of mating connectors and pins for the Power, Command Input, and Diagnostic Output connectors ship with every driver board.

7.1 Power Connector (Main Board - J7)

The mating connector is a Molex 39-01-4031 or 39-01-4030 connector with (3) Molex 39-00-0183 or 39-00-0184 pins. The pins should be used with AWG 22-28 wire.

The power connector (**J7)** is used to deliver the appropriate voltage to the servo driver board. Pin 1 is the positive supply voltage. Pin 2 is the ground. Pin 3 is the negative supply voltage.

A power supply with sufficient output current should be used. The output current required depends on the supply voltage, galvanometer model, mirror load, and command waveform and duty cycle. Lower supply voltages, larger galvanometers, larger mirrors, and more demanding waveforms and duty cycles will require more current. It is a good practice to setup your application with a laboratory power supply and measure the required current during the most demanding application your system can run. Then select a power supply appropriate for your application.

The QD-4000 has two generous output capacitors, which supply instantaneous peak current to the output drive amplifiers and lower the peak output requirements of your system power supply.

Power Connector – J7 (see Servo Driver Drawing)

Pin No.	Function
1	+ V Supply (+ 15 to +24V)
2	Ground
3	- V Supply (- 15 to -24V)

7.2 Command Input Connector (Main Board - J3)

The mating connector is a Molex 43025-0400 connector with (4) Molex 43030-0003 or 43030-0009 pins. The pins should be used with AWG 20–24 wire.

The analog command input comes in on connector **(J3)**. For differential inputs, Pin 1 is the positive (+) command input, Pin 2 is ground, and Pin 3 is the negative (-) command input. Switching the input polarity of Pins 1 and 3 will reverse the rotation of the galvanometer shaft.

The input can be configured for single-ended or differential operation.

IMPORTANT NOTE: For single-ended operation Pin 1 is the positive (+) command input, Pin 2 is the ground, and Pin 3 is also tied to ground. This is done by applying a solder bridge to R77

Input Command Connector – J3 (see Servo Driver Drawing)

Pin No.	Function
1	+ Command
2	Ground
3	- Command
4	Offset Adjust *
* Introduced in Release 2	

An external offset adjust is provided on pin 4 of the input command connector. This option is generally not used and this pin may be left floating. The offset is adjusted internally to zero at the factory.

For certain 3-axis applications it may be desirable to externally calibrate the third axis (focus) by introducing an analog dc offset to pin 4. Up to ±10 volts may be applied; however the combination of command and offset can not exceed the normal range of motion.

7.3 Diagnostic Output Connector (Personality Board - J12)

The mating connector is a Molex 51090-0800 connector with (8) Molex 50212-8000 or 50212-8100 pins. The pins should be used with AWG 24–30 wire.

The diagnostic output connector **(J12)** provides several output signals that are used to monitor various functions of the servo and galvanometer. See the output signal specifications in Section 4 for more details.

Diagnostic Output and Servo Enable Connector – J12 (Optional)

Pin No.	Function
1	Galvo Position Output
2	Galvo Error Output
3	AGC Monitor
4	Velocity Output
5	Ground
6	Slew Rate Output
7	Current Monitor
8	No Connect

7.3.1 Position Output

The position output signal **(J12, Pin 1)** provides a scaled instantaneous position output from the galvanometer that is buffered through an amplifier. The signal may be used to trigger an event when a position is reached or used when tuning the servo driver.

7.3.2 Position Error Output

The position error output signal **(J12, Pin 2)** is the difference between the command input signal and the position signal. It can be used to signal the arrival at a command location or as a tracking offset (continuous position error).

7.3.3 AGC Monitor

The AGC signal **(J12, Pin 3)** is a voltage that drives the galvanometer position detector's oscillator. If found to be excessive, this could suggest position detector problems.

7.3.4 Velocity Output

The Velocity output signal **(J12, Pin 4)** is the instantaneous angular velocity of the galvanometer rotor. It is used for tuning the servo drive and to monitor variations in velocity, which may be important in some applications like raster scanning.

7.3.5 Slew Rate Output

The Slew-Rate output signal **(J12, Pin 6)** is the command signal being passed to the control loop if the Slew-Rate circuit has been enabled.

7.3.6 Current Monitor

The Current signal (**J12, Pin 7**) is the current that is being sent to the galvanometers coil. The signal is represented as 1V/Amp of current in the coil.

7.4 Servo Enable Connector (Main Board – J8)

The mating connector is a Molex 51090-0400 connector with (8) Molex 50212-8000 or 50212-8100 pins. The pins should be used with AWG 24–30 wire.

Pin No.	Function
1	Servo Ready High
2	Servo Ready Low
3	Servo Enable
4	Ground

The servo enable input **(J8, Pins 3 and 4)** allows the host control system to remotely enable or disable the servo driver. When Pin 3 is pulled low by connecting it to the ground available at Pin 4, the servo is enabled. When Pin 3 is floating, the servo is disabled and will not move in response to input commands.

NOTE: This input should not be used as an interlock. The use of a shutter or other safety measure should be used for protection from laser radiation.

NOTE: The servo board is shipped with a solder bridge (**R78)**, which disables the remote servo enable. The solder bridge (R78) must be removed for the remote servo enable operation to function.

7.5 Galvanometer Cables and Connections

Each galvanometer requires two cables for connection to the servo driver board. One cable provides current to the drive coil (stator). The other cable provides power to the position detector circuit and communicates the return position signal to the servo. The two cables are shielded and separated to prevent coupling of the drive signal into the position feedback signal.

7.5.1 Galvanometer Coil Connector (Main Board - J6)

The mating connector is a Molex 50-57-9403 connector with (3) Molex 16-02-0082 or 16-02-0097 pins. The pins should be used with AWG 24–30 wire.

The galvanometer drive coil connector **(J6)** receives the galvanometer drive cable. The drive cable connects between **(J6)** on the servo driver board and the drive coil connector on the galvanometer. There are two conductors and a shield that terminates to a floating terminal inside the galvanometer.

Galvanometer Coil Connector – J4 (see Servo Driver Drawing)

Pin No.	Function
1	Coil +
2	Coil -
3	Shield

7.5.2 Galvanometer Position Signal Connector (Main Board - J1)

The mating connector is a Molex 51046-0500 connector with (5) Molex 50212-8000 or 50212-8100 pins. The pins should be used with AWG 24–30 wire.

The galvanometer position signal connector **(J1)** receives the galvanometer position cable. The position cable connects between **(J1)** on the servo drive board and the position signal connector on the galvanometer. There are four conductors and a shield that drains to the servo only; it is not connected to galvanometer. The other conductors carry the +/- position signals, power, and ground.

Galvanometer Position Signal Connector – J1 (see Servo Driver Drawing)

Pin No.	Function
1	Position +
2	Position -
3	Ground
4	OSC Power (AGC)
5	Shield

8. Power Requirements

Input Voltage: ±15 to ±24VDC
Ripple: < 100mV Ripple
Noise: < 0.5% DC to 30MHz
Maximum Drive Current Limit:
Peak: 10 Amperes per leg
RMS: 4.0 Amperes per leg (power supply, load, & heat sink dependent.)
Quiescent Current: 400mA per leg (Servo Enabled, Galvo Resting)

A power supply with sufficient output current should be used. The output current required depends on the supply voltage, galvanometer model, mirror load, and command waveform and duty cycle. Lower supply voltages, larger galvanometers, larger mirrors, and more demanding waveforms and duty cycles will require more current. It is a good practice to setup your application with a laboratory power supply and measure the required current during the most demanding application your system can run. Then select a power supply appropriate for your application.

Select a high quality power supply with good clean DC outputs. Power supplies with excessive ripple or noise will cause scanning problems in your system.

The QD-4000 has two generous output capacitors, which supply instantaneous peak current to the output drive amplifiers and lower the peak output requirements of your system power supply.

9. Heat Sink Requirements

WARNING: The servo driver board MUST be attached to an additional heat sink before applying power. Failure to provide proper heat sinking could result in damaged components and could void the manufacturer's warranty.

Each servo drive board has two output amplifiers and two voltage regulators, which require heat sinking. These devices are mounted to an "L"-shape heat sink attached to the board. This heat sink is not sufficient for normal operation. The servo drive heat sink must be attached with at least two screws to a larger thermally conductive surface such as an aluminum plate. Make sure that the surface is flat and that the two plates are in good contact with each other. NTI recommends selecting a heat sink surface with exposure to the outside surface of the host system. The use of thermal paste is a good idea for demanding applications.

The amount of heat that needs to be dissipated depends on several factors including the size of the galvanometer and mirror, the galvanometer stator resistance, the command waveform and duty cycle, and the ambient temperature.

As a guideline, one Quantum Scan 7 galvanometer and servo drive with 10mm mirrors running an aggressive vector pattern, requires about 325 square centimeters of surface area. This can be achieved with heat sink fins if surface area is limited. Blowing air across the heat sink will also reduce the surface area requirements. In this example, the galvanometer and servo driver consume about 30 watts of power, most of which is dissipated in the servo drive.

It is suggested that the temperature of the servo driver heat sink near the output amplifiers not exceed 55 degrees Celsius. Some trial and error may be required in each application to reach the appropriate amount of heat sinking.

10. Tuning

NOTE: Each servo driver is factory tuned and matched with a galvanometer and mirror load. Unauthorized attempts to tune the servo driver in the field may result in damage to the servo, galvanometer, or mirror. The manufacturer will not cover damage as a result of unauthorized attempts to tune the servo drive. The customer may be assessed an additional fee if the servo driver and galvanometer have to be factory tuned as a result of unauthorized tuning in the field.

Tuning the servo drive refers to adjusting the terms in the servo loop to optimize performance for a given set of parameters. The parameters are:

Galvanometer Model (rotor inertia, coil resistance, inductance, position detector sensitivity, etc.)
Mirror Inertia
Maximum Rotor Angular Displacement
Command Waveform (Step, Vector, Raster, Sinusoid)
Performance (Speed, Accuracy)
Supply Voltage (+/- 15 to +/- 24 volts)

Once the parameters are determined, a technician trained in the skill of servo tuning can set up a servo driver board with a given galvanometer/mirror combination and a set of operating parameters.

10.1 Servo Tuning Potentiometers (Personality Board)

Reference the Jumpers and Potentiometer drawing in Section 6.2.

10.1.1 Position Proportional (R22)

Position Proportional **(R22)** is a pot used to adjust the gain of the position proportional term.

10.1.2 Integrator (R47)

Integrator **(R47)** is the pot used to adjust the gain of the servo loop at DC. This is useful for the scanner to achieve its commanded location at steady state.

10.1.3 Damping (R23)

Damping **(R23)** is the pot used to adjust the amount of damping in the servo loop.

10.1.4 Error Proportional (R24)

Position Error **(R24)** is the pot used to adjust the gain of the position error in the servo loop. Increasing this term causes faster response to a command input.

10.1.5 High Frequency Bandwidth (R57)

High Frequency Bandwidth (R57) is used to adjust the frequency range in which the High Frequency Damping is invoked.

10.1.6 High Frequency Damping (R73)

High Frequency Damping (R73) is used to dampen higher frequency transients during very fast step responses.

10.1.7 Notch Filter 1 (R134)

Notch Filter 1 (R134) is used to attenuate the primary mechanical resonance of the galvo-mirror system.

10.1.8 Notch Filter 2(R162)

Notch Filter 2 (R162) is used to attenuate the secondary mechanical resonance of the galvo-mirror system.

10.2 Potentiometers (Main Board)

10.2.1 DC Offset (Command Offset) (R139)

DC or Command Offset **(R139)** is the pot that changes the center position of the galvanometer rotor by adding a small DC offset into the command input signal. This pot is often used to adjust the center position of scan angle.

10.2.2 PD Gain (R11)

PD Gain (R11) is used to adjust the gain of the Galvanometer's Position Detector before it enters the control loop.

10.2.3 Slew Rate Limiter (R14)

When enabled via jumper (J4) adjusts a threshold at which a step-command is transformed into a ramp-command. This is done so that the Galvanometer and mirror remain under control during large-field instantaneous jumps.

10.2.4 Command Attenuator (R66)

Command Attenuator (R66) attenuates the command signal prior to entering the servo loop.

10.3 Match Tuning of X and Y Galvanometers

Match tuning of X and Y galvanometers refers to tuning each servo to have the same response time to a given command input. If a set of X and Y servo drivers in a 2 axis head are not match tuned, a command that would draw a 45-degree line may result in a line that looks "bowed." This would be caused by one servo responding faster than the other.

10.4 Vector Tuning

Vector tuning refers to tuning a servo drive to respond to a variety of different size step commands where the galvanometer is continuously moving. Laser marking is a good example of a vector application.

10.5 Raster Tuning

Raster tuning refers to tuning the servo drive to have constant velocity over a wide angle and then have the ability to “fly” back to its start of scan location. A typical raster command input waveform is a saw tooth waveform. The important parameters are the frequency (Hz) of the waveform, the desired fly back time and the velocity linearity of the active scan. A triangle waveform produces a bi-directional raster scan with no fly back. Typical applications are film imaging, metrology, fluorescent microscopy and laser TV projection.

11. Protection Circuits

The QD-4000 was designed with built in protection circuits to guard against unsafe operating conditions. Although the servo design includes these protective features, Nutfield Technology, Inc. makes no warrants and assumes no responsibility in the event of a servo or galvanometer failure resulting in lost productivity, property damage or personal injury. The system integrator of NTI products assumes all responsibility for the safe operation of equipment.

11.1 Servo Faults

The QD-4000 has a green Servo Power LED (D8) and a red Fault LED **(D7)** that indicate that if one of the fault conditions has occurred. The board also provides to the user on the Main Board Connector **J8,** two unique signals that indicate if a fault has occurred.

Servo Status LED's – D7 and D8 (see Servo Driver Drawing)

LED #	COLOR	STATUS
D8	Green	Power On
D7	Red	Servo Fault

- **Servo Power:** The +/- voltage regulators are on.
- **Fault:** A fault condition has occurred.

11.1.1 Power Failure Condition

If the green LED is off or dim, one of the two voltage rails (+ or – supply voltage) is not present.

11.1.2 Under Voltage Condition

If the red LED is on, one or both of the voltage rails may be less than +14 or –14 volts.

11.1.3 Over Position Condition

If the red LED is on, the galvanometer rotor may be more than 6% out of position range.

11.1.4 AGC Fail / Open Loop Condition

If the red LED is on, there may be a failure in the automatic gain control loop or the servo loop is open.

11.1.5 Servo Ready Signal

When the servo drive is ready, the Servo Ready Hi output signal **(Pin 1 of connector J8)** goes low (0 volts) and the Servo Fault LED **(Red, D7)** is off. If there is a fault, the Servo Ready output will go high and the Fault LED **(Red, D7)** is on. The Servo Ready Lo output is an inverted version of the Servo Ready Hi output.

J8 Pin No.	Fault	No Fault
1 (Servo Ready Hi)	0V	+5V
2 (Servo Ready Lo)	+5V	0V

11.2 Fuse

The QD-4000 Servo Drive Fuse

The QD-4000 has one 5 Amp slow blow fuse to protect against excessive coil current. The fuse manufacturer and part number are the following:

Littelfuse World Headquarters
800 E. Northwest Highway
Des Plaines, IL 60016 USA
Phone: 1-847-824-1188
Fax: 1-847-391-0894
www.littelfuse.com
Part Number: 0454005.

Replacement fuses are available from the following:

Digi-Key Corporation
701 Brooks Avenue South
Thief River Falls, MN 56701 USA
Phone: 1-800-344-4539
Fax: 1-218-681-3380
www.digikey.com

Digi-Key Part Number: 0454005.MR-ND

13. Service And Support

Your satisfaction is important to us. If you need assistance please contact your local representative first. If the local representative is unable to assist you, contact NTI at the address below.

13.1 Product Return Procedure

If a product is to be returned to the factory, please go to our web-site:

http://www.nutfieldtech.com/nutfield/service.asp

and fill out the RMA request form.

13.2 Contact Information

Nutfield Technology, Inc.
49 Range Road
Windham, NH 03087 USA

TEL: 603-893-6200

FAX: 603-893-6214

www.nutfieldtech.com

info@nutfieldtech.com

14. Warranty

Nutfield Technology, Inc. (NTI) warrants this product to be free from defects in materials and workmanship for 12 months from the date of shipment. Nutfield Technology, Inc. will, at its option, repair or replace the product if it is defective within the warranty period and returned, freight pre-paid, to a service center designated by NTI.

Nutfield Technology, Inc. requests that customers obtain a Return Authorization Number prior to returning units, and that they carefully pack units in their original packing or equivalent.

Under warranty, NTI is not obligated to repair damage to any units resulting from the following conditions (customers are responsible for defining which conditions are applicable to their product):

1) Personnel other than NTI representatives attempting to repair or service the product.
2) Connecting the product to incompatible equipment.
3) Personnel other than NTI representatives modifying the product.
4) Scratches and chips on any optical surface after three weeks from the date of receipt.
5) Damage to any optical surface from improper handling or cleaning procedures. This applies specifically to those items subjected to excess laser radiation, contaminated environments, extreme temperature or abrasive cleaning.
6) Customers assume all responsibility for maintaining a laser-safe working environment. OEM customers must assume all responsibility for **CDRH** (Center for Devices and Radiological Health) certification.

There is no implied warranty of fitness for a particular purpose, and NTI is not responsible for consequential damages. Individual components manufactured by NTI or others may be covered by their own warranties. Refer to the appropriate manuals for this information.

