primatics

# PCL40
# Reference & Maintenance Manual

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## PCL40 Manual
**Revision Information**

| Revision Date | Notes |
|---|---|
| June 06 | Original Release |
| Sept 06 | Corrected Home sensor activation location graphic |
| Nov 06 | Updated ordering info |
| Feb 12 | Update Commutation chart |
| Jan 14 | Updated photo |
| Jan 2014 | Changed linear guide grease |
| Jan 2015 | New logo |
| Dec 2015 | Removed Frameless Motor, Added In-Line Servo Motor information |

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For Specifications, Dimensioned Drawings and additional information, refer to the PCL40 Datasheet available from our website at www.primatics.com.

## 1) Overview

This user guide is designed to help you install and maintain your PCL40 Series linear positioning stage application. Follow these steps to ensure correct stage installation and maximum stage life:

*Step 1* Review this entire user manual. Become familiar with all installation procedures prior to integrating your system.

*Step 2* Review the safety summary to develop an understanding of standard safety practices when installing and operating automated equipment.

*Step 3* Familiarize yourself with the conventions summary.

*Step 4* Review installation procedures. For best results, follow these procedures carefully.

*Step 5* Once you successfully complete all the installation procedures, you will be ready to install and operate your stage.

*Step 6* Review preventive maintenance section for proper lubrication schedule.

## 2) Introduction – About the PCL40

The PCL40 is a low profile linear positioning stage with a precision rolled ballscrew drive train. The overall height is 40mm at the carriage and an XY stack is just 80mm tall. It is offered with travels of 50, 100, 200, 300 and 400mm with a NEMA 17 in-line motor mount. Step motor and servo motor options are offered or the customer can supply their own motor. An internal rotary rotary encoder is used with the servo motor option and can also be used with the step motor or customer supplied motor configurations.

The PCL40 includes adjustable forward and reverse limit sensors and a fixed home sensor. High stiffness and rigidity at low weight are achieved using an AL6061-T6 aluminum base.

The PCL40 can also be used with 3rd party drives and controls. Several cable assemblies are available for this purpose.

### Feature Summary

- Travels of 50, 100, 200, 300 and 400mm
- Low profile. XY stack is only 80mm tall.
- Precision Rolled ballscrew drive train with 5mm lead
- English and Metric optical bench mounting patterns
- Quiet operation
- NEMA 17 in-line mount
- Step or Servo motor options
- Integrated rotary encoder options
- Precision performance for a low price

## 3) Personal Safety

*Please review before installing your positioning stage*

Observe common industrial safety practices when installing and operating automated equipment.

- Have power connections made by qualified personnel.
- Keep fingers and other items out of any opening in the stage while it is in operation since injury or damage may result.
- Provide a safe access route and adequate room for servicing.
- Perform the recommended periodic maintenance described in this document.
- Verify that the work envelope is free of obstructions before the positioning stage is powered.
- Insure that you have the feedback wired properly to the controller before applying power to the positioning stage. Improper feedback connections can cause a motor run-away condition that has the potential to damage the stage and injure an operator.
- Only trained operators of the positioning stage should be allowed near the work environment.
- If so equipped, identify emergency stop circuits and actuators in the workcell.
- Note the places in the workcell where pinch points occur, and provide adequate safety clearance or safety curtain.
- Never operate the motor in a location that could be splashed by water, exposed to corrosive or flammable gases or is near combustible substances since this may cause an electric shock, fire or malfunction.
- Never touch the motor, driver, or peripheral devices when the power is on or immediately after the power is turned off. The high temperature of these parts may cause burns.

# 4) Conventions

## *4.1) Direction of Motion*

The positive direction of motion is defined as a motion away from the motor end of a stage. A positive direction of motion also signifies the encoder count is increasing. All cables and connectors are located at the motor end of the stage. The reverse limit switch is located on the motor end and the forward limit switch is located on the opposite end of the stage. Figure 4-1 illustrates this convention.

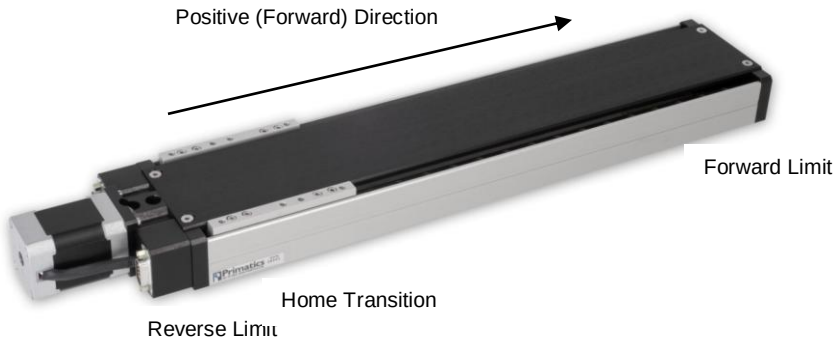



**Figure 4-1: Positive direction convention**

## *4.2) Units of Measure*

Primatics uses the metric system for all specifications and dimensions. All linear dimensions are specified in millimeters. Accuracy, repeatability, resolution, flatness and straightness for the PCL40 are specified in microns. Load capacity is specified in kilograms and moment capacity is given in Newton-meters. All torque specifications are given in Newton-meters. Thrust specifications are given in Newtons.

The following table gives some common conversions into English units:

| **Metric Unit** | **English Unit** |
|---|---|
| 1 Kilogram equals | 0.0685 slug* |
| 1 micron equals | 0.0000394 inch |
| 1 millimeter equals | 0.0394 inch |
| 1 Newton-meter equals | 8.85 in-lbs |
| 1 Newton equals | 0.2248 lbs |

*1 Kg has a weight of 2.205 lb when g = 9.8 m / $s^2$.

# 5) Installation Preparations

This section outlines installation environments. Unfavorable installation conditions may cause electric shock, fire, or breakdown. Certain breakdown situations or malfunctions in particular may lead to serious injury or other consequences. Assure that the unit is used under the following installation conditions:

- Indoors, free from being splashed by water or other liquids
- No corrosive or inflammable gases present
- Well ventilated place, minimum level of dust or waste
- An environmental temperature range between 0-40°C, and humidity between 20-80% RH (location with no condensation) Note - These values show the range in which operation can be carried out safely, but not the environmental range in which stage accuracy can be guaranteed. Stage accuracy can be guaranteed at 20°C +/- 1°C.
- Location should not be affected by electrical noise.
- Location should be where inspection and cleaning can be performed without difficulty.

## *5.1) Heat and Humidity*

All positioning stages are assembled and tested at 20°C. Any stage calibrations are also performed at 20°C. For optimum accuracy the ambient temperature should be maintained at 20°C. Deviations from this nominal temperature may result in degraded accuracy performance. Humidity should be less than 85% and there should be no condensation in the environment in which the stage is used.

Ballscrew driven stages are susceptible to thermal expansion effects. The ballscrew nut can create a localized thermal gradient if driven at high speeds. Care must be taken to limit the duty cycle of the motor to maintain highest stage performance.

## *5.2) Contamination*

The PCL40 series is intended for clean environments free from small particulates and fluids. Applications in dirty or dusty environments require the electrical, optical and mechanical components to be protected. Additional protection must also be used for stages that will be splashed with fluids. Contact your local distributor or the factory for more information on this topic.

## *5.3) Electrical Noise*

Electrical noise is the corruption of signals carried over low voltage wires. Encoder signals can be corrupted resulting in spurious encoder counts thus causing the stage to drift. Grounding, shielding, and spatial separation are all countermeasures to reduce the influences of electrical noise on performance. You can minimize the potential for electrical noise by observing the following installation precautions:

- Physically separate low voltage conductors from those carrying high voltage.
- Ensure that all components are properly grounded.
- Ensure that all wiring is properly shielded.

# 6) Installing the PCL40 Positioning Stage

## *6.1) Tools you will need*

The hex wrenches and fasteners listed below are required to install the PCL40. “M” sizes refer to Metric sizes, and fractions refer to English sizes. In reference to screw sizes, the second dimension given refers to the length of the screw thread in mm. For example, “M4 x 16” would require an M4 screw that is 16 mm long. The term BHSC refers to Button Head Socket Screws.

The PCL40 can be mounted directly to either an English (1” hole-hole) or Metric (25mm hole-hole) optical bread board. Low head cap screws (1/4’-20 or M6) are required for mounting. Do not use standard socket head cap screws which will cause an interference and possible stage damage.

If the stage is not mounting to an optical bread board use the M4 mounting holes.

**Hex Wrench Sizes**

| Base Plate (non-breadboard) | Base Plate (breadboard) | Carriage | Coupling | Top Cover | Motor Mount |
|---|---|---|---|---|---|
| 3mm | 5mm or 3/16” | 3mm | 2mm | 2.5mm | 2.5mm or 3/32” |

**Screw Sizes**

| Base Plate (non-breadboard) | Base Plate (breadboard) | Carriage | Top Cover | Motor Mount |
|---|---|---|---|---|
| M4 x 16 SHCS (minimum) | M6 x 12 or ¼-20 x ½” (minimum) Low Head Cap Screws | M4 (length is payload dependant) | M4 x 6 Flat Head Cap Screws | M3 x 12 SHCS or 4-40 x ½” SHCS |

## *6.2) Unpacking*

Carefully remove the stage from its shipping crate and inspect it for evidence of shipping damage. Report any damage immediately to your authorized dealer.

Improper handling of the stage may degrade its performance. Follow these guidelines when handling and mounting your stage.

1) Do not drop the stage onto its mounting surface. Place the stage gently on the mounting surface. Impact loads can cause high spots on mounting surfaces, misalignment of drive components and warping of the base.
2) Do not drill holes into the stage. If additional holes are necessary, contact the factory or your local distributor.
3) Lift the stage by its base structure only. Do not lift by the motor drive assembly.
4) Stage disassembly and alteration, unless specified otherwise, may void warranty.

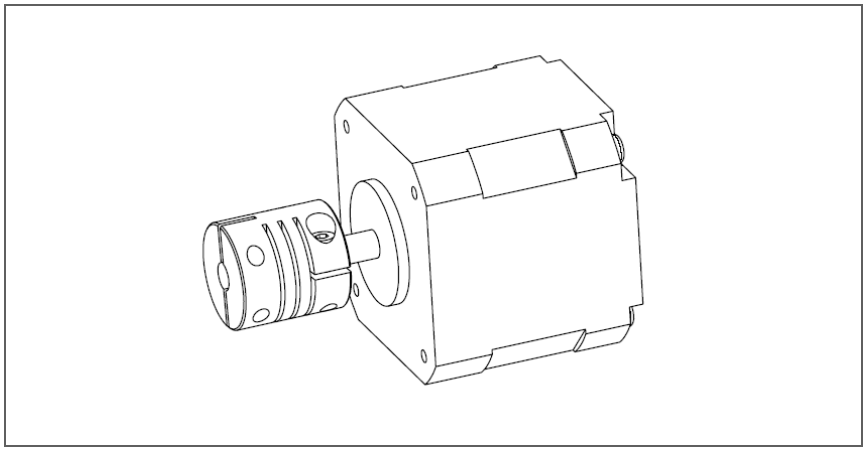
## *6.3) Installing Motors on Ballscrew Stages*

If the stage was ordered without a Primatics supplied motor or coupling, the motor and coupling will have to be installed by the user.

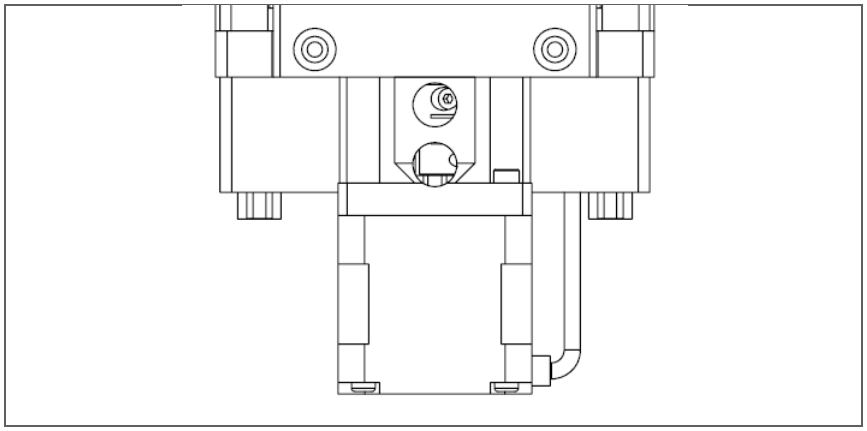
### 6.3.1) In-Line Motor Mounting

The following procedure is used to mount a motor on PC40 stages with the M1-1 Motor Mount Option.

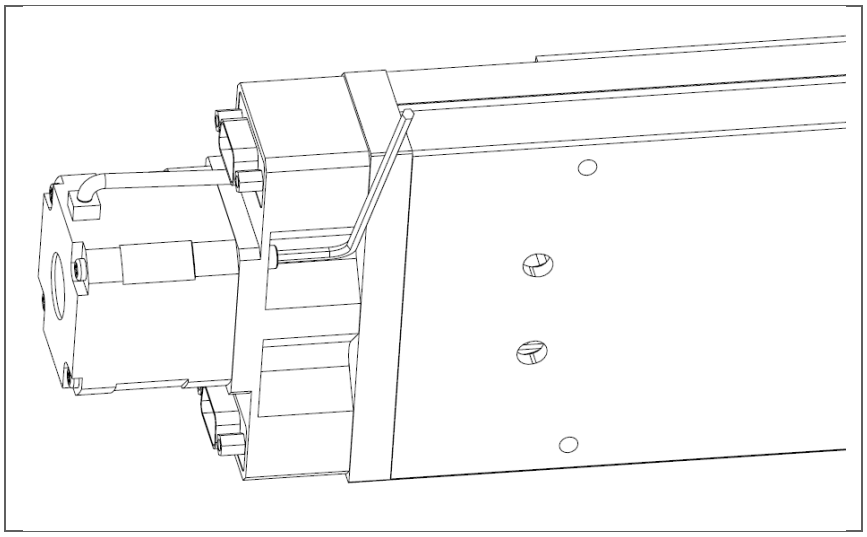
1) Install the flexible coupling on the motor shaft.



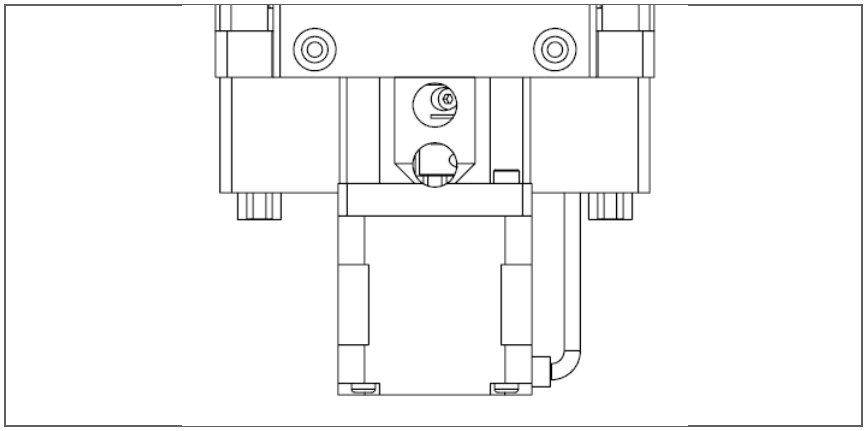
2) Slip the coupling over the ballscrew shaft and seat the motor in the motor pilot. The coupling clamp bolt should be visible. If the clamp bolt is not visible or the ballscrew shaft does not extend past the clamping bolt, repeat Step 1 and slide the coupling forward or back.



3) Mount the motor to the stage with four fasteners. A low clearance hex wrench may be required for tightening. Fully tighten all four fasteners.



4) Fully tighten the coupling clamp screw.



### *6.4) Mounting surface preparation*

The characteristics of the surface to which the positioning stage is mounted may have a large effect on system performance. An accurate and flat positioning stage will conform to the shape of the mounting surface; therefore a flat mounting surface is required. In the absence of a sufficiently flat surface, a three point mounting scheme can be utilized to rely on the inherent flatness of the stage though this is not recommended. This technique can introduce adverse dynamic effects in moment load applications because a large portion of the stage base is not in contact with the mounting surface. The flatness and straightness specifications can be affected under large loads. For best results in maintaining stage specifications we suggest the following guidelines:

1) Use a laboratory Grade AA granite surface plate
2) Before mounting stage, inspect for burrs or dings on the stage mounting surfaces
3) Clean all mounting surfaces with acetone

In the absence of a granite surface plate, we recommend a base plate made of the same material as the base of the stage. A mounting surface constructed out of a material different from the stage base material can introduce warping in the stage in the presence of a thermal gradient. The surface flatness should match the requirements of the application; a good starting point is to have the mounting surface flat to less than 5-8µm.

### *6.5) Mounting the Stage*

1) Remove top cover.


2) Insert Mounting Screws

3) Tighten Screws. Access holes are provided for hex tool. When mounting the base down to the surface plate, tighten the bolts at one end of the stage first and move towards the other end.
4) Replace top cover.

## *6.6) Electrical Connections*

All configurations include the Limit/Home/Encoder connector described in Table 6-1.

**Table 6-1: PCL40 In-Line Mount Signal Connector**

NOTE: Encoder signals are present only with E2, E3 and E4 options. Pins 7 through 15 are not used with the E1 option

| Pin | High-Density DSub15 with pins |
|---|---|
| 1 | Limit power: 5-24VDC |
| 2 | Limit signal ground |
| 3 | Forward Limit |
| 4 | Reverse Limit |
| 5 | Home |
| 6 | Not used |
| 7 | Encoder shield |
| 8 | Encoder 5V |
| 9 | Encoder ground |
| 10 | Encoder A+ |
| 11 | Encoder A- |
| 12 | Encoder B+ |
| 13 | Encoder B- |
| 14 | Encoder I+ |
| 15 | Encoder I- |

The step motor option, M1-2, uses a 9pin DSub for connection to the motor phases as described in Table 6-2.

**Table 6-2: PCL40 M1-2 Step Motor Connector**

| Pin | DSub9 with pins |
|---|---|
| 1 | Motor A+ |
| 2 | Motor A- |
| 3 | Motor case |
| 4 | Motor B+ |
| 5 | Motor B- |
| 6 | Not used |
| 7 | Not used |
| 8 | Not used |
| 9 | Motor Shield (no internal connection) |

The M1-3 servo motor option also uses a 9pin DSub for connection to the motor phases and hall sensors as described in Table 6-3.

**Table 6-3: PCL40 M1-3 Servp Motor Connector**

| Pin | DSub9 with pins |
|---|---|
| 1 | Hall V+ |
| 2 | Hall GND |
| 3 | Hall A |
| 4 | Hall B |
| 5 | Hall C |
| 6 | Motor A |
| 7 | Motor B |
| 8 | Motor C |
| 9 | Motor Case |

## *6.7) Servo Motor Commutation Sequence*

The M1-3 servo motor option commutation sequence is shown in Figure 6-1

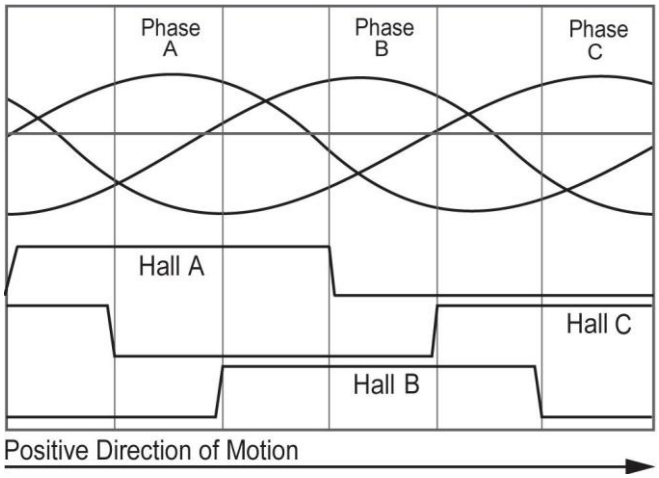



**Figure 6-1: Motor commutation chart**

### *6.8) Encoder Timing*

The E2, E3 and E4 encoder timing is shown in Figure 6-2

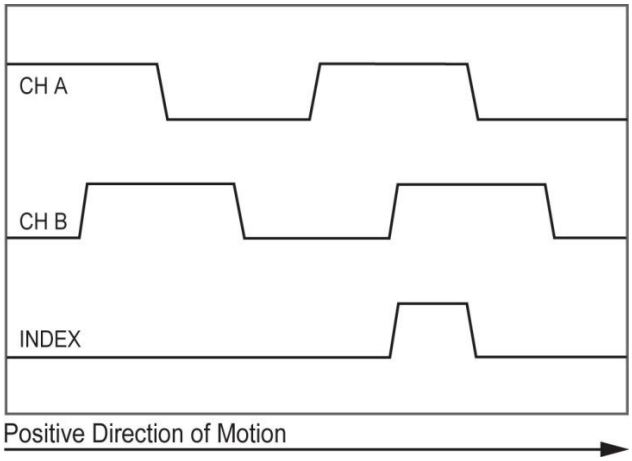



**Figure 6-2: Timing diagram for the encoder signals**

### *6.9) Home and Limit Sensors*

Each PCL40 stage includes Forward and Reverse Limit sensors and a Home sensor. Figure 6-3 shows the equivalent schematic for these switches.

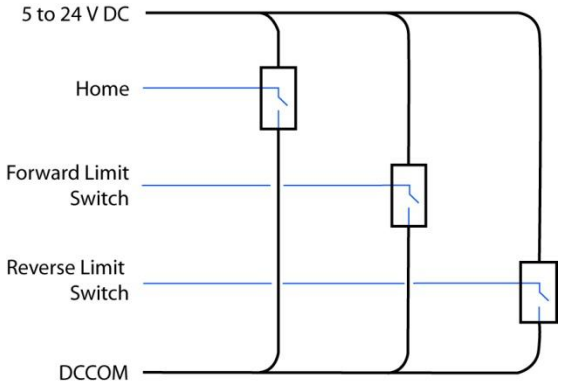



**Figure 6-3: Equivalent Limit and Home circuit schematic**

The forward and reverse limit sensors are factory set to give full advertised travel. That is a PCL40 with 100mm of travel will travel at least 50mm in either direction from the center of travel before activating a limit sensor. However both sensors can be configured in the field to reduce travel in approximately 5mm increments up to a total reduction of 15mm per sensor. Therefore a 100mm travel stage can be adjusted to yield 70mm of travel (15mm in either direction from the center of travel) between the limit sensors. Each sensor is active from its activation point through the end of travel at the hard stop.

The Home sensor is not adjustable and is fixed at approximately 20mm from the reverse end of travel. It is active from its activation point to the reverse end of travel.

Figure 6-4 illustrates the limit sensor factory default positions, the adjustment range for each sensor, and the location of the home sensor based on a 200mm travel example.

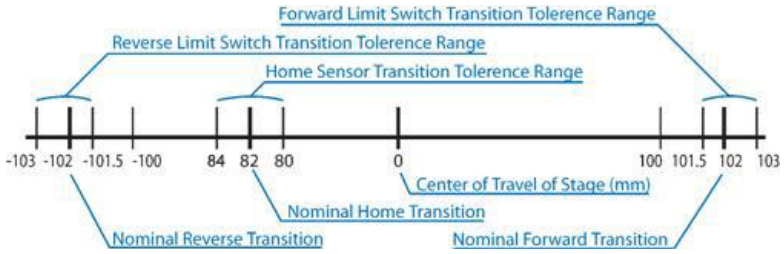



**Figure 6-4: Typical Sensor Transition Regions for Default Configuration (200mm travel example)**

### 6.9.1) Home Options:

The Home switch is ordered in either the Normally Closed (H1) or Normally Open (H2) configuration

**H1:** Switch is closed when carriage is between the negative (reverse) end of travel and the home transition point. It is open from the transition point to forward end of travel.

**H2:** Switch is open when carriage is between the negative (reverse) end of travel and the home transition point. It is closed from the transition point to forward end of travel.

### 6.9.2) Limit Options:

The Limit switches are ordered in either the Normally Closed (L1) or Normally Open (L2) configuration

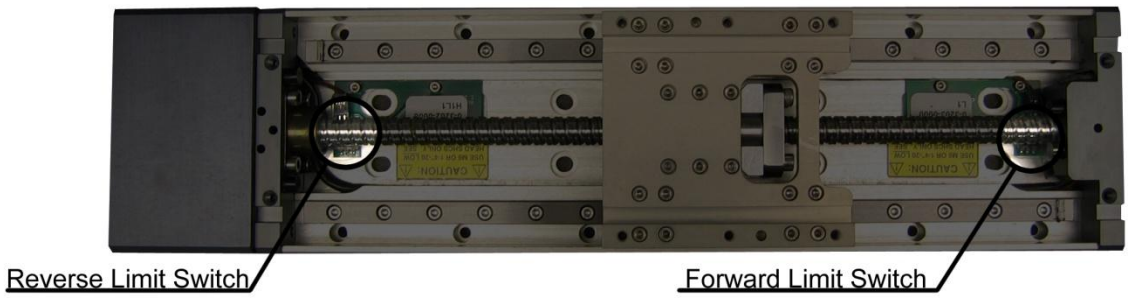
**L1:** When the carriage is in the normal operating range of travel, both limit switches are closed. When the carriage encounters a limit the switch opens. The switch will close again when the carriage is moved away from the switch.

**L2:** When the carriage is in the normal operating range of travel, both limit switches are open. When the carriage encounters a limit the switch closes. The switch will open again when the carriage is moved away from the switch.

## *6.10) Limit Switch Adjustment*

Adjusting the activation point of both the forward or reverse limit sensor is accomplished with a small 3 bit DIP switches located inside the PCL40 stage. There is a separate DIP switch for each sensor as shown in Figure 6-5.

**Figure 6-5: Limit Switch Location**




Each bit of the switch corresponds to an increment of travel reduction. From the factory all bits are off for no travel reduction. The table below describes valid switch settings and their effect for reducing travel:

| BIT 1 | BIT 2 | BIT 3 | Reduction |
|---|---|---|---|
| OFF | OFF | OFF | No reduction |
| ON | OFF | OFF | 5mm reduction |
| ON | ON | OFF | 10mm reduction |
| ON | ON | ON | 15mm reduction |

IMPORTANT: Any other switch pattern than the four shown above are invalid and are not to be used.

Example: An application using a PCL40AL0200 stage (200mm of travel) requires that the limit switches be configured to yield 90mm of travel from center in the forward direction and 95mm of travel in the reverse direction. The DIP switches are set as follows:

Forward Limit – BIT 1 and BIT 2 ON, BIT 3 OFF for 10mm of reduction
Reverse Limit – BIT 1 ON, BIT 2 and BIT 3 OFF for 5mm of reduction

## *6.11) Recommended System Test*

Before attaching a load or applying power to your stage, verify the encoder and limit switches are working properly. Move the stage carriage by hand in the positive direction and verify the encoder count is increasing. Runaway conditions caused by miswired encoders can result in stage damage and personal injury. Move the carriage to each end of travel to ensure limit switches are working properly. When closing the position loop for the first time, set the torque limit of your controller to a low value and use conservative tuning gains. Once the control loop is working properly, payloads can be added to the stage carriage.

# 7) Preventive Maintenance

Performing preventive maintenance procedures on your stage will extend its life and improve its long-term performance.

## *7.1) Lubrication*

It is recommended to use only the following greases for lubricating the ballscrew and linear bearings. Do not mix different greases as a chemical incompatibility may occur. Primatics offers a grease kit that has all the necessary hardware to re-lubricate the ballscrew and linear bearings.

For low duty cycle applications, it is recommended that the ballscrew and linear guides are re-greased every 4-6 months. High duty cycle applications may require more frequent re-lubrication. Lubrication intervals depend on duty cycle, load and ambient conditions. Inspection of the drive train elements may be required to determine the proper lubrication interval.

**ALWAYS DISCONNECT MOTOR POWER BEFORE RE-LUBRICATING THE STAGE.**

### 7.1.1) Ballscrew Lubrication

The ballscrew should be re-greased with **NSK grease part #GRS LG2**. To gain access to the component to grease, remove the stage top cover after power has been disconnected from the stage, a light film of grease can be smeared along the length of the ballscrew. Cycle the stage back and forth to distribute the grease and wipe off any excess.

### 7.1.2) Linear Guide Lubrication

The linear bearings should be re-greased with the following grease depending on the stage serial number.

| | **Stage Serial #'s 0 to 8955** | **Stage Serial #'s 8956 to ∞** |
|---|---|---|
| Grease | NSK grease part #GRS LG2 | Dynalube 520 |

To gain access to the linear guides, remove the stage top cover after power has been disconnected from the stage. On the end of each bearing block are one or two small grease holes where grease is injected using a syringe (see Figure 8-1). Typical grease volume is up to 0.03 $cm^3$ per hole (0.06 per bearing block) or until grease is seen extruding from the sides of the bearing block. Cycle the stage back and forth to distribute the grease and then wipe off any excess. Reinstall the top cover.

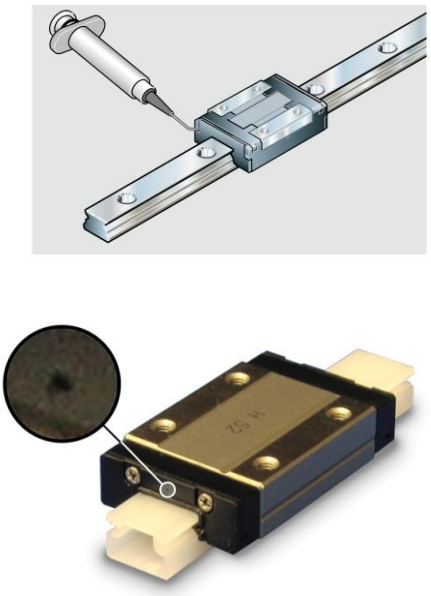


**Figure 7-1: Bearing block lubrication port**

# 8) Service

## *8.1) Troubleshooting Help*

For further assistance contact the factory:
M-F 8AM to 5PM Pacific Time

| | |
|---|---|
| Phone: | [541] 791-9678 |
| Fax: | [541] 791-9410 |
| Web: | www.primatics.com |
| E-mail: | service@primatics.com |

## *8.2) Service*

Should your device require factory service, contact the factory for a Return Materials Authorization (RMA). When inquiring about an RMA please have the following information available:

- Your contact information (name, phone, email, address)
- Unit Serial Number
- Symptom of problem
- History of troubleshooting steps already taken


**Figure 8-1: Unit Serial Number Location**