GRIFFIN MOTION

Hardware Manual

NPS, Standard Options, Revision A

Document Notice

This manual contains pertinent safety information for the proper integration, use, maintenance, and decommissioning of certain NPS 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, please contact 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This manual is subject to change without notice and is superseded by any new revision.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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Copyright Information

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1 Hardware Manual Scope

1.1 Intended Use

This manual is intended for use by qualified technicians or experienced system integrators.

The NPS series linear stages are designed for laboratory or light industrial applications. They operate best in temperature-controlled environments free of dirt, oil, and condensing moisture.

The primary function of the NPS is to provide dynamic, high-precision positioning of externally mounted loads within its design limits. Typical applications include microscope inspection, laser processing, additive manufacturing, automatic dispensing, and general-purpose positioning. This manual provides safety guidance and installation procedures specific to the NPS's positioning capabilities, not its end-use applications.

In its standard configuration, the NPS is designed to be mounted on a flat, horizontal surface. Some sub-models may also be suitable for vertical use, contact Griffin Motion for details.

For optimal safety, performance, and longevity, appropriate controls and cabling must be selected or manufactured. The NPS is designed for integration into a control system for hands-free operation. Simply following the hazard and caution notices in this manual may not be sufficient to meet regulatory requirements for your specific application.

For questions regarding controls or cabling, please contact Griffin Motion.

1.2 Hazards and Warnings

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. The associated controls and cables must be fully de-energized before connecting to the NPS.
2. De-energize and disconnect power sources before servicing.
3. Use an appropriate grounding scheme to preclude accidental shock during fault conditions.
4. Install a control system that can detect fault voltages and raise alarm.
5. Where the potential for human contact 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 the Mechanical Overview and Installation chapter.
2. Where potential for touching is expected during operation, consider additional protection such as:
    a. Install additional warning labels.
    b. Install additional guards or enclose the equipment.
    c. Install a power interruption system (ex. sensor curtain) to de-energize the equipment.
3. Consider lowering motor current limits as low as is practicable for your application.
4. Create and post operating instructions and warning labels on the final equipment.

ATTENTION: 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, consider additional protection such as:
    a. Install temperature warning signs on motor housings.
    b. Install temperature monitoring equipment or additional thermal guards.
2. Consider lowering motor current limits as low as is practicable for your application.
3. 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 and feedback cables as outlined in 4.3.6 and 4.4.4.
3. Create RF shields for any other sensitive equipment in the vicinity of the 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 the manual of the associated controller.

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 the operator is in the vicinity of the 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 the user of abnormal machine operation.
2. Remove power to the machine when an unsafe condition exists.
3. Arrest or halt motion as required.
4. Prevent unexpected start-up or motion.

Figure 1 shows the most apparently areas on the stage that may present any of these hazards.

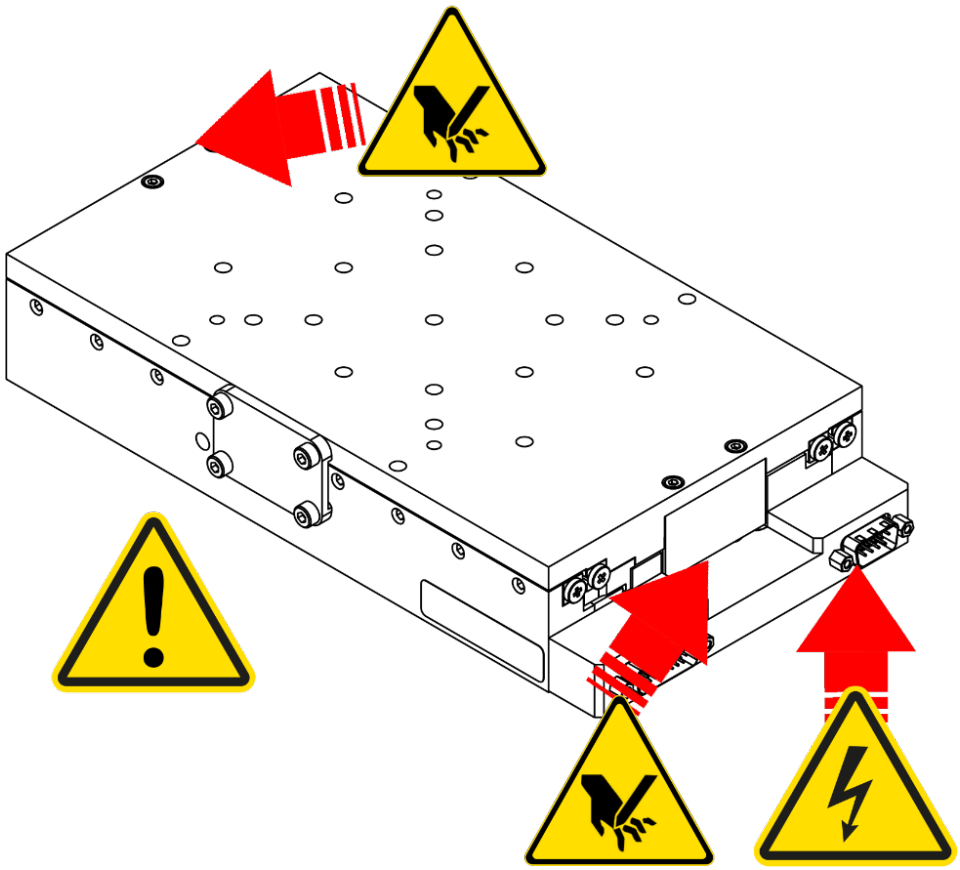


Figure 1. View of Hazards

2 Hardware Overview

2.1 General Description

The NPS is Griffin Motion's highest-precision linear stage, engineered for applications that demand exceptional accuracy and dynamic performance with light payloads. Featuring crossed-roller bearings, high-resolution encoders, and an ironless linear motor, the NPS achieves sub-micron positioning with excellent reliability.

Ideal for research, metrology, photonics, and semiconductor applications, the NPS delivers precision typically associated with air-bearing stages while maintaining a clean, low-maintenance design. Its compact form factor and seamless integration into larger motion systems make it a trusted solution for researchers and engineers facing the most demanding positioning challenges.

2.2 Environmental Requirements

To prevent damage to the NPS stage, the specifications in the table below must be adhered to.

Table 1. Environmental Specifications

Specification	Value
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 10°C and 35°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.

2.3 Ordering Options

The NPS can be ordered in many different standard configurations. Stage travel, encoder configuration, and precision grade can be altered. In addition to the standard configurations, customizations may be available. Table 2 details the standard ordering options for the NPS, and how they correspond to the nomenclature convention.

Table 2. Ordering Options

NPS Ordering Options	
Product Series	NPS: Linear Motor Driven, Crossed-Roller Linear Stage
Stage Travel (mm)	35
	110
	160
Drive Type	LM: Direct Drive Linear Motor
Motor Code	AA: Ironless Linear Motor
Feedback Code	HH: 1Vpp, 50 Periods/mm
	KK: RS422, 200,000 cts/mm
	LL: RS422, 400,000 cts/mm
	MM: BiSS C Absolute, 10,000 cts/mm (all with Limits, Index, Home)
Precision Grade	S: Standard Precision; P: High Precision
Additional Options	0: No Additional Options
Customizations	00: Standard Product; 01-99: Custom Stage, Customer Specific
Example Part Number:	NPS-110-LM-AA-LL-S-0-02

2.4 Ordering Guide

Table 3 below is intended to provide some basic guidance for NPS part number selection. To ensure the ideal configuration is selected, it is recommended that you contact Griffin Motion before ordering the NPS.

Table 3. Ordering Guide

NPS Ordering Guide	
Stage Travel (mm)	This value represents the nominal travel of the stage, not the total mechanical travel. Nominal travel is defined by the limit switches (when present).
Feedback Code	Minimum step size, and max velocity are two primary drivers when determining the proper encoder configuration. Drive compatibility and electrical noise resistance are also considerations. Contact Griffin Motion for assistance with encoder selection.
Precision Grade	"S" Precision is typical for a vast majority of applications. Higher precision "P" precision may be useful when improved repeatability, flatness, straightness, pitch or yaw are required.
Customizations	Contact Griffin Motion for available customizations. Common customizations include custom tapped holes, limit switches, and connector boxes.

2.5 Performance Specifications

The specifications contained in Table 4 pertain to standard NPS configurations with the standard “S” precision grade (as shown in Table 2). All accuracy, repeatability, pitch, and yaw specifications are measured for each stage via laser interferometer, with the retroreflector mounted 30-50mm above the surface of the NPS tooling plate (shown in Figure 2). Accuracy, pitch, and yaw values are defined to be “zero” at the stage’s center position; the specified values indicate the total indicator reading or “TIR” measurement. Test reports for a stage’s accuracy, repeatability, pitch, and yaw are provided with each NPS stage.

Straightness and flatness are (optionally) measured as defined by Renishaw White Paper TE325, as “fixed reflector” measurements, with endpoints fitted. Flatness does not indicate running parallelism with the bottom surface of the stage. Straightness does not indicate running parallelism with the sides of the stage base. Additional charges may apply to certify straightness and flatness measurements.

Each NPS is tested while affixed to a metrology-grade granite table, in a thermally stable room at 20°C. To achieve similar precision, the NPS should be used in similar conditions. Mounting surface flatness requirements are specified in 3.4.

The axis convention for the load capacities can be found in Figure 2.

Table 4. Performance Specifications

Stage Travel (mm)	35	110	160
Mechanical Accuracy (±µm)[1,3]	2.0	4.0	6.0
Calibrated Accuracy (±µm)[2,3]		0.4	
Bi-Directional Repeatability (µm)[1,3]		0.2	
Straightness (µm)[4]	2.0	4.0	6.0
Flatness (µm)[4]			
Pitch (±arc-sec)[1,3]	4.0	8.0	12.0
Yaw (±arc-sec)[1,3]			
Maximum Velocity (mm/s)	300 (Encoder Dependent)		
Continuous Motor Force (Fx) (N)		13.8	
Y Load Capacity (Fy) (N)		100.0	
Z Load Capacity (Fz) (N)		100.0	
Moment Load Capacity (Mx) (Nm)		1.8	
Moment Load Capacity (My) (Nm)		1.8	
Moment Load Capacity (Mz) (Nm)		1.8	
Moving Mass (kg)	1.0	1.4	1.8
Stage Mass (kg)	2.2	3.1	4.1

Notes:

1. Specification is verified via laser interferometer on every stage
2. To have a stage calibrated and verified, Griffin Motion must perform the controls configuration
3. Improved specifications are available by ordering the “P” precision grade
4. Specification may be verified by laser interferometer upon request

3 Mechanical Overview and Installation

3.1 Product View and Nomenclature

Figure 2 details the basic components of the NPS, the coordinate convention, and the positive direction of motion. These will be referenced throughout the document.

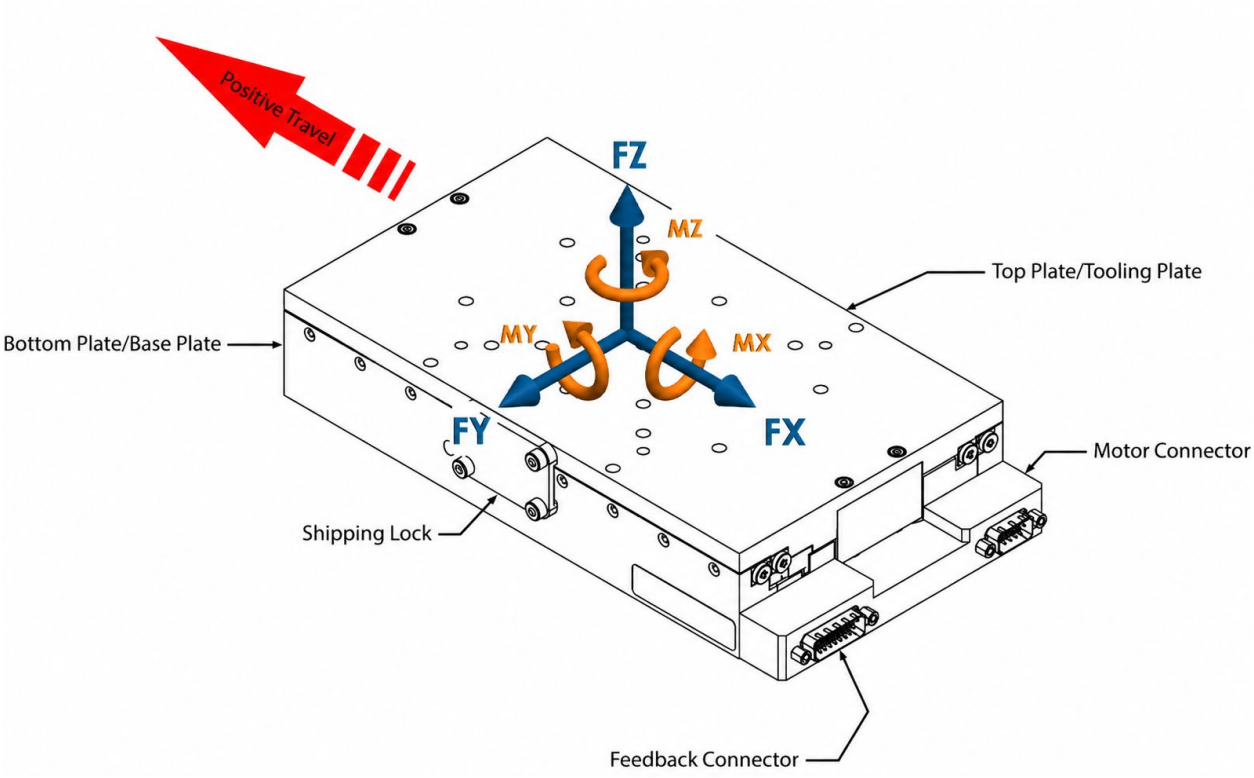


Figure 2. Axis Orientation and Components

3.2 General Dimensions

Basic NPS dimensions and mounted details are show on Figure 3.

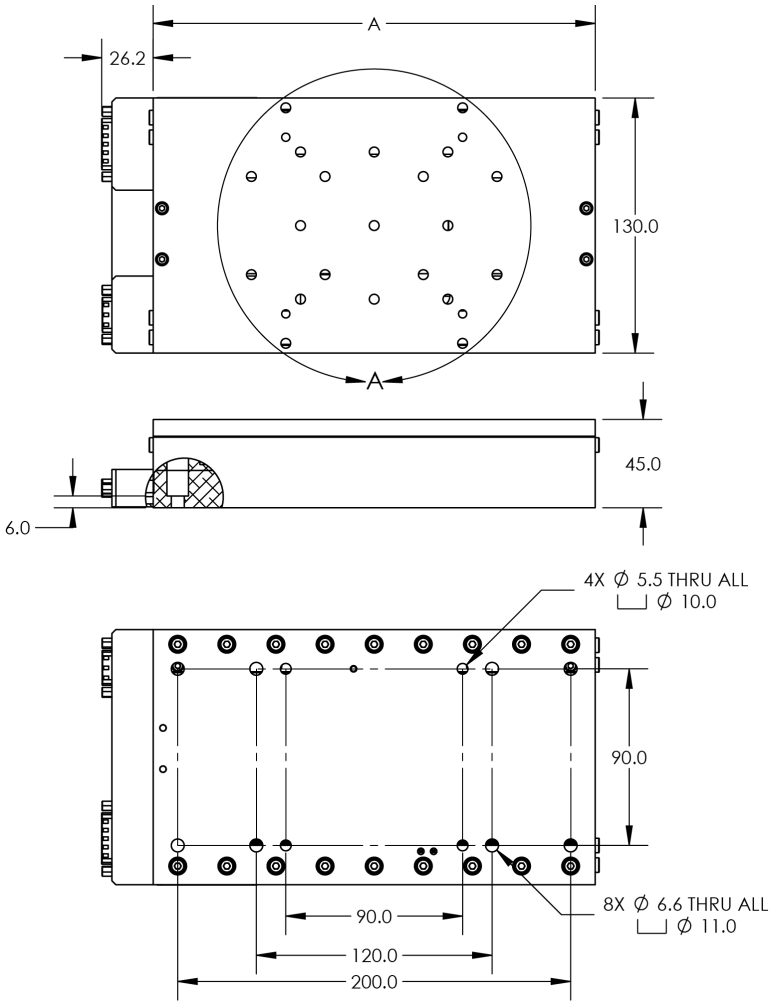


Figure 3. General Dimensions

The length of the NPS stage (Dimension "A") varies depending upon its nominal travel. Table 5 contains these values.

Table 5. General Dimensions

Stage Travel (mm)	Dimension A (mm)
35	150
110	225
160	275

3.3 Unpacking and Handling

CAUTION: The NPS stage is a very 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.

CAUTION: The encoder scale is exposed on the underside of the stage (see Figure 4). When handling or setting down the stage, do not contact, scratch, or apply pressure to the encoder scale, as damage to this surface may degrade feedback accuracy or render the stage inoperable.

Figure 4 shows the underside of the stage, where the encoder scale is exposed; take care to avoid contacting this surface when handling the stage.

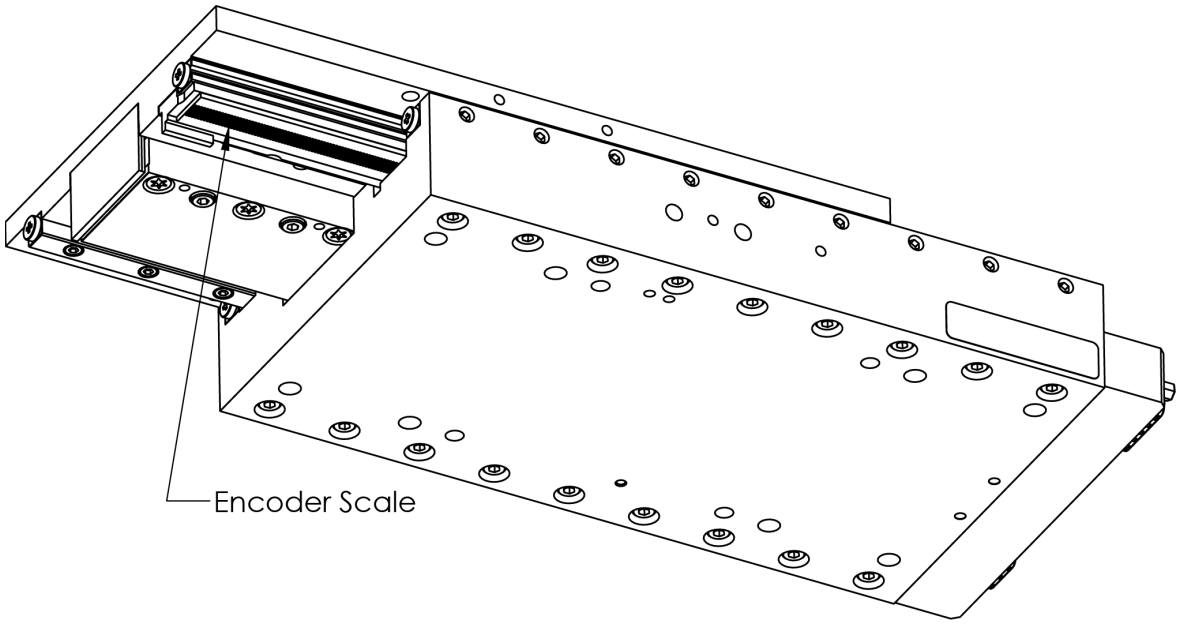
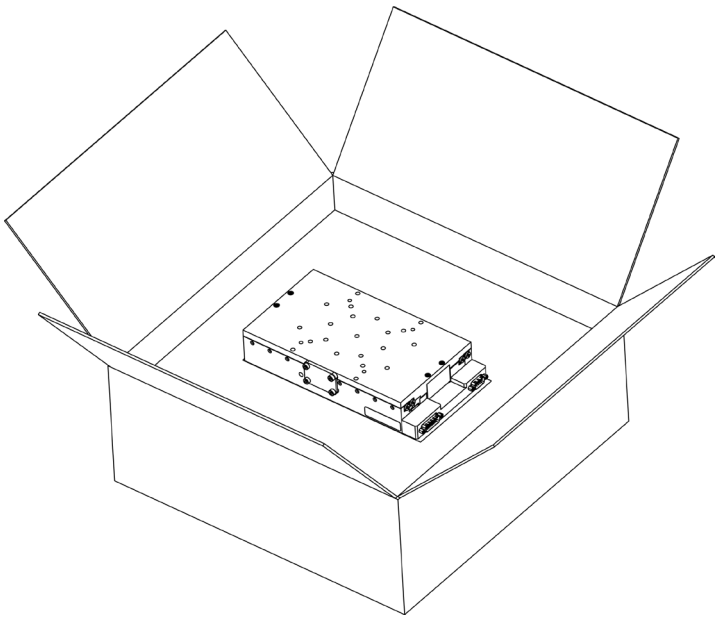


Figure 4. Encoder Scale Access (Underside View)

Upon receiving the NPS stage, please ensure that the Griffin Motion logo on the box is upright. This will ensure that you are unboxing the stage from the proper orientation.

Prior to removal of the NPS stage from its packaging, please check the integrity of the box 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 NPS 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 5. Packaging Materials

CAUTION: With the shipping locks still installed, there exists a crushing risk. This is due to the weight of the NPS and the very flat surfaces all around the device. Please take care while moving the stage by hand.

CAUTION: Do not pick up, move, or manipulate the stage by grasping or holding near the electrical connectors.

Once the stage is on a stable surface, carefully remove it from the plastic packaging (if applicable) 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 to prevent striking the payload plate or bottom surface of the stage with tools or edges of other equipment. The nearly imperceptible surface imperfections caused by these mishaps will affect stage performance.

3.4 Stage Mounting

To ensure the NPS achieves its advertised performance and longevity, great care must be taken to ensure that the mounting surface is adequately flat, rigid and clean.

3.4.1 Mounting Surface Flatness

The bottom surface of the NPS is machined to a high level of flatness. It is imperative that its mating surface is equally flat. Failure to provide a flat, clean mating surface will warp the stage, degrading the performance of the NPS. Table 6 details the required mounting surface flatness.

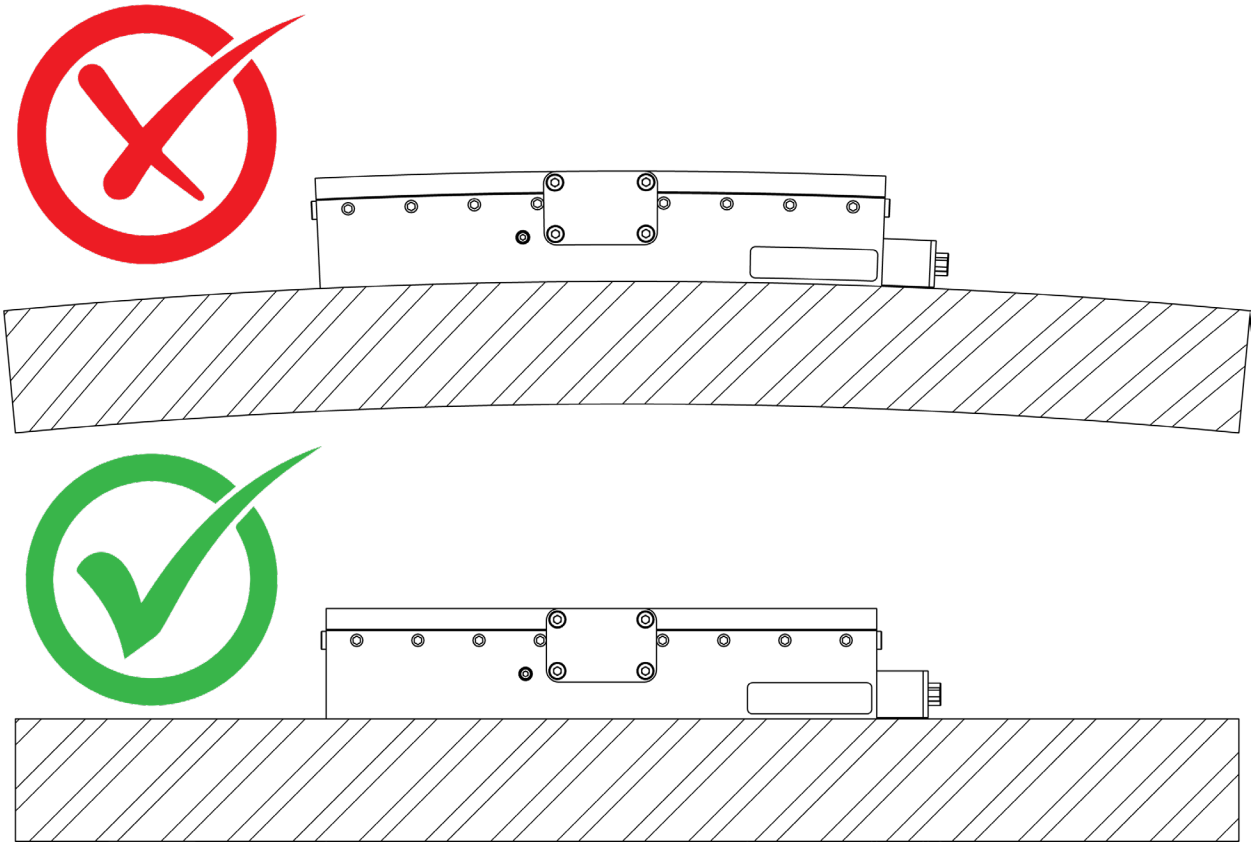


Figure 6. Stage Mounting Surface Flatness

Table 6. Mounting Surface Flatness

Specification	Value
Total Flatness (µm)	10.0
Local Flatness (µm/100mm)	5.0

3.4.2 Mounting Fasteners- Tightening Order and Torque

The NPS can be mounted via M5 or M6 socket-head cap screws. Counterbore geometry can be seen on Figure 2. Table 7 details the proper thread torque and thread engagement for these screws.

Table 7. Mounting Fastener Tightening Torque

Specification	Value	
Screw Size	M6x1.0	M5x0.8
Minimum Thread Engagement (mm)	12.0	10.0
Recommended Torque (in-lbs)	90.0	32.0

3.5 Payload Mounting

Mounting the payload to the NPS must be done with the same amount of care as mounting the stage. Flatness, rigidity and cleanliness are all critical.

3.5.1 Payload Mating Surface Flatness

The top surface of the NPS is machined to a high level of flatness. It is imperative that its mating surface on the payload is equally flat. Failure to provide a flat, clean mating surface will warp the stage, degrading the performance of the NPS. Table 8 details the required mounting surface flatness for payloads mating to the NPS top plate.

Table 8. Payload Mating Surface Flatness

Specification	Value
Total Flatness (µm)	10.0
Local Flatness (µm/100mm)	5.0

3.5.1.1 Tooling Plate Design

A payload may be fixed to the top plate via any of the tapped holes detailed on Figure 7.

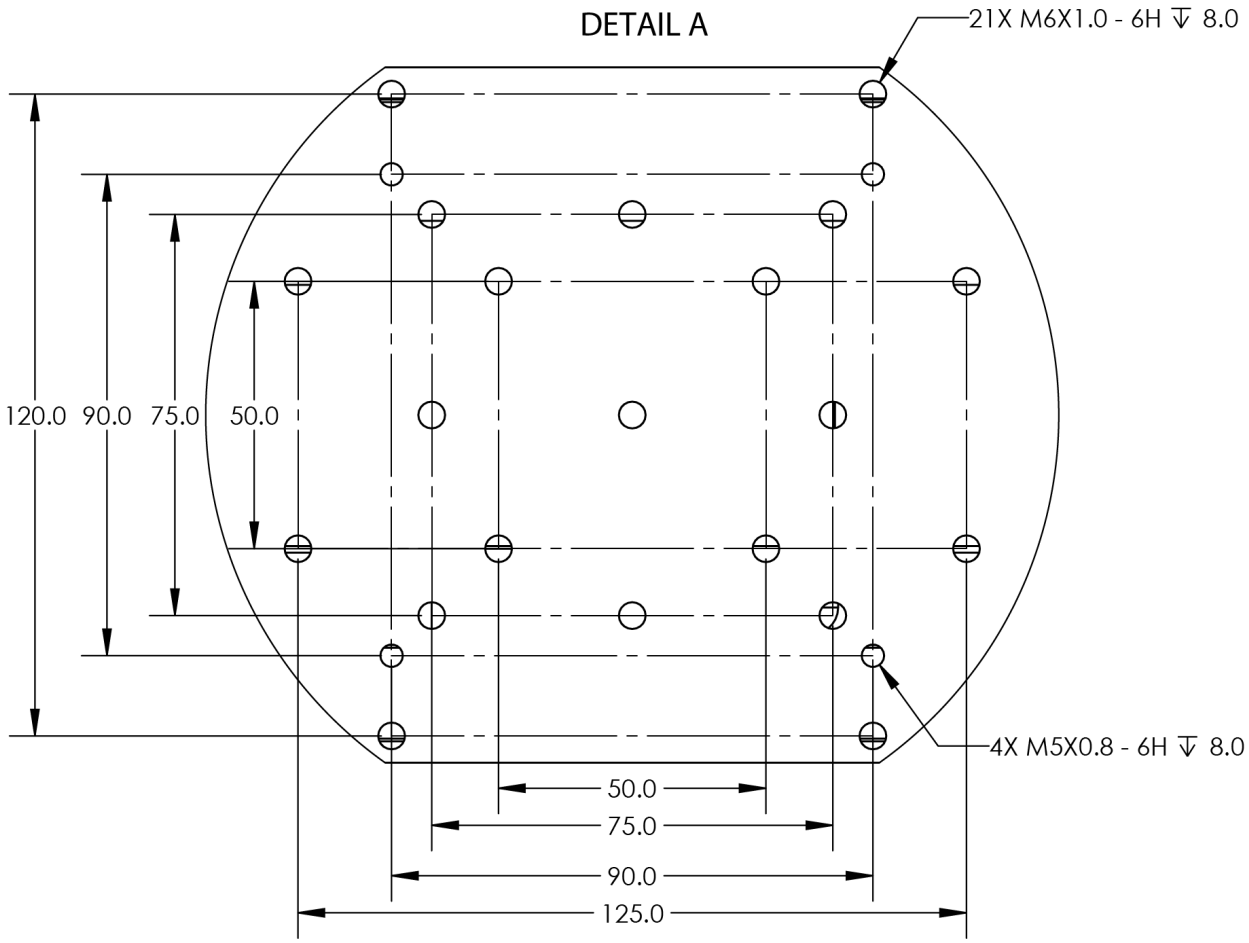


Figure 7. Tooling Plate Design

3.5.1.2 Fasteners and Tightening Torque

Recommended torque and thread engagement for payload mounting is detailed in Table 9. Exceeding the maximum thread engagement may result in damage to the stage.

Table 9. Fastener Tightening Torque

Specification	Value	
Screw Size	M6x1.0	M5x0.8
Minimum Thread Engagement (mm)	6.0	5.0
Maximum Thread Engagement (mm)	8.5	9.0
Recommended Torque (in-lbs)	70.0	32.0

3.6 Shipping Lock

Each NPS stage will arrive with an red shipping lock attached to the stage. This prevents stage motion during transit. It is critical that the shipping lock is affixed each time that the stage is handled or shipped. Do not discard the shipping lock.

3.6.1 Shipping Lock Installation and Removal

The shipping lock is fixed to the stage with 4 socket head cap screws. The proper torque for these screws is 14 in-lbs.

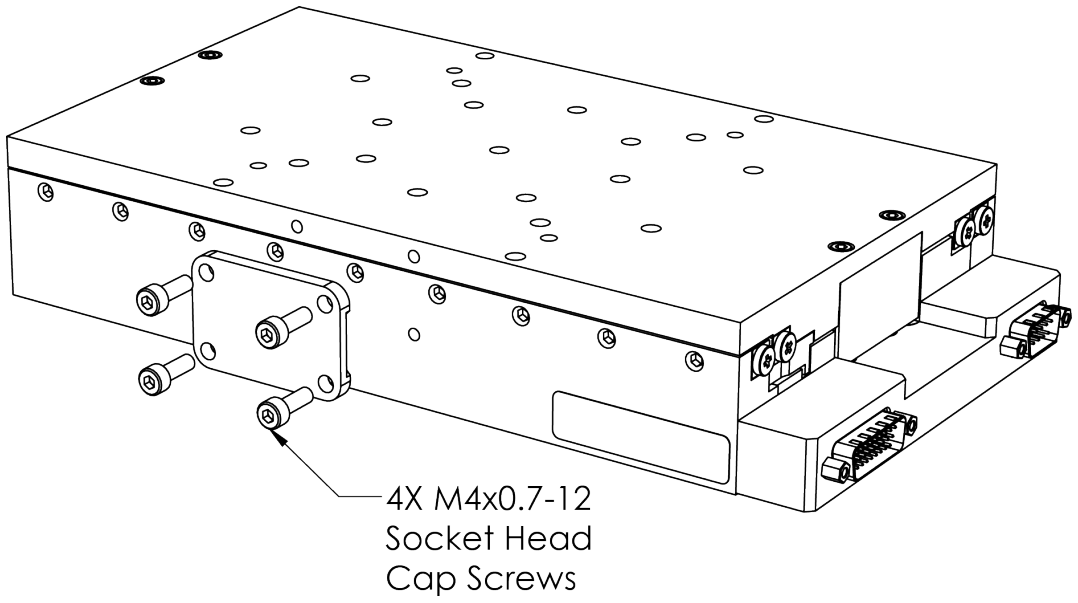


Figure 8. Shipping Lock Installation

4 Electrical Systems

The NPS contains the following electrical systems: a brushless motor, Hall effect sensors, a linear encoder, limit switches (for incremental encoders only), and an NTC type motor temperature sensor.

4.1 Electrical Connections and Pinouts

All electrical connections are made through the two connectors shown on Figure 2.

4.1.1 Motor and Feedback Connections

The three motor phases are routed through the D-Sub 9-Pin (Male) connector. The encoder, Halls, limits and motor temp are all routed through the D-Sub 26-pin (High-density, male) connector.

4.1.2 Mating Connectors

When building cables to interface with the NPS, use the connectors detailed in Table 10.

Table 10. Mating Connectors

Connector	Mating Connector
Motor Connector	D-Sub 9 Female
Feedback Connector	D-Sub 26 (High Density) Female

4.1.3 Motor Connector Pinout

The motor connector pinout is shown in Table 11.

Table 11. Motor Connector Pinout (9-Pin)

Motor Connector Pinout (DSUB9M)	
Pin No.	**Signal**
1	MOTOR/HOUSING SHIELD
2	*
3	*
4	*
5	*
6	Phase A
7	Phase B
8	Phase C
9	*
*Reserved	

4.1.4 Feedback Connector Pinout

The feedback connector pinout is shown in Table 12. The RS422 column applies to KK and LL feedback options. 1Vpp applies to HH, and BiSS C applies to MM feedback.

Table 12. Feedback Connector Pinout (26-Pin)

Feedback Connector Pinout (DSUB26HDF)			
Pin No.	**RS422**	**1Vpp**	**BiSS C**
1		+5V	
2	A+	SIN+	*
3	B+	COS+	*
4	Z+	IDX+	*
5	LIM+	*	*
6	*	*	*
7	*	*	Clock + (MA+)
8	*	*	Data + (SLO+)
9	*	*	*
10		OVER TEMP	
11	A-	SIN -	*
12	B-	COS -	*
13	Z-	IDX -	*
14	LIM-	*	*
15	*	*	*
16	*	*	Clock - (MA-)
17	*	*	Data - (SLO-)
18	*	*	*
19	GND	*	*
20	HALL A	*	*
21	HALL B	*	*
22	HALL C	*	*
23	*	*	*
24	*	*	*
25	*	*	*
26	*	*	*
*Reserved			

4.2 Feedback Systems

This section details the specifications and operation of the encoder, Hall effect sensors, limit switches, and motor temperature sensors.

4.2.1 Feedback Specifications

Table 13-Table 16 detail the electrical specifications for each of the 4 NPS feedback options.

Table 13. Feedback Specifications — HH

Specification	Value
Supply Voltage (V)	5.0±10%
Supply Current (mA)	200
Encoder Feedback	Yes
Encoder Type	Sinusoidal
Encoder Output	Sin, Cos, Index; Differential Pairs, 1Vpp
Encoder Resolution	20µm Signal Period
Hall Switch Output	CMOS
Hall Switch max current (mA)	±20.0
Limit Switches	Yes
Limit Switch Output Type	CMOS
Limit Switch Output current (mA)	±20.0
Limit Switch Output Low (V)	0.8
Index Pulse	Yes, center stroke
Motor Temperature Sensor	Yes
Motor Temperature Sensor type	NTC Thermistor

Table 14. Feedback Specifications — KK

Specification	Value
Supply Voltage (V)	5.0±10%
Supply Current (mA)	200.0
Encoder Feedback	Yes
Encoder Type	Incremental
Encoder Output	A, B, Z; Differential Pairs, RS422
Encoder Resolution	200,000 counts/mm
Hall Switch Output	CMOS
Hall Switch max current (mA)	±20.0
Limit Switches	Yes
Limit Switch Output Type	CMOS
Limit Switch Output current (mA)	±20.0
Limit Switch Output Low (V)	0.8
Index Pulse	Yes, center stroke
Motor Temperature Sensor	Yes
Motor Temperature Sensor type	NTC Thermistor

Table 15. Feedback Specifications — LL

Specification	Value
Supply Voltage (V)	5.0±10%
Supply Current (mA)	200.0
Encoder Feedback	Yes
Encoder Type	Incremental
Encoder Output	A, B, Z; Differential Pairs, RS422
Encoder Resolution	400,000 counts/mm
Hall Switch Output	CMOS
Hall Switch max current (mA)	±20.0
Limit Switches	Yes
Limit Switch Output Type	CMOS
Limit Switch Output current (mA)	±20.0
Limit Switch Output Low (V)	0.8
Index Pulse	Yes, center stroke
Motor Temperature Sensor	Yes
Motor Temperature Sensor type	NTC Thermistor

Table 16. Feedback Specifications — MM

Specification	Value
Supply Voltage (V)	5.0±10%
Supply Current (mA)	200.0
Encoder Feedback	Yes
Encoder Type	Absolute
Encoder Output	BiSS C (Unidirectional) 26-Bit
Encoder Resolution	10,000 counts/mm
Hall Switch Output	CMOS
Hall Switch max current (mA)	±20.0
Limit Switches	No
Index Pulse	No
Motor Temperature Sensor	Yes
Motor Temperature Sensor type	NTC Thermistor

4.2.2 Feedback Wiring Diagrams

Figure 9 shows a basic wiring diagram of the NPS feedback systems connected to a 3rd party servo drive. An individual NPS stage will not have all the signals shown in the diagram, consult the pinout chart (Table 12) to confirm which signals are applicable to your specific NPS stage.

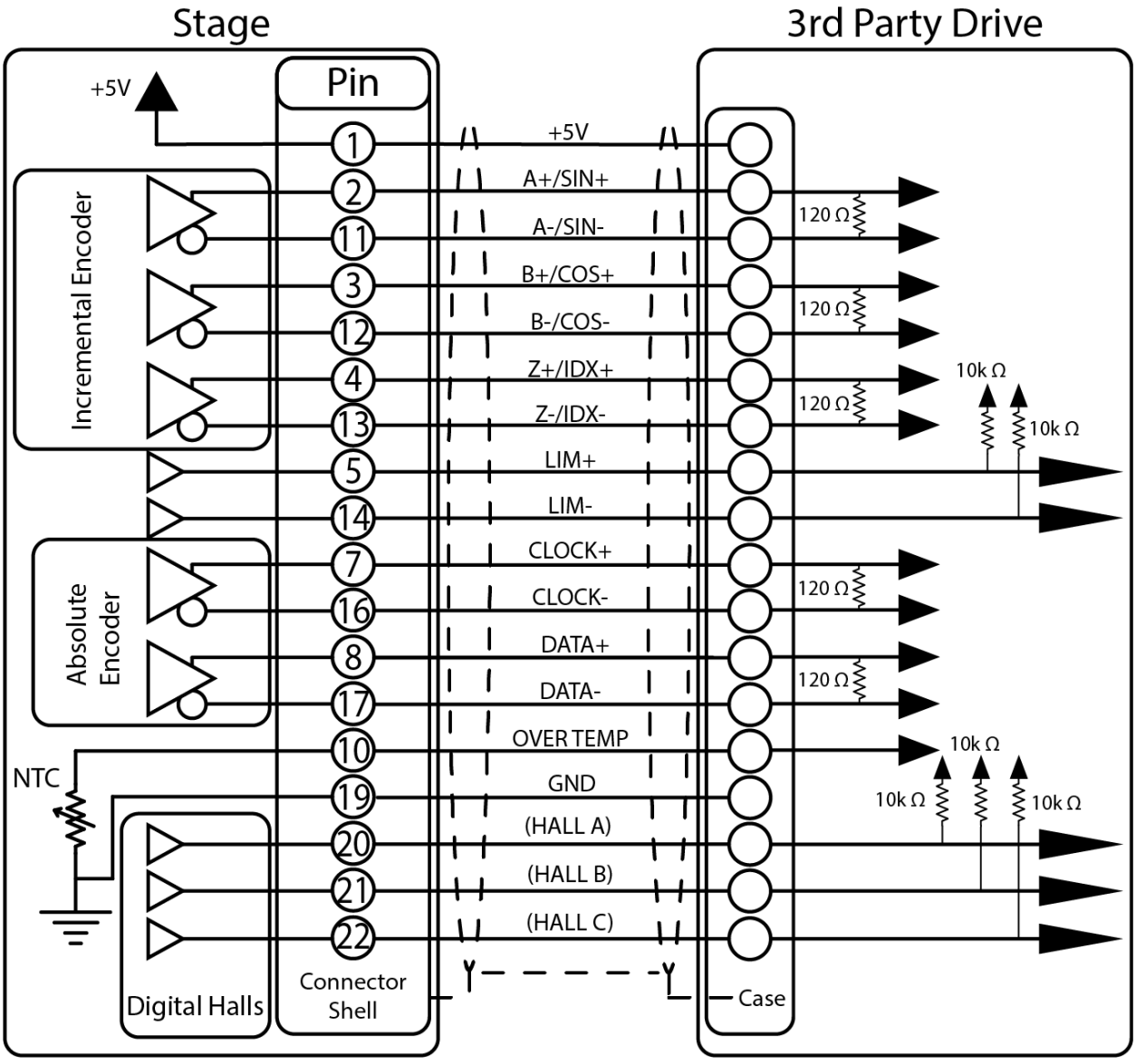


Figure 9. Feedback Wiring Diagram

4.2.3 Encoder Output and Waveforms

Figure 10 shows an example of the Sin and Cos encoder signal voltages over a 40µm span. Each channel shown represents the differential voltage between. Measured waveform amplitude may vary between 0.35 and 0.675V. DC offset is 2.5V.

These waveforms must be sub-divided within a 3rd-party servo drive into a digital waveform, where each edge represents an encoder count. Final encoder resolution will be determined by the drive. Encoder resolutions smaller than 2.5nm is not recommended.

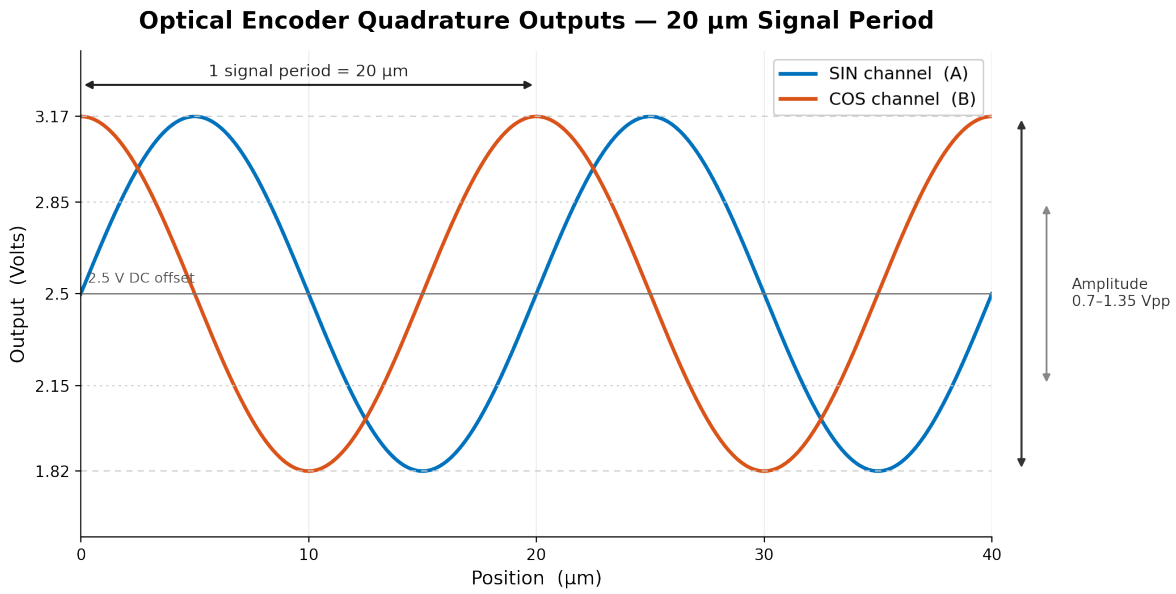


Figure 10. "HH" Encoder Output Waveforms

Figure 11 and Figure 12 shows the A-quad-B signals over a 60nm and 30nm distance.

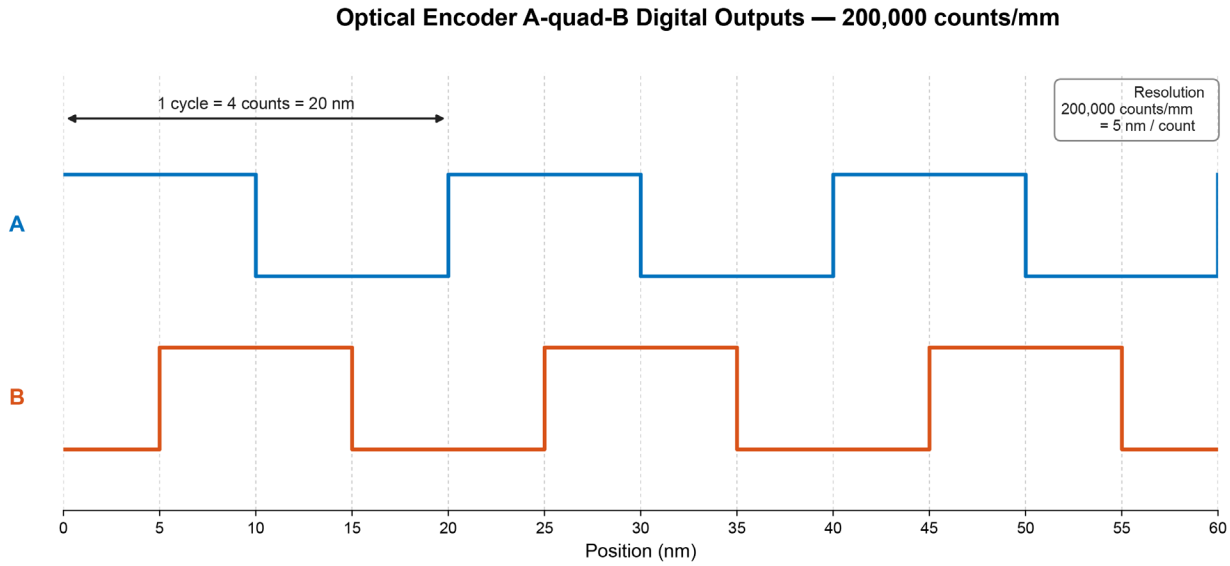


Figure 11. "KK" Encoder Output Waveforms

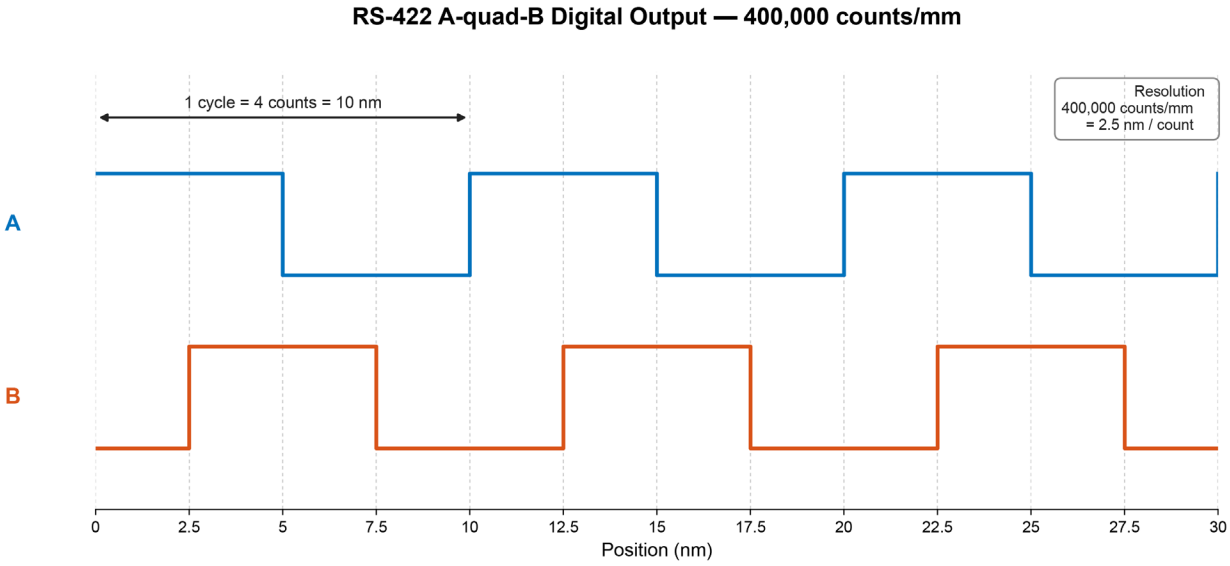


Figure 12. "LL" Encoder Output Waveforms

A-quad-B encoder out cannot be adjusted within the servo drive to achieve different resolutions.

The data format for the BiSS C (MM) Encoder feedback is shown in Figure 13.

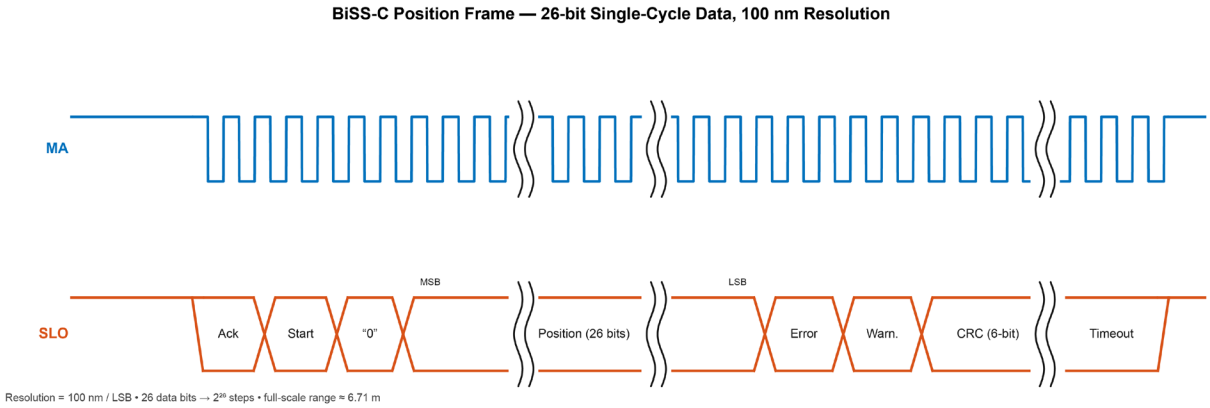


Figure 13. "MM" Encoder Serial Output

4.2.4 Markers and Mechanical Stops

In addition to the encoder counting, the incremental encoder options (HH, LL, KK) also feature optical limit switches and a home index (Z of RS422, IDX for 1Vpp) at the center of travel.

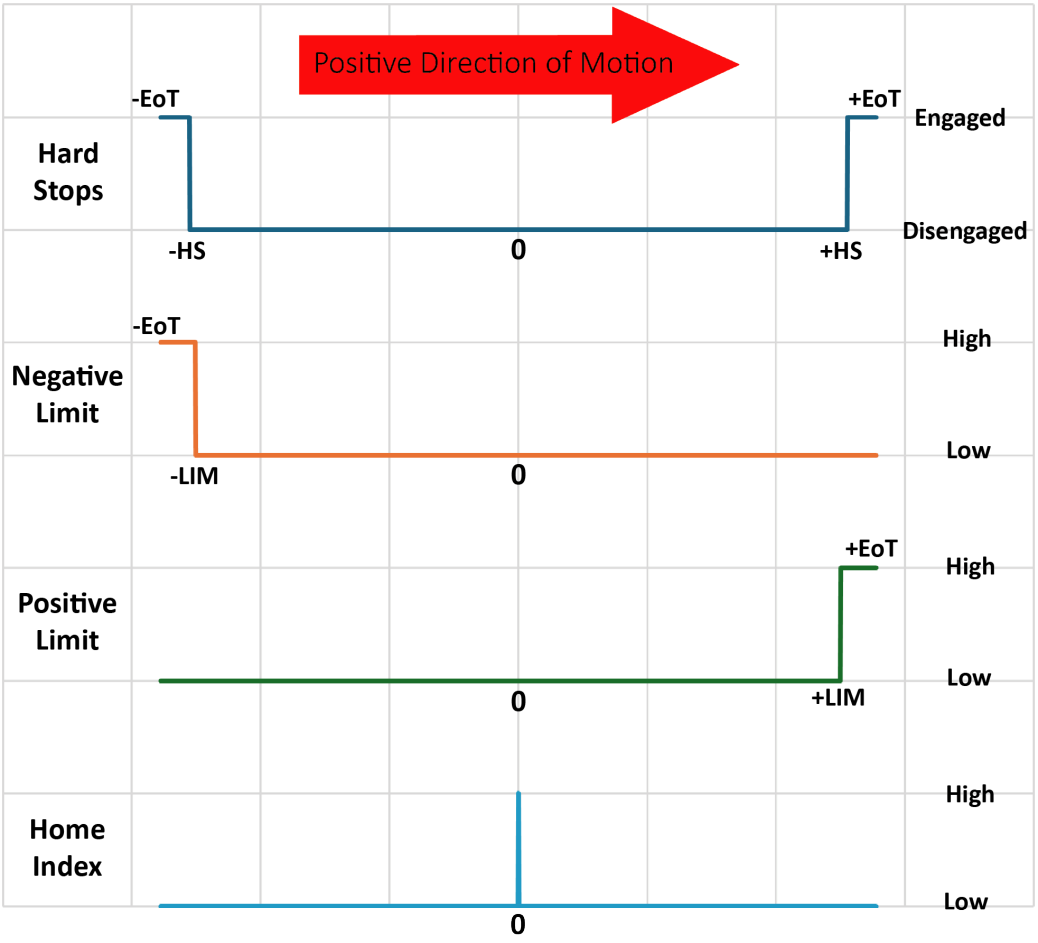


Figure 14. Markers and Mechanical Stops

The locations for NPS limit switches and hard stops are shown Table 17. Marker Locations.

Table 17. Marker Locations

Stage Travel (mm)	LIM Location (mm)	Hard Stop Locations (mm)
35	±17.5	±33.5
110	±55	±71
160	±80	±96

4.2.5 Motor Temperature Sensor

The motor coil includes a negative temperature coefficient (NTC) thermistor for monitoring coil temperature during operation. The thermistor's resistance varies with temperature, decreasing as the coil heats up. This allows the control system to monitor thermal conditions and guard against overheating.

Nominal resistance values across the operating temperature range are listed in Table 18.

Table 18. NTC Resistance vs. Motor Coil Temperature

Motor Temperature (°C)	NTC Resistance (Ω)
0	32650
10	19900
20	12490
30	8057
40	5327
50	3603
60	2488
70	1752
80	1258
90	918
100	680
110	511
120	389
130	301

The motor temp sensor alone will not prevent motor damage in all situations. It can only detect and prevent damage when temperature rise is much slower than the motors' thermal response time. The sensor has a maximum response rate slower than the motor may be capable of heating. Therefore, I^2T protection should be used if commanding higher than continuous motor current.

4.2.6 Feedback Cable Considerations

All differential signals (±A, ±B, ±SIN, ±COS, ±Z, ±IDX) should be transmitted via shielded, twisted pairs to increase noise immunity. These signals should be terminated at an appropriate differential input channel on the drive/controller.

Minimize the length of the feedback cable. This reduces signal drop and potential for inference. All feedback cables should be properly shielded.

4.3 Motor Systems

The NPS stage uses a 3-phase, ironless, linear motor. This section pertains to its specifications, characteristics and safe operation.

4.3.1 Motor Specifications

When configuring a 3rd party servo drive, all relevant motor specifications are shown in Table 19.

Table 19. Motor Specifications

Specification	Value
Force Continuous (N)	13.8
Force Peak (N)	30.1
Motor Type	3-Phase Brushless DC
Max Voltage (VDC)	60.0
Back EMF (Vp/m/s)	10.1
Electrical Time Constant (ms)	0.4
Continuous Current (Apk)	1.6
Peak Current (Apk)	3.5
Force Constant (N/Apk)	9.0
Pin-to-Pin Resistance (Ω)	7.0
Pin-to-Pin Inductance (mH)	2.5
Pole Pair Length (mm)	24.0
Motor Attraction Force (N)	0.0

4.3.2 Motor Wiring Diagram

The following diagram shows the wiring connections for the NPS motor phases, including the phase leads and their corresponding connector terminals.

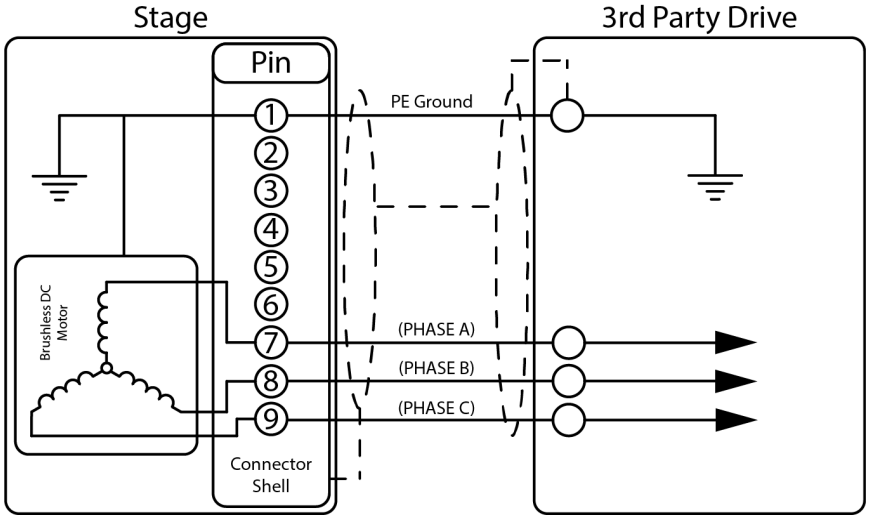


Figure 15. Motor Wiring Diagram

4.3.3 Motor Electrical Cycle and Hall Phasing

The following diagram shows the motor's electrical cycle and the digital Hall sensor phasing relative to the motor phases over one 24mm electrical cycle.

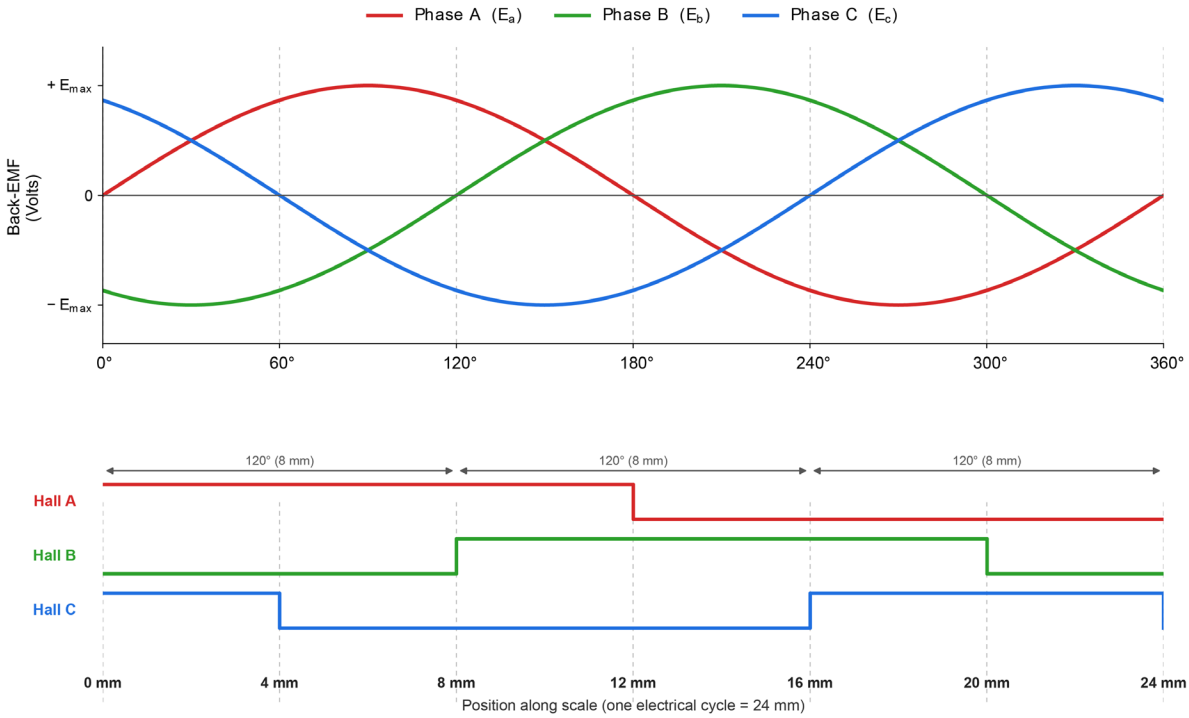


Figure 16. Motor Electrical Cycle and Hall Phasing

4.3.4 Motor Cable Considerations

To ensure safe transmission of motor current, use a wire with a gauge of at least 22 AWG (0.64mm conductor diameter).

Ensure that the PE ground pin is connected and terminated to the appropriate PE ground connection on the drive/controller.

Shielding is recommended for all motor cables. This will minimize interference with sensitive signals within the adjacent feedback cable. The shielding should be bonded to the connector shells on both the drive and stage sides of the cable.

4.3.5 Back-Driving Warning

Manually pushing, or *back driving*, the stage will generate electrical current via back EMF. If a motor cable is installed, this current will be delivered to the servo drive, potentially causing damage. If a motor cable is not installed, the user may be exposed to dangerous electrical power at the motor connection. Adhere to the following warnings and procedures to prevent injury or device damage:

CAUTION: Never handle or push the stage saddle 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.

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.

NPS stages may be slowly back-driven, when not connected to controls, to allow access to mounting holes without the need to power the stage. 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. When back driving the stage, apply slow gradual pressure by hand.
3. Do not strike the stage or slam it into the hard stops.
4. Minimize contact and maintain cleanliness of mounting surfaces prior to installation.

4.4 Shielding and Grounding

The linear motor within the NPS may create potentially harmful voltages. To best mitigate danger caused by motor fault conditions, a protective earth (PE) grounding point is provided on Pin 1 of the motor connector.

To provide a grounded terminal for stage cable shielding, both the motor and feedback connector shells are properly grounded.

For proper operation, the user must connect the cable shielding and protective earth to the points shown in the wiring diagrams in Sections 4.3.2 and 4.2.2. This will ensure safety to the user and high reliability of the motor and feedback systems to achieve optimal performance.

CAUTION: The user should not attempt to use any tapped hole not labeled “PE” if additional grounding is desired.

4.5 Control System Considerations

4.5.1 Motor Amplifier Sizing

Ideally, the drive/amplifier does not have a larger current rating than is needed by the motor in each application. This maximizes current resolution, which is beneficial for fine movements. In some applications (where full peak force is not required), it may be beneficial for the drive to have a lower current rating than the motor.

4.5.2 Current Limits

The servo drive/controller is solely responsible for implementing safe current limitations. Do not set the continuous current limit above the value specified in 4.4.1. In some applications, greater than continuous current is required for short periods. Motor protection algorithms such as I^2T should be implemented in these applications. It is recommended that the current limits should not be set higher than is necessary to achieve the desired force/acceleration.

4.5.3 Verification and Tuning

It is highly recommended that the installer first verify the stage's operation with the controller of their choice, no payload, in a horizontal orientation. After that, dummy payloads (similar mass and geometry to the final payload) can be used to tune the system and verify requirements prior to installing any sensitive payload equipment.

4.5.4 Velocity Limits

It is recommended that the velocity of the stage be limited within the drive to ensure safe operation. The maximum recommended speed will vary depending on the mass of the payload, recommendations are displayed below in Table 20.

Table 20. Recommended Velocity Limits by Payload

Payload (kg)	Vmax (mm/s)
0	300.0
0.0625	300.0
0.125	300.0
0.25	300.0
0.5	300.0
1	300.0
1.5	300.0
2	300.0
2.5	300.0
3	300.0
3.5	288.6
4	275.9
4.5	264.8
5	254.8
5.5	245.9
6	237.9
6.5	230.7
7	224.0
7.5	217.9
8	212.3
8.5	207.1
9	202.2
9.5	197.7
10	193.4

4.5.5 Position Error Limits

Many controllers actively monitor the distance between the commanded position and measured positions (as reported by the encoder). This feature can prevent runaway conditions should a cable, feedback mechanism, or current control fail to operate as desired. It can also serve as a collision detection feature.

Determining the best value for this safety variable takes time and some experience with the process. The machine integrator should consider the behavior of the control system and stage should this value be exceeded.

4.5.6 Software End-of-Travel Limits

Normal stage operation should never occur beyond the electrical limit switches. Software limits may be implemented short of the limit switches to signal that full braking force is necessary to prevent a hard stop collision.

5 Maintenance

5.1 Inspection

Depending on the cleanliness of your operating environment or system process, the inspection frequency may need to increase. For normal laboratory usage (little to no debris), the following minimum inspection interval and criteria are suggested.

Inspection Interval: Monthly

Inspection Criteria:

- Check Cables for:
  - Jacket fraying
  - Loose connections.
  - Check the resistance of protective earth bonding to the controller.
- Check the stage for:
  - Excessive debris on the stage.
  - Silicone side seal fraying (if applicable)

5.2 Cleaning and Lubrication

Clean the accessible surfaces with a lint-free cloth dampened with denatured alcohol.

Avoid ingress of cleaning agents or water into the interior of the stage, including past any side seals where present, as this will break down the lubricants, embed contaminants into seals and crevices, and ultimately affect machine life.

Cleaning and lubricating components such as the precision rails require disassembly beyond the scope of this document and is not recommended to be attempted.

Keep cleaning agents and water away from electronic components.

Lubricants used in the assembly of Griffin Motion NPS stages are intended to last the usable life of the device, given that the cleanliness of the environment is maintained consistently with the expected use.

5.3 Troubleshooting

This section provides general guidance to address a series of common stage errors.

Table 21. Troubleshooting Guide

Problem	Root Cause and/or Proposed Solution
Stage will not move (unpowered)	• Check that the shipping lock is removed.
Stage 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.
Stage runaway or erratic behavior	• Encoder feedback wrong direction. • Encoder failure or disconnection. • 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 failure or disconnection.
Stage power lower than expected	• Check current gains and monitor current admitted to motor. • Motor current ϕ 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 force required during normal operation	• Contamination in ball screw or precision rails.
Stage cannot reach electrical limit	• Stage obstructed, check pinch points. • Electrical limit or cabling has failed.
Intermittent failure or operation	• Loose cable connections. • 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 of precision rails. • Rubbing noise from power-off brake.

5.4 Scrapping and Disposal

The NPS Stage qualifies as electronic equipment that should be disposed of properly. Dispose of old equipment following the appropriate international, national, and local rules and regulations.

If you need assistance with proper disposal or would like to send the machine back to Griffin Motion for disposal, please reach out to a representative for RMA (Return Material Authorization) information.

6 Service and Support

6.1 Service

If you need any assistance regarding product integration, application, identification, inspection, repair, or new business opportunities, please contact Griffin Motion. Contact information is displayed at the beginning of this document.

6.2 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.