PPS-110 Series

Precision Positioner Stage

Reference Manual

(Open and Closed Loop Versions)

micronix USA
PRECISION MOTION SOLUTIONS

PPS-110

Precision Positioner Stage

Reference Manual

Rev 2.03

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Table of Contents

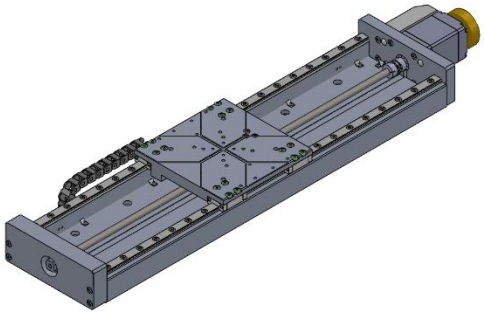
1. Introduction

1.1 Product Description

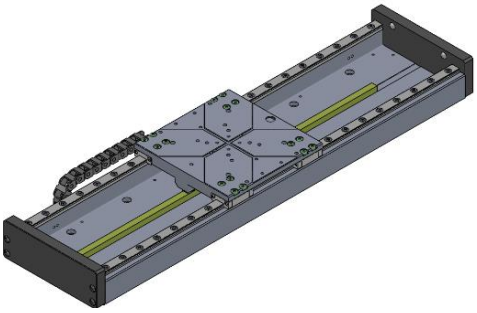
The PPS-110 is a high-precision, long travel linear stage. It is available with piezo motor, linear motor, or stepper motor with ballscrew drives. Steel recirculating ball bearings allow for smooth motion, and high guiding accuracy for loads up to 25 kg. Closed loop encoder resolution of 2 nm is achievable with a high precision digital encoder for piezo motor version.

Features:

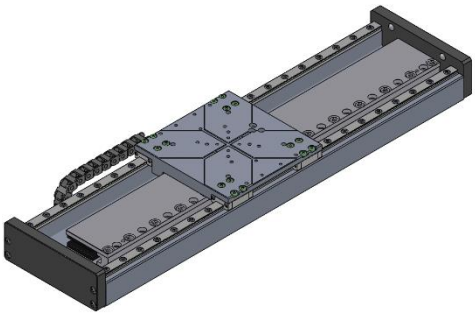
- Travel ranges of 1000 mm
- Load capacity up to 25kg
- Closed loop encoder resolution of 2 nm (Piezo motor)
- Closed loop encoder resolution of 50 nm (Stepper motor)
- Closed loop encoder resolution of 10 nm (Linear motor)



PPS-110 300mm with External Stepper Motor option



PPS-110 100mm with Piezo Motor option



PPS-110 300mm with Linear Motor option

1.2 Recommended Controllers

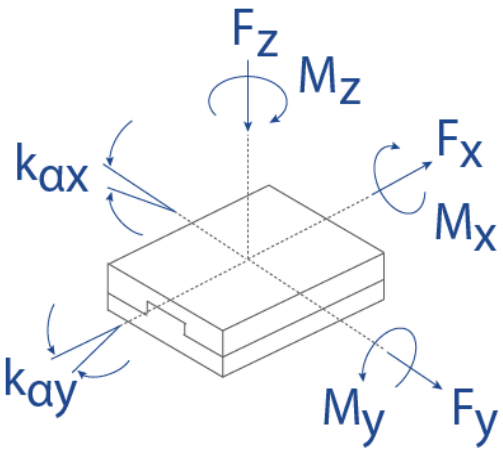
The following controllers are available from MICRONIX USA:

- MMC-110 – Piezo
- MMC-200 – Stepper

1.3 Technical Data

Motor option	PM-003		SM-008/SM-009		LM-004
Speed, max. [mm/sec]	5 (MMC-110)		10 (Higher speed on request)		250 (depending on load)
Encoder option	Open Loop	Digital (RS-422)	Open Loop	Digital (RS-422)	Digital (RS-422)
Resolution, typical [µm]	0.001	0.002	0.1	0.05	0.01
Repeatability, bi-directional [µm]	n/a	± 0.1	± 4	± 0.2	± 0.1
Repeatability, uni-directional [µm]	n/a	0.1	0.4	0.2	0.1

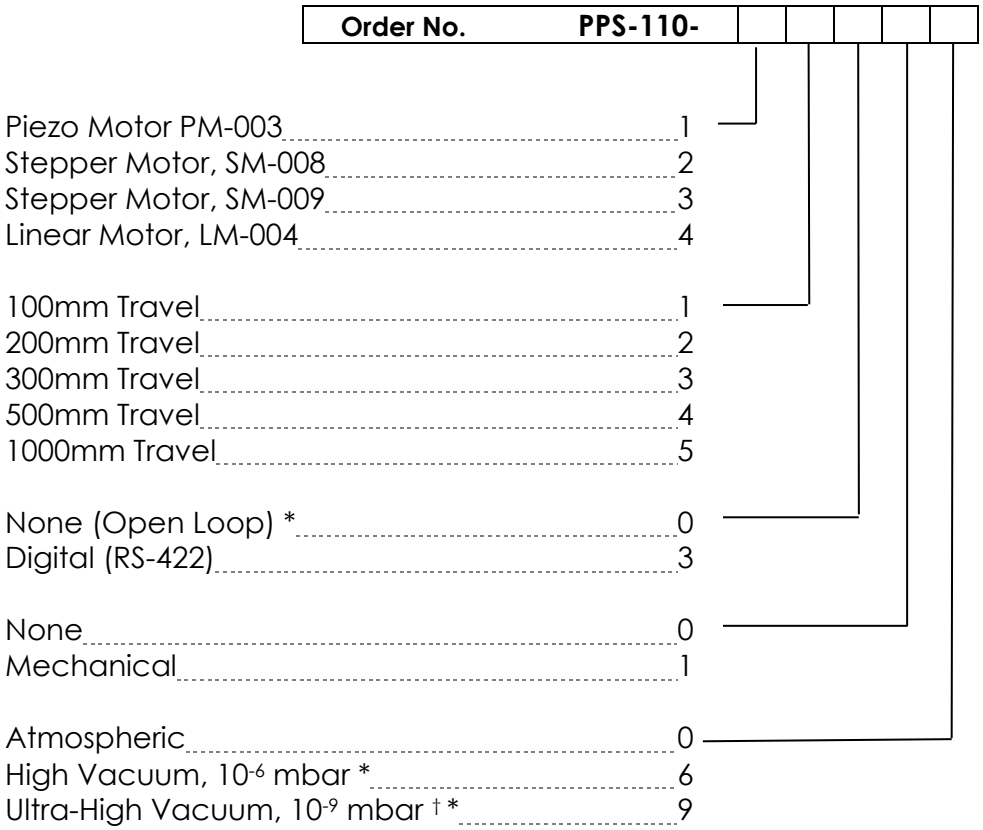
1.4 Load Characteristics



Load Characteristics	F_x [N]	F_y [N]	F_z [N]	M_x [Nm]	M_y [Nm]	M_z [Nm]	$k_{\alpha x}$ [µrad/Nm]	$k_{\alpha y}$ [µrad/Nm]
PM-003	5	150	250	60	30	35	50	50
SM-008/SM-009	30	150	250	60	30	35	50	50
LM-004	150 peak 50 continuous	150	250	60	30	35	50	50

2. Model configurations

2.1 PPS-110 Order Numbers



*Linear motor is not available with open loop and high vacuum environment.

† Only available with Piezo and Stepper motor option or externally mounted UHV stepper motor.

Contact MICRONIX USA for custom applications and stacking configurations.

3. Preparing to Install the PPS-110

3.1 Installation Preparation

When mounting the stage, it is important to consider the flatness of the mounting surface, as the stage will conform to the shape of that surface. A surface that is not flat can adversely affect the performance and structural integrity of the stage.

The stage is calibrated and guaranteed to be within specification at 20°C ±5°C, unless otherwise specified. The operating conditions of the stage are as follows:

- Mount to a clean and flat surface which is free of debris, burrs, and dings
- An indoor atmosphere free of corrosive gases, excessive dust, and condensation
- Temperature range of 0-40°C
- Relative humidity between 20-80%
- Locate away from water, heat, and electrical noise

3.2 Package Contents

If product is damaged or there are missing components, contact MICRONIX USA immediately. Do not discard product packaging in case of return shipment.

Package Should Contain:

- PPS-110 Linear Stage
- Reference Manual
- Any other previously agreed upon components such as a controller

4. Installing the PPS-110

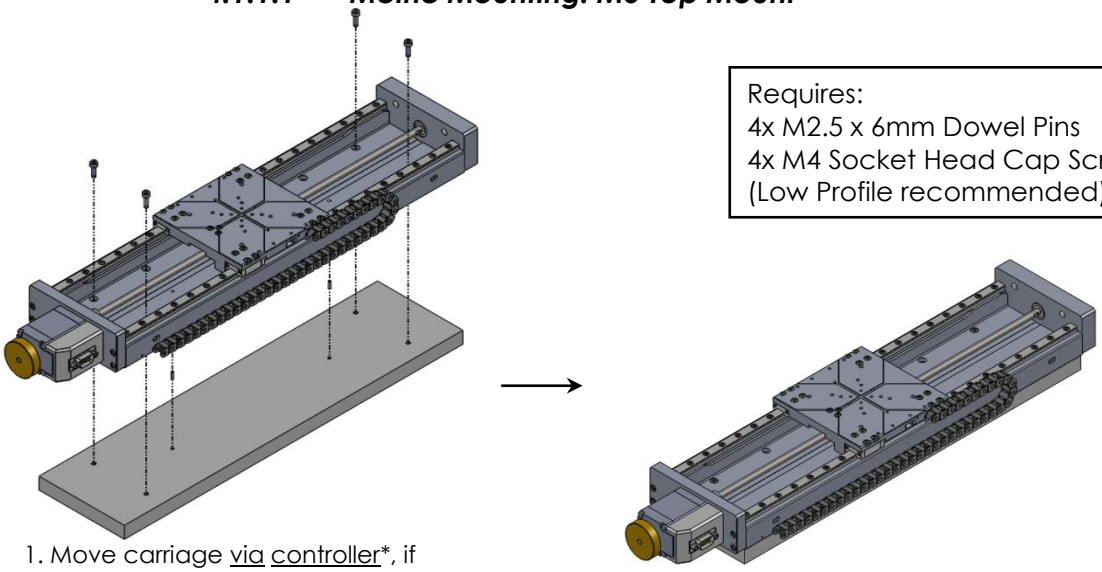
Mounting patterns require M4 socket head cap screws or pan head machine screws for mounting, as well as M2.5 x 6mm dowel pins for precision alignment. Additional brackets and screws may be required for custom applications.

4.1 PPS-110 Installation

4.1.1 *General Mounting*

For general mounting configurations, mount the base to the mounting surface using the thru holes. Move the carriage to access base mounting pattern. (Please note, it is possible to move the carriage of the linear and piezo motor configurations manually without damaging the stage, however, for *stepper versions the motor must be driven by a controller to reposition the carriage.)

4.1.1.1 Metric Mounting: M3 Top Mount

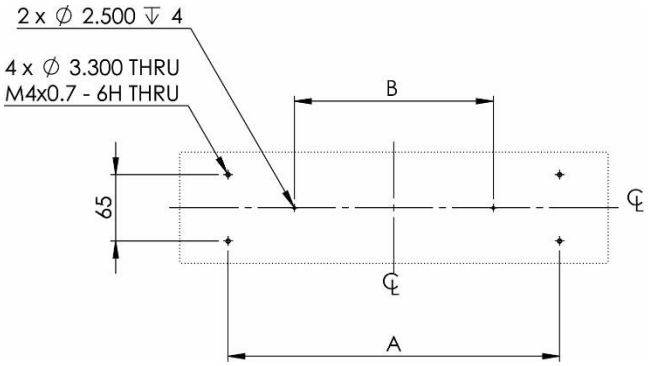


Requires:
4x M2.5 x 6mm Dowel Pins
4x M4 Socket Head Cap Screws
(Low Profile recommended)

1. Move carriage via controller*, if necessary, to access four mounting holes. Insert Pins and M4 SHCS as shown.

Metric M4 Top Mount Mounting Pattern

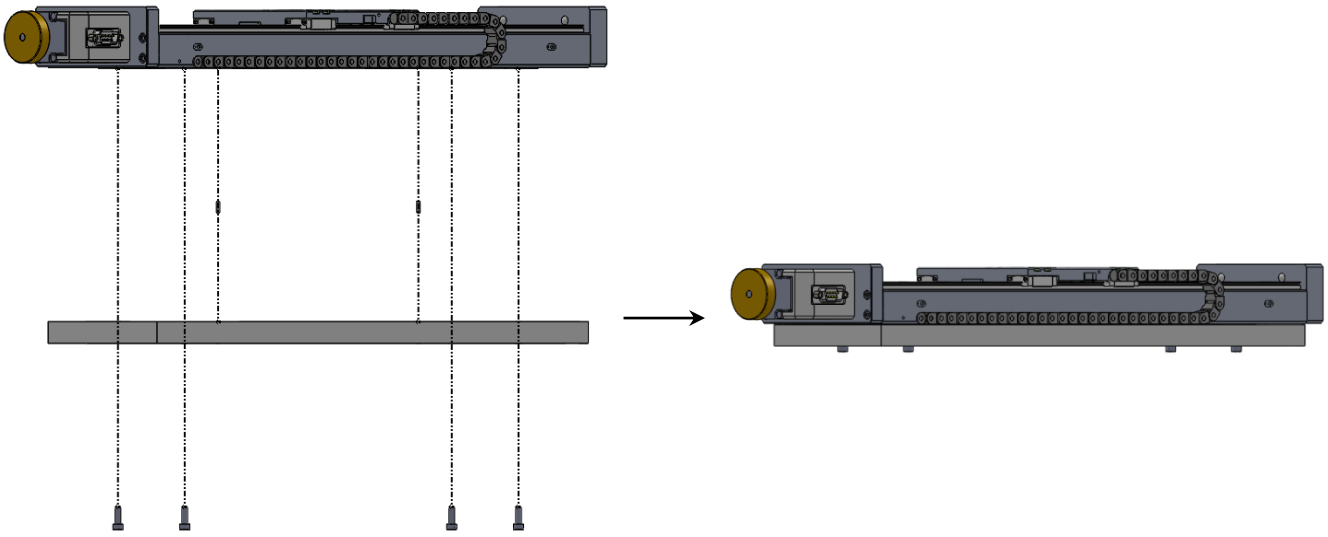
♦*For internal motor configurations: Mounting screws must be flush with base surface.*



Travel	*A [mm]*	*B [mm]*
100mm	*195*	*195*
200mm	*195*	*195*
300mm	*325*	*195*
500mm	*585*	*455*
1000mm	*1105*	*975*

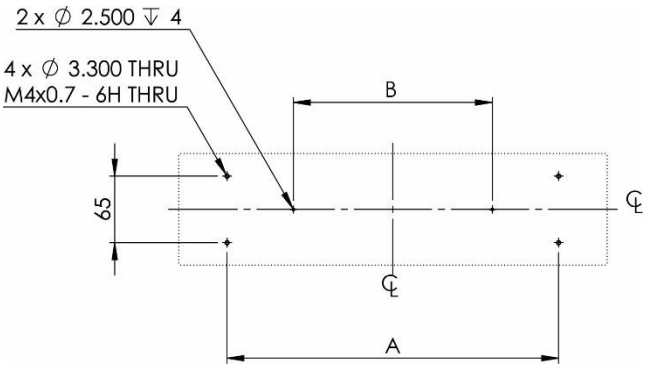
4.1.1.2 Metric Mounting: M4 Bottom Mount

Requires:
2 x M2.5 x 6mm Dowel Pins
4 x M5 Socket Head Cap Screws



Insert Pins and M5 SHCS as shown.

Metric M5 Bottom Mount Mounting Pattern



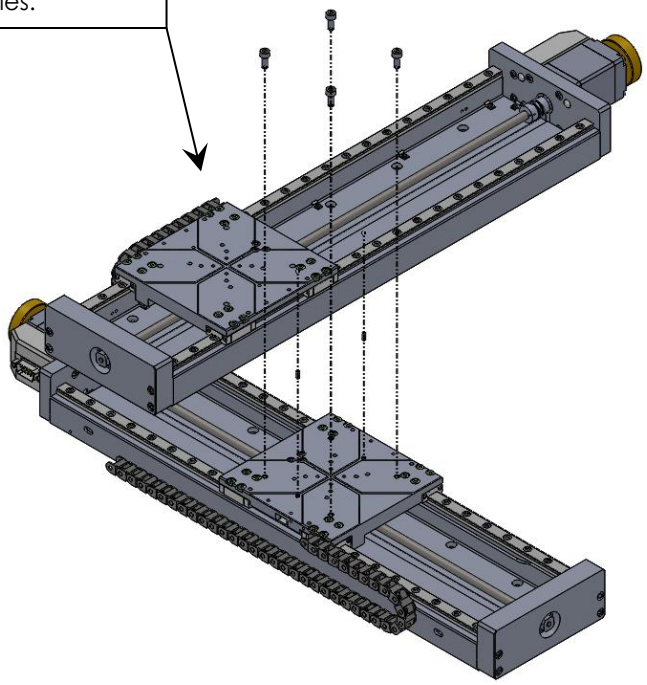
Travel	*A [mm]*	*B [mm]*
100mm	*195*	*195*
200mm	*195*	*195*
300mm	*325*	*195*
500mm	*585*	*455*
1000mm	*1105*	*975*

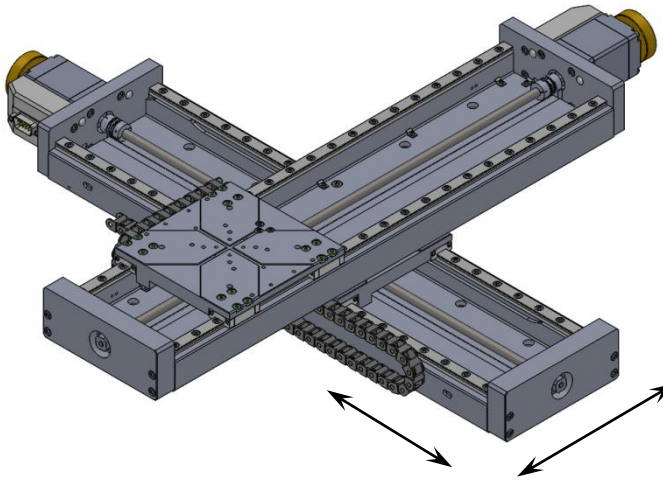
4.1.2 *X-Y Mounting*

For additional mounting configurations see Section 7: Stacking Configurations. Please note that it is possible to move the carriage of the linear and piezo motor *configurations manually without damaging the stage, however, for stepper versions the motor must be driven by a controller to reposition the carriage.*

Requires:
2 x M2.5 x 6mm Dowel Pins
4 x M4 Socket Head Cap Screws
(Low Profile recommended)

Move carriage via the controller*, if necessary, to access mounting holes.





Direction of Travel

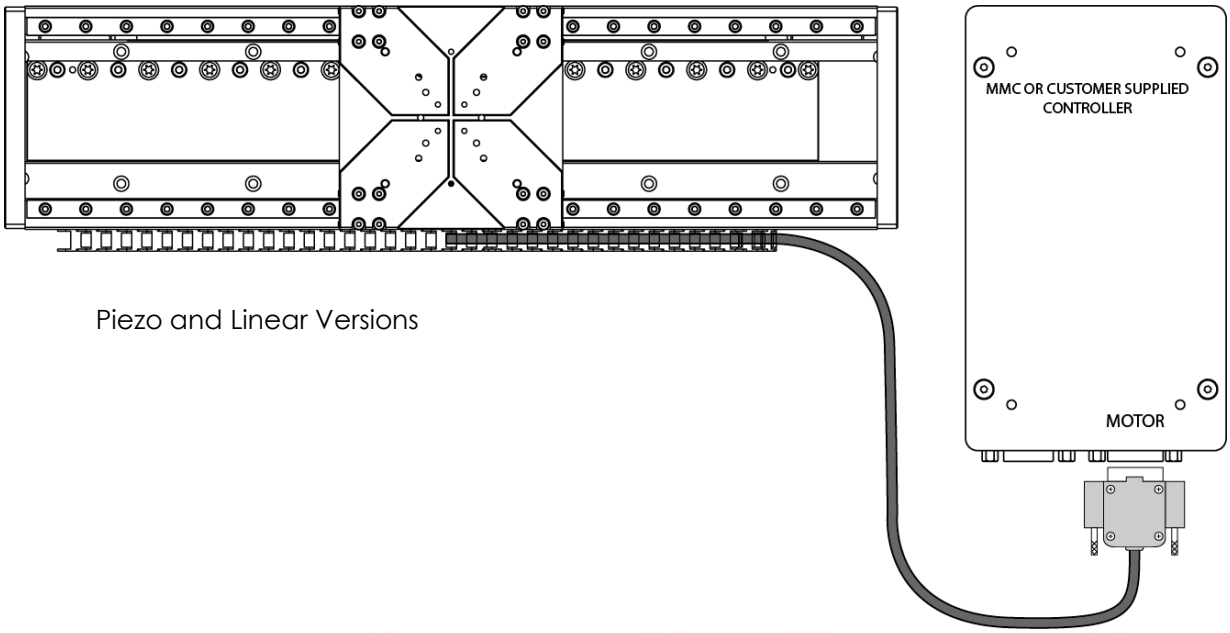
5. Connecting the PPS-110

5.1 Atmospheric Environments

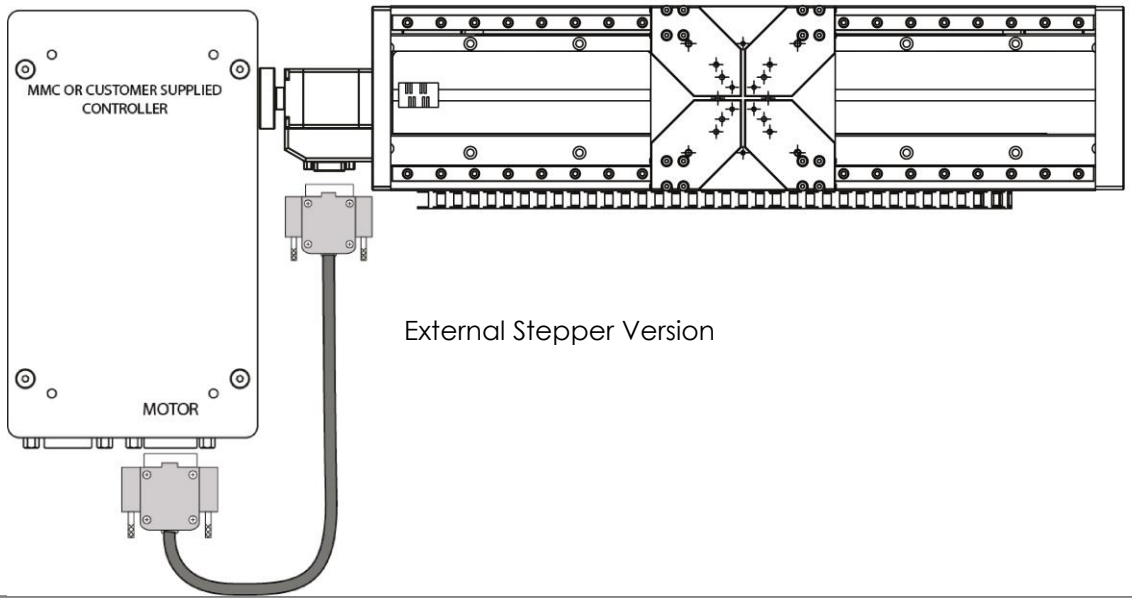
For controller information refer to the appropriate MMC controller manual.
Wiring diagrams are consistent for all piezo, stepper, and linear motor assemblies.

5.1.1 *Open Loop Installation & Wiring Diagram*

Connecting the PPS-110 in an open loop configuration only requires that the D-sub 9 Pin Motor Cable be connected to a compatible controller. No other cables or components are required. Please note, open loop configurations are only available for stepper or piezo motor versions (See Appendix A.1 or A.3 for pinout configurations).



Piezo and Linear Versions

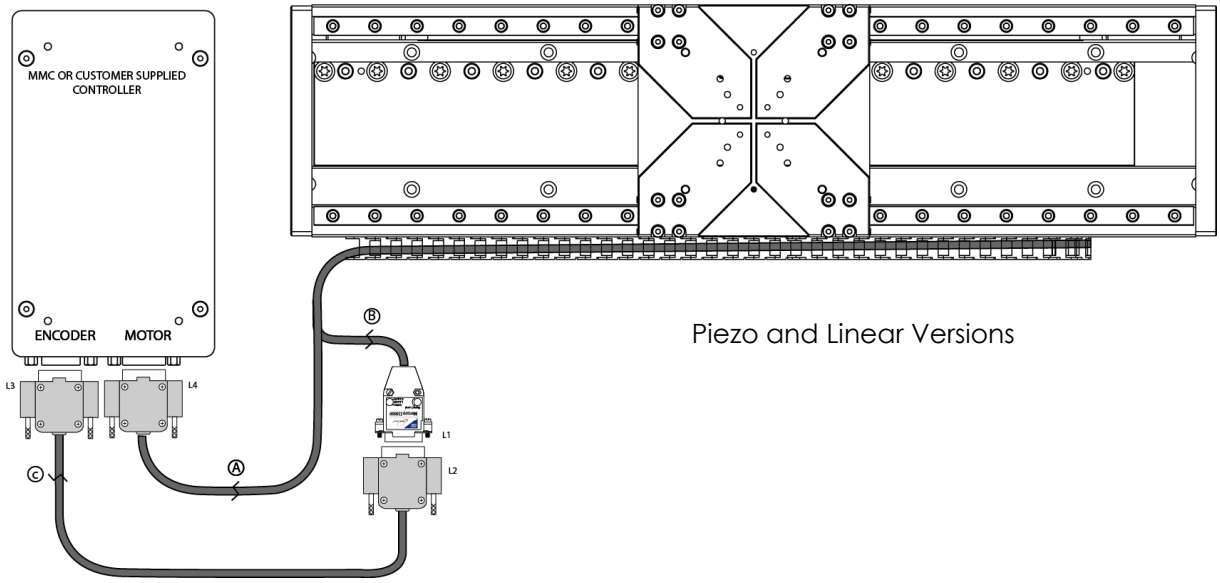


External Stepper Version

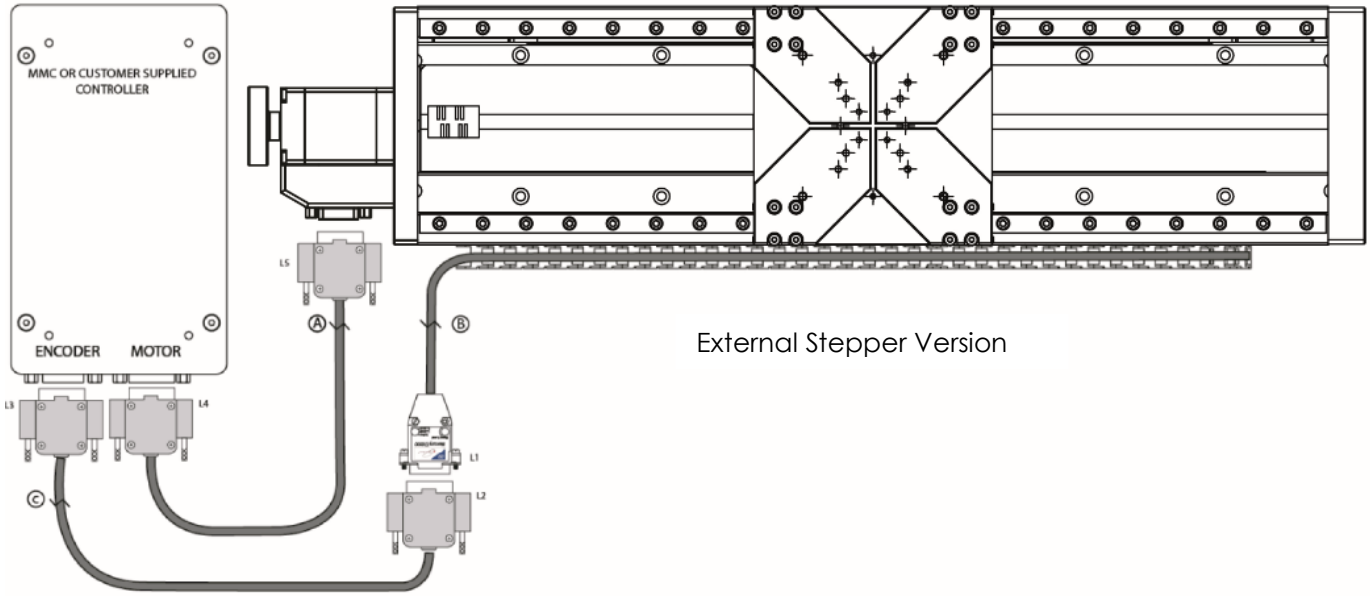
5.1.2 *Closed Loop/Encoder Installation & Wiring Diagram*

Using the PPS-110 stage with an encoder requires a closed loop compatible controller that recognizes the proper type of encoder feedback. Connect the stage as shown below.

5.1.2.1 MII 6000 Digital Encoder Wiring Diagram



Piezo and Linear Versions



External Stepper Version

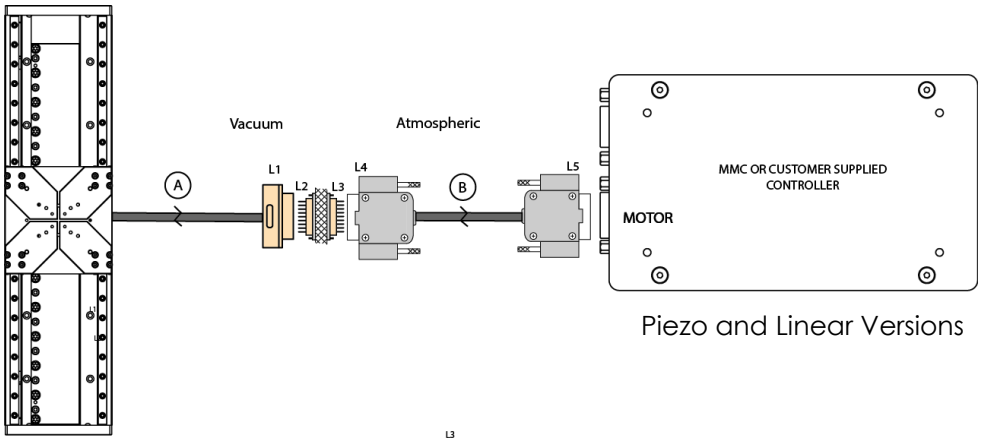
5.1 Vacuum Environments

5.1.1 Handling and Preparation

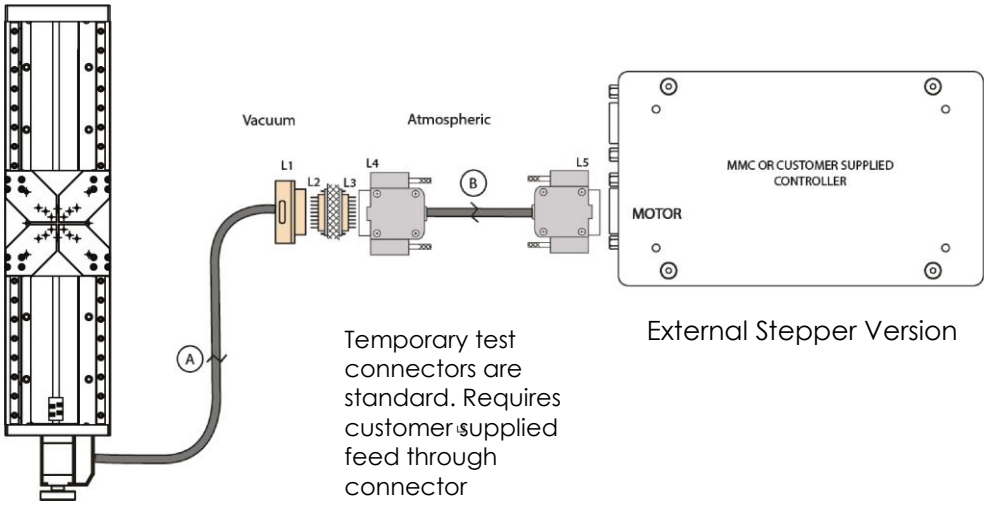
When preparing the stage for vacuum environments, take the necessary precautions (such as wearing gloves, clean room, clothing, etc.) when handling the stage as to avoid any contaminants. Maximum Bake-out temperature is 100°C. MICRONIX USA can supply the stage with vacuum compatible connectors: 9-pin female PEEK connector for open loop, 25-pin female PEEK connector for closed loop with MII 6000 digital encoder.

5.1.2 Open loop Installation & Wiring Diagram

Connecting an open loop PPS-110 in a vacuum chamber requires the use of a feed through connector at the vacuum chamber wall. The vacuum compatible PPS-110 will be supplied with wiring for a straight through feed through, not a cross over gender changer. MICRONIX USA supplies test connectors that simulate the vacuum feed through to allow for functionality testing prior to installation in a vacuum chamber. Note: Linear motor versions are not available for vacuum environments. For details regarding the pin-out and feed through specifications see the Appendix section A.5.



Piezo and Linear Versions



External Stepper Version

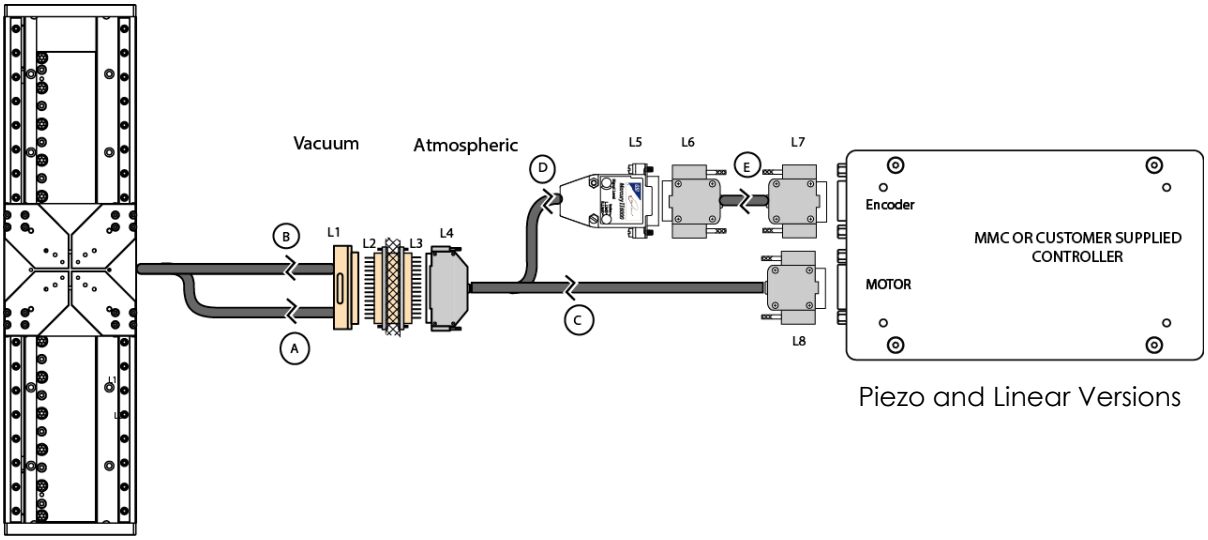
Temporary test connectors are standard. Requires customer supplied feed through connector

5.1.3 Closed Loop/Encoder Installation & Wiring Diagram

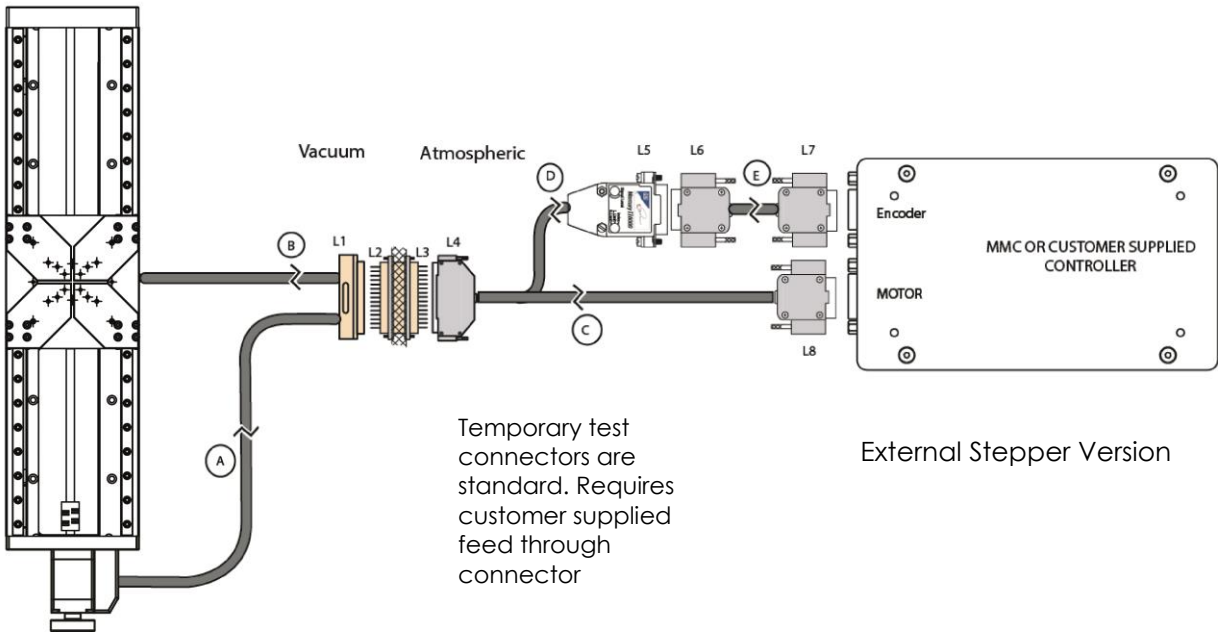
Closed loop installation of the PPS-110 stage in vacuum environments requires an intermediate feed through connector at the vacuum chamber wall that can accommodate both the motor cable, and the encoder cable.

The vacuum compatible PPS-110 will be supplied with wiring for a straight through feed through, not a cross over gender changer. MICRONIX USA supplies test connectors that simulate the vacuum feed through to allow for functionality testing prior to installation in a vacuum chamber. For details regarding the pin-out and feed through specifications see the Appendix sections A.6.5, A.6.6.

5.1.3.1 MII 6000 Digital Encoder Wiring Diagram



Piezo and Linear Versions

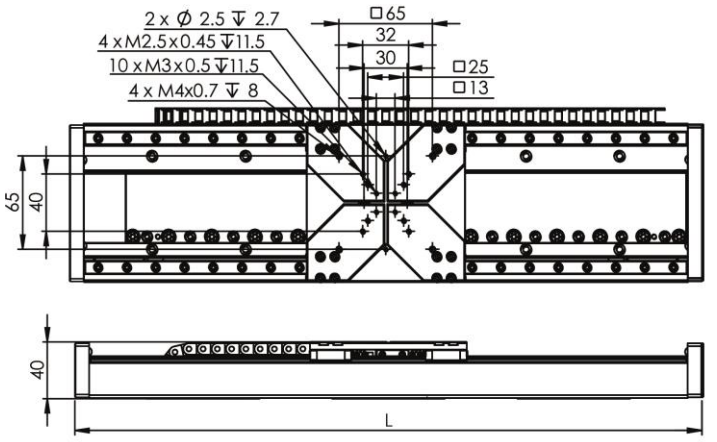


Temporary test connectors are standard. Requires customer supplied feed through connector

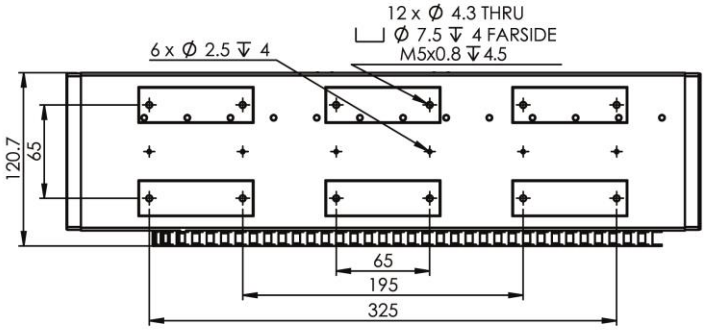
External Stepper Version

6. Dimensions

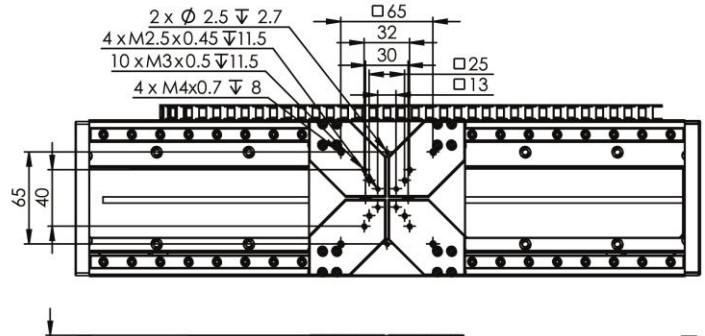
6.1 PPS-110 Internal Motor Versions (Linear and Piezo)



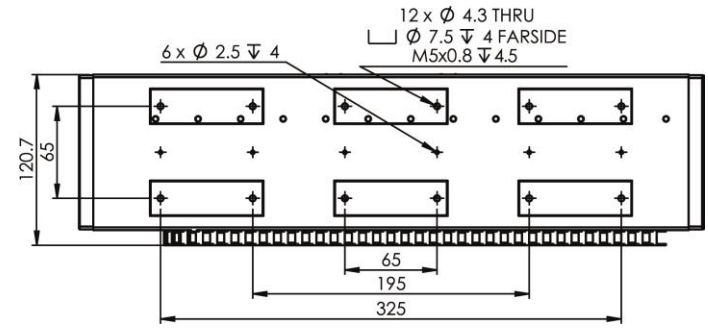
Linear Motor Version



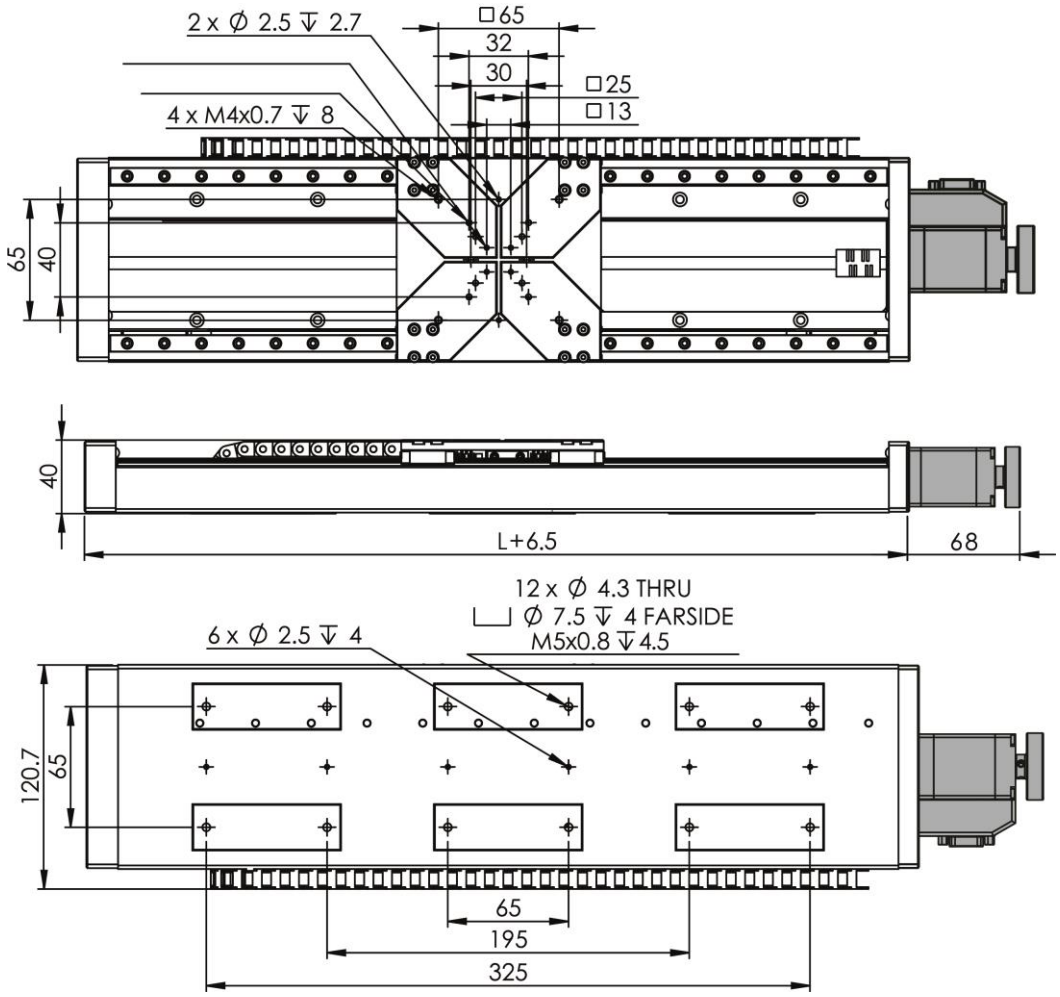
Travel [mm]	L [mm]	A [mm]	B [mm]
100	240	195	-
200	340	195	-
300	440	195	325
500	640	455	585
1000	1140	455	585



Piezo Motor Version



6.2 PPS-110 External Stepper Motor Version

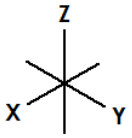


Travel [mm]	L [mm]	A [mm]	B [mm]
100	240	195	-
200	340	195	-
300	440	195	325
500	640	455	585
1000	1140	455	585

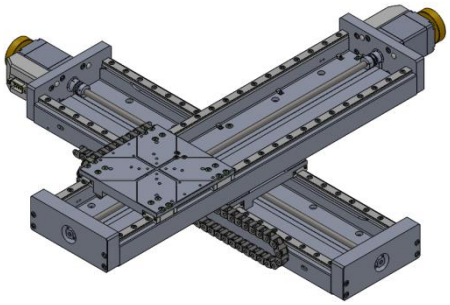
7. Stacking Configurations

7.1 Configuration Examples

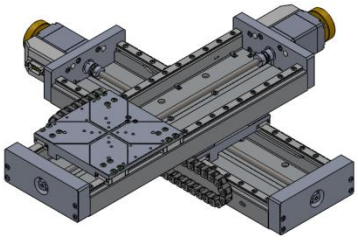
- Additional configurations available upon request
- Note: Stacking compatibility for all motor configurations.
- Positioning according to:



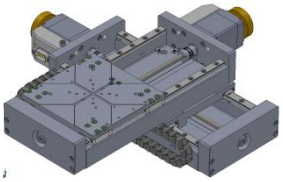
No Adapters



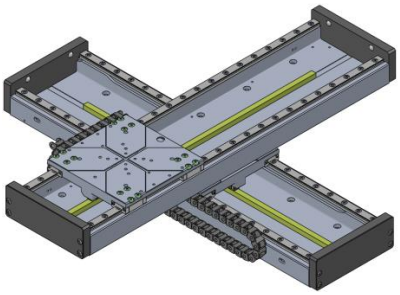
X-Y 300x300mm SM



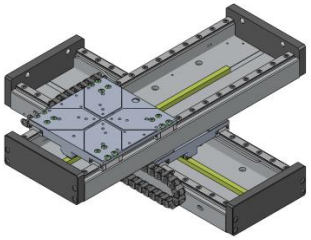
X-Y 200x200mm SM



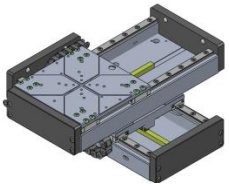
X-Y 100x100mm SM



X-Y 300x300mm PM



X-Y 200x200mm PM



X-Y 100x100mm PM

8. Supplementary Information

8.1 Maintenance

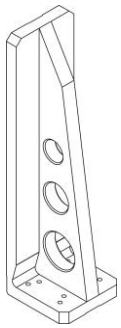
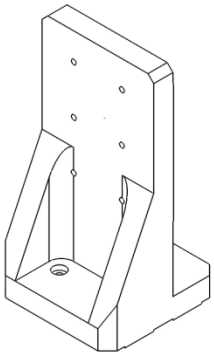
- The PPS-110 series of linear stages utilizes a maintenance free design. Do not modify the stage or perform any maintenance unless specifically instructed to do so by MICRONIX USA personal. If the stage is not performing up to the original specifications, please contact MICRONIX USA.
- The PPS-110 series of linear stages are precision mechanical device and should be handled with care. Do not drop or mishandle the stage.
- Do not touch the bearings, as this will contaminate the lubrication and jeopardize the longevity of the stage.
- Follow the *Installation Preparation* requirements and use proper cable management to ensure a clean and safe operating environment.

8.2 Units and Conventions

All measurements in this document are in the metric system of units.

Metric Unit	English Unit
1 millimeter	0.0394 inches
1 micron	0.0000394 inches
1 Newton	0.2248 lbs.
1 Newton-meter	8.85 in-lbs.

8.3 Accessories

430828 Z Bracket PPS-60	430613 Z Bracket PPS-60
	
Used to adapt the PPS-110 series to a perpendicular PPS-60 for XZ mounting configurations.	Used to adapt the PPS-110 series to a perpendicular PPS-60 for XZ mounting configurations.

A. Appendix

A.1 Stepper Motor

A.1.1 Standard Atmospheric DB-9 Male Motor Connector

		Wire Color
Pin	***Function***	***External Stepper SM-003***
1	***Motor A+***	***Red***
2	***Motor A-***	***Blue***
3	***Motor B+***	***Green***
4	***Motor B-***	***Black***
5	***Limit Switch GND***	***Brown***
6	***Limit Switch+***	***White***
7	***Limit Switch-***	***Violet***
8	***N/C***	***N/C***
9	***N/C***	***N/C***
**** White motor wire may be changed to green or blue in the future***		

- For vacuum prepared wiring, blue may be substituted for green/white, and black for red/white.

A.1.2 Stepper Motor Specifications

External Stepper Motor

Motor Type	2 Phase Bipolar
Phase Current	1.3 A Max
Step Angle	1.8°
Steps	200
Coil-Resistance	1.9 Ohms
Coil-Inductance	1.7 mH
Pitch	1 mm/rev
Resolution/Full step	5 µm

A.2 Linear Motor

A.2.1 Standard Atmospheric DB-9 Male Motor Connector

Linear Motor		
Pin	***Function***	***Wire Color***
1	***A***	***Red***
2	***B***	***Black***
3	***C***	***White****
4	***N/C***	***N/C***
5	***Limit Switch GND***	***Brown***
6	***Limit Switch+***	***White***
7	***Limit Switch-***	***Violet***
8	***N/C***	***N/C***
9	***N/C***	***N/C***

A.2.2 Linear Motor Specifications

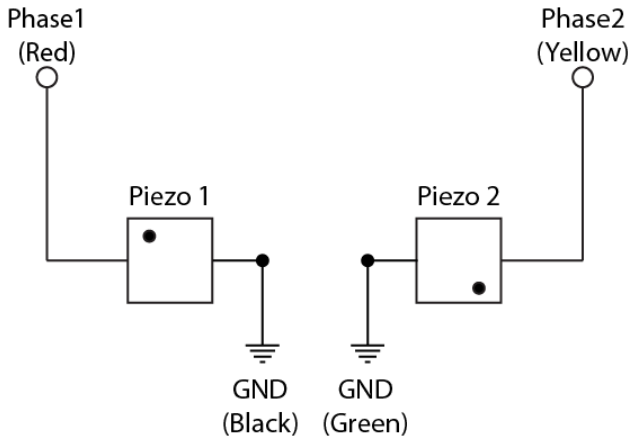
Linear Motor	
Continuous Force	2.7 N
Continuous Current	0.8 Arms
Acceleration Force	10.8 N
Acceleration Current	3.4 Arms
Force Constant (K_f)	3.2 N/Arms
Back EMF (K_e)	1.1 V/m/s
Resistance 25°C	6.8 Ohms
Inductance	1.0 mH
Electric Time Constant	0.147ms
Rated Voltage (AC)	240 V
Fundamental Motor Constant (K_m)	1.23 N$\sqrt{W}$
Magnetic Pitch (North-North)	30mm

A.3 Piezo Motor

A.3.1 Standard Atmospheric DB-9 Male Motor Connector

Piezo Motor		
Pin	*Function*	*Wire Color*
1	*Phase 1 + Motor 1*	*Red*
1	*Phase 1 + Motor 2*	*White*
5	*Phase 1 GND Motor 1*	*Black*
5	*Phase 1 GND Motor 2*	*Grey*
2	*Phase 2 + Motor 1*	*White* / *Green*
2	*Phase 2 + Motor 1*	*White* / *Blue*
5	*Phase 2 GND Motor 1*	*Green*
5	*Phase 2 GND Motor 2*	*Blue*
6	*Limit +*	*White* / *Violet*
7	*Limit -*	*Violet*
8	*Limit GND*	*Brown*

A.3.2 2 Phase Piezo Motor Wiring Connections



A.4 Limit Switches

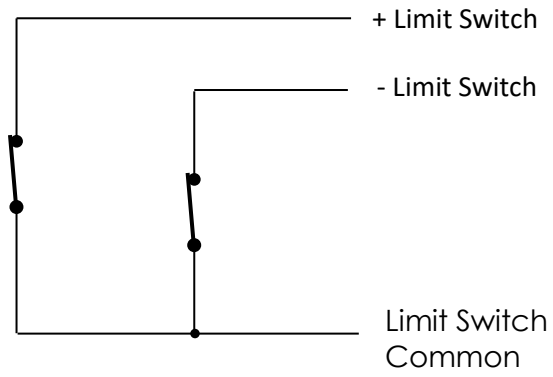
The limit switches are normally closed (when not activated) and should be connected to a compatible controller that recognizes these settings. A hard stop is designed into the PPS-110 body which will prevent the carriage from running away should the limit switches fail.

The mechanical limit switches are factory calibrated to ensure advertised travel length and cannot be adjusted by the customer. Optical limit switches can be factory adjusted to custom, specific travel lengths. For custom travel lengths, please contact MICRONIX USA.

A.4.1.1 Mechanical Limit Switches

Contact Rating	100 mA @ 30 V
Contact Type	Normally Closed
Operating Temperature	-25 to +70 °C

A.4.1.2 Limit Switch Schematic



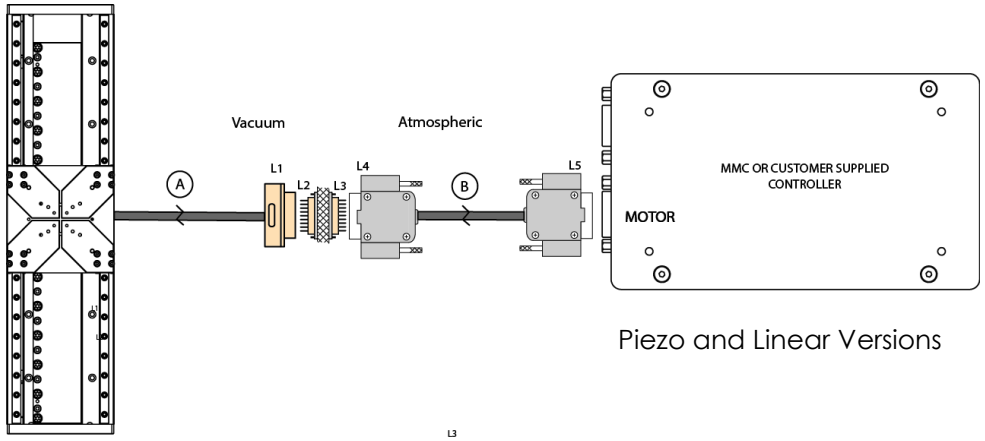
A.5 Open Loop Vacuum Wiring Diagram

Standard Cable Descriptions:

A. PPS-110 Motor Cable - Vacuum Side (Female Dsub 9 Pin Peek Connector)

B. Atmospheric Motor Connector (Female Dsub 9 Pin to Male Dsub 9 Pin)

Wiring Diagram:



Piezo and Linear Versions

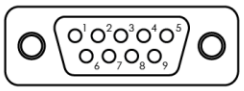
Piezo Motor Connector Pinout

Description	Color	L1	L2	L3	L4	L5
Phase 1	Red	5	5	1	1	1
Phase 2	Yellow	4	4	2	2	2
Limit Switch -	Violet	8	8	7	7	7
Motor Ground	Green&Blk	1	1	5	5	5
Limit Ground	Brown	7	7	8	8	8
Limit Switch+	White	9	9	6	6	6

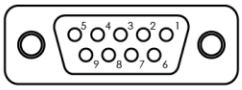
-Motor

Internal Stepper Motor Connector Pinout

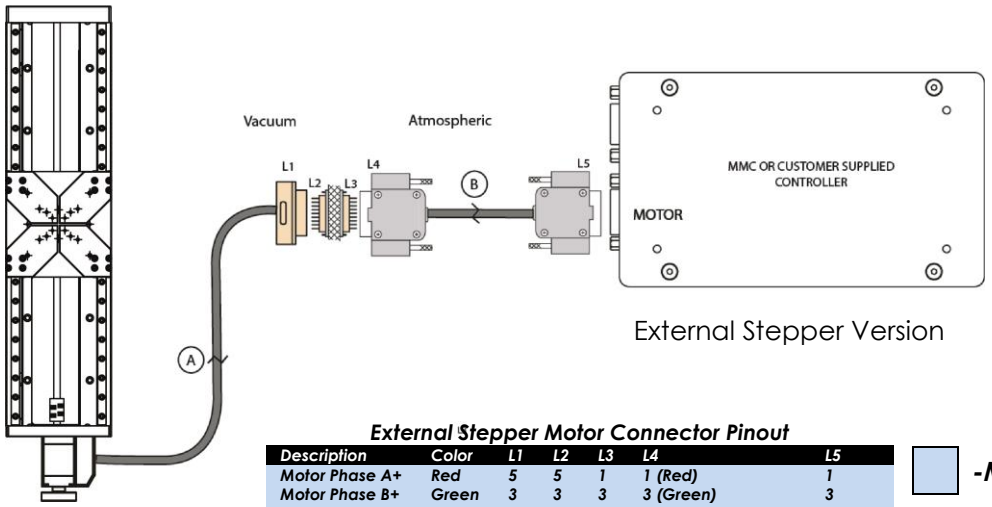
Description	*Color*	*L1*	*L2*	*L3*	*L4*	*L5*
Motor Phase A+	*Green*	*5*	*5*	*1*	*1 (Green)*	*1*
Motor Phase A-	*Green & White*	*4*	*4*	*2*	*2 (White - Green TP)*	*2*
Motor Phase B+	*Red & White*	*3*	*3*	*3*	*3 (Black)*	*3*
Motor Phase B-	*Red*	*2*	*2*	*4*	*4 (Red)*	*4*
Limit Ground	*Brown*	*1*	*1*	*5*	*5 (Brown)*	*5*
Limit Switch +	*Violet*	*9*	*9*	*6*	*6 (Violet)*	*6*
Limit Switch-	*White*	*8*	*8*	*7*	*7 (White - Violet TP)*	*7*
Shield	*-*	*6*	*6*	*9*	*9 (Shield)*	*Casing*



Female Dsub9 Connector - Rear View



Male Dsub9 Connector - Rear View

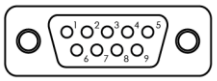


External Stepper Version

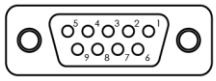
External Stepper Motor Connector Pinout

Description	Color	L1	L2	L3	L4	L5
Motor Phase A+	Red	5	5	1	1 (Red)	1
Motor Phase B+	Green	3	3	3	3 (Green)	3
Limit Switch +	White	9	9	6	6 (White - Violet TP)	6
Motor Phase A-	Blue	4	4	2	2 (Black)	2
Motor Phase B-	Black	2	2	4	4 (White - Green TP)	4
Limit Switch-	Violet	8	8	7	7 (Violet)	7
Limit Ground	Brown	1	1	5	5 (Brown)	5
Shield	-	6	6	9	9 (Shield)	Casing

-Motor

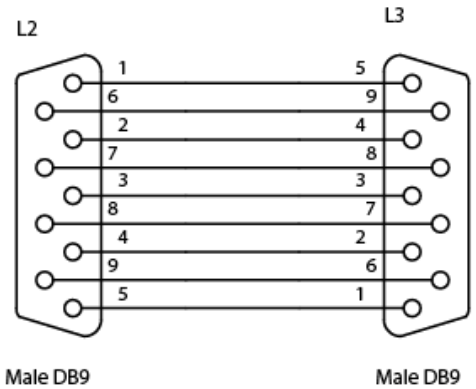


Female Dsub9 Connector - Rear View



Male Dsub9 Connector - Rear View

A.5.1 Straight Through 9-Pin Feed Through



Male DB9 Male DB9

A.6 Using the Digital Encoder Module

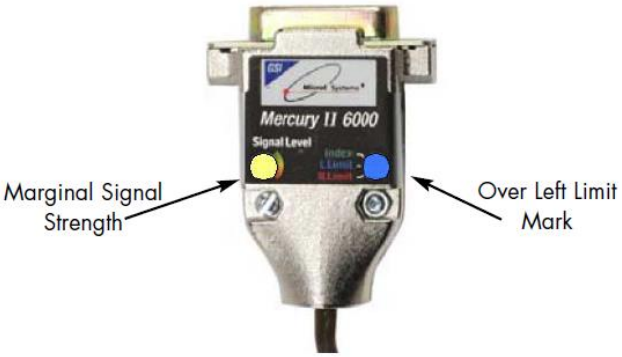
When using the digital external encoder configuration, the Encoder Module should display two green LED's indicating a power source and proper encoder alignment. A Red or Yellow Signal Level LED indicates misalignment of the Encoder Head, if this occurs contact MICRONIX USA. Do not adjust the Encoder Head or scale. For more information refer to MicroE Systems Mercury Encoders.

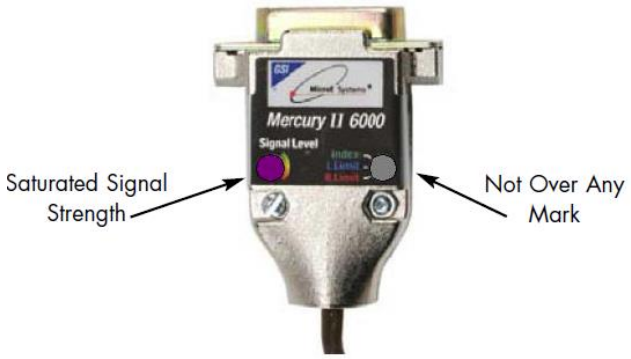
A.6.1 *Encoder Module Pin-out*

Pin	Description	Pin	Description
1	*Right Limit+	9	Ground
2	Ground	10	*Left Limit+
3	*Right Limit-	11	*Left Limit-
4	Index-	12	Index+
5	B-	13	B+
6	A-	14	A+
7	+5V	15	(not used)
8	+5V		

*-Limits must be specified at the time of order, and calibrated at the factory.
Note: Tri-state alarm: A and B are tri-stated if the encoder signal becomes too low for reliable operation.

Normal Operation

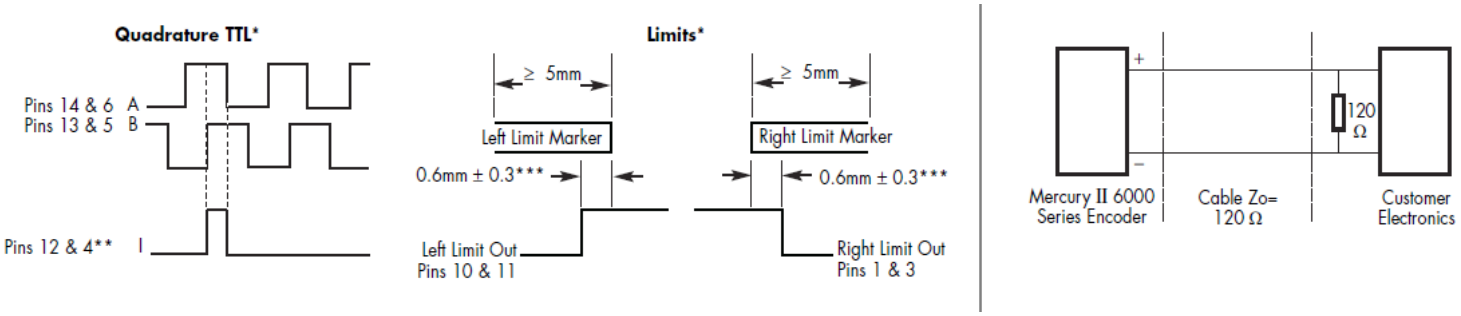




A.6.2 *Operating and Electrical Specifications*

Power Supply	5VDC ±5% @ 140mA (No outputs terminated) @ 180mA (A, B, I, and both limits terminated); 50mA at the sensor
Operating Temperature	0 to 70°C
Humidity	10 - 90% RH non-condensing

A.6.3 Output Signals & Signal Termination for A quad B, Index and limits



*Output signals are differential. Inverse signals are not shown for clarity.

**Note: At some interpolations values the index pulse may be aligned with other states of A or B than the ones shown.

***Above are with reference to the sensor's optical centerline

A.6.4 Resolution

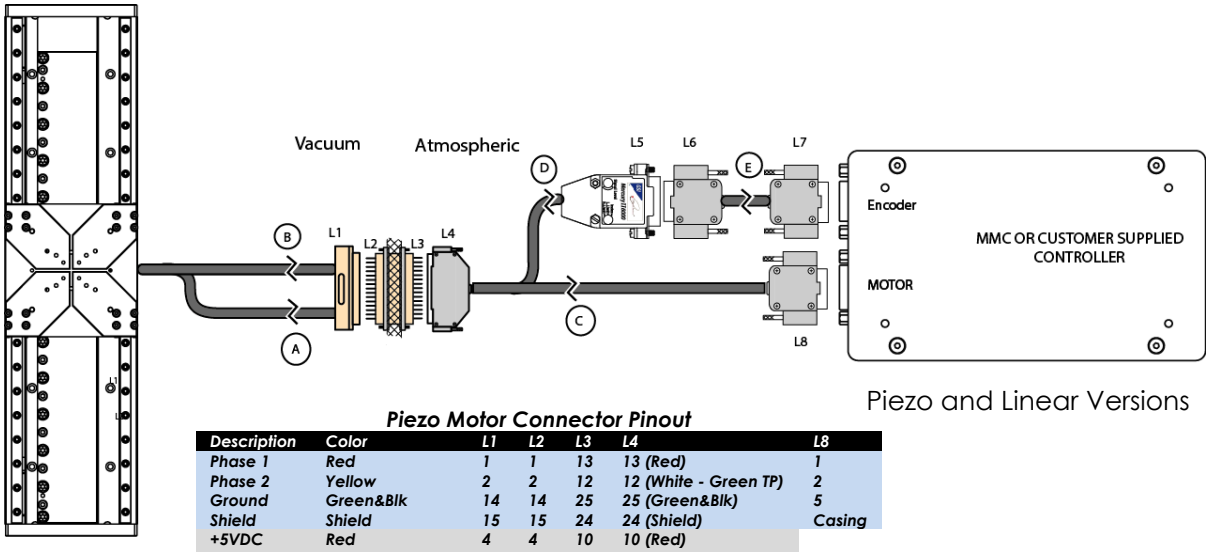
All closed loop stages are supplied with 20µm scales. The digital encoder module interpolates to a higher resolution as specified in the order. With a digital encoder an MMC controller has an achievable resolution of 2nm.

A.6.5 MII 6000 Digital Wiring Diagram

Standard Cable Descriptions:

A. PPS-110 Motor Cable - Vacuum Side
B. PPS-110 Encoder Cable - Vacuum Side
(Female Dsub 25 Pin Peek Connector)
C. Atmospheric Motor Cable (Female Dsub 25 Pin to Male Dsub 9 Pin)
D. Atmospheric Encoder Module Cable (Female Dsub 25 Pin to MII 6000 Interpolator Module)
E. Encoder Module Adapter Cable (Female Dsub 15 to Female Dsub 9 Pin)

Wiring Diagram:



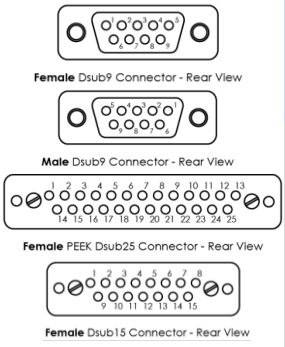
Piezo and Linear Versions

Piezo Motor Connector Pinout

Description	*Color*	*L1*	*L2*	*L3*	*L4*	*L8*
Phase 1	*Red*	*1*	*1*	*13*	*13 (Red)*	*1*
Phase 2	*Yellow*	*2*	*2*	*12*	*12 (White - Green TP)*	*2*
Ground	*Green&Blk*	*14*	*14*	*25*	*25 (Green&Blk)*	*5*
Shield	*Shield*	*15*	*15*	*24*	*24 (Shield)*	*Casing*
+5VDC	*Red*	*4*	*4*	*10*	*10 (Red)*	
GND	*Black*	*17*	*17*	*22*	*22 (Black)*	
DCLK-	*Gray*	*5*	*5*	*9*	*9 (Gray)*	
DCLK+	*White - Gray TP*	*18*	*18*	*21*	*21 (White - Gray TP)*	
MISO-	*Violet*	*6*	*6*	*8*	*8 (Violet)*	
MISO+	*White - Violet TP*	*19*	*19*	*20*	*20 (White - Violet TP)*	
MOSI-	*Blue*	*7*	*7*	*7*	*7 (Blue)*	
MOSI+	*White - Blue TP*	*20*	*20*	*19*	*19 (White - Blue TP)*	
nSS-	*Green*	*8*	*8*	*6*	*6 (Green)*	
nSS+	*White - Green TP*	*21*	*21*	*18*	*18 (White - Green TP)*	
CLK-	*Brown*	*9*	*9*	*5*	*5 (Brown)*	
CLK+	*White - Brown TP*	*22*	*22*	*17*	*17 (White - Brown TP)*	
Shield	*Shield*	*16*	*16*	*23*	*N/C*	

Internal Stepper Motor Connector Pinout

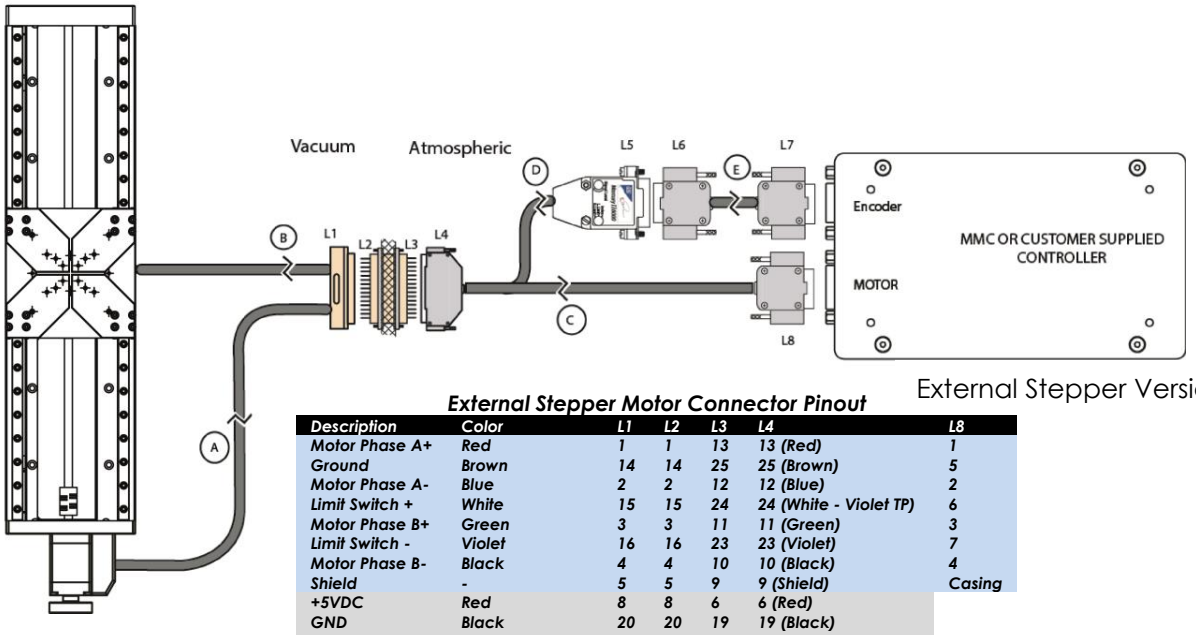
Description	*Color*	*L1*	*L2*	*L3*	*L4*	*L8*
Motor Phase A+	*Green*	*1*	*1*	*13*	*13 (Green)*	*1*
Ground	*Brown*	*14*	*14*	*25*	*25 (Brown)*	*5*
Motor Phase A-	*Green & White*	*2*	*2*	*12*	*12 (White - Green TP)*	*2*
Limit Switch +	*Violet*	*15*	*15*	*24*	*24 (Violet)*	*6*
Motor Phase B+	*Red & White*	*3*	*3*	*11*	*11 (Black)*	*3*
Limit Switch -	*White*	*16*	*16*	*23*	*23 (White - Violet TP)*	*7*
Motor Phase B-	*Red*	*4*	*4*	*10*	*10 (Red)*	*4*
Shield	*-*	*5*	*5*	*9*	*9 (Shield)*	*Casing*
+5VDC	*Red*	*8*	*8*	*6*	*6 (Red)*	
GND	*Black*	*20*	*20*	*19*	*19 (Black)*	
DCLK-	*Gray*	*9*	*9*	*5*	*5 (Gray)*	
DCLK+	*White - Gray TP*	*21*	*21*	*18*	*18 (White - Gray TP)*	
MISO-	*Violet*	*10*	*10*	*4*	*4 (Violet)*	
MISO+	*White - Violet TP*	*22*	*22*	*17*	*17 (White - Violet TP)*	
MOSI-	*Blue*	*11*	*11*	*3*	*3 (Blue)*	
MOSI+	*White - Blue TP*	*23*	*23*	*16*	*16 (White - Blue TP)*	
nSS-	*Green*	*12*	*12*	*2*	*2 (Green)*	
nSS+	*White - Green TP*	*24*	*24*	*15*	*15 (White - Green TP)*	
CLK-	*Brown*	*13*	*13*	*1*	*1 (Brown)*	
CLK+	*White - Brown TP*	*25*	*25*	*14*	*14 (White - Brown TP)*	
Shield	*-*	*7*	*7*	*7*	*7 (Shield)*	



-Encoder

-Motor

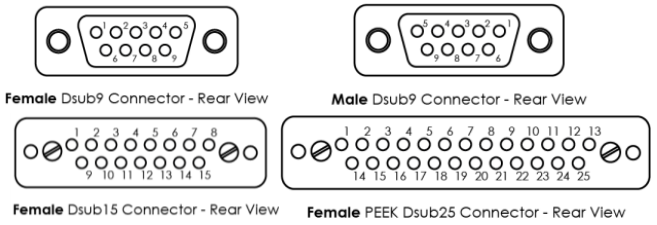
- ***Note: For the pinout of cable E, refer to the appropriate MMC manual.***

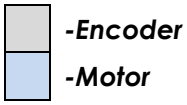


External Stepper Version

External Stepper Motor Connector Pinout

Description	Color	L1	L2	L3	L4	L8
Motor Phase A+	Red	1	1	13	13 (Red)	1
Ground	Brown	14	14	25	25 (Brown)	5
Motor Phase A-	Blue	2	2	12	12 (Blue)	2
Limit Switch +	White	15	15	24	24 (White - Violet TP)	6
Motor Phase B+	Green	3	3	11	11 (Green)	3
Limit Switch -	Violet	16	16	23	23 (Violet)	7
Motor Phase B-	Black	4	4	10	10 (Black)	4
Shield	-	5	5	9	9 (Shield)	Casing
+5VDC	Red	8	8	6	6 (Red)	
GND	Black	20	20	19	19 (Black)	
DCLK-	Gray	9	9	5	5 (Gray)	
DCLK+	White - Gray TP	21	21	18	18 (White - Gray TP)	
MISO-	Violet	10	10	4	4 (Violet)	
MISO+	White - Violet TP	22	22	17	17 (White - Violet TP)	
MOSI-	Blue	11	11	3	3 (Blue)	
MOSI+	White - Blue TP	23	23	16	16 (White - Blue TP)	
nSS-	Green	12	12	2	2 (Green)	
nSS+	White - Green TP	24	24	15	15 (White - Green TP)	
CLK-	Brown	13	13	1	1 (Brown)	
CLK+	White - Brown TP	25	25	14	14 (White - Brown TP)	
Shield	-	7	7	7	7 (Shield)	





- ***Note: For the pinout of cable E, refer to the appropriate MMC manual.***

A.6.6 Straight Through 25-pin Feed Through