User Manual

LM3, Standard Options, Revision B

Document Notice

This manual contains pertinent safety information for the proper integration, use, maintenance, and decommissioning of certain LM3 motion products provided by Griffin Motion, LLC. Please first verify the applicability of this manual to the equipment in use prior to following its guidance. If you have any questions whatsoever, please do not hesitate to reach out to a Griffin Motion representative.

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This manual is subject to change without notice and is superseded by any new revision. All previous and current revisions of this manual may be made available upon request.

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1.2 LIST OF TABLES

2 SCOPE

2.1 FOREWORD

This manual contains product information for a broad range of offerings, under the designation “LM3”. With the intent to provide a more concise user manual, most illustrations and figures depict a standard configuration (Griffin Motion Part Number: LM3-300-LM-G-M-S-F-00 and LM3-300-BS-A-H-S-F-00) which has features that can be applied across the entire product lineup. For situations where major deviations exist, a note or additional figures are provided. If you are unsure of any information provided or how it may apply to your product or requirements, please contact a Griffin Motion Representative.

In addition, through continual improvement of its products, Griffin Motion may change the listed ordering options or make small changes to the stated specifications without notice. For previous customers, the best point of reference for your equipment is the documentation you received at the time of your delivered order.

2.2 INTENDED USE

This manual is intended for use by a qualified technician or knowledgeable system integrator.

The LM3 series of linear stages are intended for use in a laboratory or light industrial application. A typical use environment for a LM3 is in a temperature-controlled room that is free of dirt, oil, and condensing moisture.

A LM3’s intended primary purpose is to provide dynamic and high precision positioning of externally mounted loads within its designed limits. Implementation examples include, but are not limited to, microscope inspection, laser processing, additive manufacturing, automatic dispensing equipment, and general-purpose positioning. Safety guidance and installation procedures are strictly related to the positioning capabilities of the LM3, and not the applied use thereof.

In its primary configuration, a LM3 is intended to be used lying on a flat surface, like a table. Vertical use can be appropriate depending on the stage sub model. Contact Griffin Motion for further details.

Where not provided directly from the manufacturer, suitable controls and cabling should be selected or manufactured to control the various aspects of the stage to provide maximum safety of the equipment and any potential user. Moreover, the LM3 was designed to be integrated into a control system with the intent of hands-free operation requiring no direct human intervention while energized. Simply complying with the hazards and caution notices of this manual may not satisfy the regulatory requirements of your intended application.

2.3 HAZARDS AND WARNINGS

This user manual, when followed by a knowledgeable person, will direct an individual on how to safely install, operate, or service this stage. It is required that the user of a LM3 stage strictly adhere to the provided instructions and guidance provided in this manual and perform risk evaluations where this manual does not cover a specific end-user application. If any portion of the information provided herein is not understood, please contact a Griffin Motion Representative by email or phone at the contact information found at the beginning of this document.

A list of identified human and machine safety factors directly related to the operation of a LM3 are compiled below. While guidance is provided below for the identified hazards, it may not be sufficient to adequately identify, reduce, or remove the risks associated with a specific user application; therefore, a risk assessment of your intended application against the applicable standards in your local jurisdiction must be conducted prior to use.

DANGER: This product may contain potentially harmful voltages. To reduce the risk of shock to a human operator, the following precautions must be followed:

1. Associated controls and cabling fully de-energized before connecting to stage.
2. De-energize and Disconnect power sources before servicing.
3. Use an appropriate grounding scheme to preclude accidental shock under fault conditions.
4. Install control systems that can detect fault voltages and provide alarm.
5. Where potential for touching is expected during operation, install additional non-conductive safety guards or power interruption equipment (ex. sensor curtain) to de-energize the equipment as required.
6. Create and post operating instructions and warning labels on the final equipment.

DANGER: This product contains crushing and shearing hazards. To reduce the risk of crushing or shearing, the following precautions must be followed:

1. Install equipment as outlined in mechanical installation chapter.
2. Where potential for touching is expected during operation, perform some or all of the following, depending on the application:
    a. Install additional warning labels.
    b. Install additional guards or enclose the equipment.
    c. Install a power interruption control system (ex. sensor curtain) to de-energize the equipment.
3. For control systems, consider lowering motor currents as low as practicable.
4. Create and post operating instruction and warning labels on the final equipment.

CAUTION: This product may produce potentially hazardous temperatures. To reduce the risk of burns to a human operator, the following precautions must be followed:

1. Where potential for touching is expected during operation, perform some or all of the following:
    a. install temperature warning signs on motor housings.
    b. install temperature monitoring equipment or additional thermal guards.
2. Control systems shall monitor for overcurrent conditions.
3. Control systems shall monitor for overvoltage conditions.
4. Create and post operating instructions and warning labels on the final equipment.

CAUTION: This product may emit electromagnetic radiation. To reduce the risk of interference with other electrical equipment, the following guidance may apply:

1. Assess the motor amplifier topology in your control system.
2. Construct shielded motor cables and feedback cables as outlined in this user manual.
3. Create RF shields for any other sensitive equipment in the vicinity of the LM3 stage.
4. Contain final equipment in RF conducting meshes or enclosures.
5. Utilize filters, transformers, or other impedance equipment to mitigate radiation from power sources as outlined in supporting controller manuals.

ATTENTION: This product may emit uncomfortable noise levels depending on how it is operated. To reduce the discomfort level due to radiated noise, the following guidance may apply:

1. Change the motor amplifier topology.
2. Re-tune the current control loop gains in the amplifier.
3. Isolate the equipment with a sound barrier.
4. Turn off machines that are not required to be in operation.
5. Limit the amount of time operator is in vicinity of equipment.

ATTENTION: This product is intended to be incorporated as part of a complete control system; some, but not all, of the key operating factors are listed:

1. Warn user of abnormal machine operation.
2. Secure power to machine when an unsafe condition exists.
3. Arrest or halt motion as required.
4. Prevent unexpected start-up or motion.

Each identified hazard above is reiterated in the various sections of the installation procedure. More details can be found in those respective sections of this manual.

3 PRODUCT OVERVIEW

3.1 ORDERING OPTIONS

This product manual contains information applicable to the LM3 products in the series as outlined in Table 1. If there are any ordering options that do not fit your set of requirements, please contact a Griffin Motion representative who may then provide clarification or information regarding our other offerings that could best suit your needs.

Table 1. Ordering Options

LM3	300	LM	G	M	S	F	00
Part Number Ordering Options							
Product Series	**Travel (mm)**	**Drive Type**	**Motor Type**	**Encoder Type**	**Precision Level**	**Additional Option**	**Custom Option**
LM3 – Linear Stage	100, 150, 200, 250, 300, 400, 500, 600, 800	LM- Linear Motor	G-Ironless Linear Motor ***(Note 3)***	H – Rotary Quadrature Encoder ***(Note 2)***	S – Standard	D – Power off brake ***(Note 2)***	00 – no custom options
		BS – 2mm ball screw ***(Note 2)***	A – Nema17 Brushless DC, 24V Winding ***(Note 2)***	M – Linear Quadrature Encoder ***(Note 3)***	P – High ***(Note 1)***	F – Silicone Side Seals	Any other value 01 through 99 ***(Note 1)***
		BF – 5mm ball screw ***(Note 1)***	M – Long Stack NEMA17 Brushless DC, 24V Winding ***(Note 1)***	L – Linear Sinusoidal Encoder ***(Note 2,3)***		G – Silicone Side Seals and Power Off Brake ***(Note 2)***	

Note 1: Non-typical options are noted for user information. These setups may include various alterations that may incur additional requirements not fully covered in this technical manual; an amended user manual, addendums, technical drawings, and other supporting documents will be provided with these orders. Please contact a Griffin Motion representative if you need document support for these ordering options.

Note 2: Option not available on stages with “LM” drive type.

Note 3: Option not available on stages with “BS or BF” drive type. Travels of 400mm and longer are not available with “BS or BF” drive type.

3.2 ENVIRONMENTAL SPECIFICATIONS

Operating and storage environment consistent with table.

Table 2. Environmental Specifications

Ambient Temperature (Operating)	Indoor controlled temperature environment between 17˚C to 27˚C. Positioning performance only tested at 20°C, will vary at different temperatures.
Ambient Temperature (Non-Operating)	Indoor long-term exposure to temperatures between -5˚C and 50˚C in original packaging.
Humidity	15% to 85% relative humidity, non-condensing
Altitude	0ft to 6000ft above sea level
Vibration	Low Vibration Environment
Protection Rating	IP00
Use	Partly assembled machine intended for indoor use, properly integrated as part of a control system; no direct contact expected while in operation. Used by a trained operator or integrator.

3.3 BASIC SPECIFICATIONS

Some of the orderable LM3-LM stage configurations are shown in Table 3. Note that not every permutation of the orderable options of Section 3.1 are provided; please contact a Griffin Motion representative with your inquiries regarding ordering a configuration not listed.

Table 3. Basic Product Specifications for LM3-LM Stages

	LM3-100-LM	LM3-150-LM	LM3-200-LM	LM3-250-LM	LM3-300-LM	LM3-400-LM	LM3-500-LM	LM3-600-LM	LM3-800-LM
Height (mm)	62								
Length (mm)	330	380	430	480	530	630	730	830	1030
Width (mm)	258								
Limit Switches	Yes								
Encoder Output	A quad B, Index								
Encoder Resolution (µm)	0.1								
Accuracy	6	8	10	12	15	15	18	20	24
Repeatability	1								
Pitch +/- (arc-sec)	5	5	8	10	12	15	17	20	24
Yaw +/- (arc-sec)	5	5	8	8	8	10	12	20	24
Stage Mass (kg)	6.44	6.78	7.12	7.61	8.39	9.43	10.57	11.71	14.00
Moving Mass (kg)	2.02								
Straightness (µm)	3	4	4	5	5	6	8	10	14
Flatness (µm)	3	4	4	5	5	6	8	10	14
Maximum Velocity	900								
Force X (N) [1]	50								
Force Y (N) [1]	200								
Force Z (N) [1]	440								
Moment X (Nm) [1]	50								
Moment Y (Nm) [1]	50								
Moment Z (Nm) [1]	25								
Expected Life (hours)[2]	20,000								

Some of the orderable LM3-BS stage configurations are shown in Table 4. Note that not every permutation of the orderable options of Section 3.1 are provided; please contact a Griffin Motion representative with your inquiries regarding ordering a configuration not listed.

Table 4. Basic Product Specifications for LM3-BS

	LM3-100-BS	LM3-150-BS	LM3-200-BS	LM3-250-BS	LM3-300-BS
Height (mm)	62				
Length (mm)	391	441	491	541	591
Width (mm)	165				
Limit Switches	Yes				
Encoder Output	A quad B, Index				
Encoder Resolution (µm)	0.125				
Accuracy	13	15	17	20	25
Repeatability	2				
Pitch +/- (arc-sec)	5	8	12	12	15
Yaw +/- (arc-sec)	5	8	12	10	10
Stage Mass (kg)	6.25	6.58	6.91	7.39	7.87
Moving Mass (kg)	1.79				
Straightness (µm)	3	6	6	8	10
Flatness (µm)	3	6	6	8	10
Maximum Velocity	150				
Force X (N) [1]	150				
Force Y (N) [1]	200				
Force Z (N) [1]	440				
Moment X (Nm) [1]	50				
Moment Y (Nm) [1]	50				
Moment Z (Nm) [1]	25				
Expected Life (hours)[2]	20,000				

Note 1: Refer to Figure 1 for axis orientation for forces and moments.
Note 2: Expected life to mean the reasonable application of the LM3 in its intended use at moderate velocities, payloads, and duty cycles with respect to the stated limits.

Listed accuracy specifications assume the stage is mounted in a similar fashion and environment to which it was tested at the factory. The nominal mounting condition is flat against the base plate to a stable granite surface, with an evenly distributed mounting torque after both the device and the mounting surface have reached thermal equilibrium. Every unit is tested and verified to the specifications listed and provided with a formal test report. Interferometry testing is conducted at 35mm spacing above the loading (top) plate on the device.

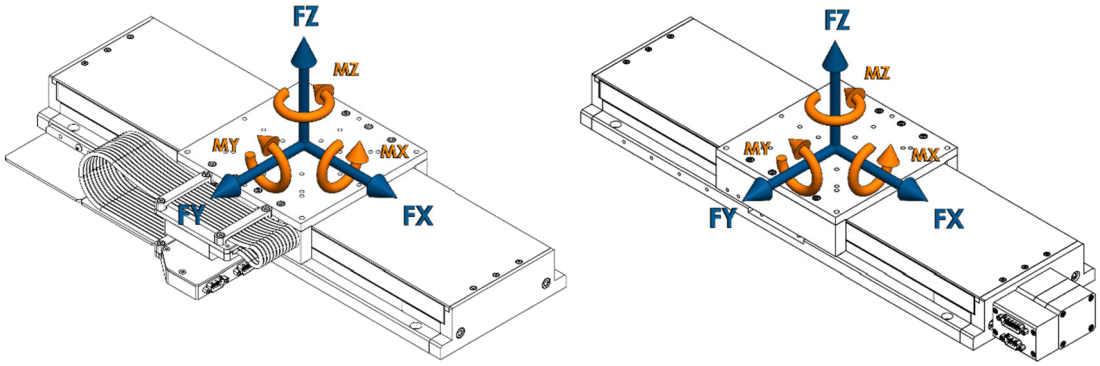


Figure 1. LM3 Load Direction Reference

3.4 PRODUCT VIEWS AND LABELS

3.4.1 GENERIC VIEW

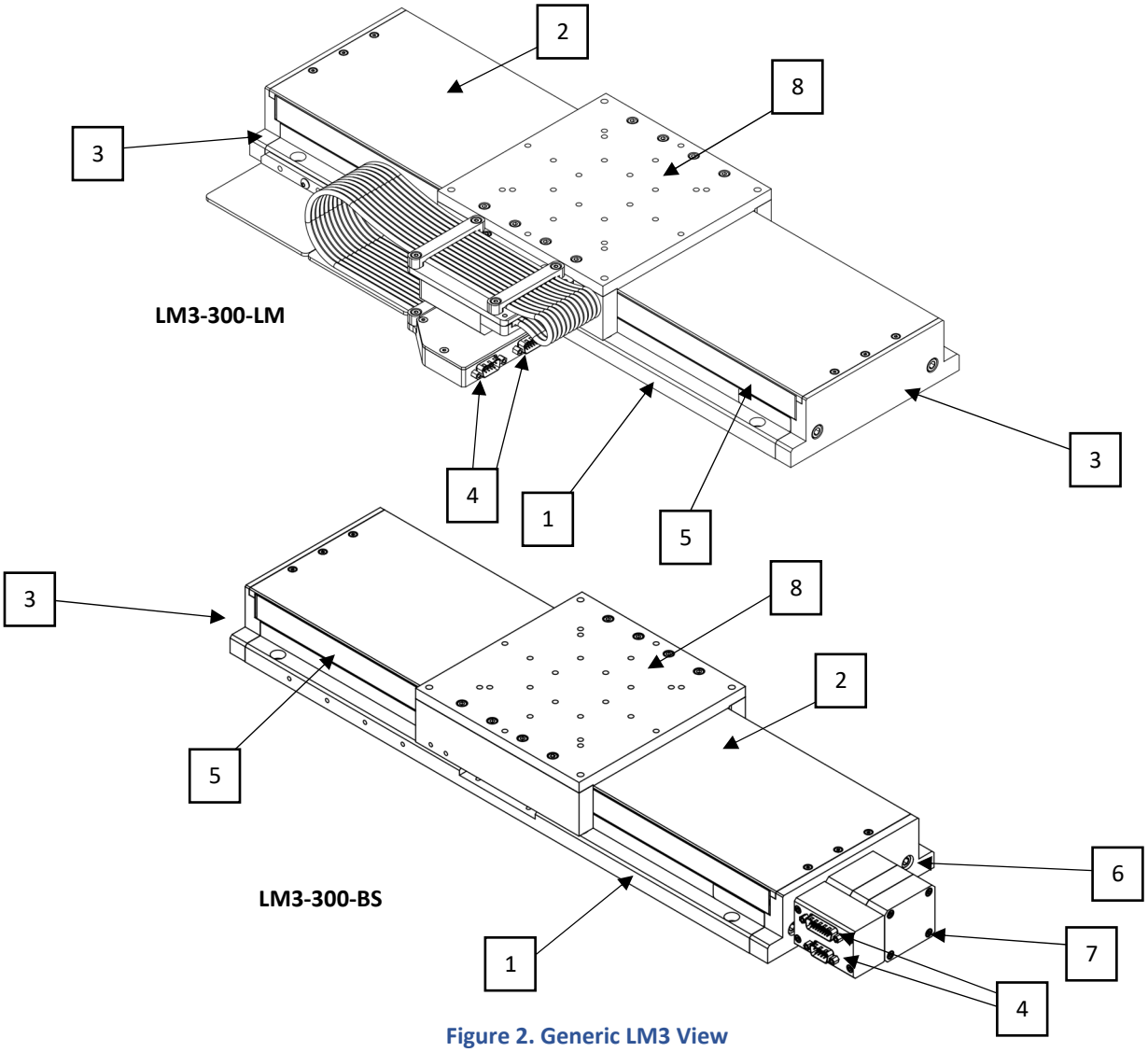


Figure 2. Generic LM3 View

Table 5. LM3 Components

LM3 Components	
Number	**Item**
1	Stage Base
2	Way Cover
3	End Plates
4	Electrical Connectors
5	Side Seals
6	Thrust Plate
7	Rotary Motor Housing
8	Payload Plate

3.4.2 VIEW OF MECHANICAL HAZARDS

DANGER: Due to the intended design of the LM3, there exists pinch points (as shown in Figure 3) that are unavoidable. De-energize the equipment whenever direct contact with the LM3 stage is required. Labels are not provided on the product for this specific hazard; depending on your intended use, labels may be required to be affixed to the machine locations highlighted below.

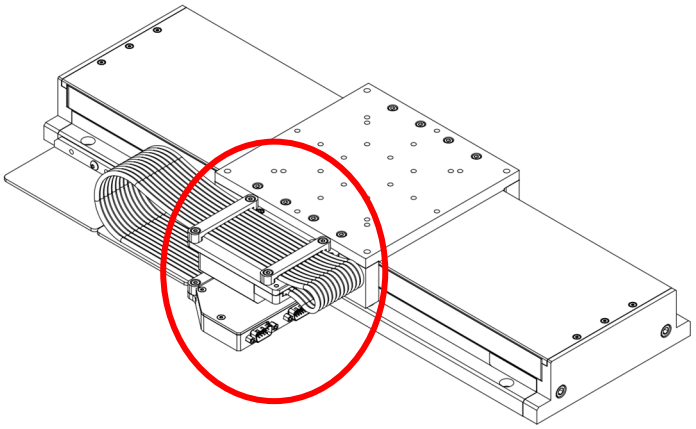


Figure 3. LM3 Pinch Point Hazard Locations

CAUTION: If motor current is not monitored properly, the housing (as pointed out in Figure 2.) may reach temperatures that could burn an operator during operation or service. Labels are not provided on the product for this specific hazard.

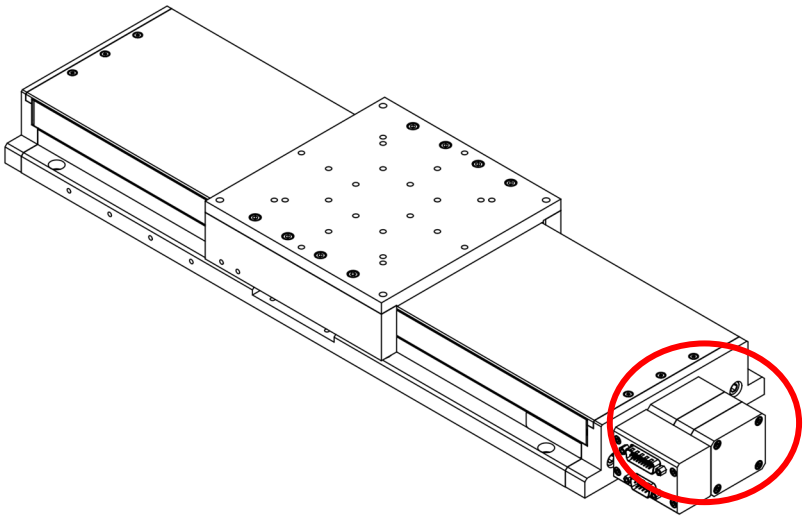


Figure 4. LM3-BS Motor Heat Location

3.5 DIMENSIONS

The sub-sections of this chapter will illustrate the primary dimensions of the LM3. Illustrated are the overall dimensions of the product, tooling plate patterns, and mounting patterns.

3.5.1 LM3-LM DIMENSIONS

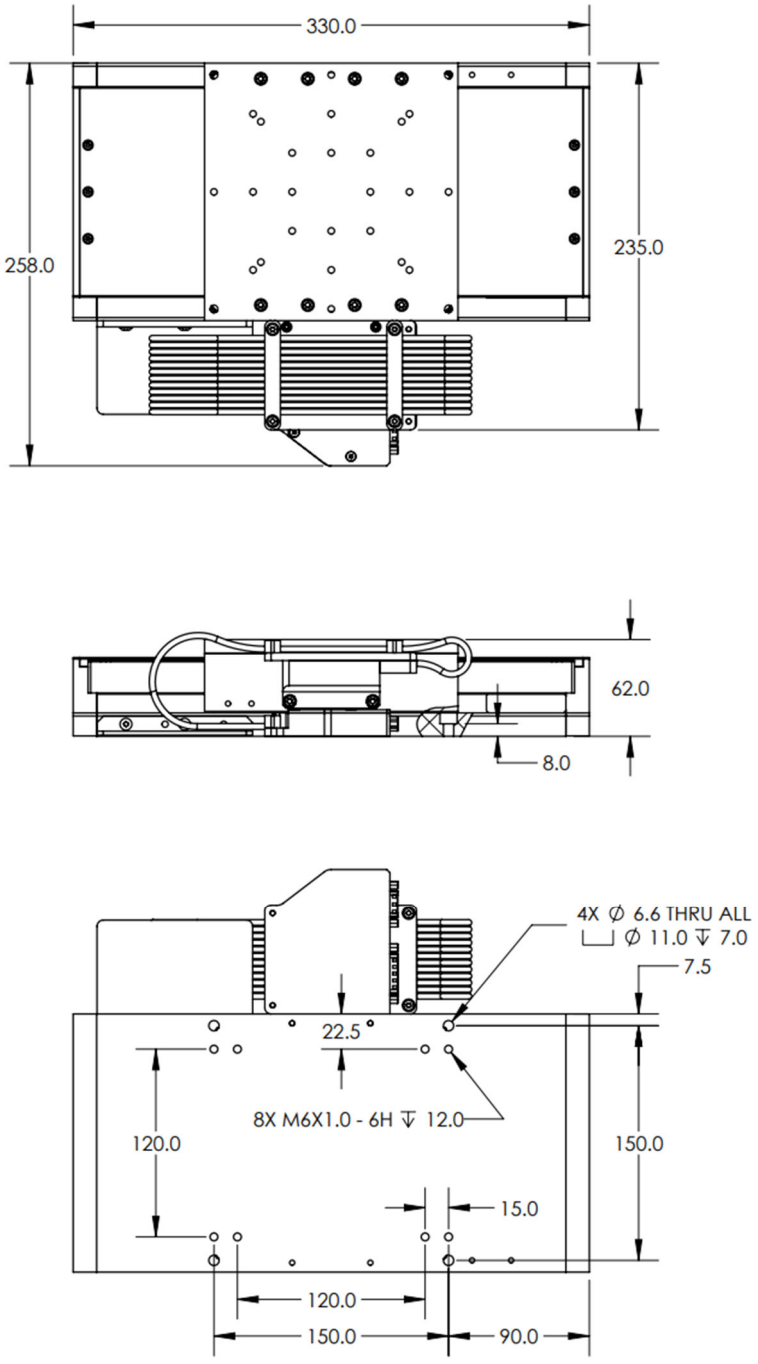


Figure 5. LM3-100-LM

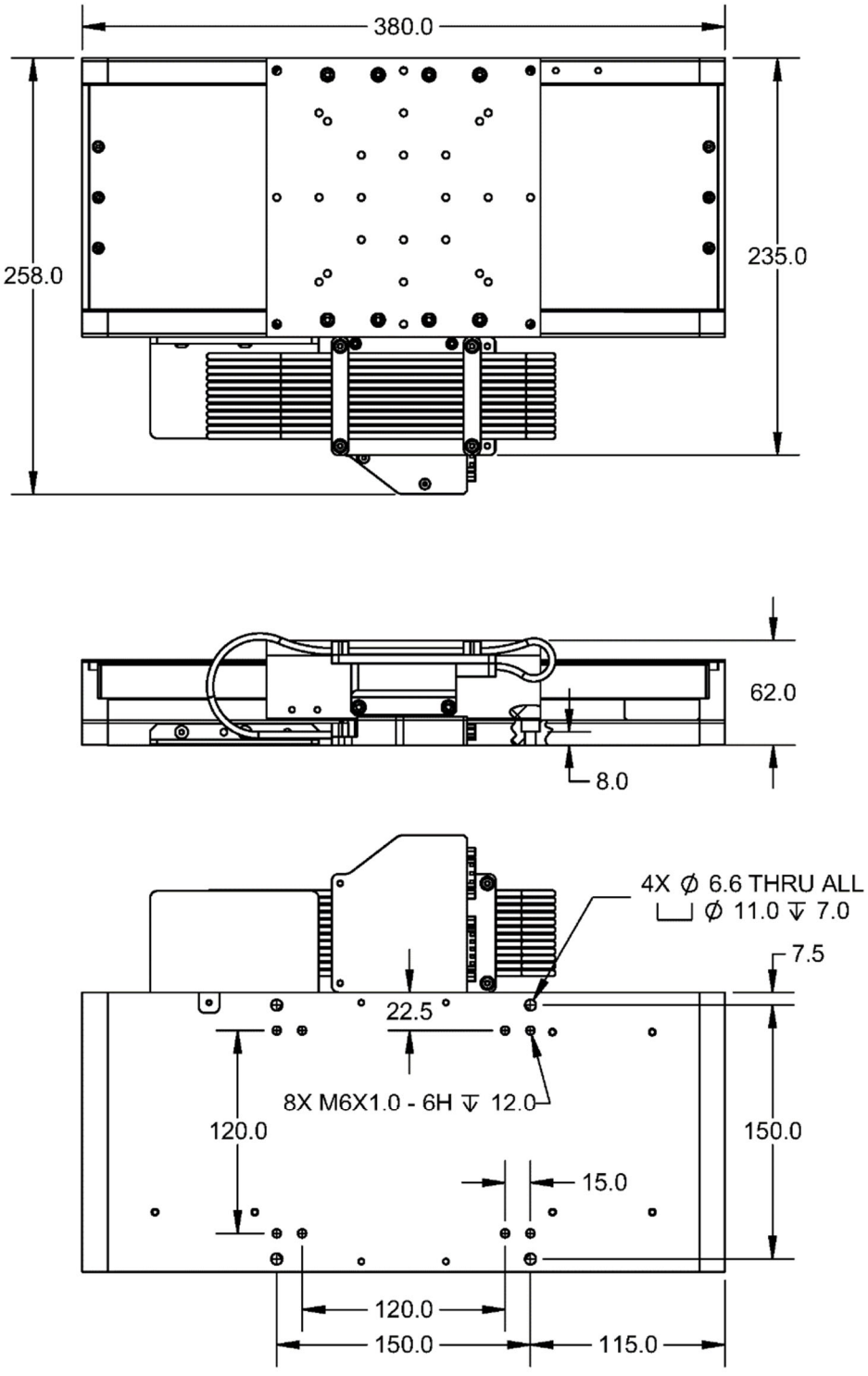


Figure 6. LM3-150-LM

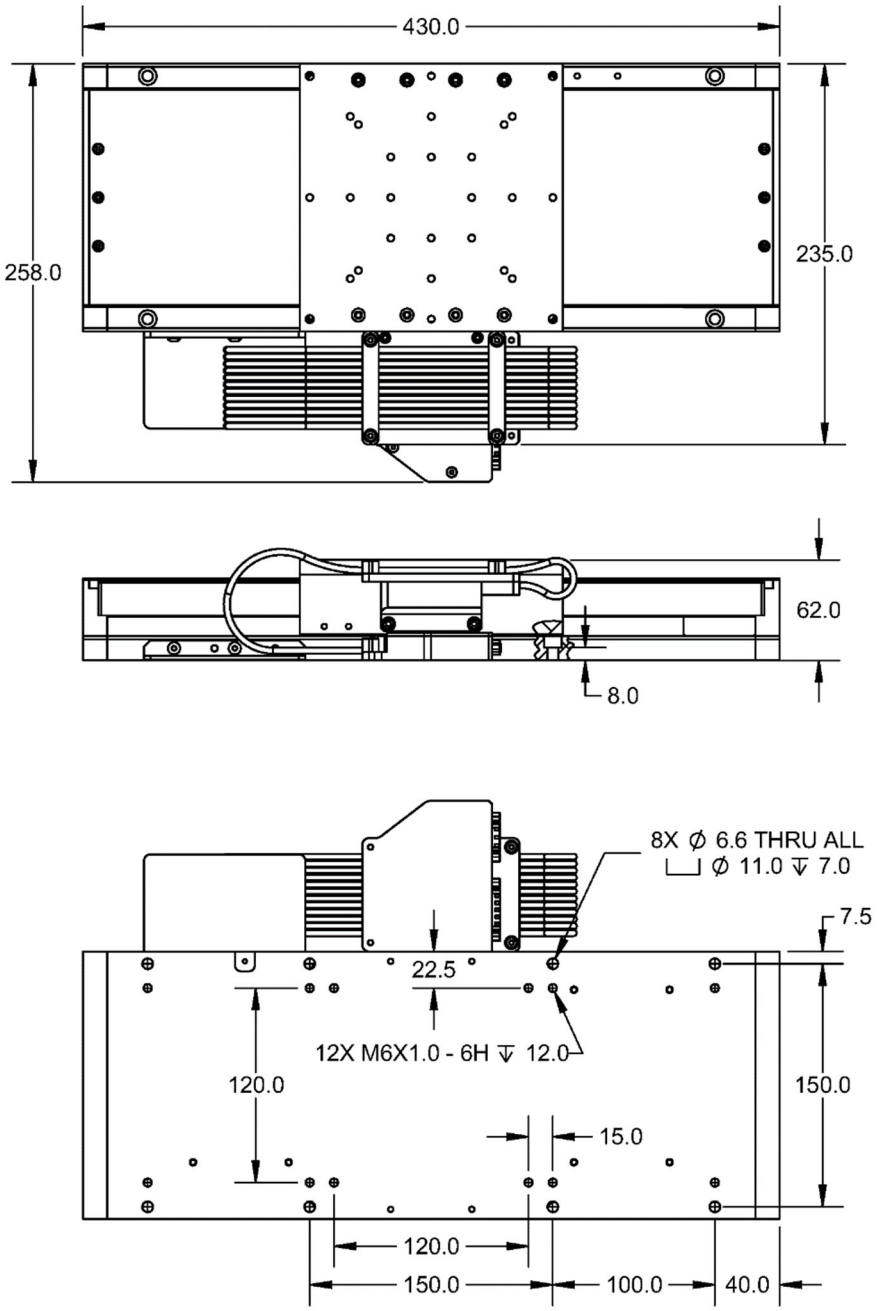


Figure 7. LM3-200-LM

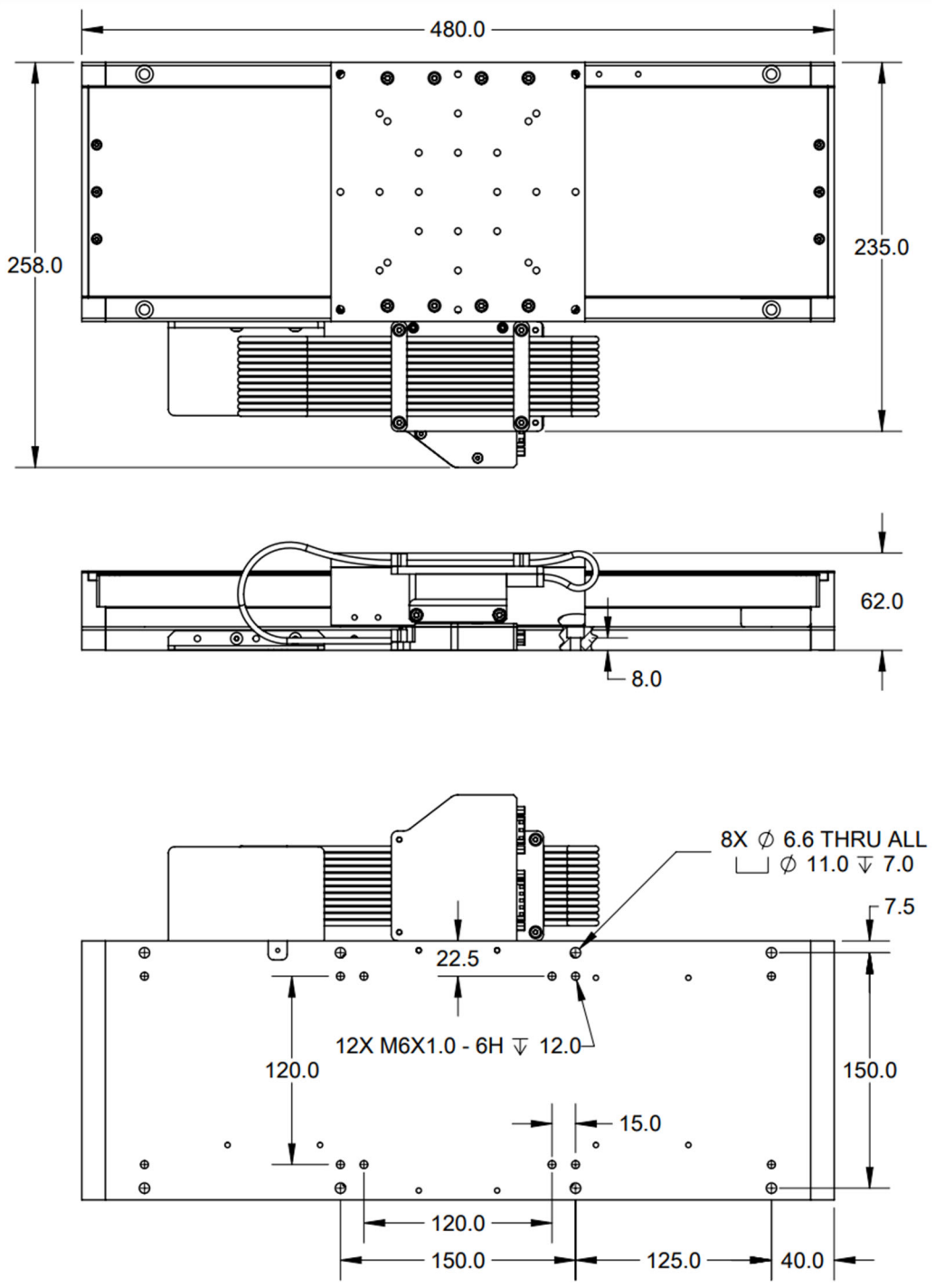


Figure 8. LM3-250-LM

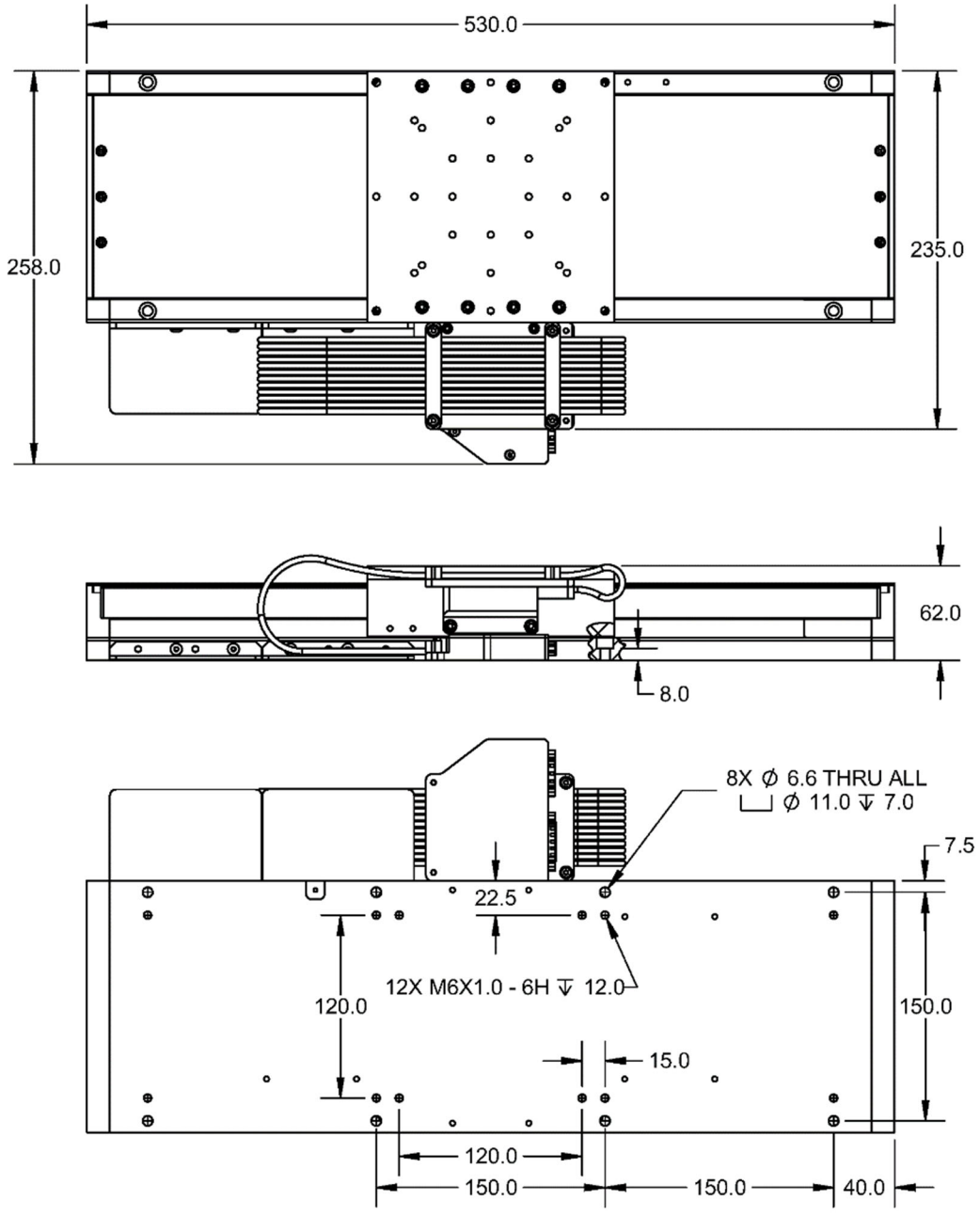


Figure 9. LM3-300-LM

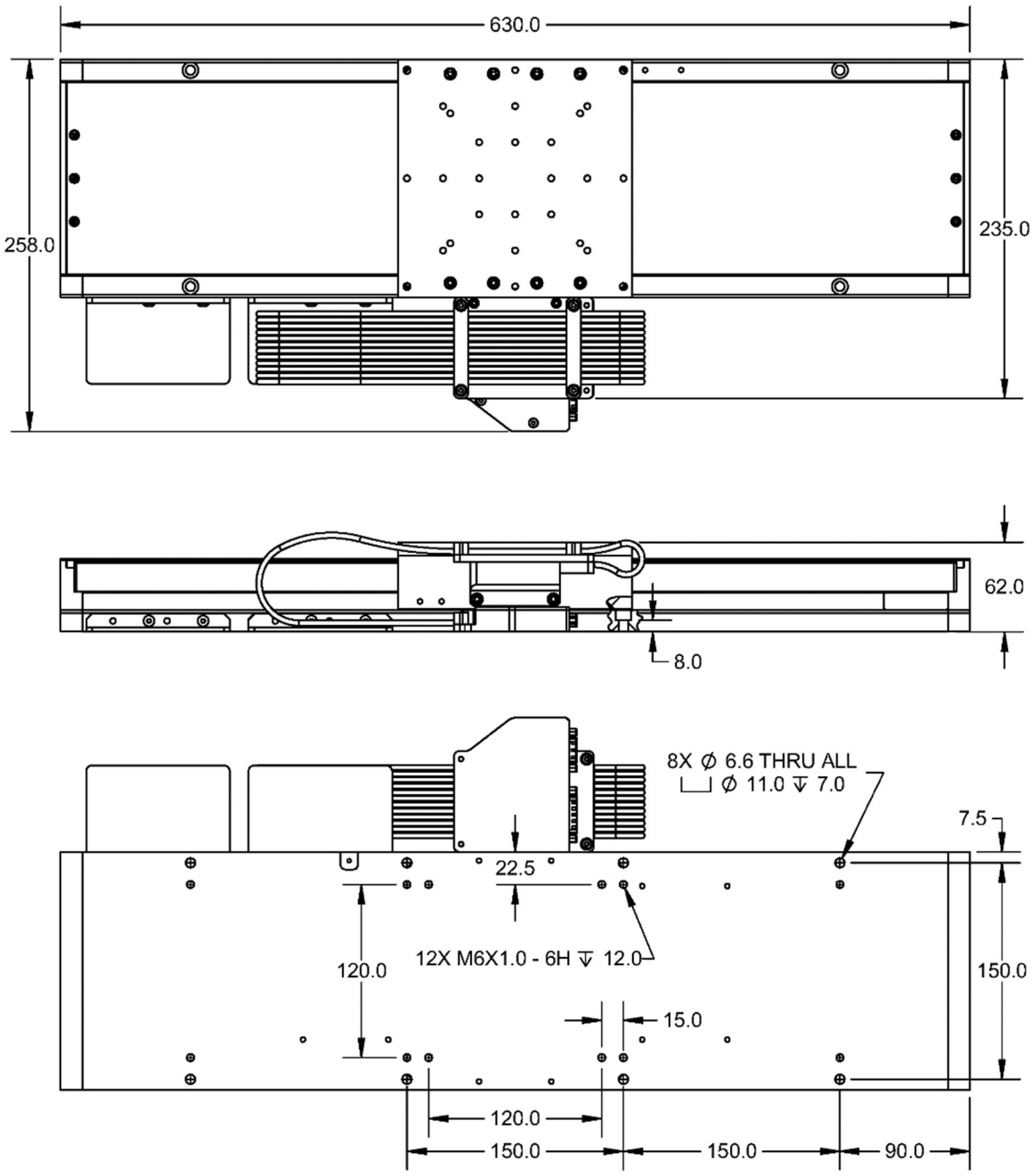


Figure 10. LM3-400-LM

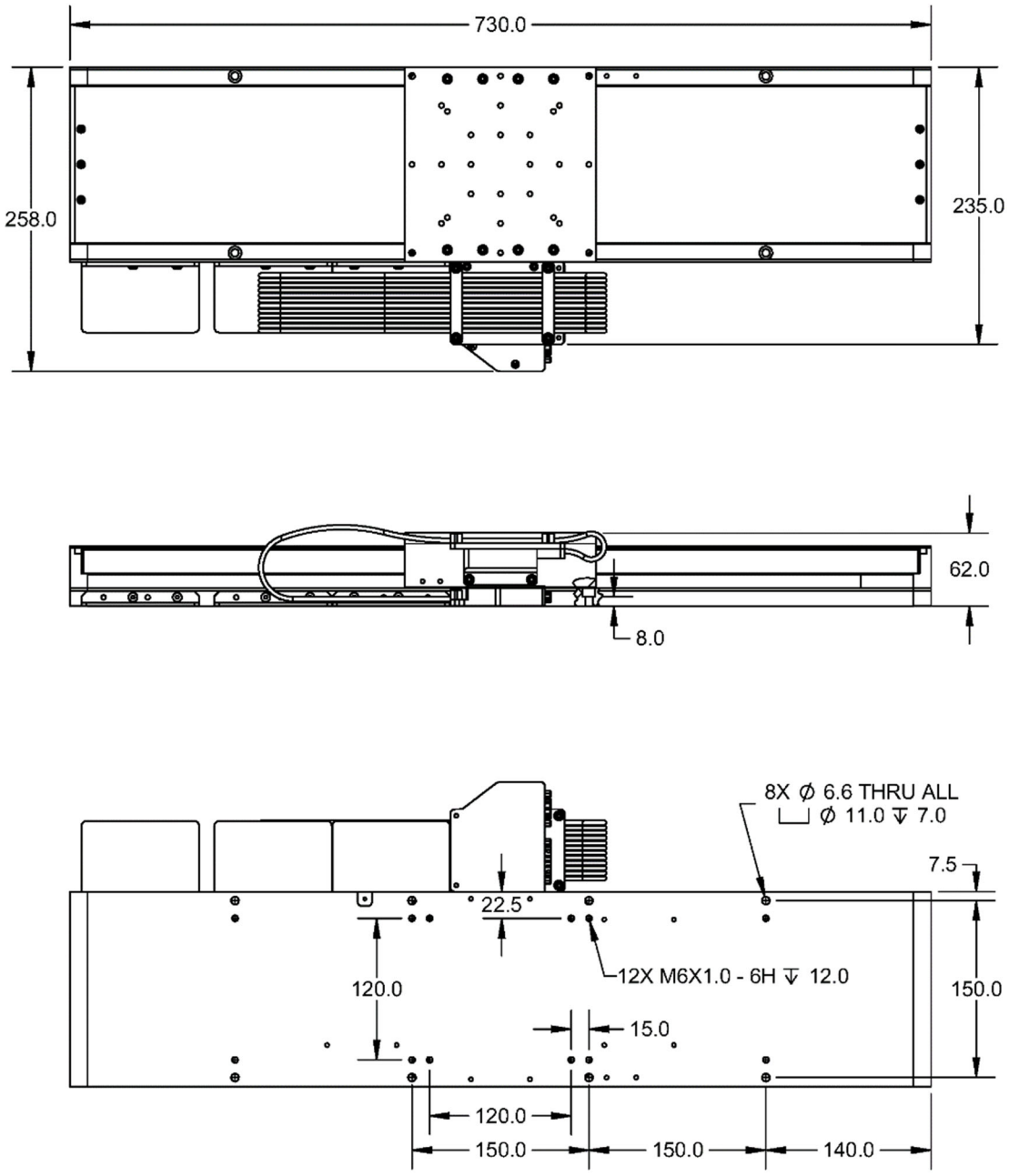


Figure 11. LM3-500-LM

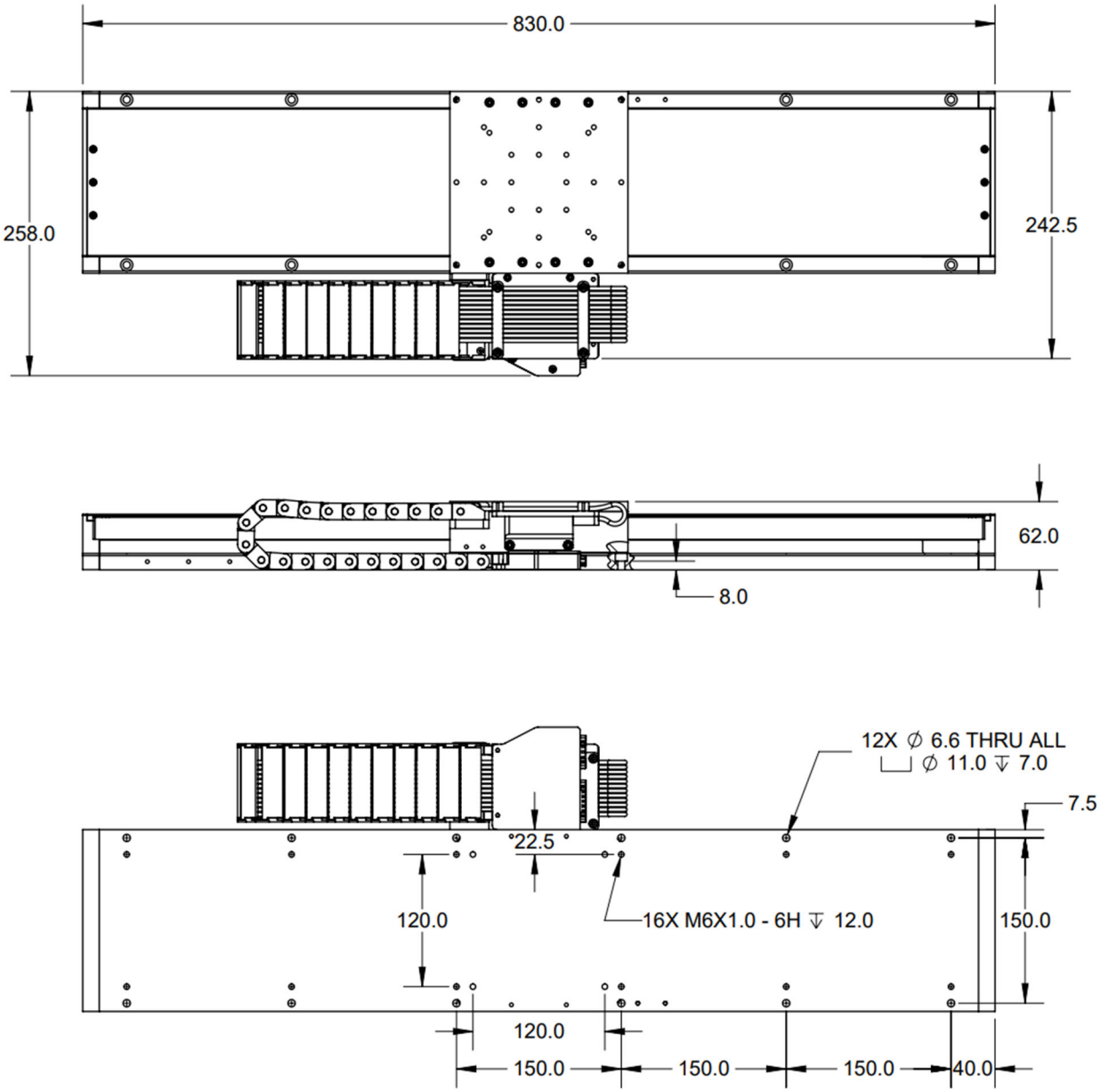


Figure 12. LM3-600-LM

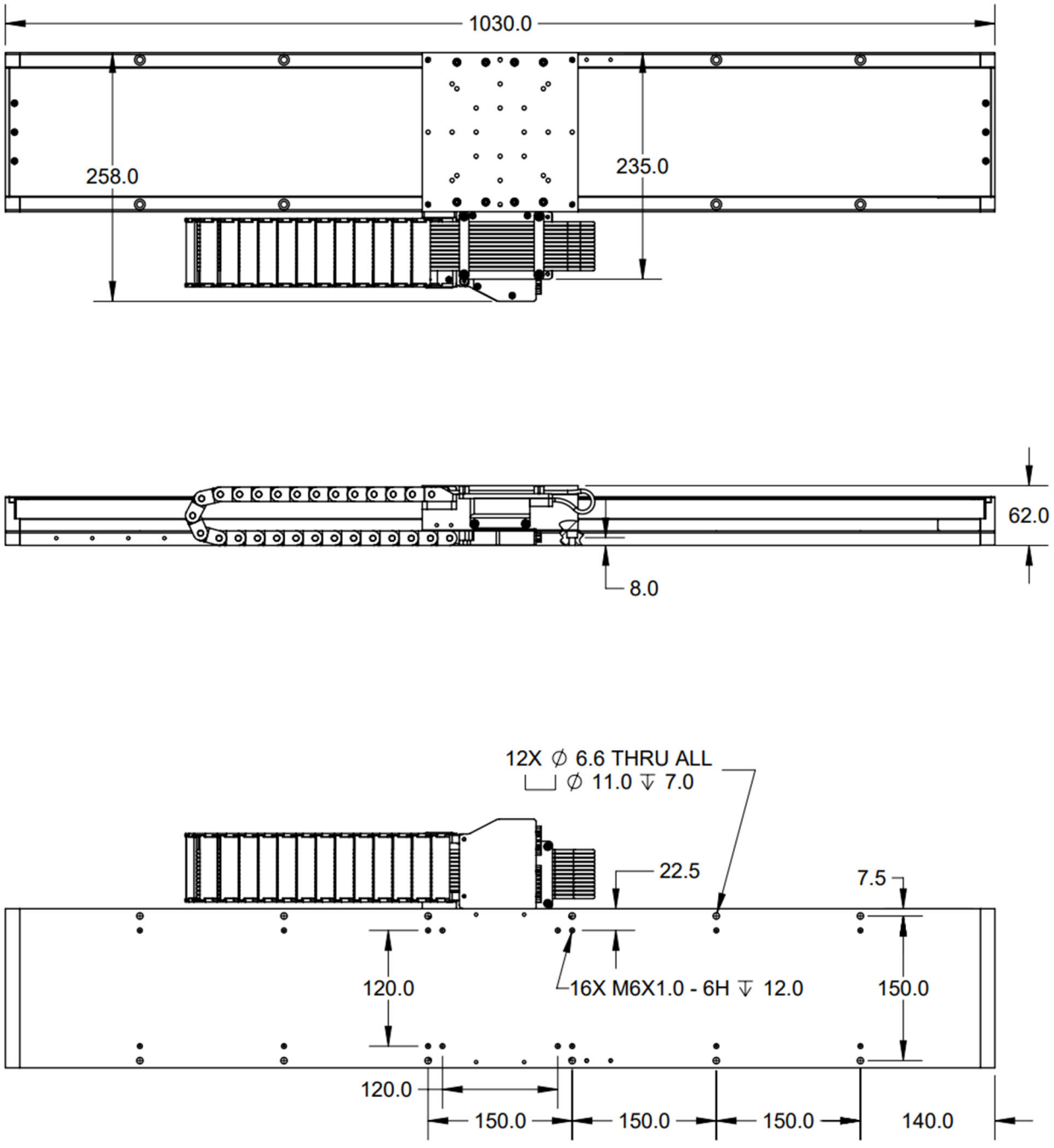


Figure 13. LM3-800-LM

3.5.2 LM3-BS DIMENSIONS

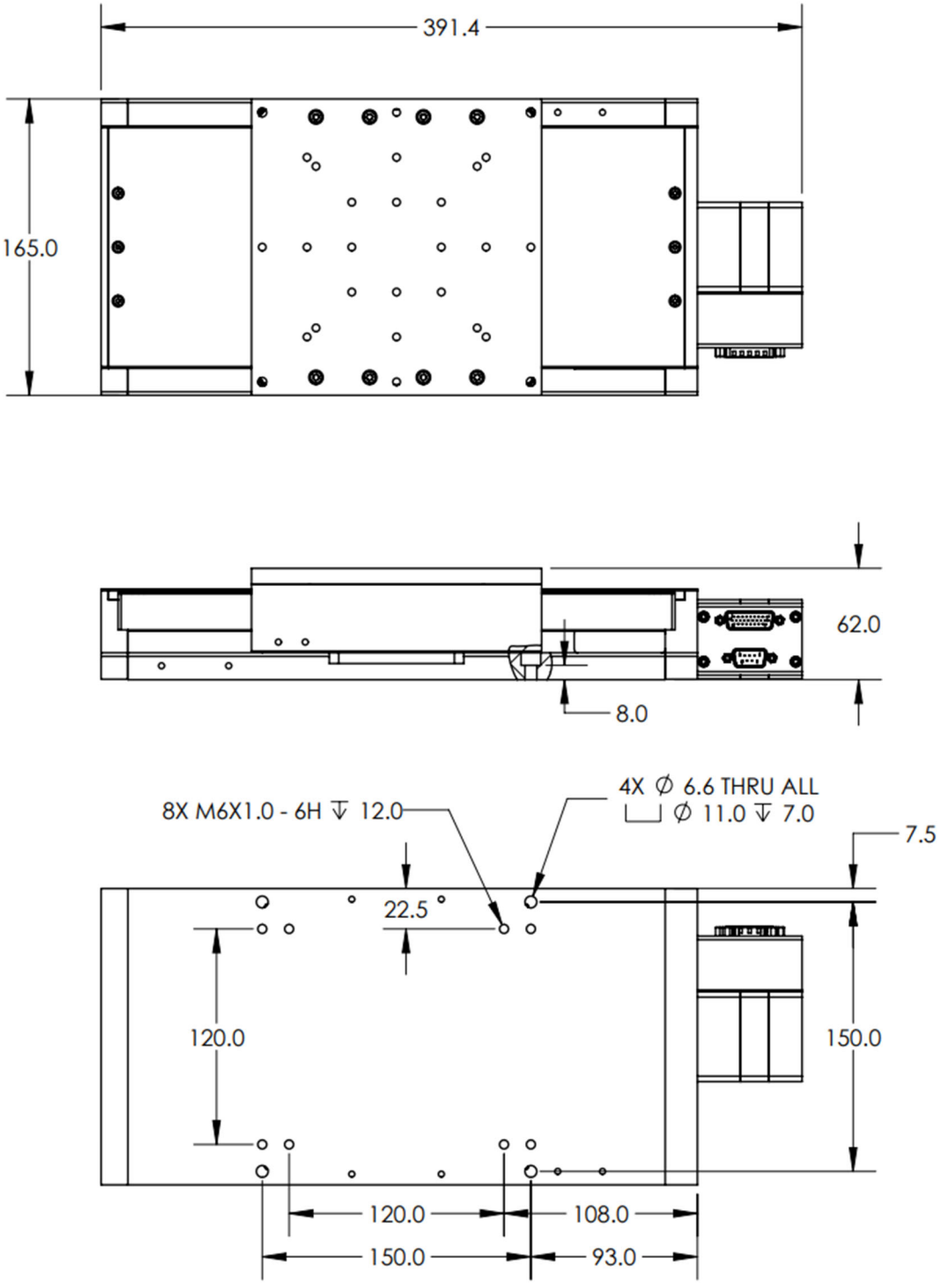


Figure 14. LM3-100-BS

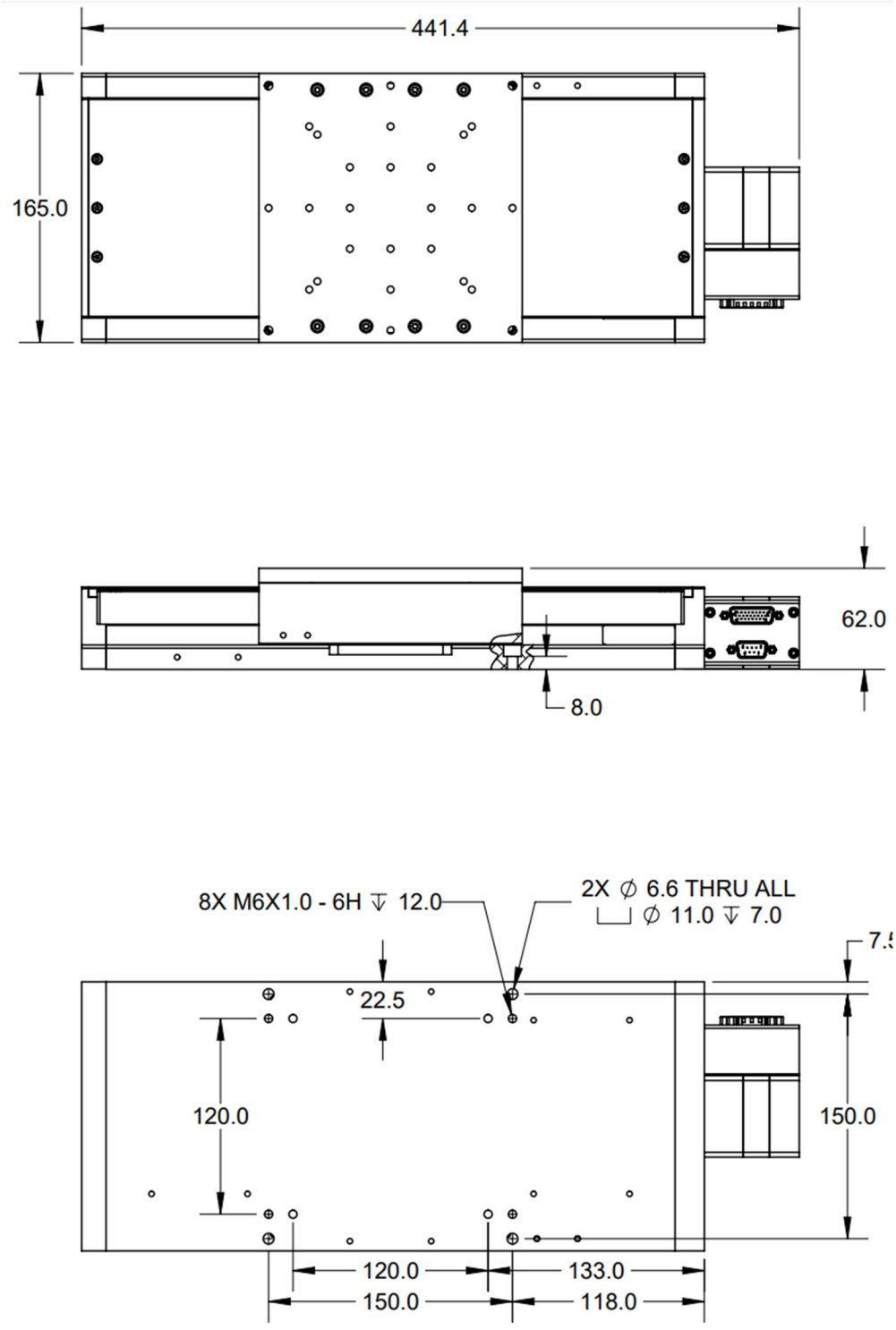


Figure 15. LM3-150-BS

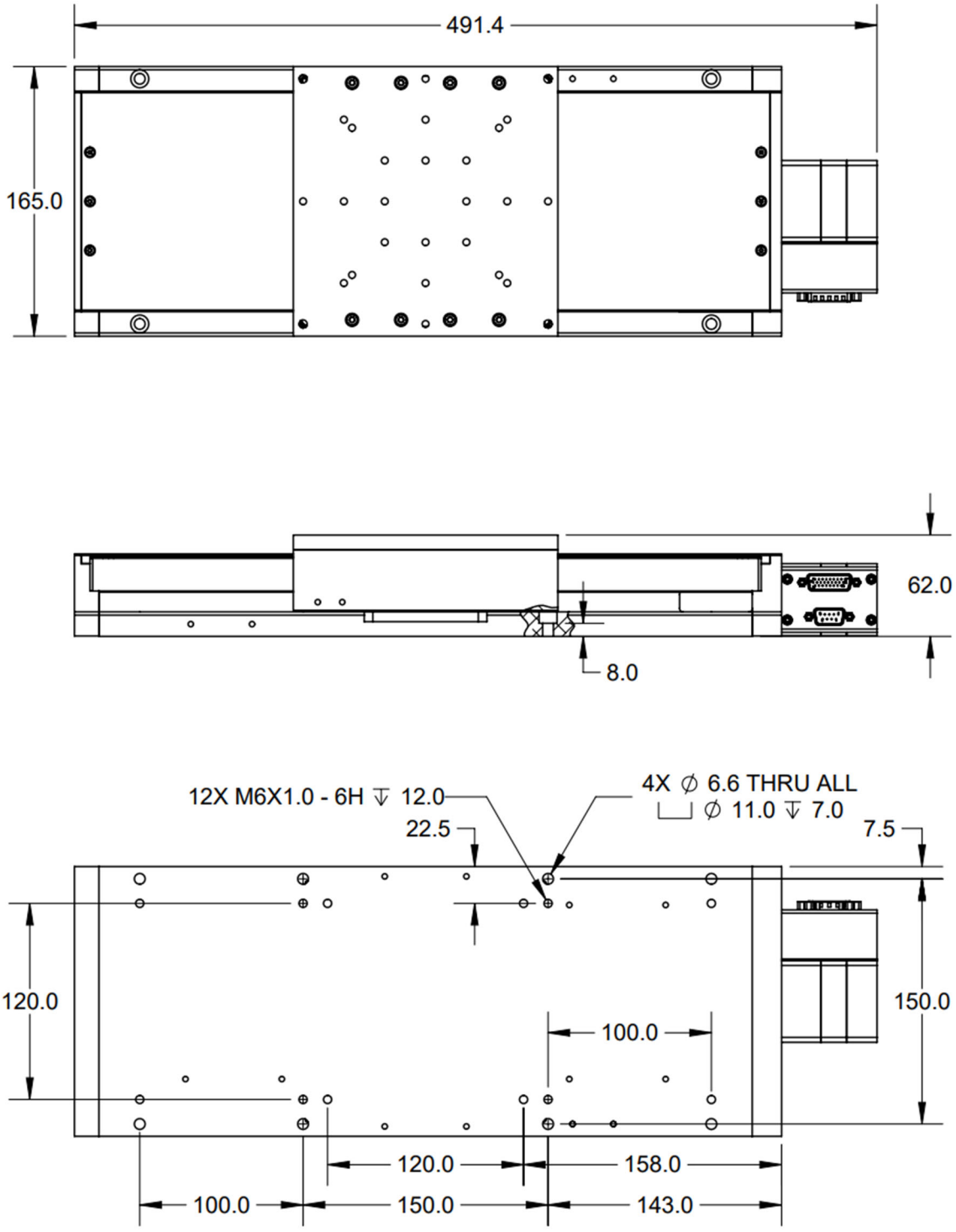


Figure 16. LM3-200-BS

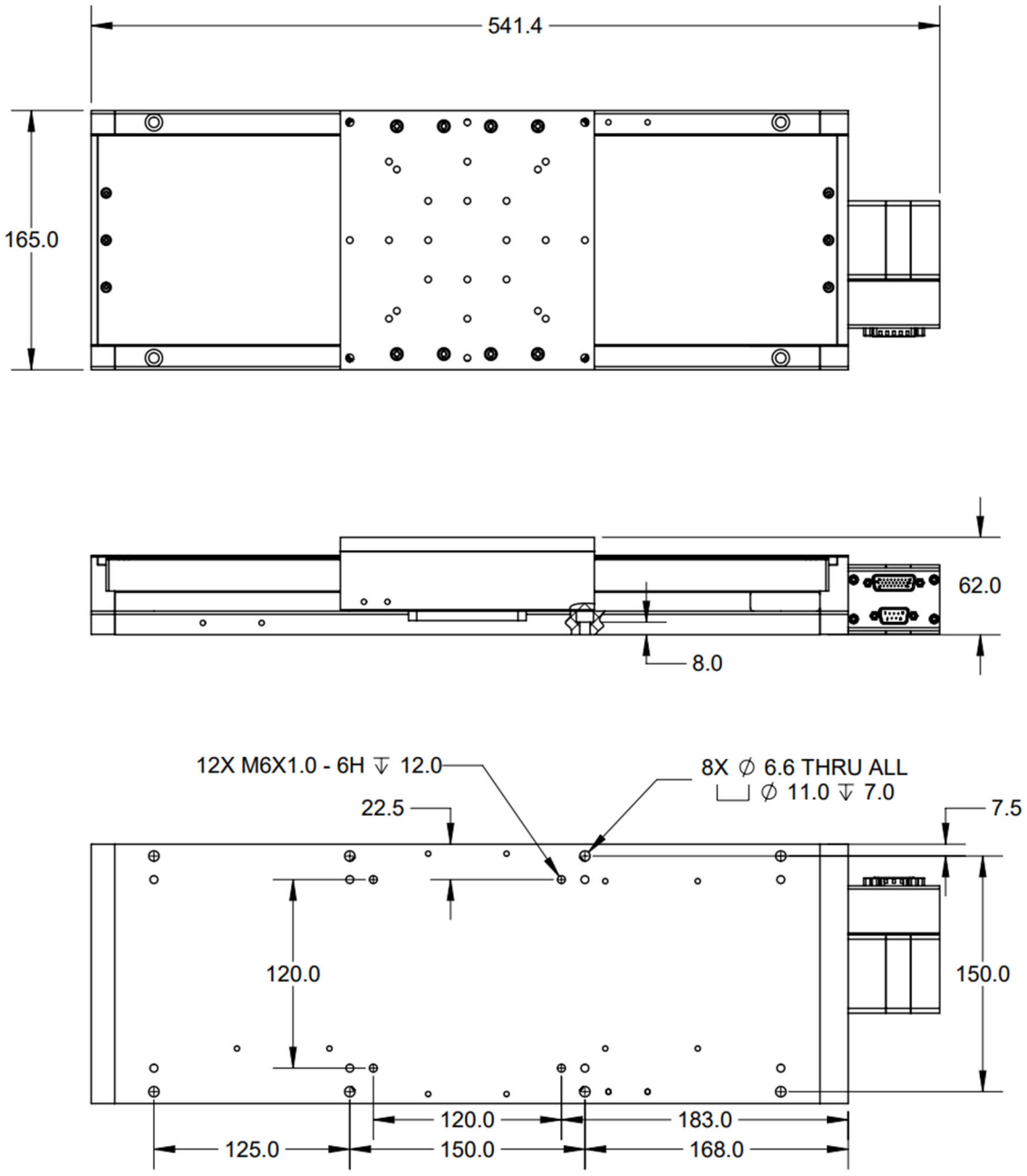


Figure 17. LM3-250-BS

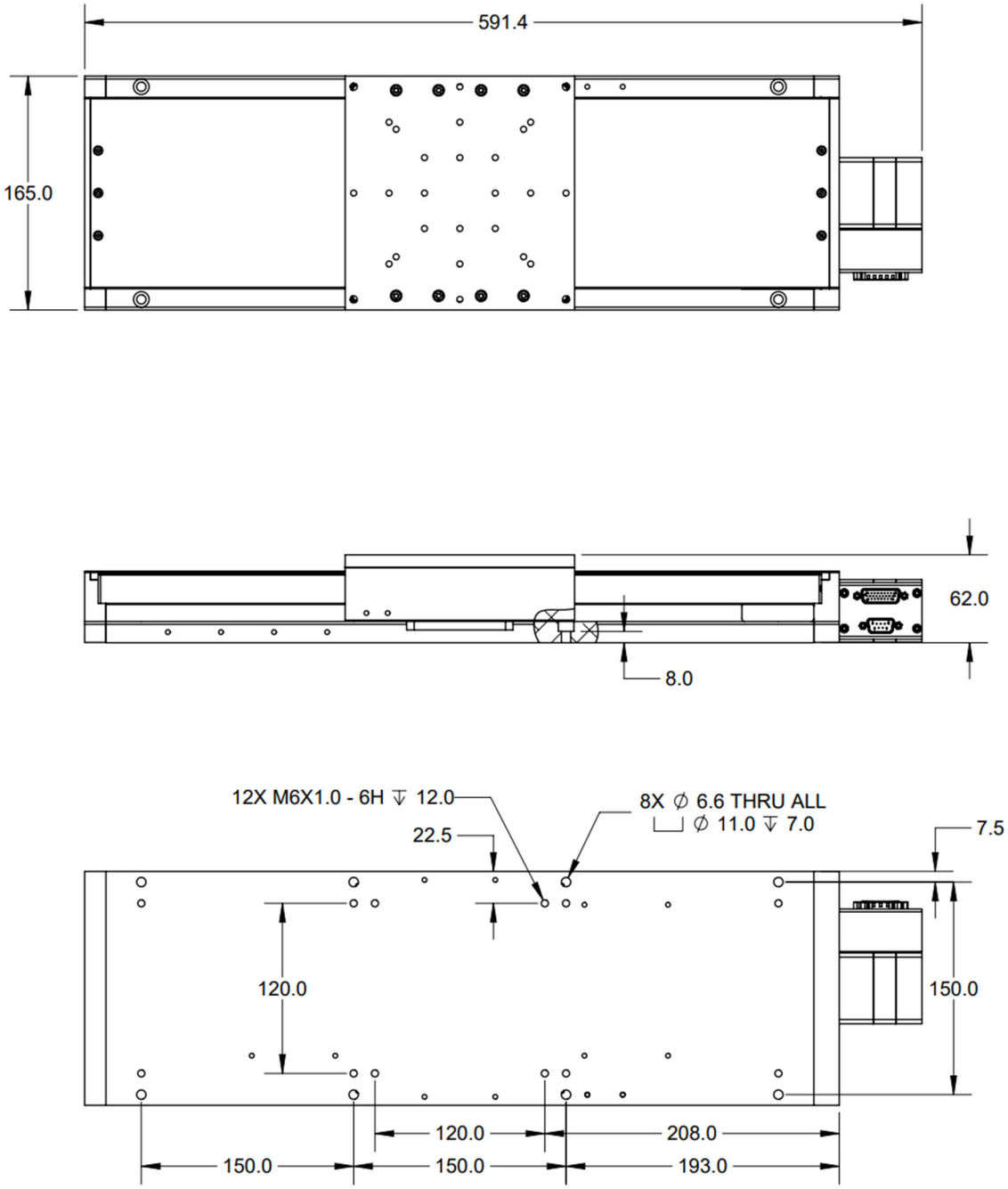


Figure 18. LM3-300-BS

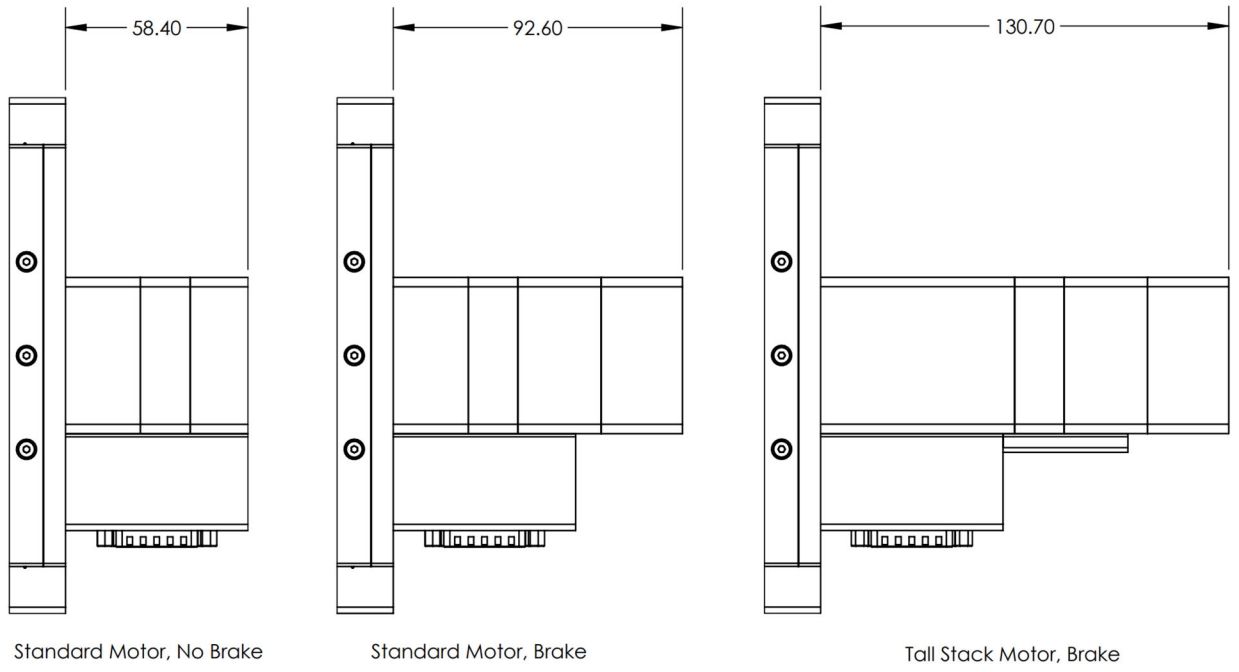


Figure 19. LM3-BS Motor Dimensions

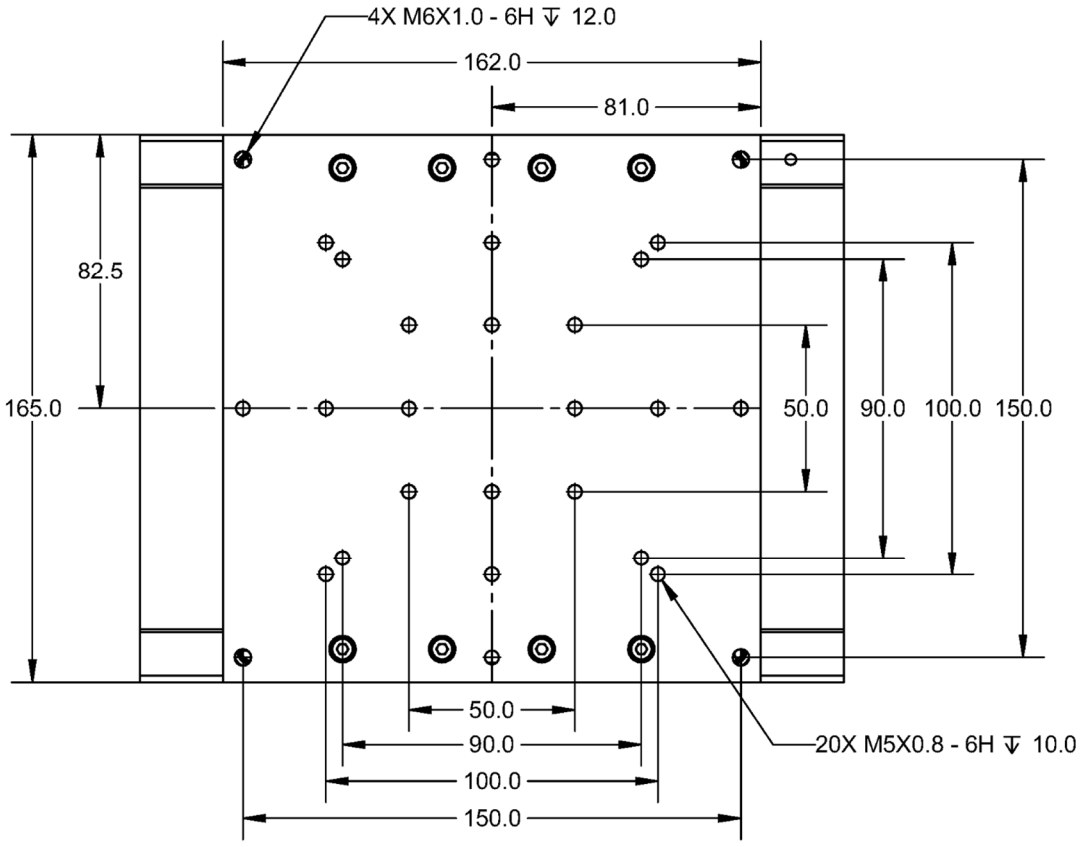


Figure 20. LM3 Tooling / Payload Plate

3.6 ELECTRICAL SPECIFICATIONS

3.6.1 MOTOR AND BRAKE SPECIFICATIONS

The motor specifications of Table 6 are for the standard Motor Ordering Option “A”, NEMA17 DC motor. Table 7 displays specifications for the tall stack NEMA 17 DC motor, Motor Ordering Option “M”. Table 8 contains specifications for the Motor Ordering Option “G”.

Table 6. Standard NEMA17 Servo Motor Specifications

Motor Type	3 phase Brushless DC
BEMF Constant (V/Krpm)	1.88
Electrical Time Constant (ms)	0.38
Bus Voltage (Vdc)	40
Max Continuous Current (A)	3.0
Motor Torque Constant (Nm/A)	0.027
Peak Current (A)	10.0
Pin to Pin Inductance (mH)	0.55
Pin to Pin Resistance (ohm)	1.51
Poles per Revolution	6

Table 7. Tall Stack NEMA17 Servo Motor Specifications

Motor Type	3 phase Brushless DC
BEMF Constant (V/Krpm)	3.8
Electrical Time Constant (ms)	0.65
Bus Voltage (Vdc)	40
Max Continuous Current (A)	6.3
Motor Force Constant (Nm/A)	.050
Peak Current (A)	12.6
Pin to Pin Inductance (mH)	0.47
Pin to Pin Resistance (ohm)	0.72
Poles per Revolution	6

Table 8. Standard Ironless Linear Motor Specifications

Motor Type	3 phase Brushless DC
BEMF Constant (V/m/s)	30
Electrical Time Constant (ms)	0.35
Bus Voltage (Vdc)	300
Max Continuous Current (A)	1.6
Motor Force Constant (Nm/A)	36.3
Peak Current (A)	5.5
Pin to Pin Inductance (mH)	6
Pin to Pin Resistance (ohm)	18.6
Magnetic Pole Pitch (mm)	30

The specifications for the power-off brake, Additional Ordering Option “D”, are listed in Table 9. This option can be applied to either axis but is more typical on the Z axis.

Table 9. Power-Off Brake Electrical Specification

Brake Type	Power-off engaged
Winding Voltage (Vdc) Nominal	24
Winding Current (A) Nominal	0.17
Winding Resistance (Ohm)	138

3.6.2 FEEDBACK SPECIFICATIONS

The basic electrical feedback specifications of the LM3 are listed in the tables below for the different encoder ordering options. For proper integration with your controls, phase and signal tables are illustrated in the electrical installation chapter, Section 5.

Linear encoder feedback, Encoder Type Ordering option “M”, specifications are listed in Table 10. The linear encoder option has a center mounted, highly repeatable, index mark.

Table 10. Combined Feedback Specification (Linear Encoders)

Supply Voltage	5Vdc +/- 10%
Supply Current Max (mA)	<250
Encoder Feedback Type	Incremental
Encoder Output	Square Wave Quadrature, RS-422 compatible, A, B, Z, Differential Pairs
Encoder Resolution	10000 counts / mm (Z travel)
Hall Switch Output Type	Open collector, no internal pullup
Hall Switch max current (mA)	-20
Limit Switch Output Type	CMOS
Limit Switch Output Current (mA)	-20
Over-Temp Switch Type	CMOS
Over-Temp Switch Polarity	Logic high is over-temp; Low is Normal

Rotary Encoder feedback, Encoder Type Ordering option “H”, specifications are listed in Table 11. This table applies to only the linear axis.

Table 11. Combined Feedback Specification (Rotary Encoder)

Supply Voltage	5Vdc +/- 10%
Supply Current Max (mA)	250
Encoder Feedback Type	Incremental
Encoder Output	Square Wave Quadrature, RS-422 compatible, A, B, Z, Differential Pairs
Rotary Encoder Resolution	16,000 counts / rev
Functional Encoder Resolution	8,000 counts/ mm
Hall Switch Output Type	Open collector, no internal pullup
Hall Switch max current (mA)	-20
Limit Switch Output Type	CMOS
Limit Switch Output Current (mA)	±20
Home Switch Output Type	CMOS
Home Switch Output Current (mA)	±20

4 MECHANICAL INSTALLATION

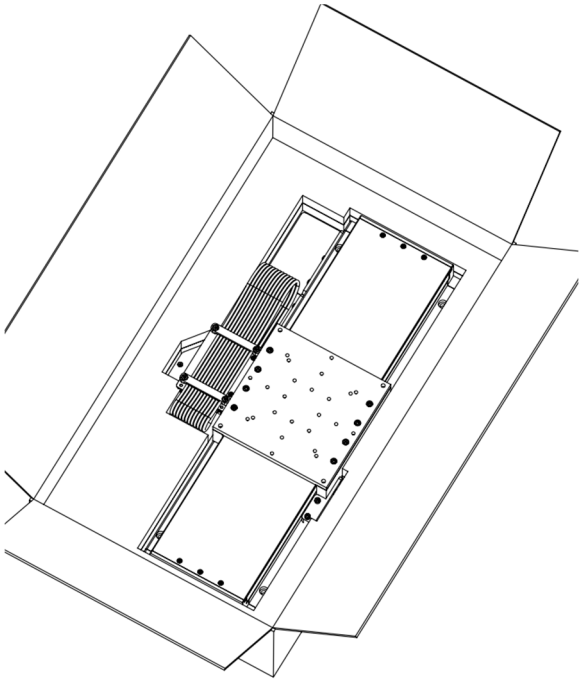
4.1 UNPACKING AND HANDLING

4.1.1 RECEIPT INSPECTION

CAUTION: The LM3 stage is a sensitive device! Handle with great care as to minimize the risk of damage to the precision surfaces, rail alignments, and feedback mechanisms.

CAUTION: Do not disassemble any portion of the equipment unless specifically directed by this user manual. Improper installation will cause the stage to no longer hold the promised accuracy specifications or cause damage rendering the device inoperable.

Prior to removal of the LM3 stage from its packaging, please check the integrity of the box or crate that it was shipped in. Any excessive dirt or debris, crushed corners, or general weathering may indicate improper handling during shipment. After inspection, please verify the contents of the package for any missing materials.



Items included in packaging:

1. The LM3 Stage
2. Cut-to-size foam
3. Performance Test Report
4. Instruction manual*
5. Other data sheets*

Should any of these materials be missing, please contact a Griffin Motion Representative so we may convey them to you.
*Items 4 and 5 may be sent electronically

Figure 21. Packaging Material List and View

NOTE: Please keep all packaging materials with your equipment for a reasonable period. For warranty or service requests, shipment of the equipment back to Griffin Motion in the original packaging is the preferred method.

4.1.2 REMOVAL FROM PACKAGING

CAUTION: Do not pick up, move, or manipulate the stage by grasping or holding the motor housing or cable support as indicated in red in Figure 22. The sensitive alignment of the ball screw may be affected and render the stage inoperable.

With the stage in its included plastic packaging, pick up and move the stage to a clean, stable surface. For recommended lifting locations, see Figure 22.

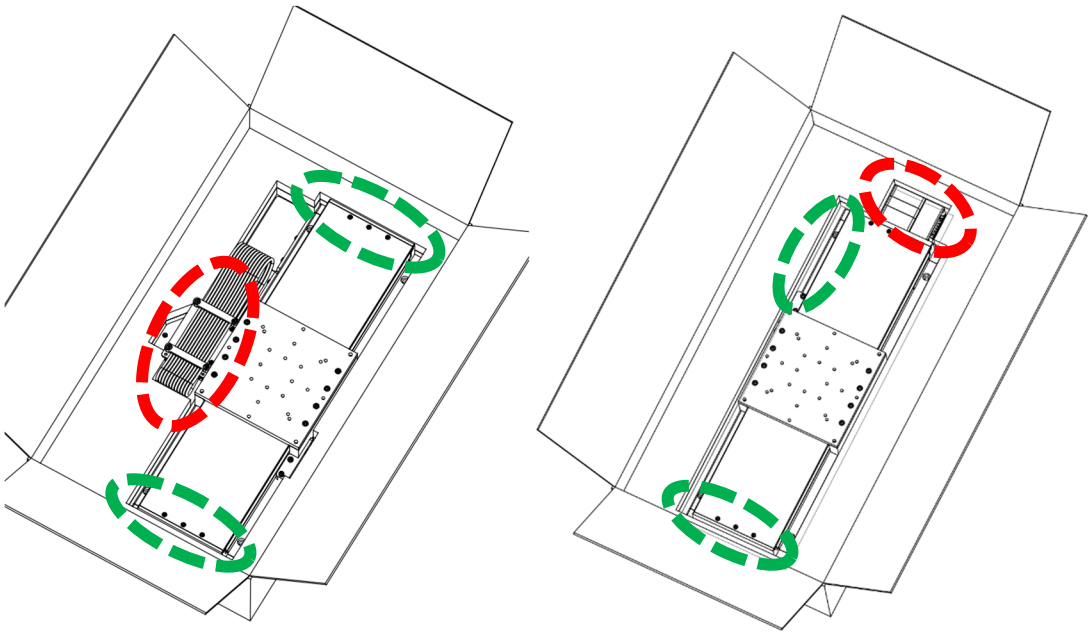


Figure 22. Recommended Handling locations of the LM3-LM

Once the stage is on a stable surface, carefully remove it from the plastic packaging with clean hands or while using gloves to minimize the contamination on the bottom mounting surface.

Maintaining cleanliness is key to proper installation in its final configuration. Particles like dust and hair cannot be compressed under final torque and will cause distortion of the base plate and cause the stage to not hold promised accuracy levels.

CAUTION: During handling, install, or removal, pay attention as to not strike the payload plate or bottom surface of the base plate with tools or edges of other equipment. The nearly imperceptible surface imperfections caused by these mishaps will affect stage performance.

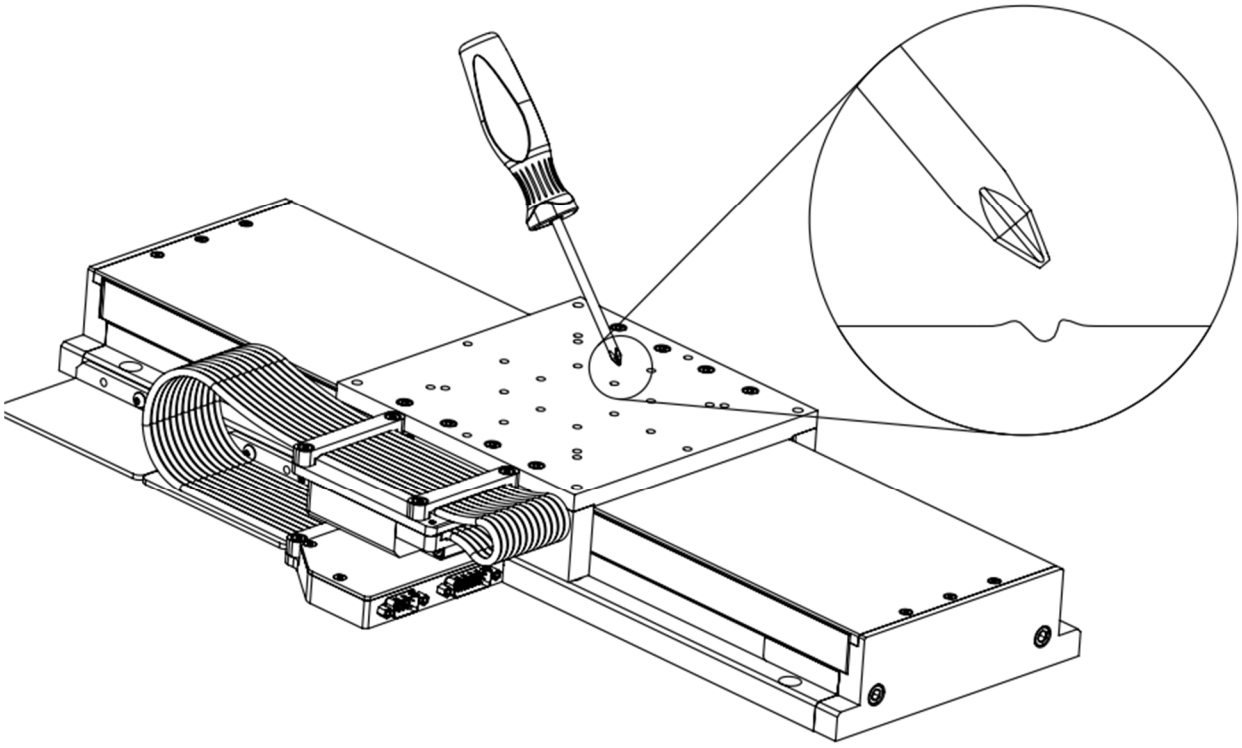


Figure 23. Damage to LM3 surface due to striking

4.1.3 BACKDRIVING THE STAGE

CAUTION: Never handle the stage when connected to a controller. This is to preclude accidental shock to the user, and to avoid potentially damaging the controller amplifier due to the BEMF generated by the motor (reverse power).

DANGER: When back driving, move the stage slowly and in a controlled manner. The BEMF generated by the motor may be higher than the permitted safety limits, if the motor speed is sufficiently high. Connection of a temporary shunt network to the motor connector may be used to limit generated voltages.

Stages may be slowly back-driven, when not connected to controls, to allow access to better handholds and mounting holes without the need to power the stage (except where a power-off brake prevents an axis from moving). As discussed in previous sections, follow the precautions listed below when manipulating the stage by hand:

1. Never touch the stage under servo control, de-energize and disconnect first.
2. Never pick up the stage from the top loading plate or motor housings.
    a. Firmly grasp the stage from the base plate.
3. You can disengage the power off brake by applying 24V to the appropriate pins on the motor connector, see Table 14, Table 9, and Figure 24.
    a. Observe the appropriate electrical safety precautions.
    b. The only power source connected to the equipment shall be the 24Vdc supply.
    c. Ensure the protective earth connection is connected to the stage.
4. When back-driving the stage, apply slow gradual pressure by hand.
5. Do not strike the stage or slam it into the hard stops.
6. Minimize contact and maintain cleanliness of mounting surfaces prior to installation.

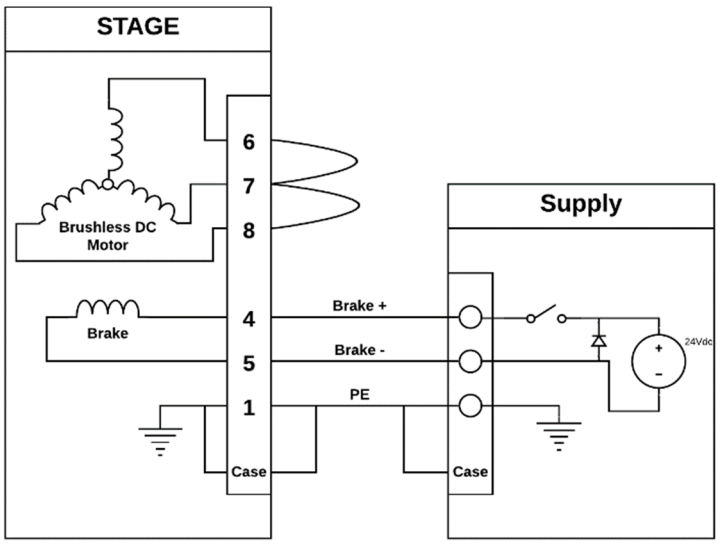


Figure 24. Example Brake override circuit

4.2 MOUNTING TO SURFACES

4.2.1 MOUNTING SURFACE REQUIREMENTS

Mounting surfaces for which an LM3 stage is intended to be affixed must be stable, clean, flat, and adequately stiff to support the anticipated load. Any compromise to these mounting surface requirements will distort the baseplate of the device and decrease the overall accuracy. The LM3 will generally conform to the shape of the mounted surface as shown in Figure 25, thusly it is important that the surface meet the flatness requirements specified.

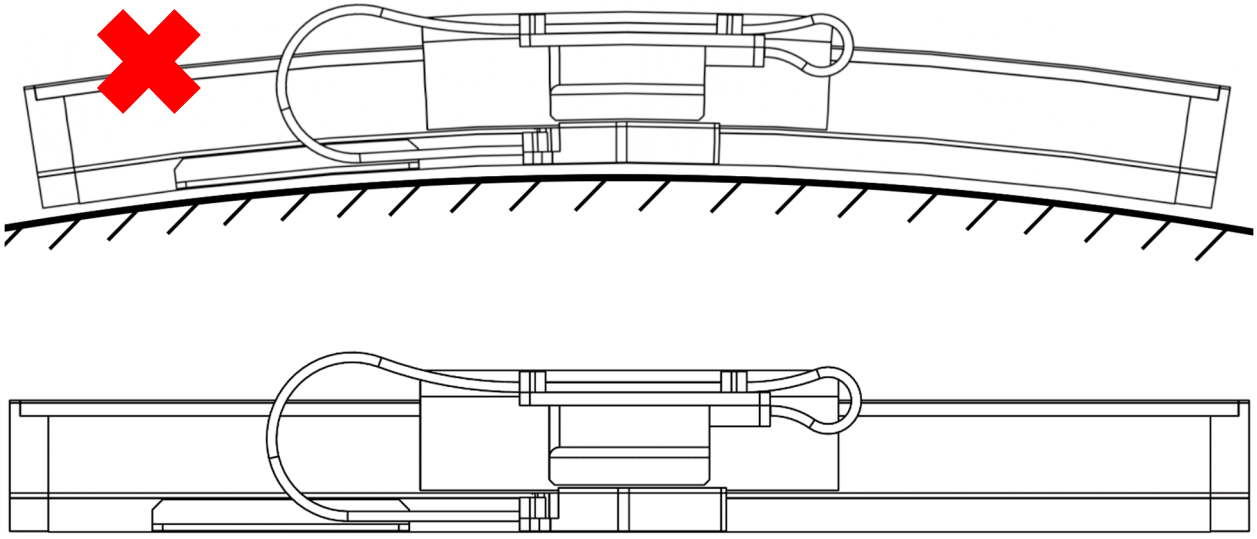


Figure 25. The LM3 warping to mounting surface contour.

The surface flatness requirement to achieve the listed accuracy is provided in Table 12.

Table 12. Mounting Surface Flatness Specifications

LM3 Series	Flatness/Length
LM3-100	5µm / 100mm
LM3-150	
LM3-200	
LM3-250	
LM3-300	
LM3-400	
LM3-500	
LM3-600	
LM3-800	

4.2.2 GENERAL INSTALL

The procedure below assumes that the proper mounting surface has been prepared for use; taking into consideration the mounting hole pattern, mounting hole depth, flatness specification, cleanliness, surface stability, and means to override power-off brakes where applicable.

1. Ensure that the stage is not connected to a controller under servo control.
2. Install the mounting hardware loosely and center the stage about all four mounting screws that have been partially installed. Once in position, torque the screws to the proper torque for the M6 Socket Head Cap Screws.

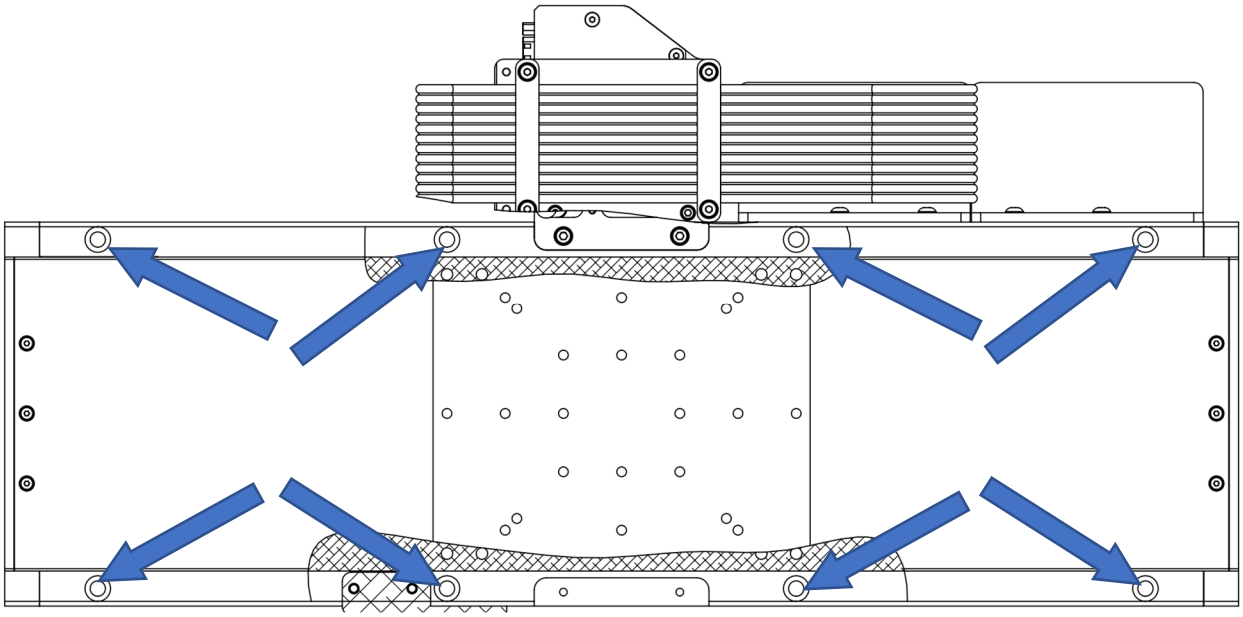


Figure 26. LM3 Mounting Holes

3. Unless otherwise intended, check that the stage has full range of motion and will not contact any other surface or hardware.

4.3 MOUNTING OF PAYLOADS

4.3.1 PAYLOAD REQUIREMENTS

Payloads intended to be affixed to the LM3 payload plate must be stable, clean, flat, and adequately stiff to support the anticipated load. Any compromise to mounting the payload properly will distort the structure of the LM3 and alter its positioning performance. The payload flatness requirement to achieve the listed accuracy is provided in Table 13.

Table 13. Payload Flatness Specifications

LM3 Series	Flatness
LM3-All	10µm / 100mm

In addition, considerations for mounting orientation of the stage with respect to payload mass, payload position, and other forces should be made with respect to the stages listed specifications.

CAUTION: Ensure that retaining bolts for mounted payloads are the proper size and engagement depth. Improper installation may cause damage to the payload plate and reduce system performance or potentially render the stage inoperable.

5 ELECTRICAL INSTALLATION

5.1 CONNECTORS AND PINOUTS

The interface between a stage axis and a controller is provided through a D-sub 9 pin motor connector and a D-sub 26 high density feedback connector. Cabling with retainer screws is highly recommended.

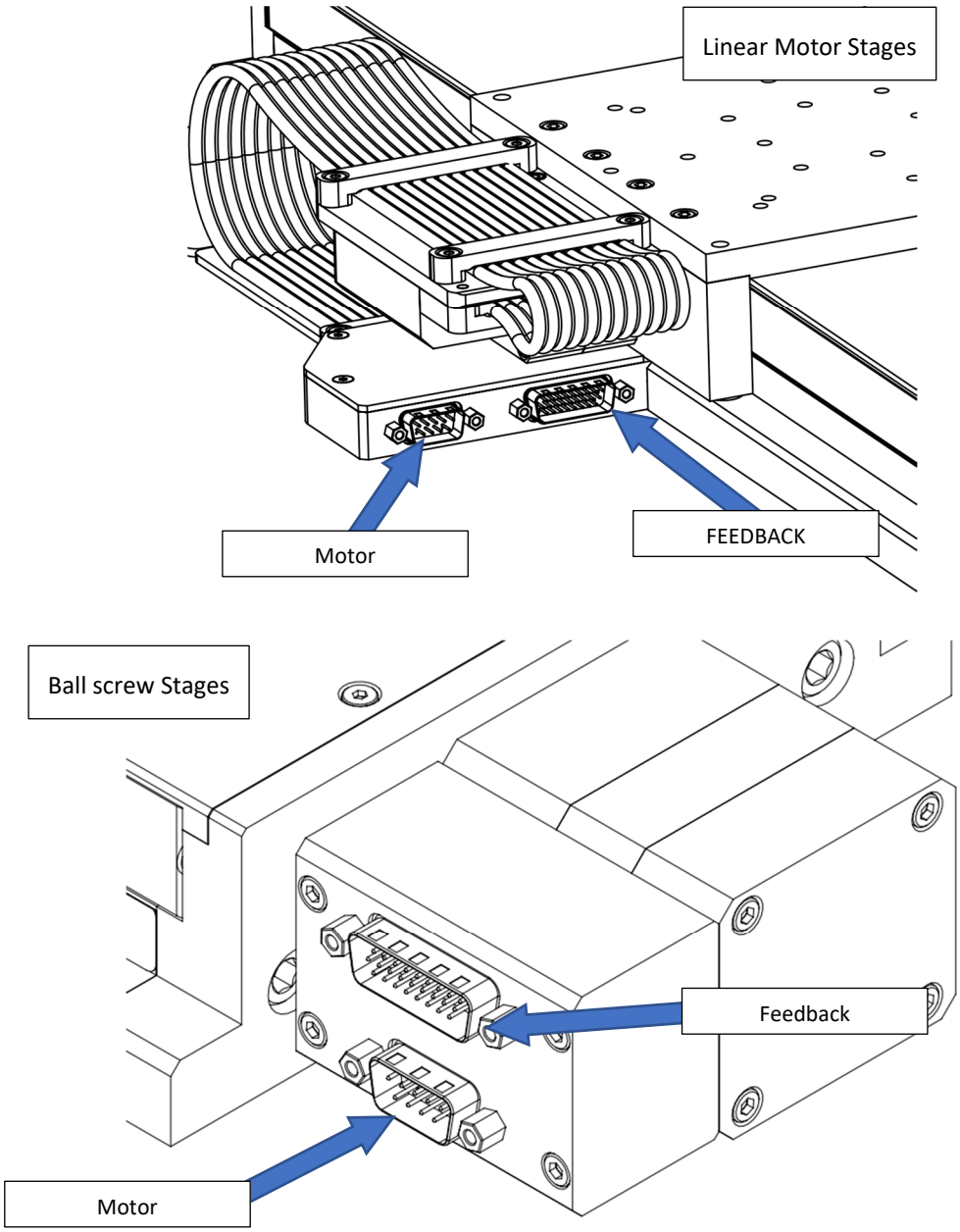


Figure 27. LM3 Feedback and Motor Connectors View

5.1.1 MOTOR CONNECTOR

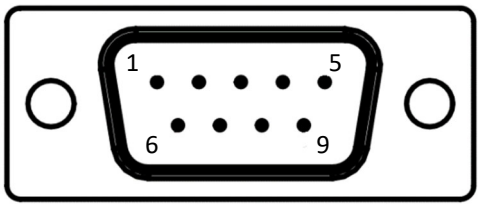
The motor connector provides power to two elements on the stage:

1. Brushless DC motor
2. Power-off brake (if equipped by additional option “D”)

Pin out for the male gendered motor connector, on the stage, is provided in Table 14.

Table 14. Motor Connector Pinout

PIN	DESCRIPTION
CASE	Protective Earth
1	Protective Earth
2	n/c
3	n/c
4	POWER-OFF BRAKE 24Vdc supply
5	POWER-OFF BRAKE 24Vdc return
6	Phase A
7	Phase B
8	Phase C
9	n/c



Example female gendered mating parts for motor connections is provided in Table 15.

Table 15. Mating Motor Connectors

Part Description	Manufacturer	Part Number
CONN D-SUB RCPT 9POS PNL MNT	Norcomp Inc.	171-009-203L001
CONN BACKSHELL SHLD	FCT Electronics	FMK1G

5.1.2 FEEDBACK CONNECTOR

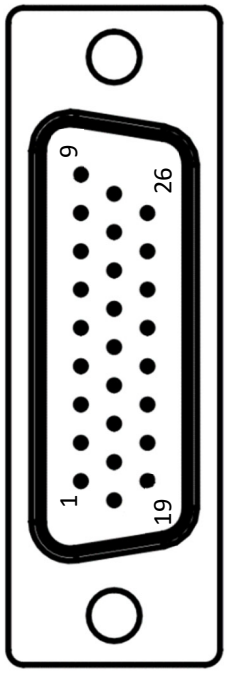
The feedback connector is the interface between all the primary feedback elements of the stage to a controller. This includes signals such as:

1. Motor halls
2. Forward and reverse limits
3. Index and home signals
4. Encoder output (quadrature or sinusoidal)
5. Motor Temperature Sensor

Pin out for the male gendered feedback connector on the stage is provided in Table 16. Note that the linear encoder and rotary encoder ordering options are nearly identical, except for the addition of a home signal on the rotary encoder.

Table 16. Feedback Connector Pinout

PIN	DESCRIPTION	
	Rotary Enc.	Linear Enc.
CASE	Protective Earth	
1	+5Vdc	
2	A+	
3	B+	
4	IDX+	
5	LIM+	
6		
7		
8		
9		
10		TEMP
11	A-	
12	B-	
13	IDX-	
14	LIM-	
15		
16		
17		
18		
19	GND	
20	HALL A	
21	HALL B	
22	HALL C	
23	HOME	
24		
25		
26		



Example female gendered mating parts for the feedback connections is provided in Table 17.

Table 17. Mating Feedback Connectors

Part Description	Manufacturer	Part Number
CONN D-SUB HD RCPT 26POS PNL MNT	Norcomp Inc.	180-026-203L001
CONN BACKSHELL SHLD	FCT Electronics	FMK2G

5.2 WIRING OVERVIEW

The diagrams found in this section elaborate on the basic interface requirements pictorially, which are representative of the previously specified characteristics as tabulated in Section 3.6. Example supporting circuit elements expected from the user's controller are also shown.

For details on the phasing relationships between motor BEMF, halls, and other feedback signals, refer to Section 5.4 of this user manual.

5.2.1 MOTOR ELECTRICAL DIAGRAM

The LM3 brushless DC motor connections are shown in Figure 28; note that the brake is pictured but is only available if the addition ordering option "D" or "G" is equipped.

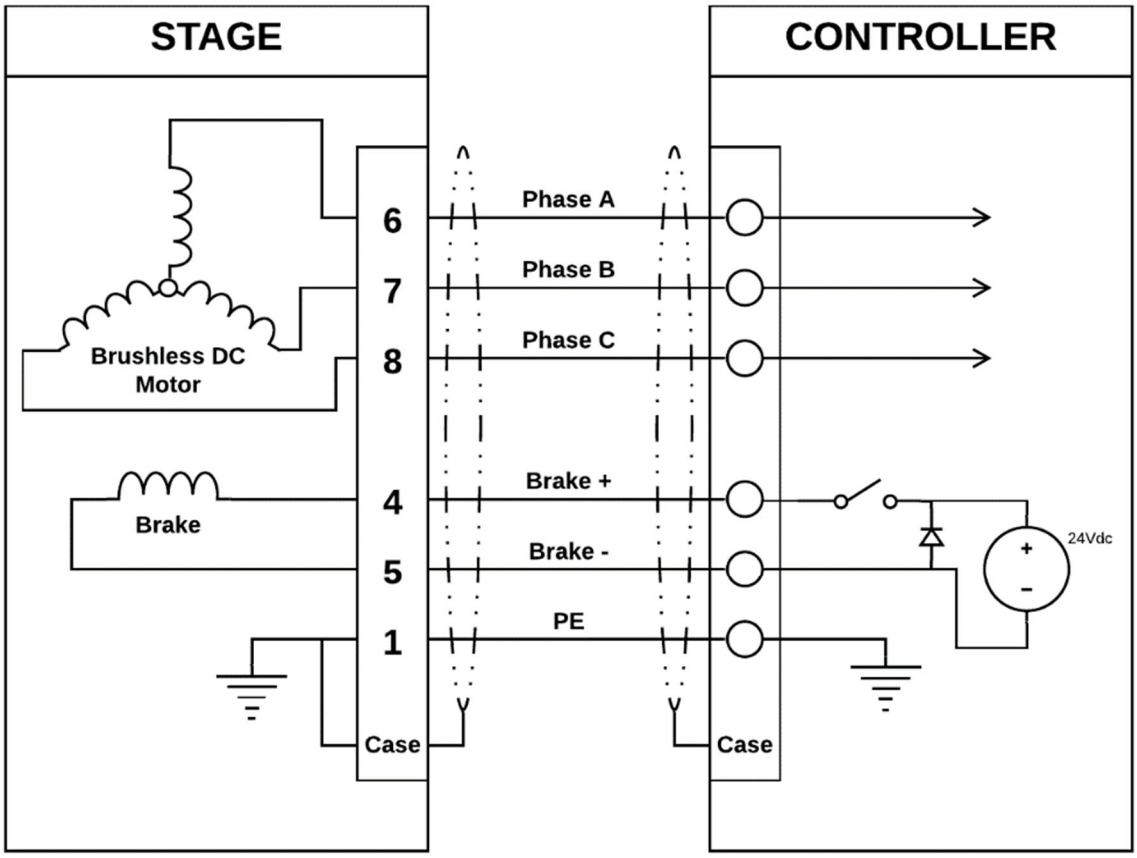


Figure 28. LM3 Motor Connector Wiring Diagram

5.2.2 ROTARY ENCODER TYPE ELECTRICAL DIAGRAM

The LM3 feedback connections for the variant using a rotary encoder, is shown in Figure 29.

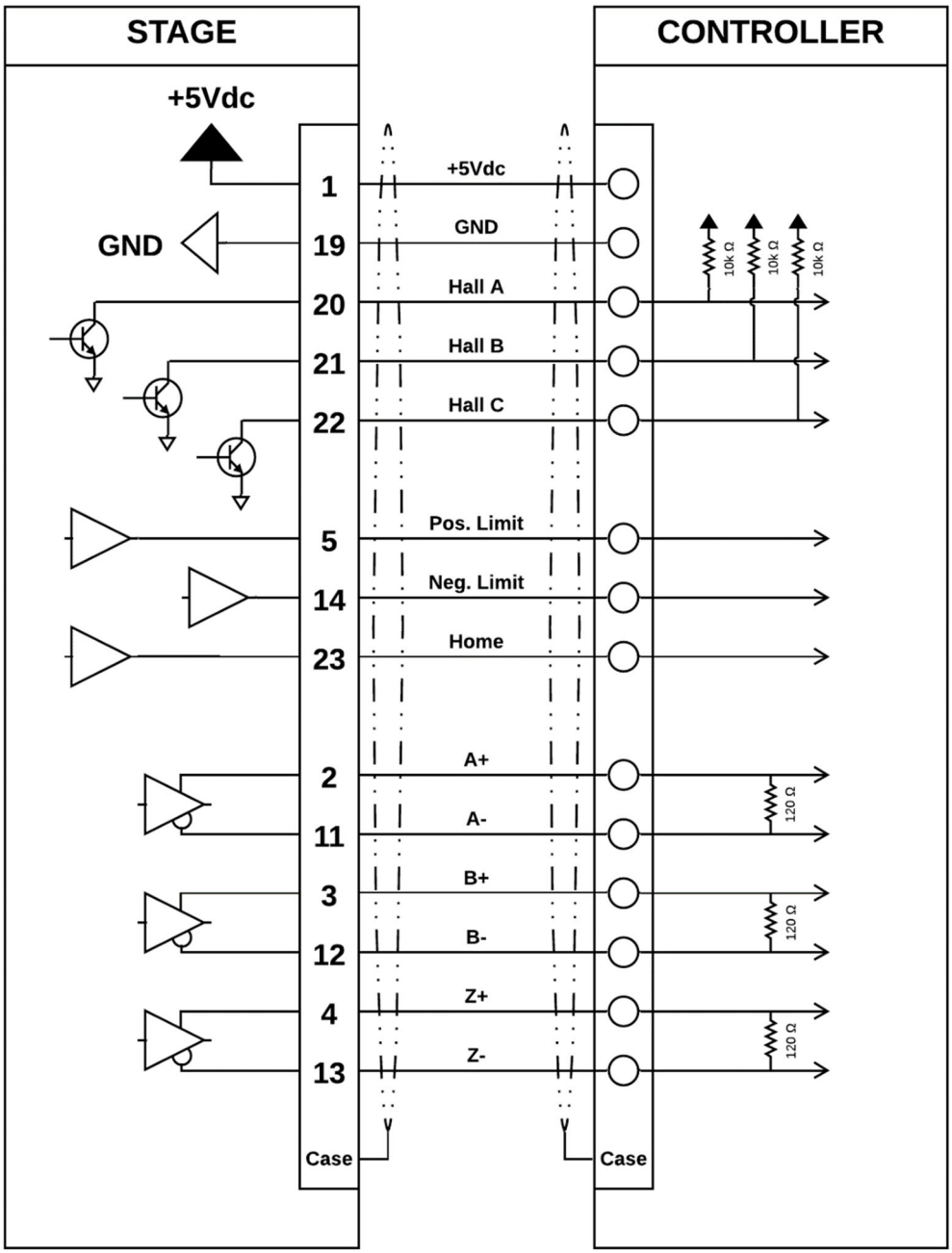


Figure 29. Rotary Encoder Electrical Diagram

5.2.3 LINEAR ENCODER TYPE ELECTRICAL DIAGRAM

The LM3 feedback connections for the variant using a linear encoder setup, is shown in Figure 30.

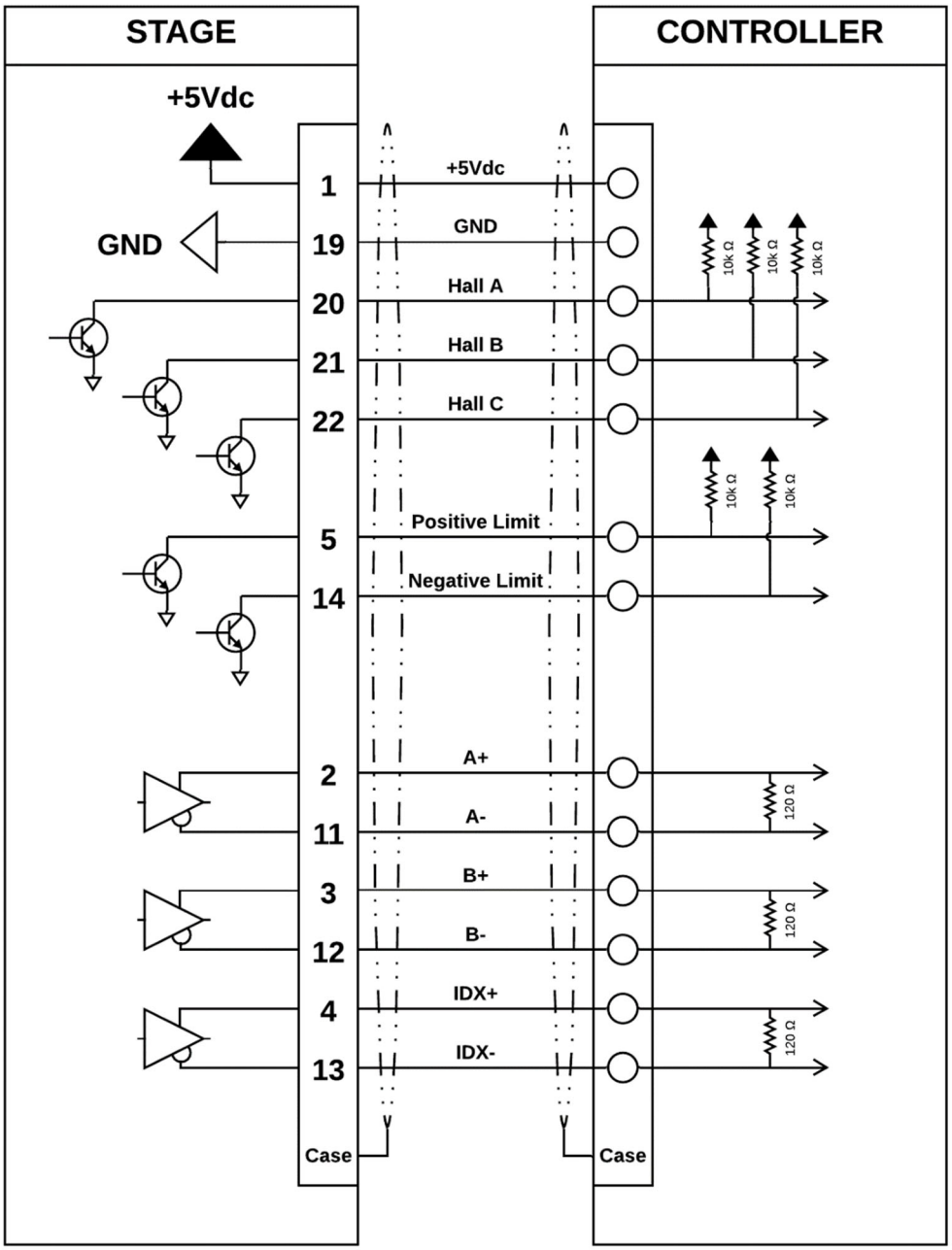


Figure 30. Linear Encoder Wiring Diagram

5.3 SHIELDING AND GROUNDING

As shown in Figure 31, the protective earth ground pin on the motor connector and shielding connection points are shown. These are the primary connections provided to the user to interface with.

For proper operation, the user must connect the shielding and protective earth grounding points as shown in the example electrical wiring diagrams of Section 5.2. This will ensure safety to the user, and high reliability of the motor and feedback systems of the stage to achieve optimal performance.

CAUTION: The user should not attempt to use any bolt hole not labeled “PE” if additional grounding is desired. Improperly using bolt holes on the LM3 chassis may provide an unreliable safety ground point and may cause damage to the alignment of rails or precision surfaces.

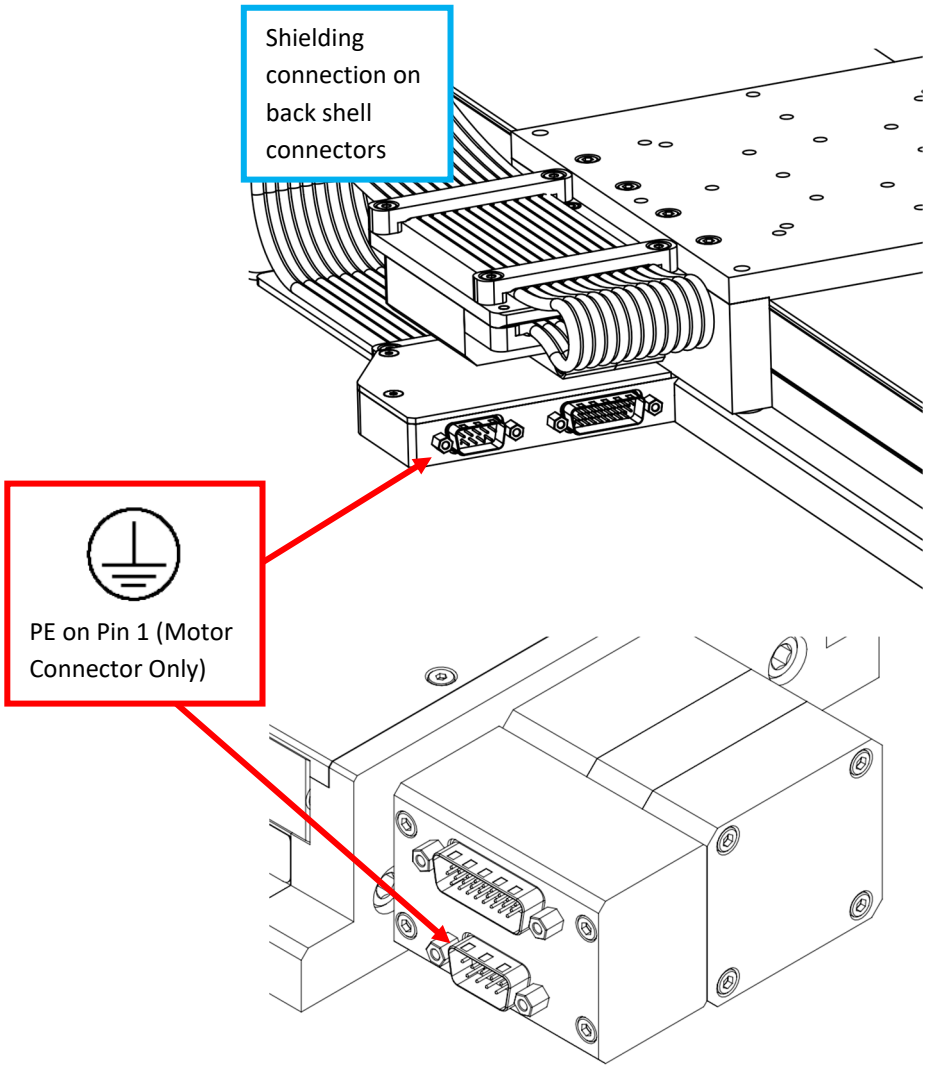


Figure 31. LM3 Protective Grounding and Shielding Locations

5.4 MACHINE DIRECTION AND PHASING

5.4.1 MACHINE DIRECTION

The machine direction is the mechanical traversal of an axis in a specified direction, such that the associated electrical signals are phased and aligned in a defined and repeatable manner. Advanced controllers have the capability of easily reading and redefining the machine direction to a user's needs, however, for those controllers which do not have this capability, Section 5.4 elaborates on the expected electrical signal sequences that the hardware is expected to produce.

For conciseness, all phasing diagrams in this section will represent forward direction traversal of an axis on the stage from the left to the right-hand side of each graphic.

The positive machine direction for either variation of the LM3 is as shown in Figure 32.

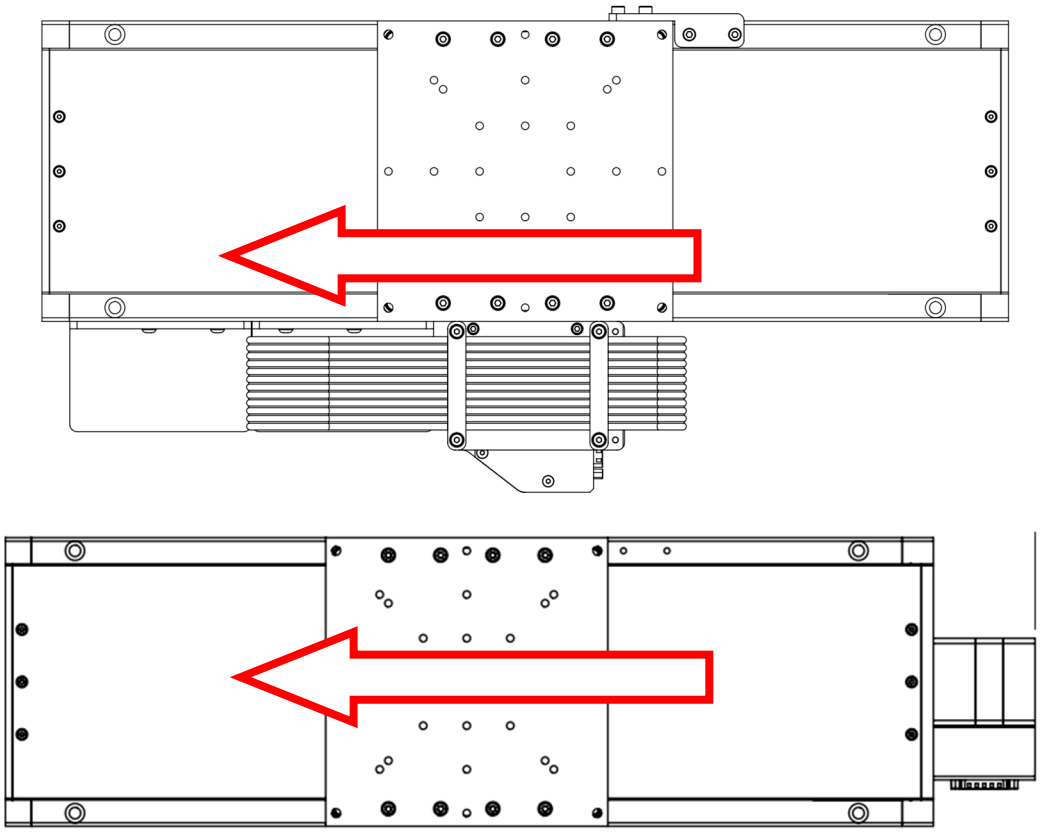


Figure 32. LM3 Positive Travel Directions

5.4.2 MOTOR, ENCODER, AND HALL PHASING

Figure 33 details the Motor BEMF with respect to the Hall outputs in the sequence that would be observed in the forward direction from left to right. BEMF waveforms are referenced to the respective phases as indicated, and the Hall signal levels are shown as pulled up by an external resistor and referenced to ground.

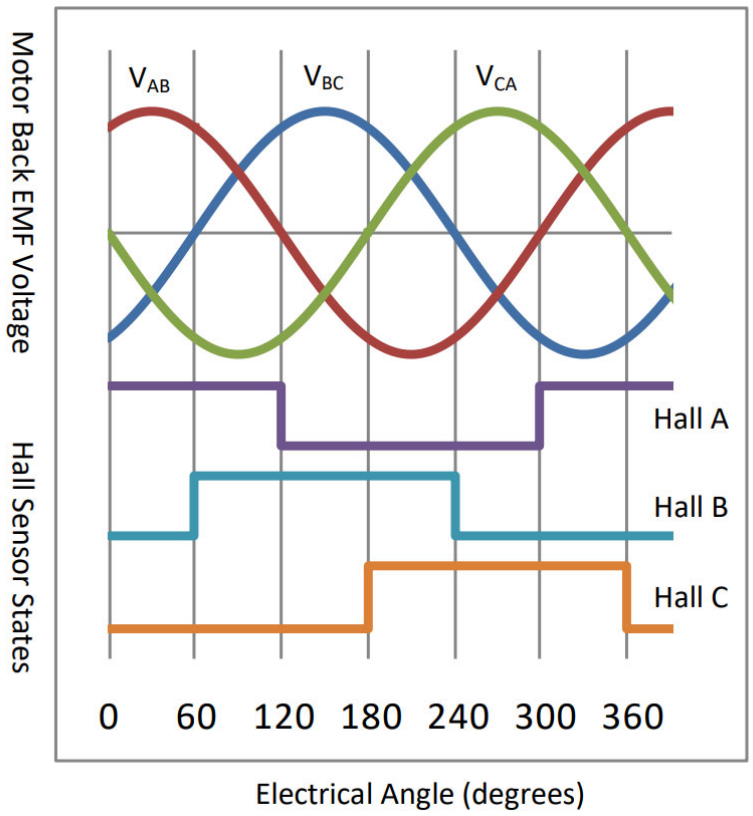


Figure 33. Motor and Hall Output in Forward Direction (left to right)

Figure 34 details the quadrature phasing as the stage travels in the forward direction. Waveforms are measured from the Positive Signal (A+ or B+) with respect to the negative counterpart (A- or B- respectively).

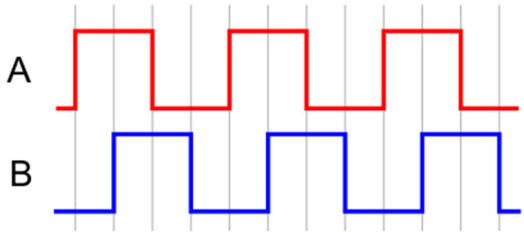


Figure 34. Quadrature Output in Forward Direction (left to right)

5.4.3 ROTARY ENCODER MARKERS

A home switch is provided near center mechanical travel and a limit switch at each end of travel. The encoder will output one index pulse per revolution of the motor; the index pulse is a function of the ball screw pitch. This pulse is highly repeatable and can be used in coordination with the home switch to find an absolute position after power-up.

The limit switches will be pulled low throughout the travel range of the stage. The output will swing high at the end of travel and remain high until the mechanical limit of the stage is reached. This also applies to the rotary axis of the LM3.

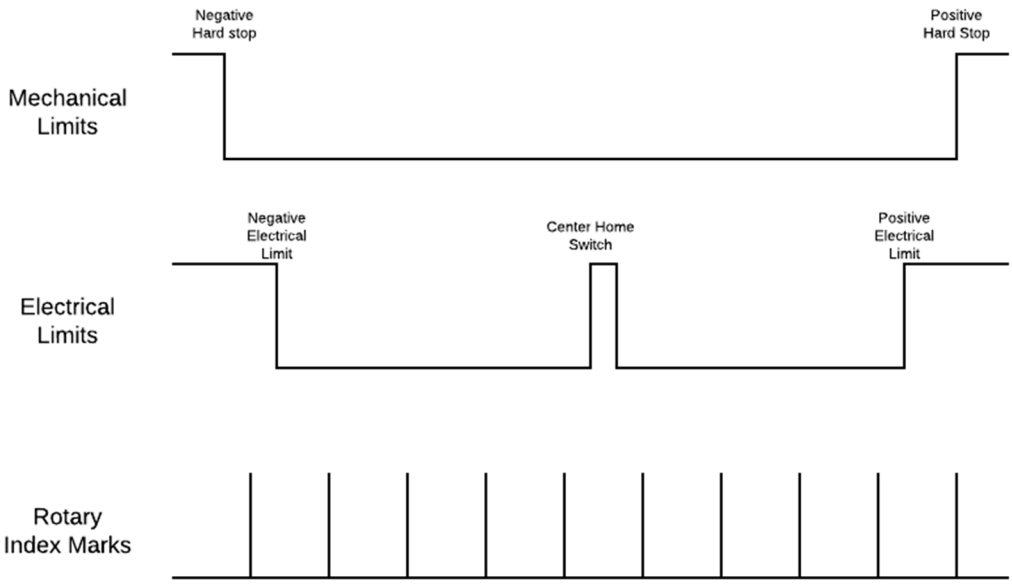


Figure 35. Diagram of Rotary Encoder Markers

5.4.4 LINEAR ENCODER MARKERS

The encoder will output one index pulse near center travel. This pulse is highly repeatable and can be used upon power-up to find an absolute position to use for further measurements.

Two limit switches are provided at the ends of travel. The limit switches will be pulled low throughout the travel range of the stage. The output will swing to high-impedance at the end of travel and remain high-impedance until the mechanical limit of the stage is reached.

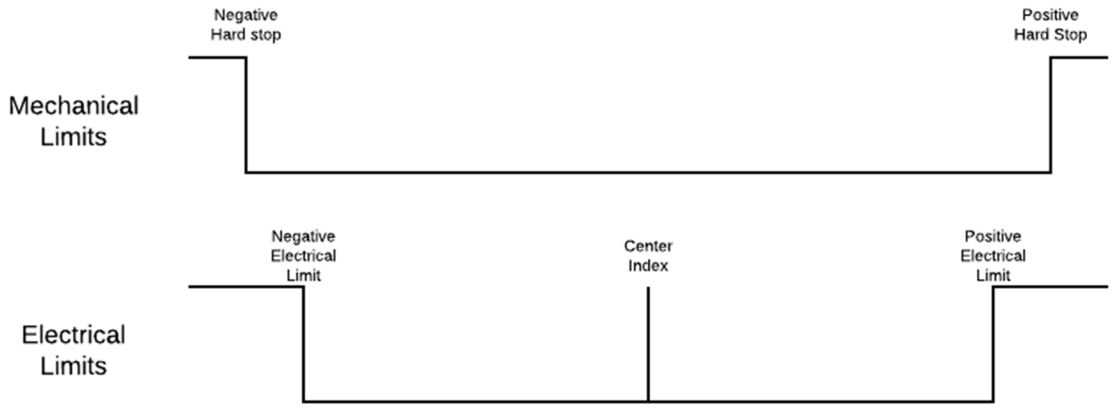


Figure 36. Diagram of Linear Encoder Markers

5.4.5 LINEAR ENCODER OVER-TEMP SENSOR

The motor temp sensor will remain low during normal operation, and swing high when the motor reaches an over-temperature condition, as defined by Griffin Motion. It should be noted that the sensor has a maximum response of 4.5°/s. I^2T (a common feature in modern servo drives) protection should be used if commanding higher than continuous motor current.

5.5 CABLE CONSTRUCTION CONSIDERATIONS

In assisting the integrator, a couple design considerations are discussed below which will help prevent common system failures and help increase reliability concerning cable construction and use in a control system.

Twisted Pairs – encoder signals (A, B, Z or Index) are provided as differential outputs. It is highly recommended that these signals are connected to the controller from the stage using twisted pair wires to increase noise immunity and terminated at an appropriate differential input channel on the controller.

Shielding – shield the feedback cable and motor cable to prevent induced susceptibility and radiated emissions problems. Connect ground and PE connection points from the stage to controller for maximum safety and EMC considerations.

Retainers – Connectors with retaining screws are highly recommended to prevent incidental disconnection during operation.

5.6 CONTROL SYSTEM CONSIDERATIONS

There is a myriad of suitable controllers on the market today which have the capability of driving the Griffin MotionLM3stage. Listed below are a few recommended fault and limit functions which should be implemented to maintain safe and efficient operation of the stage:

Verification and Tuning – It is highly recommended that the installer first verifies operation of the stage with a controller of their choice, with no payload attached in the lying flat orientation. After which dummy payloads simulating their device can be used to tune the system and verify requirements prior to installing sensitive equipment.

Velocity Limit – set in a manner as to not exceed machine mechanical limits and electrical limits; for example, set velocity limit to prevent overrun of the quadrature output of the encoder or the capability of the controller to read the quadrature input.

Position Error Limit – prevent runaway conditions should a cable, feedback mechanism, or current control fail to operate as desired.

Continuous and Peak Current Limits – the controller is responsible for implementing safe current regulation. Simple peak and continuous current limitations may not be sufficient, whereas protection algorithms such as I2T should be implemented.

Electrical and Software End-of-Travel Limits – operation should never occur beyond the electrical limits; additionally, the user application at certain velocities may require a smaller operating envelope so that a controller may have sufficient time and distance to decelerate the stage before hitting a hard stop; consider implementing software limits where applicable.

6 MAINTENANCE

6.1 INSPECTION

Depending on the cleanliness of your operating environment or system process, the general inspection interval may need to increase. For normal laboratory use, not involving the creation of debris, the following minimum inspection interval and criteria are suggested.

Inspection Interval: Monthly
Inspection Criteria:

- Check Cables
  - Visually inspect cables for fraying.
  - Check cables for loose connections.
  - Replace damaged cables.
  - Check resistance of protective earth bonding to controller.
- Check Cleanliness
  - Debris on ball screw.
  - Debris in between base plate and compound plate.
  - Debris in between the compound plate and the loading plate.
  - Debris in rails
  - If excessive debris is found, follow the guidance in the lubrication section.

6.2 CLEANING AND LUBRICATION

Cleaning of large accessible surfaces can be achieved by use of a lint free cloth dampened with ethanol alcohol.

Avoid getting cleaning agents or water into the ball screw or precision rails, as this will breakdown the lubricants, embed contaminants into seals and crevices, and ultimately affect machine life.

Lubricants used in the assembly of Griffin MotionLM3stages are intended to last the useable life of the device, given that the cleanliness of the environment is maintained consistent with the expected use. If the user believes that the precision rails or ball screw are contaminated to a point that would compromise continued operation, please reach out to a Griffin Motion representative for guidance.

Cleaning and lubrication of components such as the precision rails and ball screw require disassembly beyond the scope of this document and is not recommended to be attempted by a technician without proper training. Disassembly without specific direction may render theLM3inoperable or incapable of achieving the listed specifications.

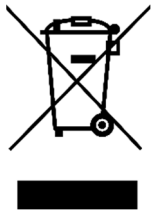
6.3 TROUBLESHOOTING

Some common troubleshooting issues, with resolutions are listed below in Table 18.

Table 18. Troubleshooting common LM3 issues

Problem	Root Cause and/or Propose Solution
Axis will not move (unpowered)	• Axis may contain a power-off brake. Verify part number and documentation. Defeat with jumper or controls.
Axis will not move (powered)	• Verify motor pinout from controller to stage. • Hall phase order may be incorrect. • Hall sensor may not be detected, check schematic implementation. • Motor failure, check pin-to-pin resistance to verify. • Controller requirements to servo may not be met, check manual.
Stage Runaway or erratic behavior	• Encoder feedback wrong direction • Encoder not connected or failed. • Improper current or servo tune loop gains. • Improper shielding of feedback cable causing erroneous encoder or hall effect sensor signals.
Missing or additional feedback counts	• Improper shielding of feedback cable or motor cable. • Loose connection on feedback cable. • Machine velocity too high, missing counts. • Encoder not connected or failed.
Stage stuck at end of travel	• Controller won't energize motor beyond limit, push to center. • Stage has struck the mechanical hard-stop and is bound.
Stage power lower than expected	• Check current gains and monitor current admitted to motor. • Motor current phase angle offset is incorrect.
Excessive Vibration	• Servo or current tune loop gains need adjustment. • System setup has a resonant frequency that must be damped.
High Torque during normal operation	• Contamination in ball screw or precision rails. • (if equipped) power-off brake has not been disengaged.
Stage cannot get to electrical limit	• Stage obstructed, check pinch points. • Ball screw mis-aligned. • Electrical limit or cabling has failed.
Intermittent failure or operation	• Loose cable connections to stage or controls • Amplifier VBUS unstable or too low • Encoder read head damaged • Motor hall effect sensors damaged. • Motor winding damaged.
Motor noise during operation	• Current loop gains set too high • Contamination in ball screw or precision rails • Rubbing noise from power-off brake.

6.4 SCRAPPING AND DISPOSAL



TheLM3Stage is electrical and electronic equipment that should be disposed of in a proper manner. Dispose of old equipment in accordance with the appropriate international, national, and local rules and regulations.

If you need assistance in proper disposal, or you would like to send the machine back to Griffin Motion for disposal, please reach out to a representative for RMA information.

7 SERVICE AND SUPPORT

7.1 SERVICE

If you need any assistance regarding product integration, application, identification, inspection, repairs, or new business opportunities, please contact a Griffin Motion Representative so that we may better assist you. Contact information is displayed at the beginning of this document.

7.2 GENERAL WARRANTY

Griffin Motion, LLC [hereafter GM] warrants that, for a period of one year from the date a [machine] is delivered to the Buyer, such [machine] will be free from material defects in workmanship and materials provided by GM. Buyer's sole and exclusive remedy for a breach of this warranty will be, at GM's option, either (i) credit in the amount of the purchase price of the defective [machine], or (ii) repair or replacement, at GM's expense, of the defective [machine] within [twenty (20)] days after receipt by GM of written notice of the defect from Buyer. Costs in connection with GM's repair or replacement of any defective [machine], including, parts, labor, cost of standard return transport from GM to buyer, will be borne by GM. If available, GM will provide Buyer a temporary loaner [machine] while repairs are made to any defective [machine]. This warranty will continue as to the repaired or replaced [machines] for the remainder of the original 1-year warranty period. This warranty will not apply to defects arising from neglect, accidental damage, repair or maintenance not performed by GM, or use of the [machine] for any purpose other than the purpose for which it was designed. GM DISCLAIMS ANY AND ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, WITH RESPECT TO THE [MACHINES]. GM WILL HAVE NO LIABILITY FOR CONSEQUENTIAL, INDIRECT, SPECIAL, INCIDENTAL, EXEMPLARY, OR SIMILAR DAMAGES ARISING OUT OF OR RELATING TO THE [MACHINE] OR THE USE THEREOF BY BUYER, INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS OF PROFITS, BUSINESS INTERRUPTION, OR OTHER PECUNIARY LOSS, EVEN IF GM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.