

AVL1000 Stage

Hardware Manual ES16151-1

P/N: EDS127 (Revision 1.02.00)



Dedicated to the Science of Motion
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Chapter 1: Overview

This manual describes Aerotech's AVL1000 linear motor driven Z axis stage. Figure 1-1 shows a typical AVL1000 positioning stage.

This chapter introduces standard and optional features of the AVL1000 stages, explains the model numbering system, and gives general safety precautions.

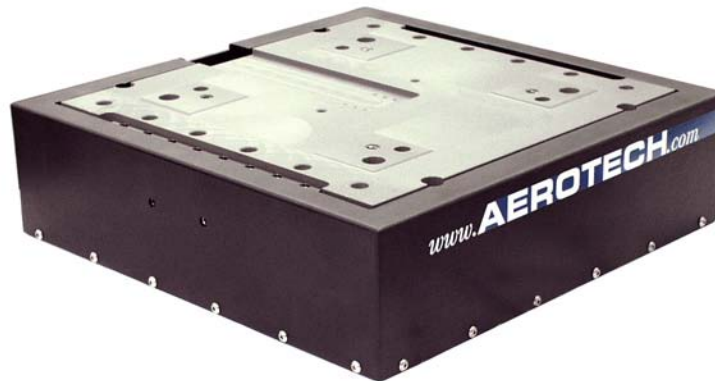


Figure 1-1: Typical AVL1000 Series Linear Positioning Stage

NOTE: Aerotech continually improves its product offerings, and listed options may be superseded at any time. Refer to the most recent edition of the Aerotech Motion Control Product Guide for the most current product information at www.aerotech.com.

1.1. Standard Features

The AVL1000 is a high-capacity lift stage designed for smooth operation and optimized for mechanical stiffness. Lift motion of the table is generated via a linear motor driven wedge. The linear motor is completely cog-free, allowing for tight velocity control and zero backlash. Also, the magnetic field is completely self-contained within the U-channel design. A non-contact linear encoder provides high resolution feedback for excellent accuracy and repeatability performance.

The AVL1000 includes an internal pneumatic counterbalance to balance the load on the stage. A precision regulator is provided with the stage to adjust the pressure to the counterbalance.

1.1.1. Optional Features

Custom configurations are common and readily available, contact Aerotech for more details.

1.1.2. Model Numbers

The stage model number indicates the optional features on a particular stage. To determine the options on your stage, refer to Table 1-1 for an explanation of the numbering system.

Table 1-1: Model Numbering System

AVL1000 Series Linear Motor Stage	
AVL1000	1 mm (0.039 in) travel stage with linear motor and limits
AVL1000	2 mm (0.079 in) travel stage with linear motor and limits
Linear Encoders	
-LTA	Linear Encoder for AVL1000; amplified sine output
Limits	
-NC	Normally-closed end of travel limit switches (standard)
-NO	Normally-open end of travel limit switches

1.2. Dimensions

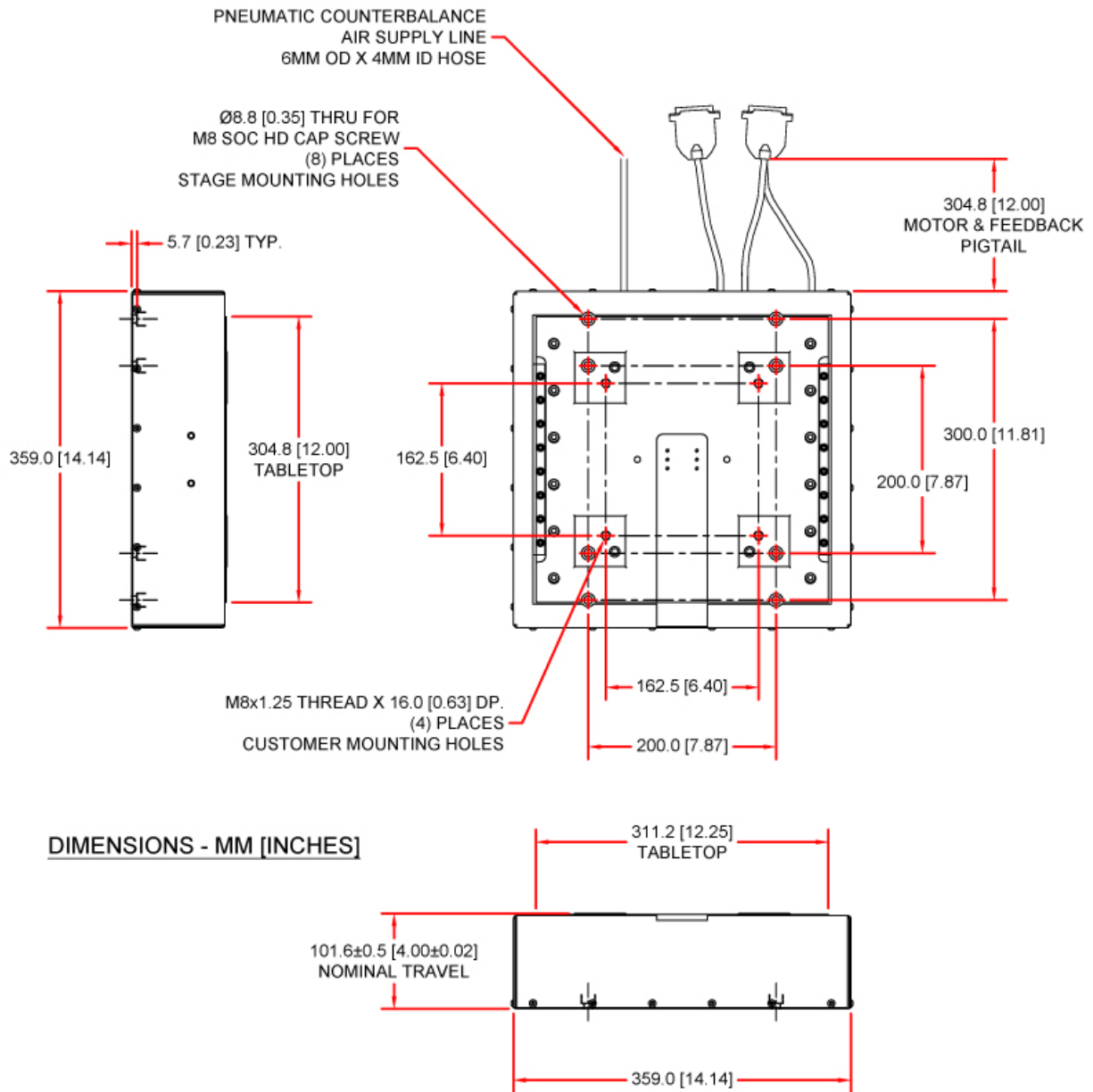


Figure 1-2: AVL1000 Dimensions

1.3. Safety Procedures and Warnings

The following statements apply throughout this manual. Failure to observe these precautions could result in serious injury to those performing the procedures and damage to the equipment.

This manual and any additional instructions included with the stage should be retained for the lifetime of the stage.



DANGER

To minimize the possibility of electrical shock and bodily injury or death, disconnect all electrical power prior to making any electrical connections.



DANGER

To minimize the possibility of electrical shock and bodily injury or death when any electrical circuit is in use, ensure that no person comes in contact with the circuitry when the stage is connected to a power source.



DANGER

To minimize the possibility of bodily injury or death, disconnect all electrical power prior to making any mechanical adjustments.



DANGER

Moving parts of the stage can cause crushing or shearing injuries. All personnel must remain clear of any moving parts.



WARNING

Improper use of the stage can cause damage, shock, injury, or death. Read and understand this manual before operating the stage.



WARNING

If the stage is used in a manner not specified by the manufacturer, the protection provided by the stage can be impaired.



WARNING

Stage cables can pose a tripping hazard. Securely mount and position all stage cables to avoid potential hazards.



WARNING

Do not expose the stage to environments or conditions outside the specified range of operating environments. Operation in conditions other than those specified can cause damage to the equipment.



WARNING

The stage must be mounted securely. Improper mounting can result in injury and damage to the equipment.



WARNING

Use care when moving the stage. Manually lifting or transporting stages can result in injury.



WARNING

Only trained personnel should operate, inspect, and maintain the stage.



WARNING

This stage is intended for light industrial manufacturing or laboratory use. Use of the stage for unintended applications can result in injury and damage to the equipment.



WARNING

Before using this stage, perform an operator risk assessment to determine the needed safety requirements.

1.4. EC Declaration of Incorporation

Manufacturer: Aerotech, Inc.
101 Zeta Drive
Pittsburgh, PA 15238
USA



herewith declares that the product:

Aerotech, Inc. AVL1000 Stage

is intended to be incorporated into machinery to constitute machinery covered by the Directive 2006/42/EC as amended;

does therefore not in every respect comply with the provisions of this directive;

and that the following harmonized European standards have been applied:

EN ISO 12100-1,-2:2003+A1:2009

Safety of machinery - Basic concepts, general principles for design

ISO 14121-1:2007

Safety of machinery - Risk assessment - Par 1: Principles

EN 60204-1:2005

Safety of machinery - Electrical equipment of machines - Part 1: General requirements

and further more declares that

it is not allowed to put the equipment into service until the machinery into which it is to be incorporated or of which it is to be a component has been found and declared to be in conformity with the provisions of the Directive 2006/42/EC and with national implementing legislation, i.e. as a whole, including the equipment referred to in this Declaration.

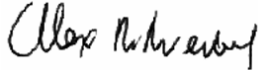
This is to certify that the aforementioned product is in accordance with the applicable requirements of the following Directive(s):

2011/65/EU

RoHS 2 Directive

Authorized Representative: Manfred Besold
Address: AEROTECH GmbH
Süd-West-Park 90
D-90449 Nürnberg

Name:

Alex Weibel / 
Engineer Verifying Compliance

Position:

Location: Pittsburgh, PA

Date: November 29, 2010

Chapter 2: Installation

This chapter describes the installation procedure for the AVL1000 stage, including handling the stage properly, preparing the mounting surface to accept the stage, securing the stage to the mounting surface, attaching the payload, and making the electrical connections.



Installation must follow the instructions in this chapter. Failure to follow these instructions could result in injury and damage to the equipment.

2.1. Unpacking and Handling the Stage

Carefully remove the stage from the protective shipping container. Set the stage on a smooth, flat, and clean surface. Before operating the stage, it is important to let the stage stabilize at room temperature.

The AVL1000 stage is packaged with a shipping clamp installed to prevent stage table movement. The shipping bracket is a red anodized plate that prevents motion of the wedge. This must be removed before the stage table can be operated. For the AVL1000 ES16151-1 stage, the shipping bracket is mounted to the side of the stage. Loosen the two captive thumbscrews on the shipping bracket and then remove the bracket (see Figure 2-1).

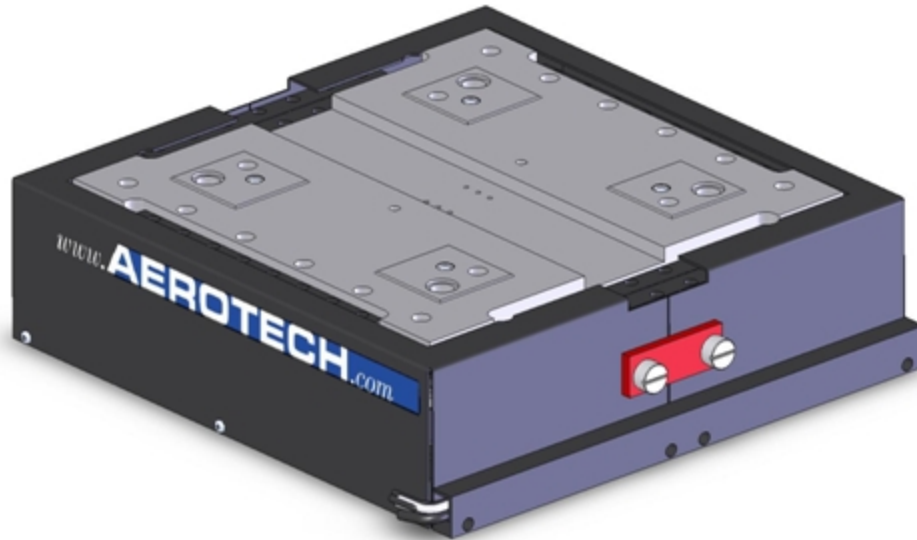


Figure 2-1: Shipping Bracket Location

Each stage has a label listing the system part number and serial number. These numbers contain information necessary for maintaining or updating system hardware and software. Locate this label and record the information for later reference. If any damage has occurred during shipping, report it immediately.



WARNING

Improper stage handling could adversely affect the stage's performance. Use care when moving the stage. Manually lifting or transporting the stage can result in injury.



WARNING

Lift the stage only by the base.



WARNING

Do not use the stage table as a lifting point.

2.2. Preparing the Mounting Surface

The mounting surface should be flat and have adequate stiffness in order to achieve the maximum performance from the stage. When an AVL1000 series stage is mounted to a non-flat surface, the stage can be distorted as the mounting screws are tightened. This distortion will decrease the overall accuracy of the stage. Adjustments to the mounting surface must be done before the stage is secured.

Clean the mounting surface with isopropyl alcohol, acetone, or an applicable solvent on a lint-free cloth. Run a precision flat stone across the mounting surface to remove any burrs or chips that may be present on the surface. Clean the surface again with a lint-free cloth and solvent. Repeat this procedure on the bottom mounting pads of the stage prior to mounting.

NOTE: To maintain accuracy, the mounting surface should be flat within 2.5 μm per 50 mm.

NOTE: The stage base is precision machined and verified for flatness prior to stage assembly at the factory. If machining is required to achieve the desired flatness, it should be performed on the mounting surface rather than the stage base. Shimming should be avoided if possible. If shimming is required, it should be minimized to improve the rigidity of the system.

2.3. Securing the Stage to the Mounting Surface

To access the mounting holes of the stage, the shipping clamp must be removed and the moving wedge must be centered in travel. The stage is designed to use socket head cap screws (SHCS) to secure the base to the mounting surface. Use M8 x 20mm long SHCS with flat washers to achieve 1.5x diameter thread engagement. Torque the mounting screws to 19.6 N*m (14 ft*lb).



The stage must be mounted securely. Improper mounting can result in injury and damage to the equipment.

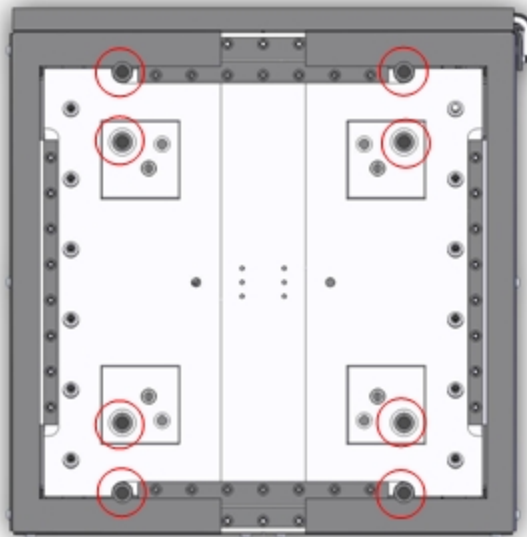


Figure 2-2: Mounting Hole Locations

2.4. Attaching the Payload to the Stage

To prevent damage to payloads, test the operation of the stage before the payload is attached to the stage table. Proceed with the electrical installation and test the motion control system in accordance with the system documentation. Document all results for future reference. For information on electrical connections, refer to Section 2.5.

The payload should be flat, rigid, and comparable to the stage in quality. Prior to mounting, clean the mounting surface of the payload and also the table top of the AVL1000 stage as outlined in Section 2.2.

Gently lower the payload onto the AVL1000 stage and align the payload mounting holes to the tapped holes in the table top. The table top has four M8-1.25 x 16mm Helicool insert tapped holes for payload mounting (see Figure 2-2).

NOTE: For valid system performance, the mounting interface should be flat within 1 μm per 25 mm.



Do not attach a payload to the stage table with screws that are too long. A screw passing through the stage table can come into contact with moving parts, affecting travel and possibly damaging the stage.

2.5. Electrical Installation

Installation instructions in this section are for stages equipped with standard Aerotech motors intended for use with an Aerotech motion control system. Contact Aerotech for further information regarding stages that are otherwise configured.

Aerotech motion control systems are adjusted at the factory for optimum performance. When the AVL1000 series stage is part of a complete Aerotech motion control system, setup involves connecting a stage and motor combination to the appropriate drive chassis with the cables provided. Connect the provided cables to the feedback and motor connectors on the stage. Labels on the drive indicate the appropriate connections. Refer to your drive manuals and documentation for additional installation and operation information. In some cases, if the system is uniquely configured, a drawing showing system interconnects is supplied.

An integral linear motor comes mounted to all AVL1000 stages. The electrical wiring from the motor, encoder, and limit switches are integrated into two main connectors at the factory. Refer to Section 3.6. for standard motor wiring and connector pin outputs.



Never connect or disconnect any electrical component or connecting cable while power is applied, or serious damage can result.



The stage's protective ground is located on pins 2, 14, and 15 of the motor connector. If you are using cables other than those provided by Aerotech, you must connect pins 2, 14, and 15 to a ground connection.

Chapter 3: Operating Specifications

The surrounding environment and operating conditions can affect the performance and service life of the stage. This chapter provides information on ideal environmental and operating conditions. Also included are instructions for estimating load capability given various loading situations.

3.1. Environmental Specifications

The environmental specifications for the AVL1000 are listed in the following table.

Table 3-1: Environmental Specifications

Ambient Temperature	Operating: 10° to 35° C (50° to 95° F) The optimal operating temperature is 20° C \pm 2° C (68° F \pm 4° F). If at any time the operating temperature deviates from 20° C degradation in performance could occur. Contact Aerotech for information regarding your specific application and environment.
	Storage: 0° to 40° C (32° to 104° F) in original shipping packaging
Humidity	Operating: 40 percent to 60 percent RH The optimal operating humidity is 50 percent RH.
	Storage: 30 percent to 60 percent RH, non-condensing in original packaging
Altitude	Operating: 0 to 2,000 m (0 to 6,562 ft) above sea level Contact Aerotech if your specific application involves use above 2,000 m or below sea level.
Vibration	Use the system in a low vibration environment. Excessive floor or acoustical vibration can affect stage and system performance. Contact Aerotech for information regarding your specific application.
Dust Exposure	The AVL1000 stages are not suited for dusty or wet environments. This equates to an ingress protection rating of IP00.
Use	Indoor use only



Do not expose the stage to environments or conditions outside the specified range of operating environments. Operation in conditions other than those specified can cause damage to the equipment.

3.2. Accuracy and Temperature Effects

The accuracy specification of AVL1000 series stages is measured at the center of travel 25 mm above the table with the stage in a horizontal position.

Aerotech stages are designed for and built in a 20°C (68°F) environment. Any change from this temperature will cause changes in accuracy specifications. The severity of temperature effects depends on many different environmental conditions, including how the stage is mounted. The thermal expansion coefficient of the stage encoder is 1.18 $\mu\text{m}/\text{m}/^\circ\text{C}$.

3.3. Basic Specifications

Basic AVL1000 series positioning stage specifications are shown in Table 3-2. Motor specifications are shown in Table 3-3.

Table 3-2: AVL1000 ES16151-1 Specifications

Basic Model	AVI1000-2
Total Travel	2 mm (.079 in)
Drive System I	Linear Brushless Servomotor (BLM-203-A) 60.96mm Fundamental Pole Pitch 60.96mm Fundamental Pole Pitch
60.96mm Fundamental Pole Pitch	Noncontact Linear Encoder (1Vpp Analog Sine) 20µm Fundamental Period 1µm Effective Period
Maximum Load (Horizontal)	50.0 kg (110 lb) Requires pneumatic counterbalance
Accuracy (Calibrated)	±0.5 µm (±20 µin)
Repeatability (Bi-directional)	0.4 µm (16 µin)
Wedge Ratio	20:1
Moving Mass (Wedge)	10kg
Nominal Stage Weight	29 kg (63.8 lb)
Construction	Aluminum Body / Anodize
<ul style="list-style-type: none"> • All performance specifications are measured on a single axis basis. • Repeatability and accuracy include linearity correction and minimum thermal change during measurement. • Selected motor and drive will limit performance specifications. 	

Table 3-3: AVL1000 Motor Specifications

Model	BLM-203	
Winding Designation	-A	
Performance Specifications (1,5)		
Continuous Force, 20 psi, 1.4 bar (2)	N	195.0
	lb	43.8
Continuous Force, No Cooling, (2)	N	118.8
	lb	26.7
Peak Force (3)	N	780.1
	lb	175.4
Electrical Specifications (5)		
BEMF Constant (line to line, max)	V / m / sec	25.77
	V / in / sec	0.65
Continuous Current, 20 psi, 1.4 bar (2)	A, pk	8.70
	A, rms	6.15
Continuous Current, No Cooling (2)	A, pk	5.30
	A, rms	3.75
Peak Current, Stall (3)	A, pk	34.80
	A, rms	24.61
Force Constant, Sinusoidal Drive (4,8)	N / A, pk	22.42
	lb / A, pk	5.04
	N / A, rms	31.70
	lb / A, rms	7.13
Motor Constant (2,4)	N / √W	10.94
	lb / √W	2.46
Resistance, 25 °C (line to line)	Ohms	4.0
Inductance (line to line)	mH	3.20
Thermal Resistance, 20 psi, 1.4 bar	°C / W	0.31
Thermal Resistance, No Cooling	°C / W	0.85
Maximum Bus Voltage	VDC	340
<p>(1) Performance is dependent upon heat sink configuration, system cooling conditions, and ambient temperature (2) Values shown @ 100 °C rise above a 25 °C ambient temperature, with motor mounted to the specified aluminum heat sink (3) Peak force assumes correct rms current, consult Aerotech (4) Force Constant and Motor Constant specified at stall (5) All performance and electrical specifications +/- 10% (6) Maximum winding temperature is 125 °C (7) Ambient operating temperature range: 0 °C - 25 °C, consult Aerotech for performance in elevated ambient temperatures (8) All Aerotech amplifiers are rated Apk; use torque constant in N-m / Apk when sizing</p>		

3.4. Load Capability

It is recommended that application loads be symmetrically distributed whenever possible (i.e., the payload should be centered on the stage table and the entire stage should be centered on the support structure). With the stage lying flat (horizontal) and the application load vertically applied and symmetrically distributed, the maximum vertical load carrying capacity of AVL1000 stages is 50.0 kg.

The counterbalance pressure must be adjusted to balance the payload. The required pressure can be estimated using the formula below:

$$\text{Pressure (MPa)} = (\text{Payload Weight}) / (1354\text{N/MPa}) + 0.19\text{MPa}.$$

3.5. Optical Limit Switch

AVL1000 stages are provided with a pair of optical limit switch assemblies mounted to the bottom of the stage table. The limit switches signal when the stage table has reached its maximum useable travel distance in both directions.

3.5.1. Limit Switch Operation

Each limit switch has a light source and detector mounted to a small printed circuit board. Each limit switch board is mounted at the ends of the stage table with their emitter–detector axes perpendicular to the direction of table motion. When movement of the stage table causes the blade mounted to the stage base to break the light beam from the emitter to the detector, a limit signal is generated. The limit switch itself can be configured as normally closed (NC) or normally open (NO).

3.5.2. Limit Switch Wiring

Limit switches are open-collector, TTL-compatible, electro–optical devices powered by 5 Volts that change output states when the stage approaches its maximum travel distance and breaks the light beam. Since they are open-collector devices, they may be interfaced to 24V logic inputs. Each limit switch is mounted on a small printed circuit board. Standard AVL1000 Stages include limit switch wiring integrated into one of the two main connectors.

Assuming a NC limit configuration, the input to the controller is seen as a logic 0 (typical 0.4V @ 12.8mA) when no limit condition is present. When the limit switch is activated, a 5V source through a pull-up resistor causes a logic 1 (typically 4.8-5V) to be seen by the controller input. The limit switch operation for a NO limit configuration is the exact opposite as described above. See Figure 3-1 for a diagram of limit switch wiring.

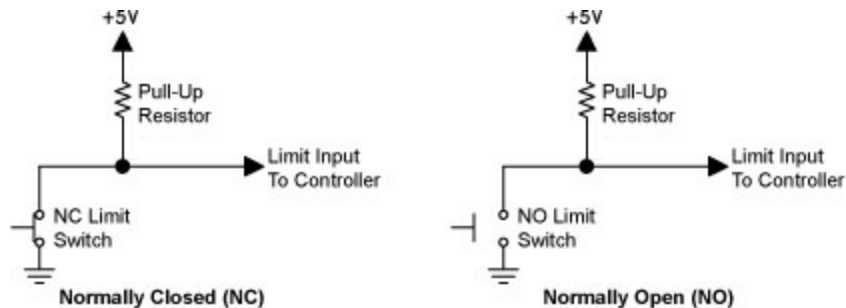


Figure 3-1: Normally Closed (NC) and Normally Open (NO) Limit Switch Wiring

3.6. Standard Motor Wiring

Stages fitted with standard motors and encoders come from the factory completely wired and assembled. For reference, connector pin assignments and general wiring information is given in the following tables. Pin assignments are described in Table 3-4 and Table 3-5 and defined in Table 3-6.

NOTE: If you are using your own cables to connect the stage, ensure that motor and ground wires can handle current higher than the continuous current listed in Table 3-3. The voltage rating of the wire insulation must be greater than the maximum bus voltage listed in Table 3-3.

Table 3-4: Feedback Connector Pin Assignments

Pin	Description	Pin	Description
1	SIG SHLD	14	COS
2	N.C.	15	COS-N
3	ENC +5V	16	LMT +5V
4	N.C.	17	SIN
5	Hall B	18	SIN-N
6	MKR-N	19	RESERVED
7	MKR	20	Limit Common
8	N.C.	21	Encoder Common
9	N.C.	22	N.C.
10	Hall A	23	N.C.
11	Hall C	24	-LMT
12	+LMT	25	RESERVED
13	RESERVED		

Table 3-5: Motor Connector Pin Assignments

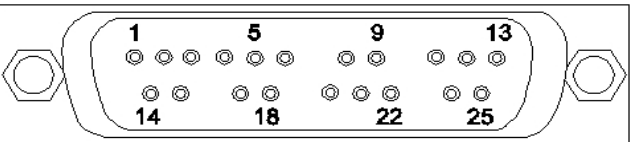
			
Pin	Description	Pin	Description
1	MTR SHIELD	14	FRM GND
2	FRM GND	15	FRM GND
3	RESERVED	16	RESERVED
4	MTR ØC	17	MTR ØC
5	MTR ØC	18	MTR ØC
6	MTR ØC	19	RESERVED
7	RESERVED	20	MTR ØB
8	MTR ØB	21	MTR ØB
9	MTR ØB	22	MTR ØB
10	RESERVED	23	RESERVED
11	MTR ØA	24	MTR ØA
12	MTR ØA	25	MTR ØA
13	MTR ØA		

Table 3-6: Limit/Motor Wiring Pin Output Descriptions

Pin Output	Description
+LMT	Active high signal indicating maximum travel produced by positive stage direction.
COS	Cosine. Incremental encoder output; either TTL line driven or amplified sine wave type signal.
COS-N	Incremental encoder output. Complement of cos.
-LMT	Active high signal indicating stage maximum travel produced by negative stage direction.
ENC +5V	+5 V supply input for optical encoders. Typical requirement is 250 mA.
Hall A	Hall Effect A. Brushless motor commutation track output. TTL line driven signal with rotary motor.
Hall B	Hall Effect B. Brushless motor commutation track output. TTL line driven signal with rotary motor.
Hall C	Hall Effect C. Brushless motor commutation track output. TTL line driven signal with rotary motor.
LMT +5v	+ 5 V supply input for optical limit switch boards. Typical requirement is 50 mA.
MKR	Marker. Incremental encoder output pulse given once per revolution. Typically used for home reference cycle.
MKR-N	Incremental encoder output; either the compliment of Marker with a line driven, TTL type encoder or 2.5 V DC bias level with amplified sine wave type encoder.
SIN	Sine. Incremental encoder output; either TTL line driven or amplified sign wave type signal.
SIN-N	Incremental encoder output. Complement of sin.
MTR ØA	Motor Phase A.
MTR ØB	Motor Phase B.
MTR ØC	Motor Phase C.
RESERVED	Not used.
SIG SHLD	Feedback connector shield.
SIG COM	Common ground for feedback connector wiring..
SETUP	Analog output that represents quality of encoder signal, used for troubleshooting and setup. LT encoders only.
MTR SHLD	Shield for motor connector wiring.
FRM GND	Motor common ground.

NOTE: Refer to the other documentation accompanying your Aerotech equipment. Call your Aerotech representative if there are any questions on system configuration.

3.7. Vacuum Operation

Due to the pneumatic counterbalance design of this stage, it cannot be operated in a vacuum environment.

Chapter 4: Maintenance

This chapter will cover information about intervals between lubrications, detail the lubrication and inspection process, and cover which lubricants are recommended for use.

NOTE: Refer to the other documentation accompanying your Aerotech equipment. Call your Aerotech representative if there are any questions on system configuration.



Do not attach a payload to the stage table with screws that are too long. A screw passing through the stage table can come into contact with moving parts, affecting travel and possibly damaging the stage.

4.1. Service and Inspection Schedule

Lubricant inspection and replenishment in AVL1000 series stages depends on conditions such as duty cycle, speed, and the environment. An inspection interval of once per month is recommended until a trend develops for the application. Longer or shorter intervals may be required to maintain the film of lubricant on the bearing surfaces. In general, it is recommended that stages operating in a clean environment be lubricated annually, or 500 km, whichever comes first. For stages operating under conditions involving excessive debris, lubrication every six months is recommended. The motor is completely non-contact and requires no lubrication.

NOTE: If the application process uses only a small portion of travel for most of the duty cycle, it is recommended that the stage be periodically driven through full travel to redistribute the lubrication in the bearings.

4.2. Cleaning and Lubrication

4.2.1. Recommended Lubricants and Cleaning Solvents

NSK LGU grease is used in standard AVL1000 stages.

If a solvent is necessary for cleaning the stage, acetone or isopropyl alcohol may be used.

For high-speed applications (i.e., near maximum speed at a duty cycle of 50%), frequent maintenance with standard lubricants is required.

4.2.2. Important Notes on Lubrication

When cleaning and/or lubricating components of the AVL1000 stages:

1. Be sure to use a clean, dry, soft, and lint-free cloth for cleaning.
2. Take the opportunity during the lubrication procedure to inspect the linear motion guides for any damage or signs of wear.
3. In applications that have multiple stages bolted together to form multi axis systems, the orthogonality may be lost if the stage tables of the support stages are loosened. Precision aligned stages should not be loosened or disassembled.

4.2.3. Lubrication and Cleaning Process

The lubrication and cleaning process is outlined in the steps that follow.

1. Disable and then remove power to the stage.
2. Be sure the pressure to the pneumatic counterbalance is still supplied to the stage.
3. Remove the button head screws that attach the outer covers to the stage base and then remove the covers.
4. Remove any accumulated dust or debris from the inside of the assembly.
5. Remove any dirty or dried lubricant from the crossed roller bearing ways. Use a clean, lint-free cloth with a side-to-side motion. A swab soaked in Isopropyl Alcohol may be used to remove stubborn debris.
6. Apply a thin, continuous film of lubricant to the linear bearing ways. A good quality, natural bristle artist's brush makes an excellent applicator.
7. Manually move the wedge to the opposite end of travel. This will work the grease into the linear bearings. The stage table should move freely with little resistance.
8. Repeat steps 3 through 5 for any areas covered by the original table position.
9. Refasten the covers
10. Restore power to the stage and drive the stage table back to its original position to redistribute lubricants.



To minimize the possibility of bodily injury, confirm that all electrical power is disconnected prior to making any mechanical adjustments.

4.2.4. Flexure Constraints

The AVL1000 uses flexures to fix the table top in the X and Y directions. These flexures vital to the fundamental operation of the stage (see Figure 4-1, flexure highlighted in green).

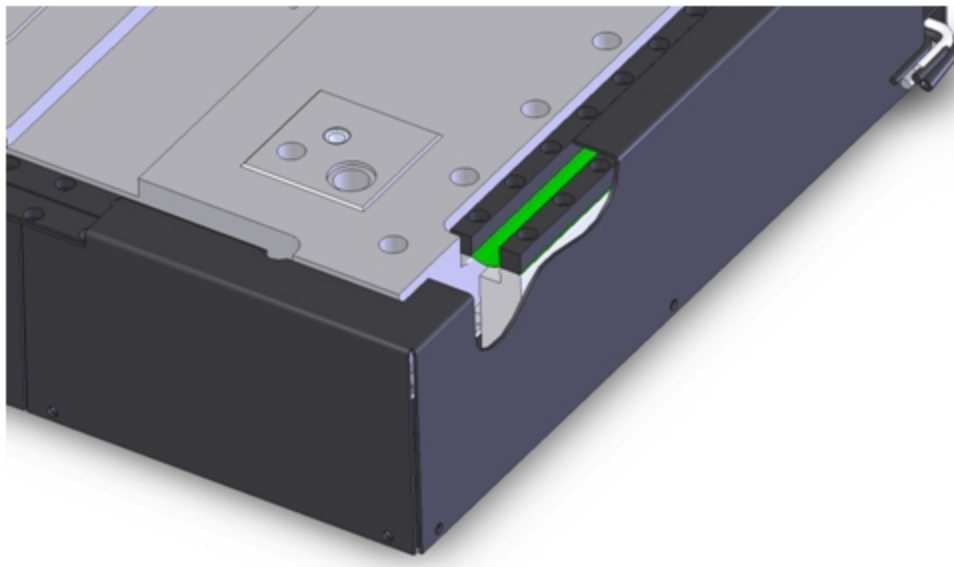


Figure 4-1: Cutaway View of an AVL1000 Flexure

The flexures are delicate and must not be tampered with, scratched, or dented. Covers protect the flexures from damage and should be kept in place during normal stage operation.

When the covers are removed during maintenance and servicing, be sure not to damage these flexures. This may cause premature fatigue failure of the flexures due to stress concentration.

Appendix A: Warranty and Field Service

Aerotech, Inc. warrants its products to be free from defects caused by faulty materials or poor workmanship for a minimum period of one year from date of shipment from Aerotech. Aerotech's liability is limited to replacing, repairing or issuing credit, at its option, for any products that are returned by the original purchaser during the warranty period. Aerotech makes no warranty that its products are fit for the use or purpose to which they may be put by the buyer, where or not such use or purpose has been disclosed to Aerotech in specifications or drawings previously or subsequently provided, or whether or not Aerotech's products are specifically designed and/or manufactured for buyer's use or purpose. Aerotech's liability or any claim for loss or damage arising out of the sale, resale or use of any of its products shall in no event exceed the selling price of the unit.

Aerotech, Inc. warrants its laser products to the original purchaser for a minimum period of one year from date of shipment. This warranty covers defects in workmanship and material and is voided for all laser power supplies, plasma tubes and laser systems subject to electrical or physical abuse, tampering (such as opening the housing or removal of the serial tag) or improper operation as determined by Aerotech. This warranty is also voided for failure to comply with Aerotech's return procedures.

Laser Products

Claims for shipment damage (evident or concealed) must be filed with the carrier by the buyer. Aerotech must be notified within (30) days of shipment of incorrect materials. No product may be returned, whether in warranty or out of warranty, without first obtaining approval from Aerotech. No credit will be given nor repairs made for products returned without such approval. Any returned product(s) must be accompanied by a return authorization number. The return authorization number may be obtained by calling an Aerotech service center. Products must be returned, prepaid, to an Aerotech service center (no C.O.D. or Collect Freight accepted). The status of any product returned later than (30) days after the issuance of a return authorization number will be subject to review.

Return Procedure

After Aerotech's examination, warranty or out-of-warranty status will be determined. If upon Aerotech's examination a warranted defect exists, then the product(s) will be repaired at no charge and shipped, prepaid, back to the buyer. If the buyer desires an airfreight return, the product(s) will be shipped collect. Warranty repairs do not extend the original warranty period.

Returned Product Warranty Determination

After Aerotech's examination, the buyer shall be notified of the repair cost. At such time, the buyer must issue a valid purchase order to cover the cost of the repair and freight, or authorize the product(s) to be shipped back as is, at the buyer's expense. Failure to obtain a purchase order number or approval within (30) days of notification will result in the product(s) being returned as is, at the buyer's expense. Repair work is warranted for (90) days from date of shipment. Replacement components are warranted for one year from date of shipment.

Returned Product Non-warranty Determination

At times, the buyer may desire to expedite a repair. Regardless of warranty or out-of-warranty status, the buyer must issue a valid purchase order to cover the added rush service cost. Rush service is subject to Aerotech's approval.

Rush Service

On-site Warranty Repair If an Aerotech product cannot be made functional by telephone assistance or by sending and having the customer install replacement parts, and cannot be returned to the Aerotech service center for repair, and if Aerotech determines the problem could be warranty-related, then the following policy applies:

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs. For warranty field repairs, the customer will not be charged for the cost of labor and material. If service is rendered at times other than normal work periods, then special service rates apply.

If during the on-site repair it is determined the problem is not warranty related, then the terms and conditions stated in the following "On-Site Non-Warranty Repair" section apply.

On-site Non-warranty Repair If any Aerotech product cannot be made functional by telephone assistance or purchased replacement parts, and cannot be returned to the Aerotech service center for repair, then the following field service policy applies:

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs and the prevailing labor cost, including travel time, necessary to complete the repair.

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Appendix B: Technical Changes

Table B-1: Current Changes (1.02.00)

Section(s) Affected	General Information
Section 1.4.	Section added
Section 3.1.	Section added
Chapter 2: Installation, Section 2.1. , Section 2.3. , Section 2.5. , and Section 1.3.	Safety information and warnings added
Section 3.3.	Motor specifications added
Section 3.6.	Note about wire current and voltage requirements added

Table B-2: Archived Changes

Revision	Section(s) Affected	General Information
1.00.00	--	New manual
1.01.00	Section 1.2.	Dimensions section added

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