

PXL33A/B and PXL43B Reference & Maintenance Manual



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**PXL33/PXL43B Manual
Revision Information**

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1) Overview

This user guide is designed to help you install and maintain your PXL33/43B Series linear positioning stage. 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 PXL33A/B & PXL43B Stages

The PXL33A/B and PXL43B are low profile linear positioning stages with cross roller bearings and linear motor drivetrains. The PXL43B is larger, both physically and its motor size, compared to the PXL33. The linear encoder outputs are based on a 20um grating period. Both stages include fixed forward and reverse limit sensors at the end of travel. An encoder index is located at the nominal center of travel and is used for repeatable homing of the stage. Cleanroom lubrication is utilized on the linear bearings and the stage has a black anodize finish.

The PXL33 is available in nominal travels of 25mm, 60mm, and 110mm and the PXL43B is available with 25mm, 85mm, 115mm, and 150mm of travel. An optional pneumatic counterbalance assembly is available for vertical applications.

Both stages can be used with 3rd party drives and controls. Several cable assemblies are available for this purpose.

Feature Summary

- Multiple Travels
- Low profile and compact design. XY stack as low as 66 mm tall.
- Direct drive linear motor drive
- Non-moving cables for single axes
- Precision linear encoder with analog output
- Anti-creep bearings eliminate cage migration
- Cleanroom lubrication
- Black Anodize Finish
- High bandwidth for quick settling
- Quiet operation
- Optional pneumatic counterbalance

Refer to PXL33 and PXL43 datasheets for full listing of stage performance specifications.

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.
- High strength magnet fields are present. Keep ferrous metals at least 50mm away from the envelope extremes of the stage.

4) Conventions

4.1) Direction of Motion

The positive direction of motion is defined as a motion away from the cable end (or motor end if applicable) of a stage. A positive direction of motion also signifies the encoder count is increasing. The reverse limit switch is activated when the carriage moves to the cable end of the stage and the forward limit switch is activated when the carriage moves to the opposite end of the stage (furthest away from the cables). Figure 4-1 illustrates this convention.

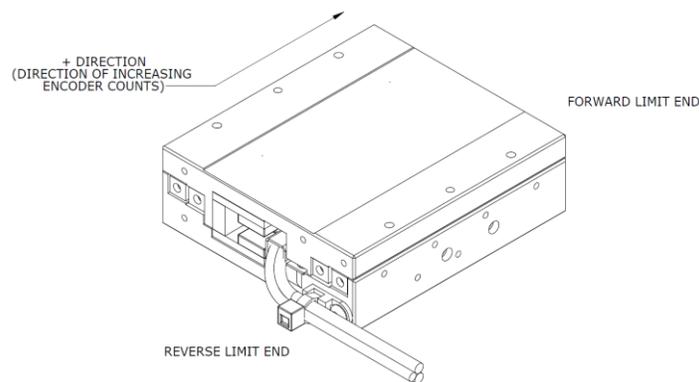


Figure 4-1: Positive direction convention

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 PXL33 and PXL43B 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 $g = 9.8 \text{ m} / \text{s}^2$.	

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
- 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 only 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) Linear Motors



CAUTION: Extremely strong magnetic fields present! Damage or injury could result from ferrous materials being attracted to the magnets. Keep ferrous materials at least 100mm away from the stage.

A high power Neodymium Iron Boron magnet track is mounted to the underside of the stage carriage. Linear motors have large magnetic flux that can draw ferrous metals inside them from large distances, destroy magnetic media, and disrupt some electronic circuits. Materials attracted to the magnets can pinch fingers and cause injury. Keep ferrous materials at least 100mm away from the stage to minimize the risk of items being attracted to the magnet track.

In addition, braking is difficult for linear motors making them inappropriate for many vertical applications. Make sure no load is attached to the linear motor stage when stage is first connected to the electronics. Linear motors can generate large accelerations and improper wiring to the control system can result in a high-speed crash.

5.2) 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 due to thermal expansion. Humidity should be less than 85% and there should be no condensation in the environment in which the stage is used.

Care must be taken to limit the duty cycle of the motor to maintain highest stage performance.

5.3) Contamination

The PXL33/43B 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.

5.4) 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 PXL33/43B Positioning Stage

6.1) Tools you will need

The PXL33 linear positioning stage uses M4x12mm (minimum) socket head cap screws in the base plate mounting. M4 tapped holes are available for customer use for mounting payloads to the carriage.

The PXL43B linear positioning stage uses M5x20mm (minimum) socket head cap screws in the base plate mounting. M5 tapped holes are available for customer use for mounting payloads to the carriage.

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 your local distributor.
- 3) Lift the stage by its base structure only. .
- 4) Stage disassembly and alteration, unless specified otherwise, may void warranty.
- 5) Remove the red shipping brackets prior to use.

6.3) Mounting surface preparation

The characteristics of the surface to which the positioning stage is mounted will 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. 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 5-8 μ m.

6.4) Mounting the Stage

The stage mounting holes can be accessed by moving the carriage to its forward and reverse limits by hand (motor power off) to expose the mounting holes. ⚠ When tightening the mounting screws, tighten the center screws first, then radiate outwards. Figure 6-1 shows the location of the mounting holes.

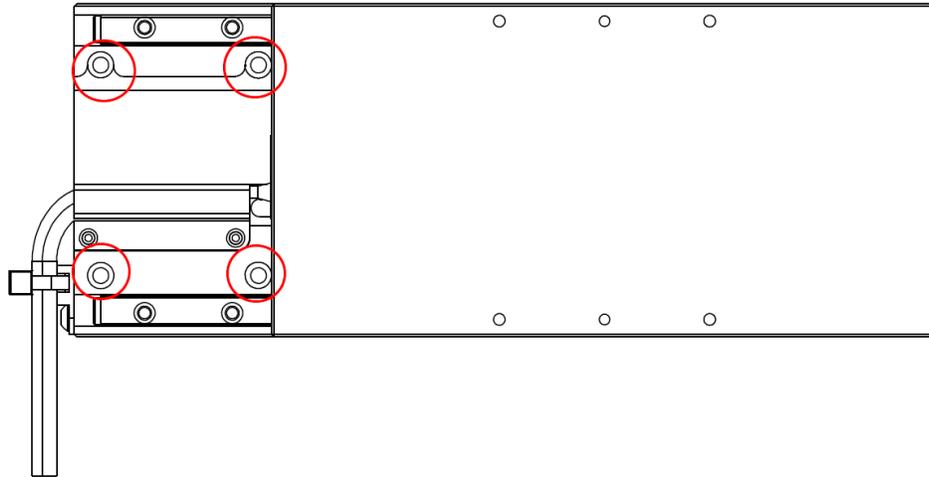


Figure 6-1: Mounting Hole Locations

6.5) Electrical Connections

Electrical connections to the stage are made through three connectors described in Table 6-1.

Table 6-1: Connection Pin-out

Motor Connector: DB9W4P		
PIN	Function	
A1	Motor Phase A	
A2	Motor Phase B	
A3	Motor Phase C	
A4	Motor Shield	
1	Hall V+	
2	Hall V-	
3	Hall A	
4	Hall B	
5	Hall C	
Shell	Signal Shield	
Encoder Connector: DB15P		
PIN	Digital Encoder	Analog Encoder
1	N/A	Encoder Cos-
2	Encoder GND	Encoder Sin-
3	N/A	Encoder Index+
4	Encoder I-	Encoder 5V
5	Encoder B-	N/A
6	Encoder A-	N/A
7	Encoder 5V	Forward Limit
8	N/A	Reverse Limit
9	N/A	Encoder Cos+
10	Reverse Limit	Encoder Sin+
11	Forward Limit	Encoder Index-
12	Encoder I+	Encoder GND
13	Encoder B+	N/A
14	Encoder A+	N/A
15	N/A	N/A
Shell	Encoder Shield	Encoder Shield

6.5.1) Hall Effect Commutation Sequence

In the event that user amplifier and controls are being implemented, use the following motor commutation timing charts.

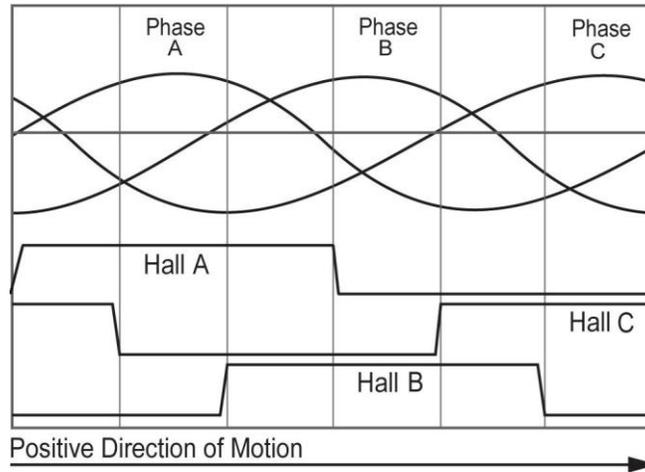


Figure 6-2: Motor commutation chart

6.5.2) Encoder Timing Diagram

The following diagram shows the encoder signal timing for the analog encoder option

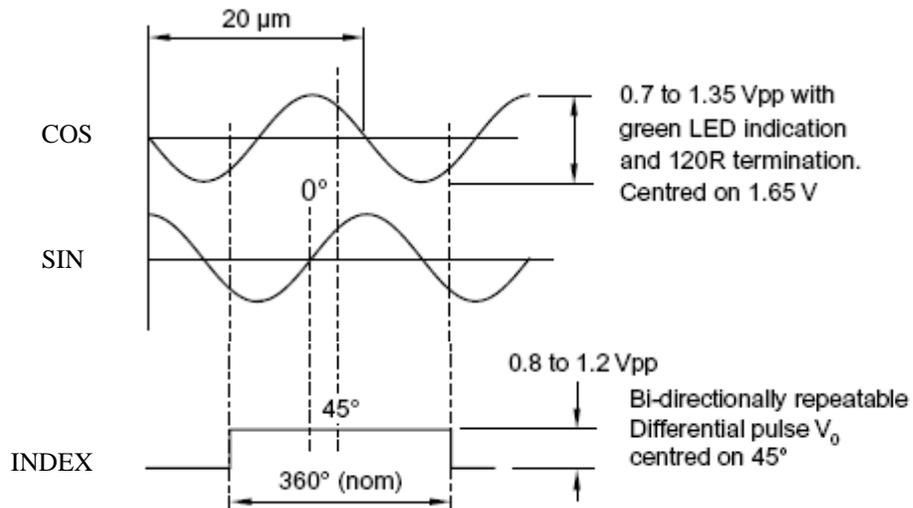


Figure 6.3: Timing diagram for the analog encoder signals

The following diagrams show the signal timing for the digital encoder options

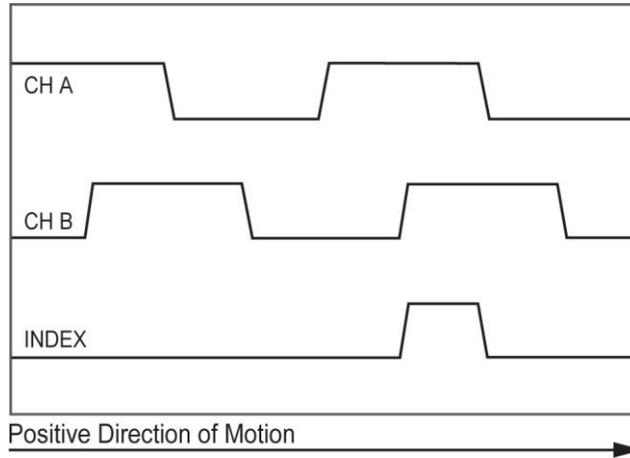


Figure 6-4: Timing diagram for the digital encoder signals

6.5.3) Encoder Electrical Specifications

Encoder		PXL33A	PXL33B
Analog Encoder Power		N/A	5VDC +/- 10%, 160mA
Digital Encoder Power		5VDC +/- 5%, 180mA	5VDC +/- 10%, 275mA
Encoder Clock Frequency		12.5 MHz (standard)	12 MHz (standard)
		25 MHz (optional)	20 MHz (optional)
Output		Square wave differential line driver	
Index		Synchronized pulse, duration equal to one resolution bit	

PXL43B encoder specifications are the same as the PXL33B.

6.5.4) Encoder Index

The linear encoder reference signal (index) is located at the nominal center of travel and is output in both directions of travel. Repeatability is guaranteed both directions. The reference mark output is synchronized with the incremental channels, giving it a unit of resolution pulse width. During a homing routine, the stage should travel to a limit switch transition, and then start searching for the index in the opposite direction. It is recommended that the homing procedure be performed as part of any power-up sequence to ensure the correct datum position is recorded.

6.5.5) Motor Parameters

	PXL33A/B	PXL43B
Primatics P/N	9-0044-0065	9-0044-0075
Continuous Force (N) ¹	9	18
Continuous Current (Amps _{rms}) ¹	1.5	1.1
Peak Force (N) ²	30	128
Peak Current (Amps _{rms}) ²	6	8
Force Constant (N/Amps _{rms})	5	16.0
Back EMF Constant (V/m/sec)	4.3	13.5
Resistance (Ω)	3.1	9.8
Inductance (mH)	0.31	2.3
Magnetic Pitch (mm)	21	30
Thermal Resistance ($^{\circ}\text{C}/\text{W}$)	1.6	2.1
Motor Constant (N $\sqrt{\text{W}}$)	2.3	5.3

¹ At 25°C temperature rise ² At 10% duty cycle and 1 second maximum

6.6) Limit Sensors

Each PXL33/43B stage includes Forward and Reverse Limit sensors. The limit sensors are part of the linear encoder. Figure 6-5 shows the equivalent schematic for these switches.

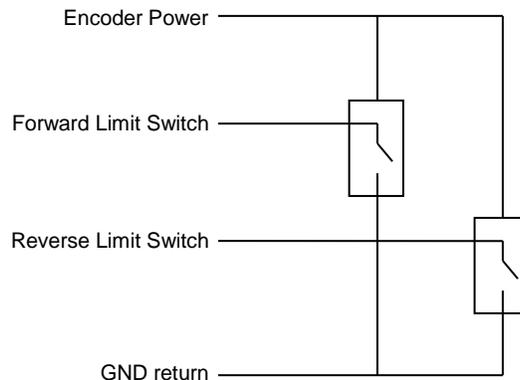


Figure 6-5: Equivalent Limit circuit schematic

The forward and reverse limit sensors are factory set to give full advertised travel. That is a stage with 25mm of travel will travel at least 12.5mm in either direction from the center of travel before activating a limit sensor. Each sensor is active from its activation point through the end of travel at the hard stop.

Figure 6-6 illustrates the limit sensor factory nominal default positions.

	PXL33-025	PXL33-060	PXL33-110
Absolute hardstop	+19.5mm	+37.5mm	+62.5mm
Bumper contact	+16.5mm	+34mm	+59mm
Forward limit trips	+14.5mm to +13.5mm	+32mm to +31mm	+57mm to +56mm
Nominal travel	+12.5mm	+30mm	+55mm
Center of travel	0	0	0
Nominal travel	-12.5mm	-30mm	-55mm
Reverse limit trips	-13.5mm to -14.5mm	-31mm to -32mm	-56mm to -57mm
Bumper contact	-16.5mm	-34mm	-59mm
Absolute hardstop	-19.5mm	-37.5mm	-62.5mm

	PXL43B-025	PXL43B-085	PXL43B-115	PXL43B-150
Absolute hardstop	+21.5mm	+51.5mm	+66.5mm	+84mm
Bumper contact	+16.5mm	+46.5mm	+61.5mm	+79mm
Forward limit trips	+14.5mm to +13.5mm	+44.5mm to +43.5mm	+59.5mm to +58.5mm	+77mm to +76mm
Nominal travel	+12.5mm	+42.5mm	+57.5mm	+75mm
Center of travel	0	0	0	0
Nominal travel	-12.5mm	-42.5mm	-57.5mm	-75mm
Reverse limit trips	-13.5mm to -14.5mm	-43.5mm to -44.5mm	-58.5mm to -59.5mm	-76mm to -77mm
Bumper contact	-16.5mm	-46.5mm	-61.5mm	-79mm
Absolute hardstop	-21.5mm	-51.5mm	-66.5mm	-84mm

Figure 6-6: Typical Limit Sensor Transition Ranges

6.6.1) 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.

6.7) 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 mis-wired 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. Retuning with the payload may be required for optimal performance.

6.7.1) Pneumatic Counterbalance for Z-axis Operation

A pneumatic counterbalance option is available for vertical operation of the PXL33/43B. Counterbalancing is achieved using a glass lined air cylinder and a precision pressure regulator.

 **Caution:** The counterbalance is a glass cylinder mounted at its end and is very fragile. Do not apply any side loads to the cylinder, which can easily happen during handling and installation.

Counterbalance operation is as follows:

- 1) Remove any shipping brackets and protective shipping items on the counterbalance assembly.
- 2) With the servo off, the payload should be mounted to the Z-axis carriage and the carriage should be resting at the end of travel under gravity. Max allowable payload for the PXL33 counterbalance is 3.3kg (7lbs) including the weight of the carriage. Max allowable payload for the PXL43B counterbalance is 6.7kg (15lbs) including the weight of the carriage.
- 3) Clean, dry, filtered air should enter the inlet side (see marking on regulator) of the pressure regulator (@ 690kPa (100psi) max inlet pressure) and should exit the regulator and enter into the air cylinder via polyurethane tubing. **Max pressure to the PXL33 cylinder is 550kPa (80psi). Max pressure to PXL43B cylinder is 340kPa (50psi).** Starting with the regulator valve closed (no air passing through), slowly open the valve until the cylinder pressurizes and the stage carriage slowly rises upwards. Slightly close the valve until the carriage stops rising. Move the carriage up and down by hand noting the resistance and adjusting the pressure regulator slightly to iterate in on uniform resistance upwards and downwards.
- 4) The counterbalancing can be optimized even more by cycling the z-axis with the servo and adjusting the regulator until the motor current requirements for constant velocity are the same for travel upward and downward.
- 5) The pressure regulator should be located as close to the cylinder as possible to improve the response of the system.
- 6) Due to the extremely low friction level of the air cylinder, it is normal for there to be slight air leakage past the piston and end seals. Adequate capacity of the air supply source should be ensured so that continuous counterbalancing can be maintained.

- 7)  **Caution:** Customer supplied external hardstops are required to prevent damage to the stage if air pressure is suddenly lost and the payload drops. Just as an automobile bumper cannot prevent damage to a vehicle in most collisions, the bumpers in the stage are only designed to restrain the stage in an unloaded condition.

7) Preventive Maintenance

Performing preventive maintenance procedures on your stage will extend its life and improve its long-term performance. The stage should be kept clean and a soft, lint-free cloth should be used wipe down the stage. Do not use compressed air to spray away dust since this may force dust into crevices.

7.1) Lubrication

ALWAYS DISCONNECT MOTOR POWER BEFORE RE-LUBRICATING THE STAGE.

The linear bearing are the only component to need relubrication and only **Nye Rheolube 723G** should be used. Do not mix different greases as a chemical incompatibility may occur.

After power has been disconnected from the stage, a small dab of grease can be applied along the length of the crossed roller bearings when the stage is at either extreme end of travel. Cycle the stage back and forth to distribute the grease and wipe off any excess.

For low duty cycle applications, it is recommended that the linear bearings are re-lubricated every 4-6 months or 500km of travel, whichever comes first. High duty cycle applications may require more frequent re-lubrication. Lubrication intervals depend on duty cycle, load and ambient conditions. Inspection of the bearing elements may be required to determine the proper lubrication interval.

The motor and linear encoder are non-contact devices and do not need lubrication.

8) Service

8.1) Troubleshooting Help

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

Phone:	[541] 791-9678
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