Daedal

Manual No. 100-5322-01
Rev. 1

412LXR Series Product Manual

Effective: February 12, 2002
Supersedes:

Electromechanical Positioning Systems

Parker
Automation

Important User Information

WARNING

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from Parker Hannifin Corporation, its subsidiaries, and authorized distributors provide product and/or system options for further investigation by users having technical expertise. It is important that you analyze all aspects of your application and review the information concerning the product or system in the current product catalog. Due to the variety of operating conditions and applications for these products or systems, the user, through its own analysis and testing, is solely responsible for making the final selection of the products and systems and assuring that all performance, safety and warning requirements of the application are met.

The products described herein, including without limitation, product features, specifications, designs, availability and pricing, are subject to change by Parker Hannifin Corporation and its subsidiaries at any time without notice.

Since Parker Hannifin Corporation, Daedal Division constantly strives to improve all of its products, we reserve the right to change this product manual and equipment mentioned therein at any time without notice.

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412LXR Series Product Manual

Table of Contents

Revision Notes

Chapter 1 - Introduction

Product Description

412LXR Positioner
The 412LXR is a slotless, brushless linear servo motor/square rail bearing positioner housed within a high strength, aluminum body with magnetically retained protective seals. The positioner is powered by three rails of high energy rare earth magnets. Load bearing members provide heavy load and moment capacity, dynamic stiffness and precise straightness and flatness of travel. The positioner's integral linear encoder provides high precision, non-contact positional feedback with selectable resolutions from 0.1 to 5.0 microns. The positioner is also offered with proximity limit & home sensors, a "Quick Connect", extended life, and a cable transport system.

Unpacking

⚠ **Unpacking**
Carefully remove the positioner from the shipping crate and inspect the unit for any evidence of shipping damage. Report any damage immediately to your local authorized distributor. Please save the shipping crate for damage inspection or future transportation.

Incorrect handling of the positioner may adversely affect the performance of the unit in its application. Please observe the following guidelines for handling and mounting of your new positioner.

- DO NOT allow the positioner to drop onto the mounting surface. Dropping the positioner can generate impact loads that may result in flat spots on bearing surfaces or misalignment of drive components.

- DO NOT drill holes into the positioner. Drilling holes into the positioner can generate particles and machining forces that may effect the operation of the positioner. Daedal will drill holes if necessary; contact your local authorized distributor.

- DO NOT subject the unit to impact loads such as hammering, riveting, etc. Impacts loads generated by hammering or riveting may result in flat spots on bearing surfaces or misalignment of drive components.

- DO NOT lift the positioner by cables or cable management system. Lifting postioner by cables or cable management system may effect electrical connections and/or cable management assembly. The unit should be lifted by the base structure only.

- DO NOT push in magnetically retained strip seals when removing positioner from shipping crate. Damaging strip seals may create additional friction during travel and may jeopardize the ability of the strip seals to protect the interior of the positioner.

- DO NOT submerge the positioner in liquids.

- DO NOT disassemble positioner. Unauthorized adjustments may alter the positioner's specifications and void the product warranty.

Return Information

Returns
All returns must reference a "*R*eturn *M*aterial *A*uthorization", *(RMA)*, number. Please call your local authorized distributor or Daedal Customer Service Department at 800-245-6903 to obtain a "RMA" number. See Daedal Catalog #8080/USA, page D34, for additional information on returns and warranty.

Repair Information

Out-of-Warranty Repair
Our Customer Service Department repairs Out-of-Warranty products. All returns must reference a "RMA" number. Please call your local authorized distributor or Daedal Customer Service Department at 800-245-6903 to obtain a "RMA" number. You will be notified of any cost prior to making the repair.

Warnings and Precautions

Hot Surfaces
DO NOT touch 'carriage forcer', (see page 7, *Assembly Diagram*, for component location), after high duty operation. Unit *may* be too HOT to handle.

Electrical Shock
DO NOT take apart or touch any internal components of the positioner while unit is plugged into an electrical outlet. SHUT OFF power before replacing components to avoid electrical shock.

High Magnetic Field
Unit may be HAZARDOUS to people with Pace Makers or any other 'magnetically-sensitive' medical devices. Unit may have an effect on 'magnetically-sensitive' applications.

Ferrous Materials
The positioner's 'protective seals' MAY NOT keep out all small ferrous materials in applications with air born metallic particles. The customer must take additional precautions in these applications to keep positioner free of these highly magnetic particles.

Vertical Operation
The 412LXR is NOT recommended for vertical operation. The carriage and customer's load will fall in power loss situations potentially causing product damage or personal injury.

General Safety
Because linear motors can accelerate up to 5 g's, and sometimes positioners move without warning, keep all personnel away form dynamic travel range of positioner.

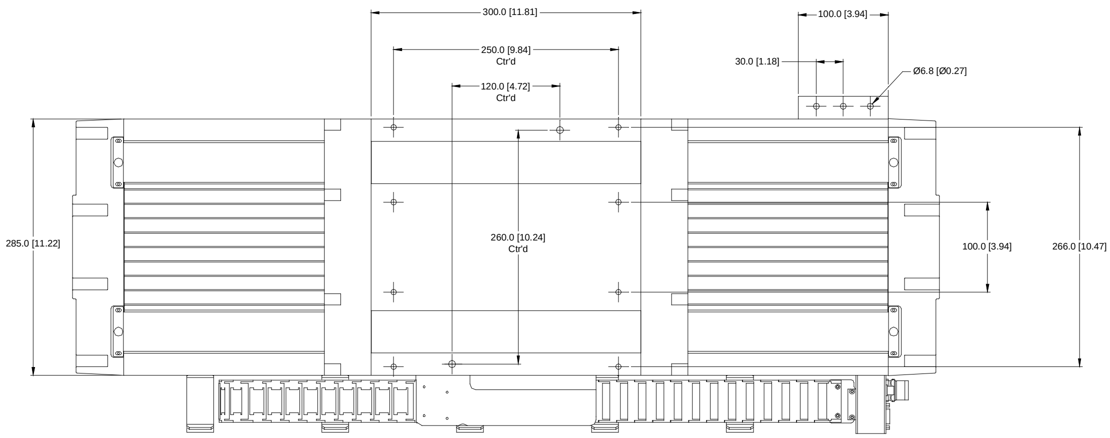
Specification Conditions and Conversions

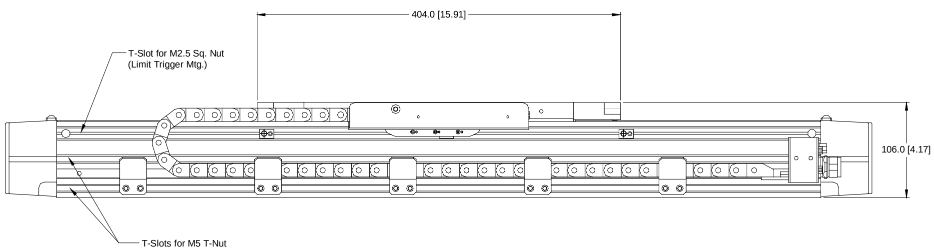
Specifications are Temperature Dependent
Catalog specifications are obtained and measured at 20 Degrees C. Specifications at any other temperature may *deviate* from catalog specifications. Minimum to maximum continuous operating *temperature range* (with NO guarantee of any specification except motion) of a standard unit before failure is 5 - 40 Degrees C.

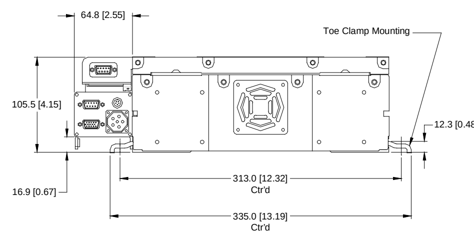
Specifications are Mounting Surface Dependent
Catalog specifications are obtained and measured when the positioner is *fully supported*, *bolted down*, and is mounted to a work surface that has a *maximum flatness error of 0.013mm/300mm (0.0005”/ft).*

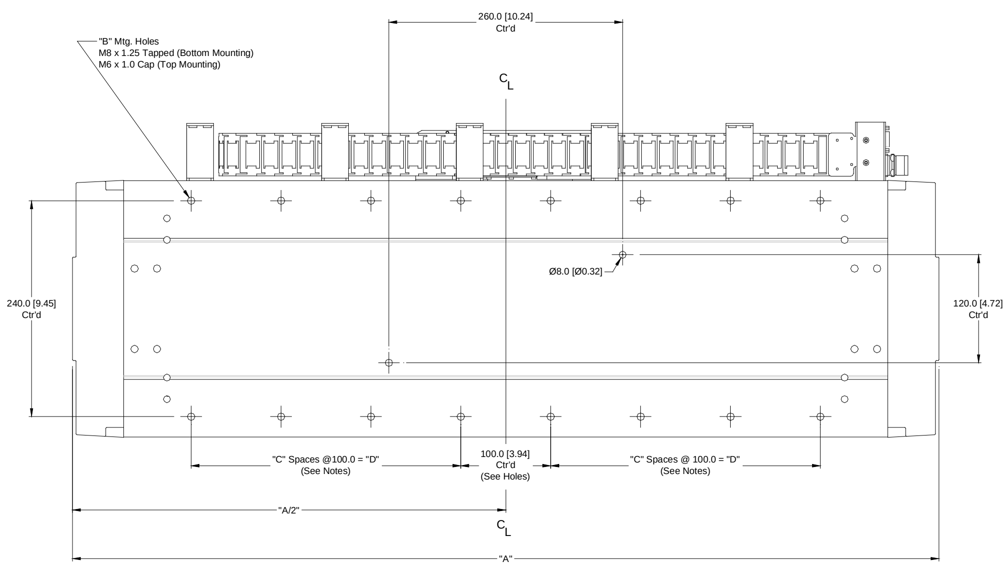
Specifications are Point of Measurement Dependent
Catalog specifications and specifications in this manual are measured from the center of the carriage, 38 mm above the carriage surface. All measurements taken at any other location may deviate from these values.

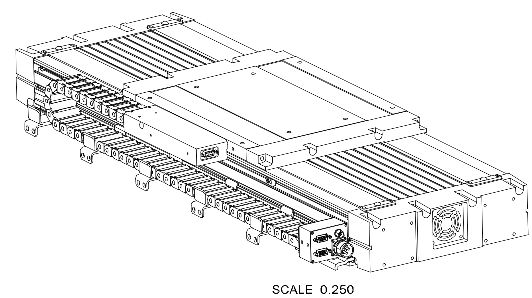
Assembly Diagrams











Notes:
- Base mounting holes for models 412T10 and 412T12 are patterned from one hole on centerline
- Dimensions "C" and "D" reflect 100.0 mm dimension from centerline

Model	Travel	“A”	“B”	“C”	“D”
412T01	150	764	12	2	200
412T02	250	864	16	3	300
412T03	350	964	16	3	300
412T04	650	1264	24	5	500
412T05	800	1414	24	5	500
412T06	1000	1614	28	6	600
412T07	1200	1814	32	7	700
412T08	1500	2114	40	9	900
412T09	1750	2364	44	10	1000
412T10	2000	2614	50	12	1200
412T11	2500	3114	60	14	1400
412T12	3000	3614	70	17	1700

Chapter 2 - 412LXR Series Table Specifications

Order Number Nomenclature

412LXR How to Order

Order Example

412	T09	LXR	M	P	D15	H3	L3	CM2	Z2	E2	R1	A7	P1

Series 412

Travel (mm) 12 Pole Motor

150 ...	T01	1200 ...	T07
250 ...	T02	1500 ...	T08
350 ...	T03	1750 ...	T09
650 ...	T04	2000 ...	T10
800 ...	T05	2500 ...	T11
1000 ...	T06	3000 ...	T12

Model .... LXR

Mounting (metric).......... M

Grade

Precision .... P

Drive Type

Free Travel (No Motor) D5

12 Pole Motor D15

Home Sensor

None-Free Travel (only) H1

N.C. Current Sinking.......... H2

N.O. Current Sinking H3

N.C. Current Sourcing H4

N.O. Current Sourcing H5

Limit Sensor

None-Free Travel (only) L1

N.C. Current Sinking.......... L2

N.O. Current Sinking L3

N.C. Current Sourcing L4

N.O. Current Sourcing L5

Pinning Option

P1 No Multi-Axis Pinning

P2 X-Axis Carriage - Dowel Pins (matched to Y-Axis Base)

P3 Y-Axis Base - Dowel Pin Holes (matched to X-Axis Carriage)

Digital Drive

A1 No Drive

A7 GV-U12E Drive

A8 GV6-U12E Controller/Drive

Environmental

R1 Class 1000, Strip Seals

R2 Class 10 Clean Room Prep

Encoder Option

E1 None

E2 1.0 µm Resolution Linear

E3 0.5 µm Resolution Linear

E4 0.1 µm Resolution Linear

E5 5.0 µm Resolution Linear

E7 Sine Output Encoder

Z Channel Location*

Z1 None

Z2 Positive End Position

Z3 Center Position

Z4 Negative End Position

*Refer to dimension drawing on page 18

Cable Management

CM1 No Cables - Free Travel

CM2 Cable Transport Module (only)

CM3 3.0 m OEM Cable Set-FL

CM4 7.5 m OEM Cable Set-FL

CM5 3.0 m OEM Cable Set-Gem

CM6 7.5 m OEM Cable Set-Gem

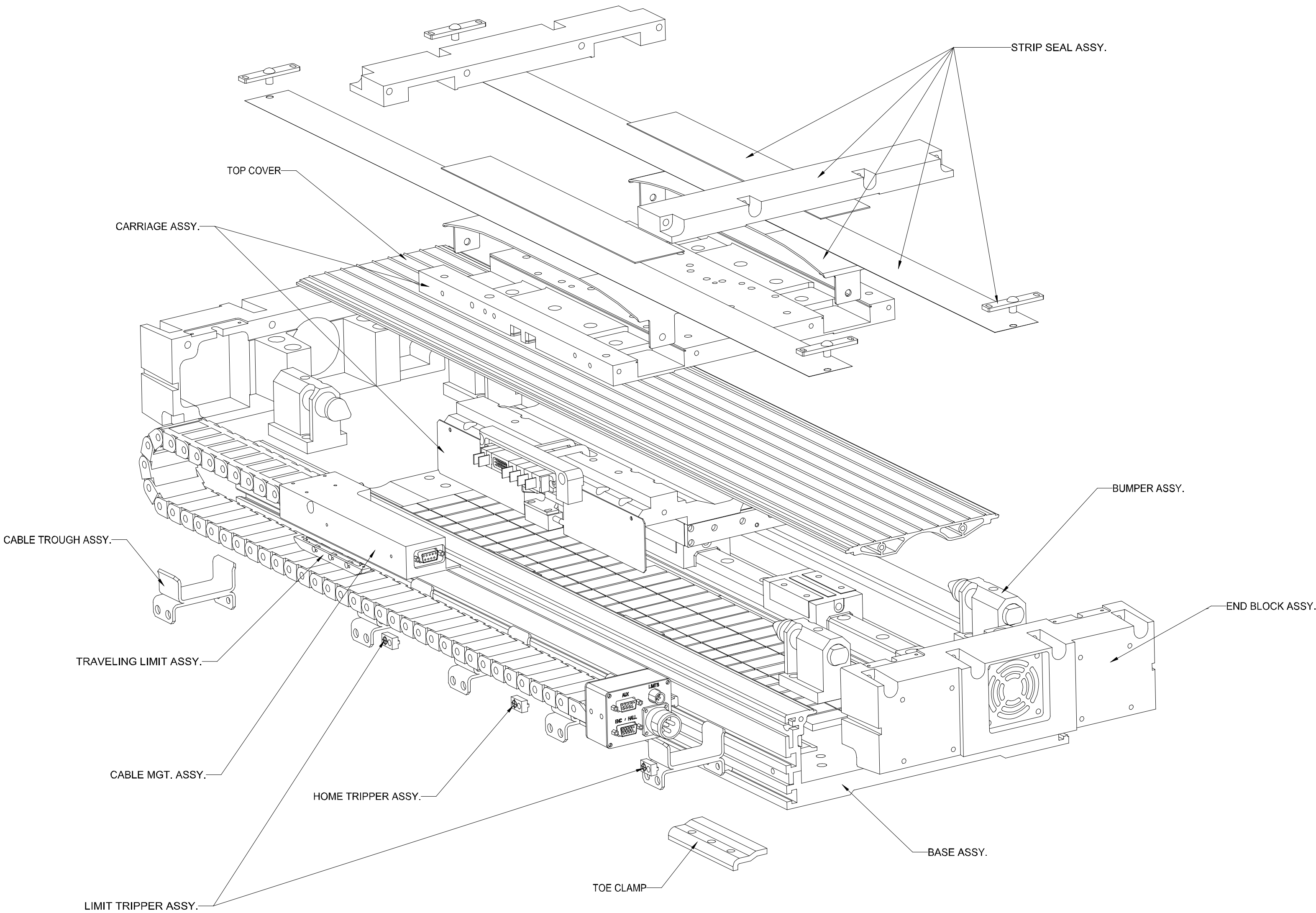
CM7 Cable Trans Mod. 3.0 m-FL

CM8 Cable Trans Mod. 7.5 m-FL

CM9 Cable Trans Mod. 3.0 m-Gem

CM10 Cable Trans Mod. 7.5 m-Gem

Dimensional Drawings



General Table Specifications

Specifications

Motor Model		12 Pole
Rated Load		900 kg
Maximum Acceleration		5 Gs
Maximum Velocity		
Resolution:	0.1 um	0.3 m/sec
	0.5 um	1.5 m/sec
	1.0 um	3.0 m/sec
	5.0 um	3.0 m/sec
Positional Repeatability		
Resolution:	0.1 um	+/- 1.0 um
	0.5 um	+/- 1.0 um
	1.0 um	+/- 2.0 um
	5.0 um	+/- 10.0 um
Maximum Force (Peak)		1000 N 225 lb.
Maximum Force (Continuous)		355 N 80 lb.
Carriage Weight		12.3 kg

Travel Dependent Specifications

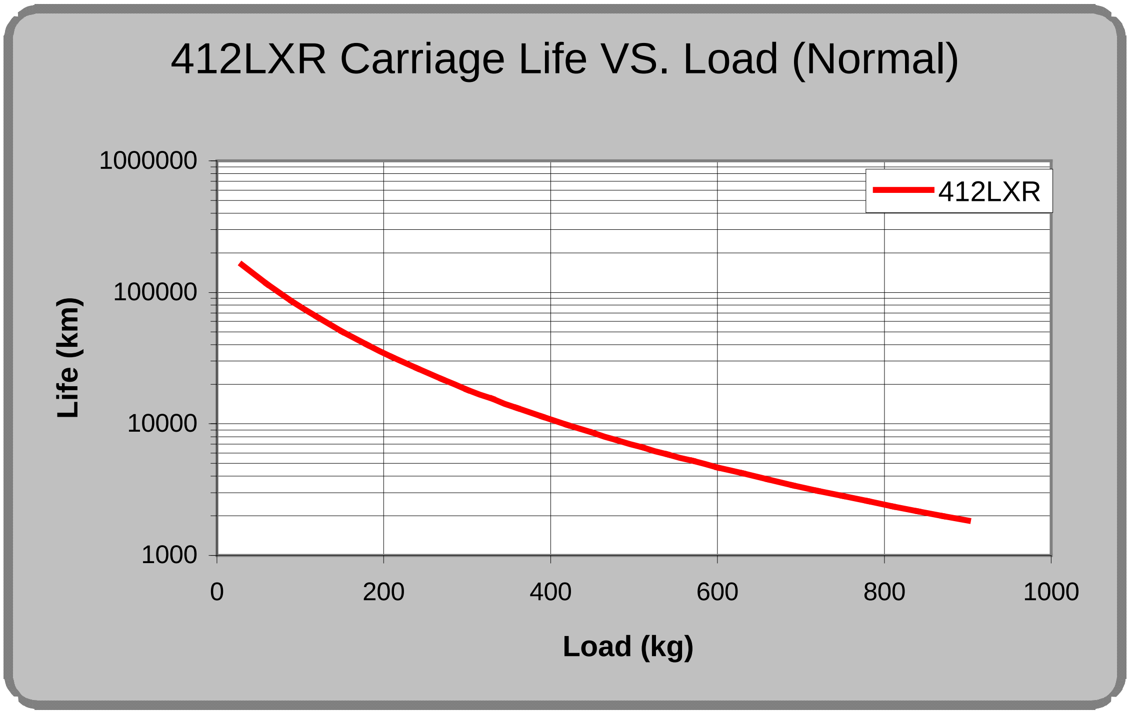
Travel (mm)	Accuracy*			Unit Weight (kg)
	Positional		Straightline Accuracy* (um)	
	0.1, 0.5, 1.0 resolution (um)	5.0 resolution (um)		
150	8	18	9	41
250	12	22	14	45
350	16	26	19	49
650	26	36	33	61
800	31	41	39	67
1000	35	45	47	75
1200	39	49	55	83
1500	44	54	64	95
1750	46	56	75	105
2000	48	58	79	113
2500	50	60	84	133
3000	50	60	84	153

* Accuracy stated is at 20 degrees C, utilizing slope correction factor provided.

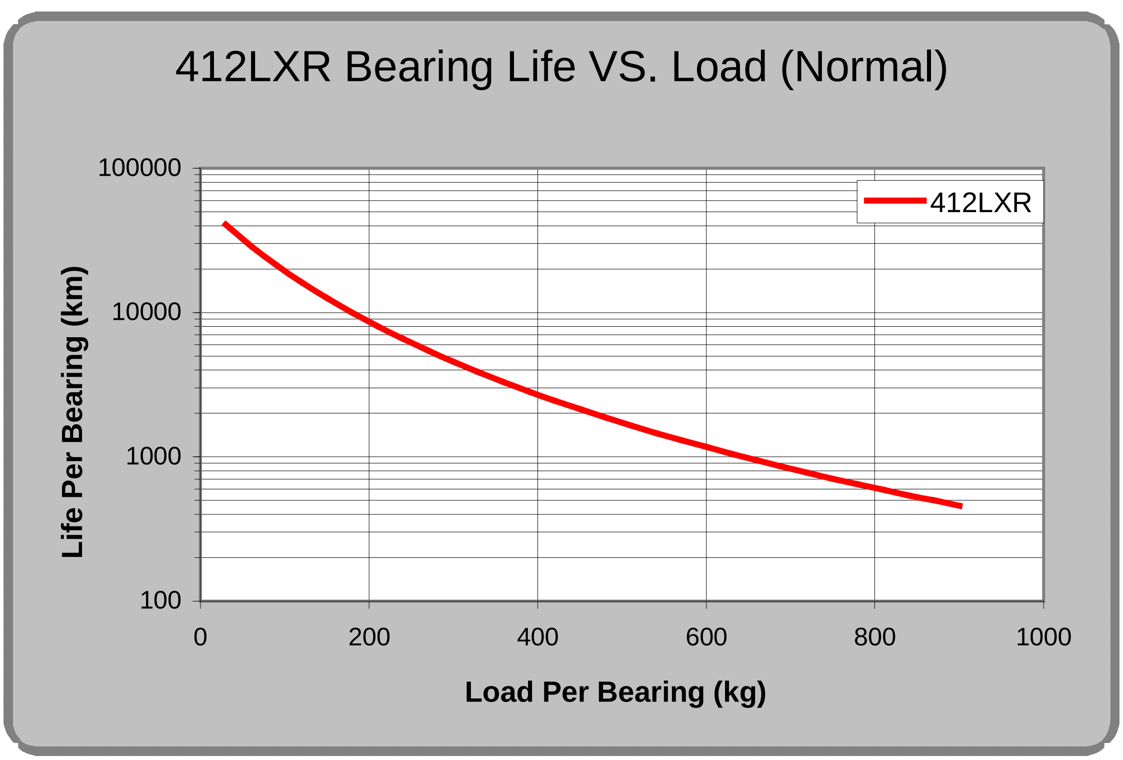
412LXR Series Technical Data

The useful life of a linear table at full catalog specifications is dependent on the forces acting upon it. These forces include both static components resulting from payload weight, and dynamic components due to acceleration/deceleration of the load. In multi-axes applications, the primary positioner at the bottom of the stack usually establishes the load limits for the combined axes. When determining load/life, it is critical to include the weight of all positioning elements that contribute to the load supported by the primary axis. The life/load charts are used to establish the table life relative to the applied loads.

Table Load Chart
The "Table Load" chart is intended to provide a rough-cut evaluation "life/load" characteristics of the carriage support bearings. This curve is based on the applied load being centered on the carriage, normal to the carriage mounting surface.

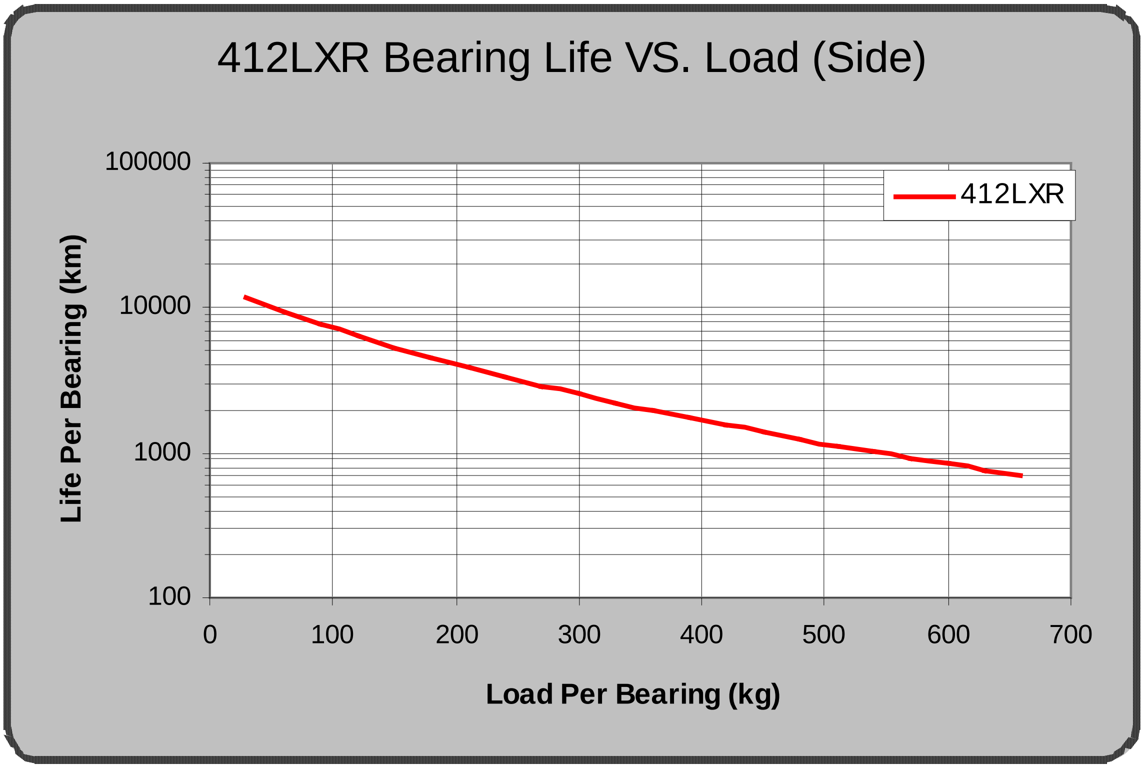


Bearing Load Chart
The "Bearing Load" chart is to be used in conjunction with the corresponding formulas on the following pages to establish the life/load for each bearing (4 per table). Several dimensions and the load geometry are required for these computations. The dimensions are referenced below.



Side Bearing Load Chart

The "Side Bearing Load" chart is to be used in conjunction with the corresponding formulas on the following pages to establish the life/load for each bearing (4 per table). Several dimensions and the load geometry are required for these computations. The dimensions are referenced below.



	d1	d2	da
12 Pole	205	192	43

Horizontal Translation — Normal Load

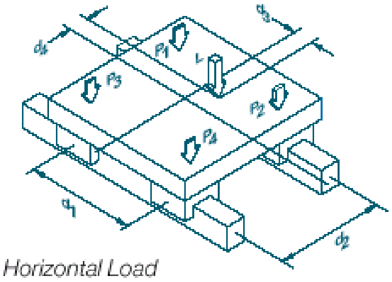


Figure 1: Horizontal Load

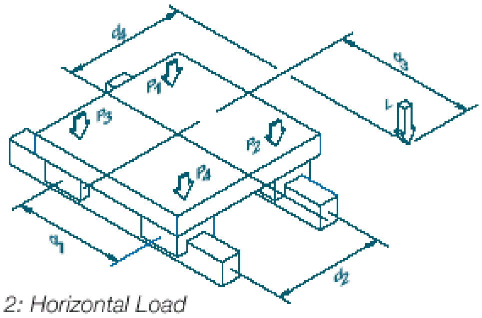


Figure 2: Horizontal Load

$$P_1 = \left[\frac{L}{4}\right] - \left[\frac{L}{2} \cdot \frac{d_3}{d_1}\right] + \left[\frac{L}{2} \cdot \frac{d_4}{d_2}\right]$$

$$P_2 = \left[\frac{L}{4}\right] + \left[\frac{L}{2} \cdot \frac{d_3}{d_1}\right] + \left[\frac{L}{2} \cdot \frac{d_4}{d_2}\right]$$

$$P_3 = \left[\frac{L}{4}\right] - \left[\frac{L}{2} \cdot \frac{d_3}{d_1}\right] - \left[\frac{L}{2} \cdot \frac{d_4}{d_2}\right]$$

$$P_4 = \left[\frac{L}{4}\right] + \left[\frac{L}{2} \cdot \frac{d_3}{d_1}\right] - \left[\frac{L}{2} \cdot \frac{d_4}{d_2}\right]$$

Figure 1 shows a normal load applied to the carriage translating horizontally. The vector L, defined by the CG of the load, is shown applied at a point whose coordinate distances from the center of the carriage are given by distances d3 and d4.

With the positioner at rest or moving with uniform velocity, the loads on each of the four bearing blocks are given by the above equations:

Note that each of the four bearing blocks will experience either compressional or tensional loading; the magnitude of these forces at each bearing is dependent upon the location of the load vector with respect to the center of the positioner carriage. For each bearing, the maximum of the forces in tension and compression is plotted on the load charts for the specific model positioner to determine the life of the table in the application.

The calculations for loads whose CG falls outside the carriage mounting surface area, as shown in Figure 2, are identical to those used with Figure 1. In either case, accelerations and decelerations of the load must be considered in calculating the dynamic forces which determine the life of the system in a particular application.

Horizontal Translation — Side Load

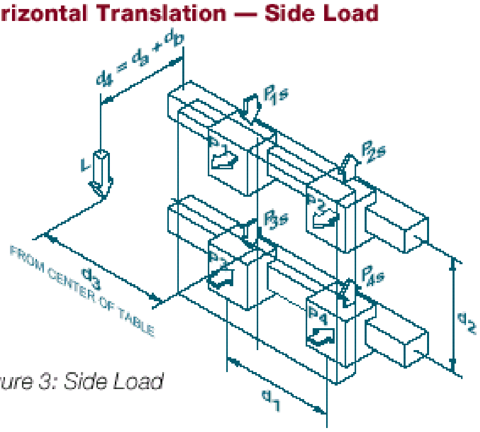


Figure 3: Side Load

$$P_1 = P_2 = \frac{L}{2}\left[\frac{d_4}{d_2}\right]$$

$$P_3 = P_4 = -\frac{L}{2}\left[\frac{d_4}{d_2}\right]$$

$$P_{1s} = P_{3s} = \frac{L}{4} + \left[\frac{L}{2} \cdot \frac{d_3}{d_1}\right]$$

$$P_{2s} = P_{4s} = \frac{L}{4} - \left[\frac{L}{2} \cdot \frac{d_3}{d_1}\right]$$

The previous loading scenarios have involved only normal forces (compressional or tensional) on the bearings. Consider a positioner as shown in Figure 3, which involves a lateral (side) load applied to the carriage which translates horizontally. The load vector (L) is shown applied at a point whose coordinate distances from the center of the carriage bearing system are given by dimensions d3 and d4. Note that d4 is the sum of distance da—the distance between bearing and center and carriage surface which is provided for each linear positioner—plus db, the distance of the load CG from the mounting surface of the carriage.

The loading felt by each of the four bearing blocks when the positioner is stationary or moving with uniform velocity is given by the above equations:

Here P1, P2, P3 and P4 are the normal loads (tensional and compressional) and P1S, P2S, P3S and P4S are the side loads. For each bearing, the largest side loads and normal loads in both tension and compression are identified for calculating the positioner life in the application.

For round rail/ball bushing type bearings, the forces are plotted individually on the appropriate curves to determine the service life.

For linear motion guide bearing positioners, an "equivalent load per bearing" is calculated for the life determination. Equations listed in Table A, page 22, apply for the Daedal positioners which incorporate linear motion guide bearings. As shown in Table A, this "equivalent load" is plotted on the indicated load/life graph to determine the positioner's service life.

Again, accelerations and decelerations of the load must be considered in calculating the dynamic forces which determine the life of the system in a particular application.

Table A – Linear Motion Guide Bearing Life/Load Computation

Positioner	Loads	Compute	Evaluate Life On
412LXR	Side & tension Ps > Pt Side & tension Ps ≤ Pt	Pe = (0.5 x Pt) + Ps Pe = (0.5 x Ps) + Pt	Side load chart Tension chart
	Side & compression Ps > Pc Side & compression Ps ≤ Pc	Pe = (0.5 x Pc) + Ps Pe = (0.5 x Ps) + Pc	Side load chart Compression chart

Example Computations

Example 1

Horizontal Translation with Side Loads, 412LXR-12 Pole Positioner

L = 150 Kgf
130 mm from carriage surface;
50 mm from carriage center.

Page 13 shows this configuration with dimensions given here.

d1 = 205 mm

db = 130 mm

d2 = 192 mm

d3 = 50 mm

da = 43 mm

d4 = da + db = 173

The normal and side force components on each bearing block are computed from the equations as shown:

$$P_1 = P_2 = \frac{L}{2}\left[\frac{d_4}{d_2}\right] = 67.6 \text{ (tension) Kgf}$$

$$P_3 = P_4 = -\frac{L}{2}\left[\frac{d_4}{d_2}\right] = -67.6 \text{ (compression) Kgf}$$

$$P_{1s} = P_{3s} = \frac{L}{4} + \left[\frac{L}{2}\cdot\frac{d_3}{d_1}\right] = 37.0 \text{ (side load) Kgf}$$

$$P_{2s} = P_{4s} = \frac{L}{4} - \left[\frac{L}{2}\cdot\frac{d_3}{d_1}\right] = -0.5 \text{ (side load) Kgf}$$

Life for each bearing needs to be evaluated independently. For bearings with a side load, refer to the combined equivalent loading factors (Table A).
Example:
Bearing 3 had P_3 = 39.6 Kgf tension and P_{3s} = 9.7 Kgf side load

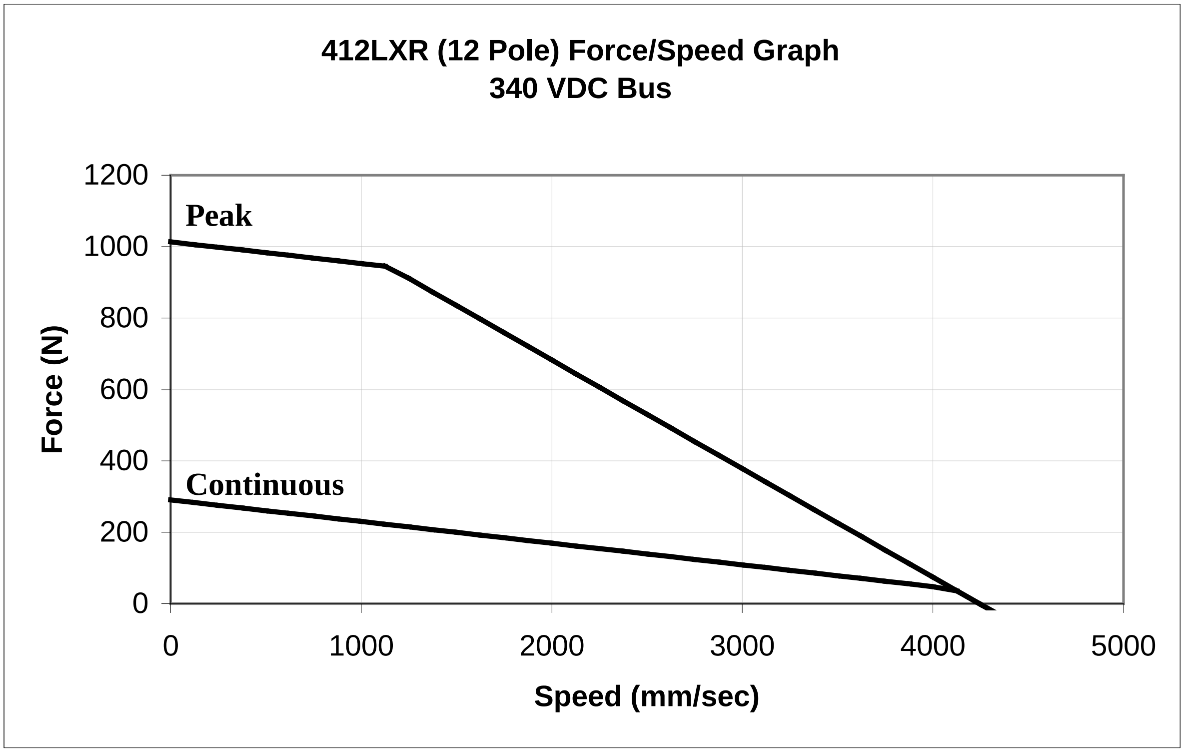
$$Ps \le Pc \Rightarrow Pe = (0.5 \times Ps) + Pc = 44.5Kgf$$

Refer to Bearing Life Normal Load (page 13)
Life @ 44.5 Kgf = 30,000 km

412LXR Series Technical Data

Force/Speed Charts

The chart on this page illustrates the characteristics of the 412LXR linear motor. The force/speed chart shows the characteristics of the motor with either a 170 VDC or 340 VDC bus voltage.



Clean Room Preparation

412LXR tables with clean room preparation were tested in Daedal's vertical laminar flow work station which utilizes ULPA filters to produce an environment having a cleanliness of class 1 prior to testing. Tables were tested in a variety of orientations with sampling both below the table and at the carriage mounting surface. Laminar flow rate is 0.65 inches W.C.

400LXR Clean Room Compatability

Table Velocity	Class	
	4.5″ below table	At carriage surface
250 mm/sec	10	1
500 mm/sec	25	1
1000 mm/sec	50	5
2000 mm/sec	250	25
3000 mm/sec	500	100

Standard Clean Room Preparation

Stringent cleaning and handling measures
Clean room rated lubricant
Strip seal replaced with hard shell cover

About Clean Rooms

A room in which the concentration of airborne particles is controlled within defined limits. Federal Standard 209E statistically defines the allowable number of particles per cubic foot of air.

The chart (right) describes the conditions that must be maintained for the cleanroom to have a specific "class" rating.

Class	Number of Allowable Particles (Measured particle size in microns (µm))				
	0.1	0.2	0.3	0.5	5
1	35	7.5	3	1	n/a
10	350	75	30	10	n/a
100	n/a	750	300	100	n/a
1000	n/a	n/a	n/a	1000	7
10000	n/a	n/a	n/a	10000	70
100000	n/a	n/a	n/a	100000	700

Electrical Specifications

Parameter	12 Pole	Units
Continuous Force $_{1}$	355	N
Continuous Current $_{1,4,8}$	6.3	Amps Peak
Continuous Current $_{1,7}$	5.5	Amps DC
Peak Force $_{6}$	1000	N
Peak Current $_{4,6,8}$	19.0	Amps Peak
Peak Current $_{6,7}$	16.4	Amps DC
Voltage Constant $_{3,4}$	65	Volt/m/sec
Force Constant $_{9}$	56.3	N/Amps Peak
Force Constant $_{3,4}$	65	N/Amps DC
Resistance $_{3}$	9.98	Ohms
Inductance $_{5}$	5.68	mH
Maximum Bus Voltage	340	Volts DC
Thermal Resist. Winding-Ambient	0.24	C/watt
Viscous Damping	40	N/m/s
Static Friction $_{13}$	50	N
Intermit Force Duration $_{10}$	160	Seconds
Peak Force Duration $_{11}$	63	Seconds
Magnetic Attraction $_{2}$	2000	N
Electrical Pitch $_{12}$	42	mm
Mass-Motor Carriage	12.3	Kg
Rated Winding Temp.	125	C/watt
Winding Class	H	-

1. @ 25^{o} C ambient, 90^{o} C Winding Temperature
2. Measured with a 0.70 mm gap
3. Measured Line to Line +/-10%
4. Value is measured peak of sine
5. +/-30% Line to Line, inductance bridge measurement @1Khz
6. Initial winding temperature must be 60^{o} C or less before Peak Current is applied
7. DC current through a pair of motor phases of a trapezoidal (six state) commutated motor
8. Peak of the sinusoidal current in any phase for a sinusoidal commutated motor
9. Total motor force per peak of the sinusoidal amps measured in any phase, +/-10%
10. Maximum time duration with 2 times rated current applied with initial winding temperature at 60^{o} C
11. Maximum time duration with 3 times rated current applied with initial winding temperature at 60^{o} C
12. The Distance from the leading edge of the north pole to the leading edge of the next north pole
13. Average Friction over total table travel

Encoder Specifications

Description	Specification
Input Power	5 VDC +/-5% 150 mA
Output (Incremental) E2, E3, E4, E5 options	Square wave differential line driver (EIA RS422) 2 channels A and B in quadrature (90^{o}) phase shift.
Output (Analog) E7 option	2 Channels V_1 and V_2 differential sinusoids in quadrature (20 µm pitch) 90^{o} phase shifted
Reference (Z Channel)	Synchronized pulse, duration equal to one resolution bit. Repeatability of position is unidirectional moving toward positive direction.
Maximum Speed	5.0 micron resolution = 3.0 meters/sec 1.0 micron resolution = 3.0 meters/sec 0.5 micron resolution = 1.5 meters/sec 0.1 micron resolution = 0.3 meters/sec Analog = 3.0 meters/sec

Hall Effect Specification

Description	Specifications
Input Power	+5 to +24 VDC, 30 mA
Output	Open collector, Current Sinking, 20 mA Max

Gemini Drive Specifications

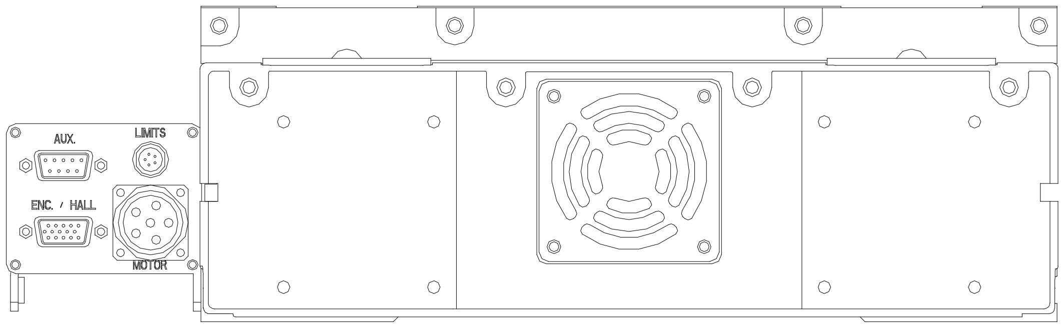
Description	Specification
Drive Input Power	
Voltage	96-265 VAC
Phase	1Ø
Frequency	50/60 Hz
24V Keep Alive (Optional)	24 VDC +/- 20%
Drive Output Power	
Bus Voltage	170 or 340 VDC
Switching Frequency	8/16, 16/32 or 20/40 kHz (User selectable)
Continuous Current	12 Amps
Peak Current	30 Amps
Commutation	Sinusoidal
Command Inputs	
Velocity and Torque	+/-10V
Position Mode	Step & Direction or CW & CCW
Encoder Track Mode	Allows post quadrature encoder to be used as command signals
Inputs	
Enable (Required)	0-24 VDC
Reset	
Pos/Neg Limits	
User Faults	
Outputs	
Fault	Open collector, 300 mA sink capability
At Limit	Open collector, 300 mA sink capability
Position Error	Open collector, 300 mA sink capability
Analog Monitors	+/-10V scalable, 8 bit (not to be used as control functions)
Relay	Normally open, dry contact
Communications	
Type	RS232/RS485 (4 wire)
Baud Rate	Fixed at 9600
Daisy Chain	Up to 98
Environmental	
Temperature	Still air 32°F (0°C)-113°F (46°C), moving air: 32°F (0°C)-122°F (50°C)
Humidity	0–95%, non-condensing
Shock/Vibration	Shock: 15G half-sign @ 11 msec/vibration: 2G, 10-2000 Hz
Protection	
Short Circuit	Phase-to-phase, phase-to-ground
Brownout	AC drops below 85 VAC
Over Temperature	Shutdown fault at 131°F (55°C)
Standards	UL, cUL, CE (LVD), CE (EMC)

Limit and Home Sensor Specifications

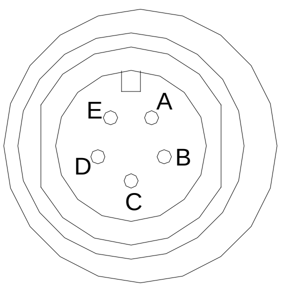
Description	Specification
Input Power	+5 to +24 VDC 60 mA
Output	Output form is selectable with product: Normally Closed Current Sinking Normally Open Current Sourcing Normally Closed Current Sourcing Normally Open Current Sourcing All types Sink or Source maximum of 50 mA
Repeatability	Limits: +/- 5 microns (unidirectional) Home: See Z channel specifications

Cabling and Wiring Diagrams

Connector Pin Out and Extension Cable Wire Color Codes

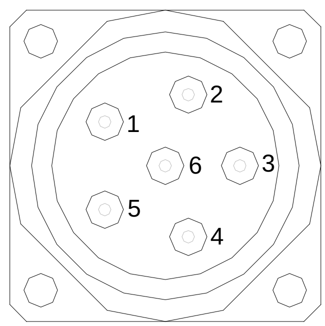


Limit/Home
5 Pin Connector



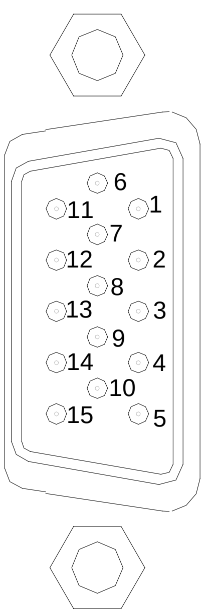
A. +5 to +24 VDC
B. Negative Limit
C. Positive Limit
D. Home
E. Ground

Motor Wires
6 Pin Connector



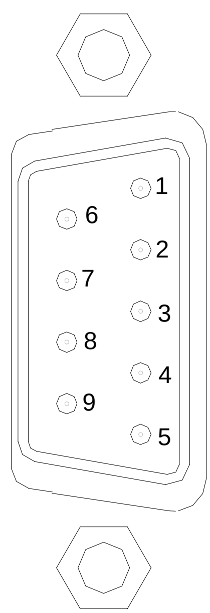
1. Phase A
2. Phase B
3. Ground
4. Reserved
5. Reserved
6. Phase C

Encoder Halls
15 Pin D-Connector



1. +5 VDC Enc
2. Ch A+
3. Ch A-
4. Ch B+
5. Ch B-
6. Ch Z+
7. Ch Z-
8. Ground, Enc
9. +5 VDC Hall
10. Hall 1
11. Hall 2
12. Hall 3
13. Temp
14. Temp
15. Ground, Hall

Auxillary
9 Pin D-Connector



1. User Defined
2. User Defined
3. User Defined
4. User Defined
5. User Defined
6. User Defined
7. User Defined
8. User Defined
9. User Defined

Motor Connections

Function	Cable Wire Color	412LXR Circular Connector Male
Phase A	Black / White #1	1
Phase B	Black / White #2	2
Phase C	Black / White #3	6
Ground	Green/Yellow	3
Reserved	Black/Red	4
Reserved	Black/Green	5

Encoder/Hall Connections

Function	Cable Wire Color	412LXR High Density 15 Pin "D" Connector
+ 5VDC (Enc.)	Red	1
Ch A+	White	2
Ch A-	Yellow	3
Ch B+	Green	4
Ch B-	Blue	5
Ch Z+	Orange	6
Ch Z-	Brown	7
Ground (Enc.)	Black	8
+5 VDC (Hall)	White/Blue	9
Hall 1	White/Brown	10
Hall 2	White/Orange	11
Hall 3	White/Violet	12
Temp	Yellow/Orange	13
Temp	Yellow/Orange	14
Ground (Hall)	White/Green	15

Limit and Home Connections

Function	Cable Wire Color	412LXR Connector Male 5 Pin Connector
+ 5 to +24 VDC	Red	A
Negative Limit	Blue	B
Positive Limit	Orange	C
Home	Green	D
Ground	Black	E

Auxiliary Connections

Function	Cable Wire Color	412LXR Connector Female 9 Pin "D" Connector
User Defined	Red	1
User Defined	Blue	2
User Defined	White	3
User Defined	Yellow	4
User Defined	Orange	5
User Defined	Green	6
User Defined	Purple	7
User Defined	Brown	8
User Defined	Black	9

Chapter 3 - How to Use the 412LXR

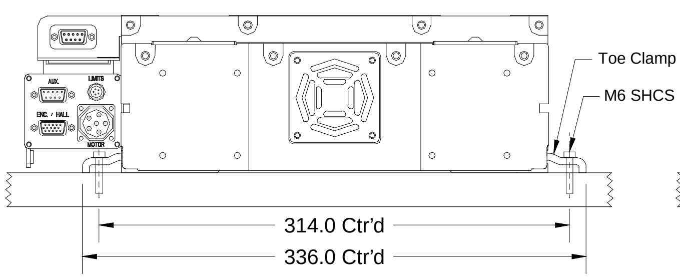
Mounting Surface Requirements

Proper mounting **of the 412LXR is** ***essential*** **to optimize product performance. All specifications are based on the following conditions:**

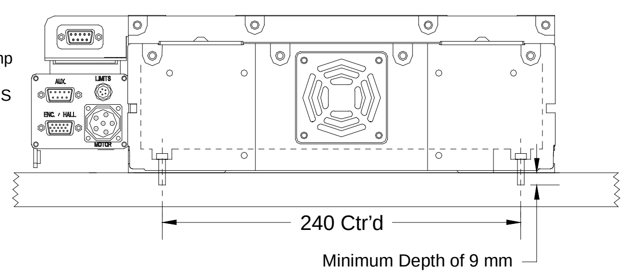
- The positioner must be bolted down along its entire length.
- The positioner must be mounted to a flat, stable surface, with a flatness error less than or equal to 0.013mm/300mm.
    - Catalog specifications may deviate for positioners mounted to surfaces that do not meet the above conditions.
    - If the surface does not met these specifications the surface can be shimmed to comply with these requirements.
- If mounting conditions require that the table base is *overhung*, table specifications will not be met over that portion of the table. Additionally, in *X-Y Systems* the *overhung* portion of the Y-axis may not met specifications due to the additional error caused by deflection and non-support of the base. Contact Daedal for guidelines on specifications of overhang applications.

Mounting Methods

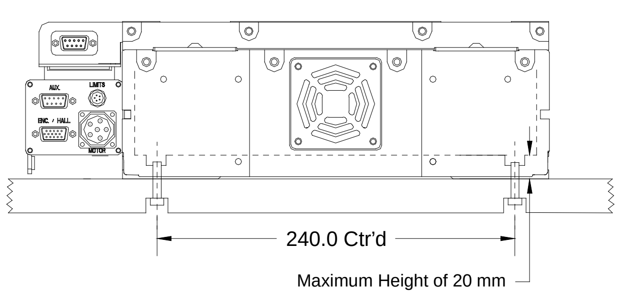
The 412LXR can be mounted via the three ***(3)*** following methods:



Toe Clamp Mounting
P/N 100-6766-01
Three (3) M6 SHCS Per Toe Clamp



Base Through Holes
Use M6 SHCS
Note: Minimum Screw Length of 22 mm



Bottom Tapped Holes
Use M8 SHCS
Note Maximum Length

Side and Inverted Mounting Concerns

Side Mounting

- Cable transport modules are NOT to be used on side mounted positioners with travels greater than 600 mm due to cable drag.

Inverted Mounting

- Cable transport modules are NOT to be used on inverted mounted positioners with travels greater than 450 mm due to cable drag. Contact factory for special bracketry.

Setting Travel Limit Sensors

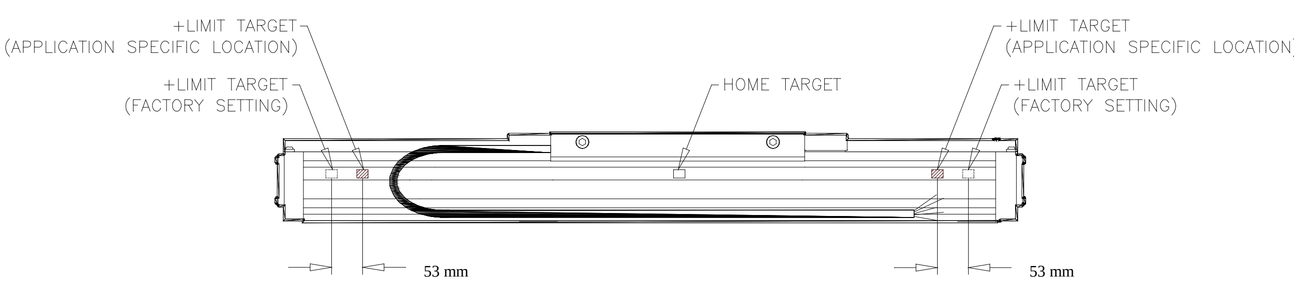
The LXR is supplied with over-travel limit sensors. Set the position of the sensors before applying power. The limit sensors are set at the factory for maximum travel. These factory settings only allow for 3mm (0.12") before the carriage contacts the deceleration bumper. In slow speed applications this may be adequate, however as the top speed of the application increases the required deceleration distance increases. To determine the safe **Deceleration Distance** the **Maximum Speed** and the **Maximum Obtainable Deceleration Rate** must be *known* or *calculated*. The maximum speed should be known from your application requirements. *Velocity limits* should be set in your program or in your amplifier to cause a fault if the speed exceeds this value. The maximum deceleration is a factor of load and available peak force of the table. Using F = ma, calculate maximum acceleration and then required deceleration distance. See the following example for calculating *maximum deceleration* for an application with a payload = 25kg on a 412LXR-D15 (12 pole motor), with a maximum speed of 1.5 m/s.

Payload mass = 25 kg, Carriage mass = 12.3 kg
Total mass = 37.3 kg
Maximum Speed = **1.5 m/sec**
Available peak force at 1.5 m/sec = 800N (See Chapter 2, *Force / Speed Curve*)
Thus: F = ma → a = F/m → a = 800N / 37.3kg → 21.4 m/sec^2 or 2.1g's

The **Maximum Obtainable Deceleration Rate** for this application is **21.4 m/sec^2**.

Now, calculate the **Deceleration Distance** for linear deceleration:
First… find the *Deceleration time*:
Ta = Max Velocity / Deceleration Rate
Ta = 1.5m/sec / 21.4 m/sec^2 → 0.070 seconds
Second… find the **Deceleration Distance**:
Distance = ((Max Velocity) * (Ta)) / 2
Distance = ((1.5 m/sec) * (0.070)) / 2 → 0.053 meters or **53 mm**

This means that both the positive and negative limit switch targets must be moved inward by 53 mm.
The limit deceleration rate should be set to 21.4 meters/sec^2.



Setting Home Sensor

The 412LXR is equipped with a “home” position reference sensor. This is located on the same PCB as the limit sensors and the target is located between the limit targets. This sensor is typically used in conjunction with the encoder “Z” marker (refer to “Z” channel reference below). If the unit is equipped with this option it will be set at the “Z” channel location. If another home location is desired the home target can be adjusted by loosening the screws on the target and sliding it along the track. Note: If the home sensor is used without “Z” channel, the home position repeatability is reduced to +/-5 microns.

Z Channel Position Reference

The Z channel is an output on the encoder. Many servo controllers support this input. The Z channel on the 412LXR is located in one of three positions, (positive end, mid travel, or negative end). The location depends on how the unit was ordered (See Chapter 2, *Order Number Nomenclature*). The Z channel is a unidirectional device. This means that the final homing direction must occur in one direction. The 412LXR is set that the final home direction is to be toward the positive end of the table (See Chapter 2, *Dimensional Drawing*, for positive direction definition). The repeatability of the Z channel is equal to +/- 2 resolution counts of the encoder (except for 0.1 micron scales which have a repeatability of +/-1 microns). Thus the repeatability of the “Z” channel equals:

Encoder Resolution	Z Channel Repeatability
5 micron	+/- 10 micron
1 micron	+/- 2 micron
0.5 micron	+/- 1 micron
0.1 micron	+/- 1 micron

NOTE: Home repeatability is also very dependent on controller input speed and homing algorithms. The above repeatability does not include possible controller tolerance. Additionally, to achieve the highest repeatability the final homing speed must be slow. Slower final speed usually results in higher repeatability.

NOTE: The “Z” channel output is only one resolution count wide. Thus the on-time may be very brief. Due to this some controllers may have difficulty reading the signal. If you are experiencing the positioner not finding the “Z” channel during homing, try reducing final homing speed; also refer to your controller manual for frequency rates of the “Z” channel input.

Grounding / Shielding

All cables are shielded. These shields are to be grounded to a good earth ground. Failure to ground shields properly may cause electrical noise problems. These noise problems may result in positioning errors and possible run away conditions.

Cabling

The 412LXR is available with two (2) types of cabling:

- Cable Transport Module

    - This is a complete cable management system including high flex ribbon cable (life rating of 20 million cycles), cable carriers, and connector system. This has been engineered for high life, maintenance free operation. Extension cables are used to connect the table connector block to the amplifier and controller. Refer to cabling diagrams for pin-out and wire color information.

    - The Cable transport module is replaceable. See Chapter 6, *Cable Management Module Replacement*, for replacement P/N's and a detailed procedure of the replacement process.

- Un-harnessed OEM Cable System

    - This option provides high flex round cables directly from the carriage. This option is provided for applications where the design of the machine already has a cable management system. Four cables come from the carriage connector: motor, encoder/Hall effect, limit/home sensor and auxiliary cables.

    - Recommended bend radius for these cables is 100mm. This radius will provide 10 million cycles of the cable. Smaller bend radius will reduce cable life while larger bend radius will increase life. The un-harnessed OEM cable system can be replaced. Refer to Chapter 6, *Cable Management Module Replacement*. The same carriage connector is used here and can be removed and replaced with a new assembly.

Chapter 4 - Performance

Acceleration Limits

Acceleration of the 412LXR is limited by four *(4)* factors:

- Linear Bearings

The Linear bearings used in the 412LXR have a continuous acceleration limit of 2 g's. This means that the bearings are design to take repetitive acceleration of 2 g's and maintain the rated bearing life. Additionally, the bearings can take a periodic acceleration of up to 5 g's, however continued accelerations of these magnitudes will reduce bearing life.

- Reduced Bearing Life

Bearing loading due to high acceleration may reduce bearing life to an unacceptable application limit. This is not usually a limiting factor unless loading is significantly cantilevered causing high moment loads during accelerations. (Chapter 2, *412LXR Series Technical Data* to determine bearing load life for your application)

- Available Motor Force

This is the primary factor that reduces acceleration. This is simply the amount of motor force available to produce acceleration. The larger the inertial and or frictional load the lower the accelerations limit.

- Settling Time

In many applications reducing cycle time is a primary concern. To this end, the "settling" time (the amount of time needed after a move is completed for table and load oscillating to come within acceptable limits) become very important. In many cases where very small incrementing moves are executed, the settling time is greater than the actual move time. In these cases accelerations may need to be reduced thus reducing the settling time.

Speed Limits

The Maximum Speed of the 412LXR is limited by three *(3)* factors:

- Linear Bearings

The linear bearings are limited to a maximum speed of 3 meters/second.

- Linear Encoder Limit

The linear encoder has speed limits relative to encoder resolution; these limits are listed below:

Encoder Resolution	Maximum Velocity	Required Post Quadrature Input Bandwidth ([2])
5 micron	5 meters/second ([1])	2 Mhz
1 micron	3 meters/second	6.7 Mhz
0.5 micron	1.5 meters/second	6.7 Mhz
0.1 micron	0.3 meters/second	10 Mhz

([1]) When using an encoder with 5 micron resolution, the maximum speed is limited by the square rail bearings.

([2]) This is the bandwidth frequency that the amplifier or servo control input should have to operate properly with the encoder output at maximum speeds. This frequency is post-quadrature, to determine pre-quadrature divide above values by 4. Above frequencies include a safety factor for encoder tolerances and line loses.

- Force / Speed Limit

The available force of the 412LXR reduces as speed increases. (Chapter 2, *412LXR Series Technical Data*)

Encoder Accuracy and Slope Correction

Encoder Accuracy

The 412LXR Series makes use of an optical linear tape encoder for positional feedback. This device consists of a *readhead*, which is connected to the carriage, and a *steel tape scale*, which is mounted inside the base of the 412LXR.

The linearity of this scale is +/-3 microns per meter, however the absolute accuracy can be many times larger. To compensate for this error, an error plot of each 412LXR is done at the factory using a laser interferometer. From this plot a linear slope correction factor is calculated (see below). Then a second error plot is run using the slope correction factor. These tests are conducted with the Point of Measurement (P.O.M.) in the center of the carriage 38 mm above the carriage surface.

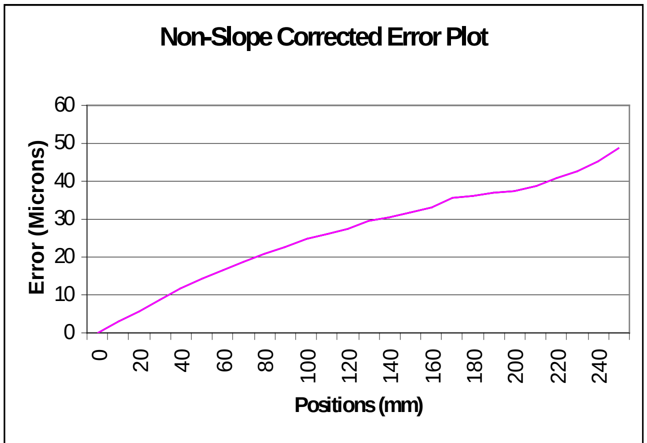
Slope Correction

Slope correction is simply removing the linear error of the table. The graphs below show an example of a non-slope corrected error plot and the same plot with slope correction. As can be seen, the absolute accuracy has been greatly improved.

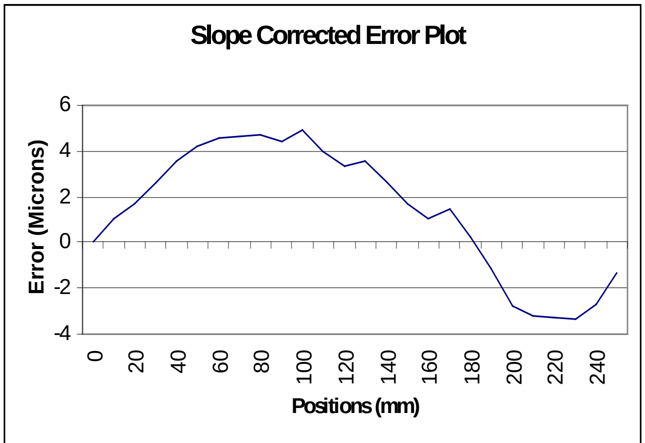
The slope factor is marked on each unit. It is the slope of the line in microns per meter. This factor may be positive or negative, depending on the direction of the error.

If your application requires absolute accuracy, the slope factor must be incorporated into the motion program. This is a matter of either assigning variables for motion positions and using the slope correction in the variable equation, or if your controller has floating decimal scaling (with high enough precision) the slope correction can be accounted for in scaling.

NOTE: The zero position (or starting point) of the error plots are at the extreme NEGATIVE end of travel (refer to Chapter 2, *Dimensional Drawing*, for Negative end location).



Non-Slope Corrected Error Plot, Total error *48 microns*
Note: Slope Factor is 200 micron / meter in this



Slope Corrected Error Plot, Total error *8.5 microns*

Below is a sample program showing how to correct for slope error using variables. This example program will work with the 6K as well as the 6000 Series Parker, Compumotor Controllers.
Step 2 through 3 of this program should be made a subroutine. This subroutine can then be executed for each distance.

……..

- Step #1

VAR1 = 880; IN THIS CASE THE DESIRED DISTANCE IS 880mm.

- Step #2

DEL SLCORR ; DELETE SLCORR PROGRAM
DEF SLCORR ; DEFINE SLCORR PROGRAM
VAR2 = (VAR1/1000)* (0.085); VAR2 EQUALS DESIRED DISTANCE (IN METERS) TIMES THE SLOPE FACTOR (mm/meter)

- Step #3

VAR3 = (VAR1-VAR2); SUBTRACT SLOPE ERROR FROM DESIRED DISTANCE

- Step #4

D(VAR3); SET DISTANCE AS VAR3
END ; END SUBROUTINE

……..

In the example above, the required move distance is 880 mm. But the LXR has a slope error of 0.085mm per meter. This is a positive slope error meaning that if uncorrected the LXR will move 0.085 mm too far for every meter it travels. To correct we must command a smaller position.

- Step #1: The required move distance is set as variable #1.
- Step #2: In this step, we first convert 880 mm to 0.88 meters my dividing by 1000. Next we multiply by the slope factor to calculate the slope error distance of this move (0.88 * 0.085) = 0.0748 mm.

- Step #3: We subtract the error from the original distance (880 – 0.0748) = 879.9252 mm.
- Step #4: Here we simply assign the new calculated distance as our current command distance.

This same program works if the slope error is negative. For example, if the slope error was –0.085 instead of +0.085 the equation would work out like this:

VAR2 = (880/1000)*(-0.085) = -0.0748
VAR3 = 880 – (-0.0748) = 880.0748

Thus correcting for the negative slope.

Note: Above are examples for incremental moves. The same program works if programming in absolute coordinates.

Note: Each unit is shipped with both the non-slope corrected accuracy plot and a slope corrected plot. These plots can be used to "MAP" the table, making positioning even more accurate. Mapping is correcting for the error of the device at each location. This can be done by knowing the motion positions and the error at each of these positions and setting up a matrix of variables in your motion program. This method provides excellent accuracy but is time consuming to setup.

Attainable Accuracy with Slope Correction

Travel (mm)	Accuracy (microns)	Travel (mm)	Accuracy (microns)
150	8	1200	39
250	12	1500	44
350	16	1750	46
650	26	2000	50
800	31	2500	50
1000	35	3000	50

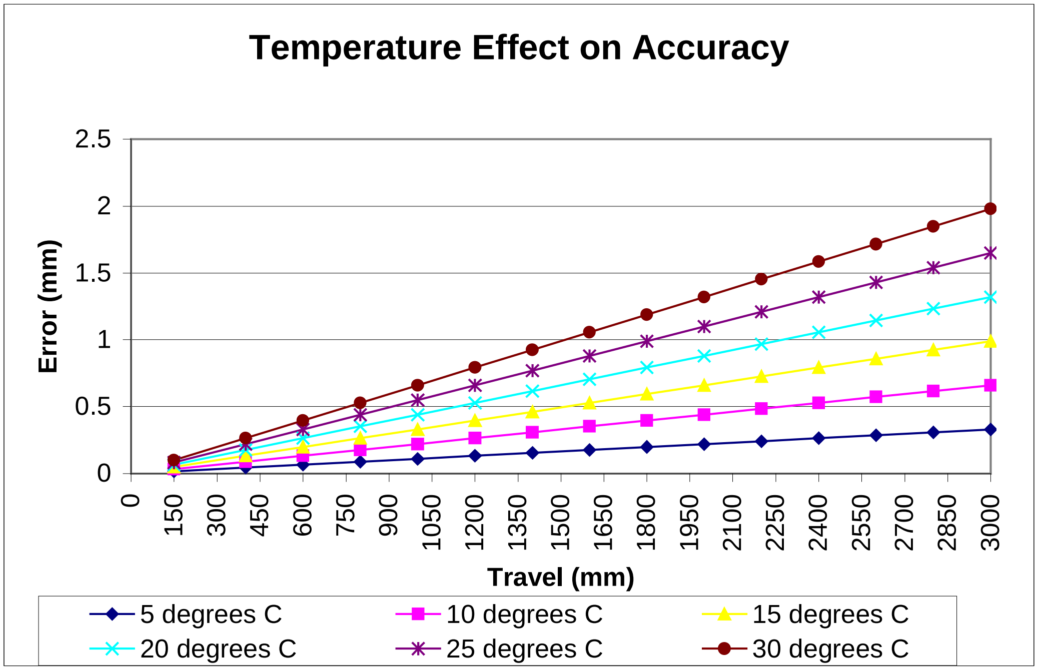
Thermal Effects on Accuracy

All specifications for the 412LXR are taken at 20° C. Variation from this temperature will cause additional positional errors. If the base of the 412LXR varies from this temperature the encoder scale will expand or contract, thus changing its measuring length and thus encoder resolution.

The factor by which this thermal effect occurs is 0.000022mm/mm/° C. Although this sounds like a very small number it can make significant accuracy and repeatability effects on your applications, especially on longer travel applications. To understand this better let's look at an example:

Example: A 412LXR with 1000mm travel is being used. The accuracy over the entire travel is 35 microns @ 20° C. If the base temperature increases by 5° C an additional error of 110 microns will be added over the total travel (0.000022mm/mm/° C)*1000mm*5° C. As you can see this error is significant. However, this additional error can be compensated for since the error is linear.

On the next page is a graph of the accuracy of the 412LXR with respect to base temperature and travel. Each line represents the additional error of the table caused by the elevated temperature.



Thermal Effects on Repeatability

Repeatability will not be effected as long as the temperature remains constant. However the repeatability will be effected as the temperature changes from one level to another. This is most commonly experienced when starting an application cold. Then as the application runs the 412LXR comes to its operational temperature. The positions defined when the unit was “cold” will now be offset by the thermal expansion of the unit. To compensate for this offset, all positions should be defined after the system has been exercised and brought to operational temperature.

Causes of Temperature Increases

One or more of the following conditions may effect the temperature of the 412LXR base:

- Ambient Temperature

  This is the air temperature that surrounds the 412LXR.

- Application or Environment Sources

  These are mounting surfaces or other items which produce a thermal change that effect the temperature of the 412LXR base (i.e. Machine base with motors or other heat generating devices that heat the mounting surface and thus thermally effect the 412LXR base).

- Motor heating from 412LXR

  Since the 412LXR uses a servo motor as its drive, it produces no heat unless there is motion, or a force being generated. In low duty cycle applications heat generation is low, however as duty cycles increase, temperature of the 412LXR will increase, causing thermal expansion of the base. With very high duty cycles these temperatures can reach temperatures as high as 30° C above ambient.

Compensating for Thermal Effects

How much you will have to compensate for the above thermal effects depend on the application requirements for accuracy. If your accuracy requirements are high, you either need to control base temperature or program a thermal compensation factor into your motion program. *Controlling the base temperature* is the best method. However, this means controlling the ambient temperature by removing all heat/cold generators from the area and operating at very low duty cycles. *Compensation* is the other way of achieving accuracy without sacrificing performance. In this case the system must be exercised through its normal operating cycle. The temperature of the base should be measured and recorded from the beginning (cold) until the base becomes thermally stable. This base temperature should be used in a compensation equation. Below is the fundamental *thermal compensation equation*:

$$Cd = (Id - ((Id) * (Te) * \Delta T))$$

Cd = Corrected displacement (mm)
Id = Incremental displacement (mm)
Te = Thermal Expansion (0.000022 mm/mm/° C)
ΔT = Temperature Differential from 20° C

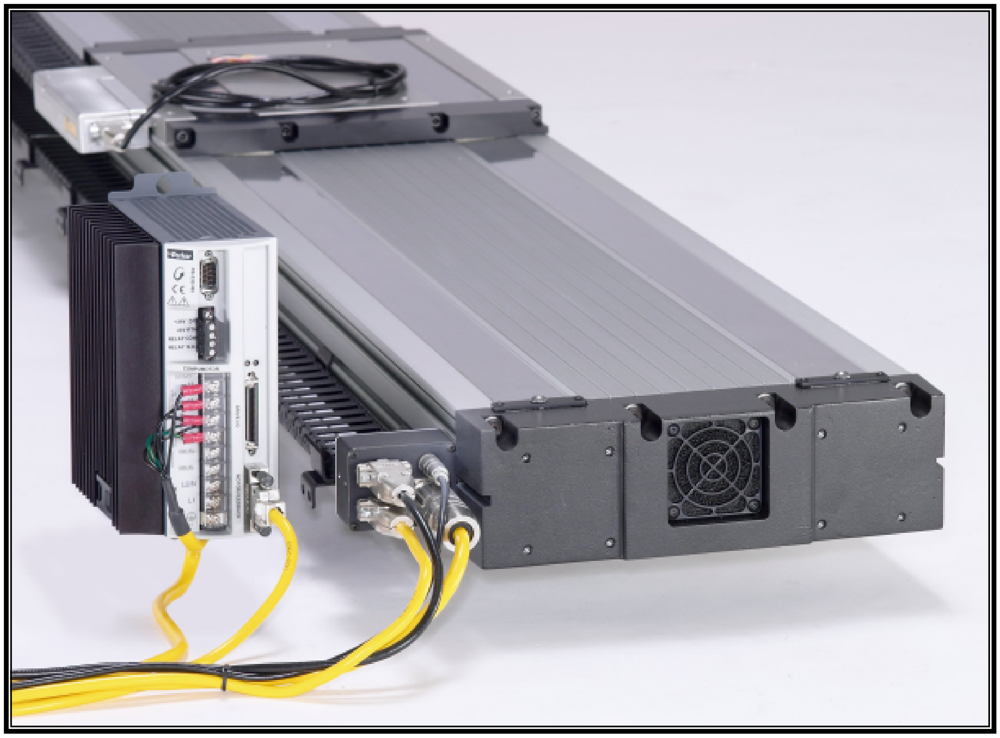
Example:
- Base Temperature of 32° C
- Required move 100mm

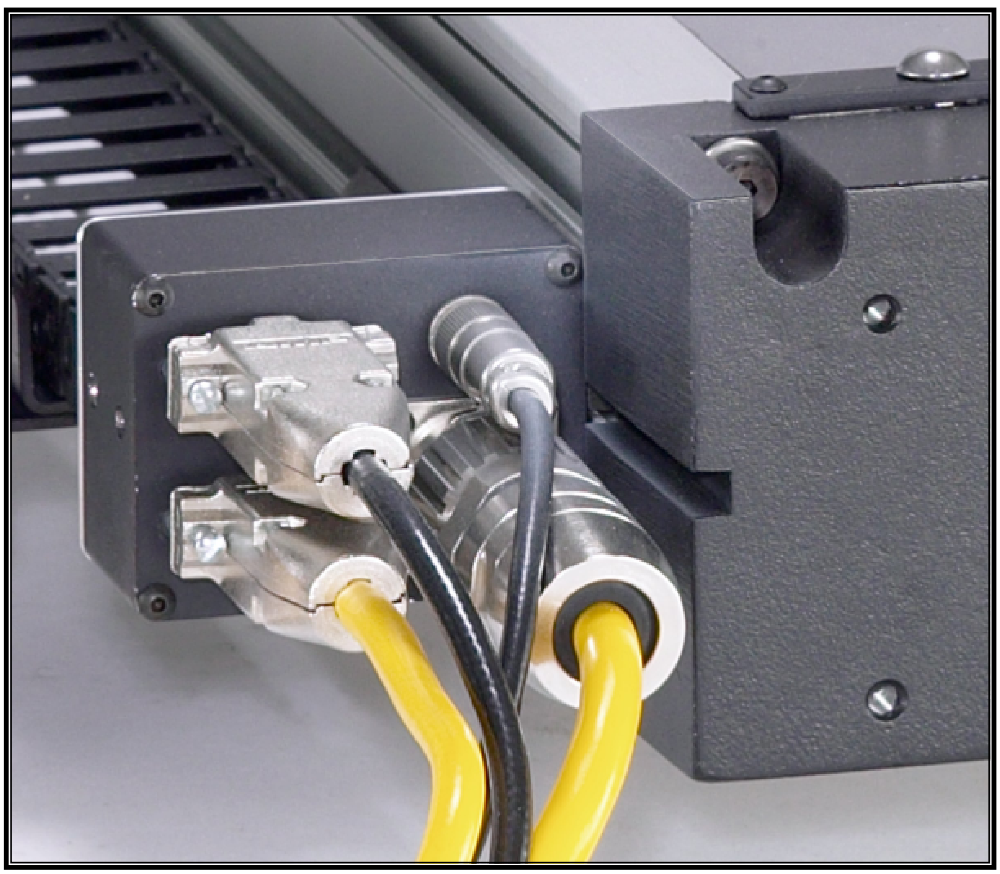
Cd = 100mm - (100mm * Te * 12° C) = *99.9736mm*

In this move the commanded move should be 26.4 microns less (100mm – 99.9736mm) than the desired move. This will compensate for the thermal expansion of the scale.

This is a simple linear correction factor and can be programmed in to most servo controllers using variables for the position commands.

Chapter 5 - Connecting the Gemini Amplifier

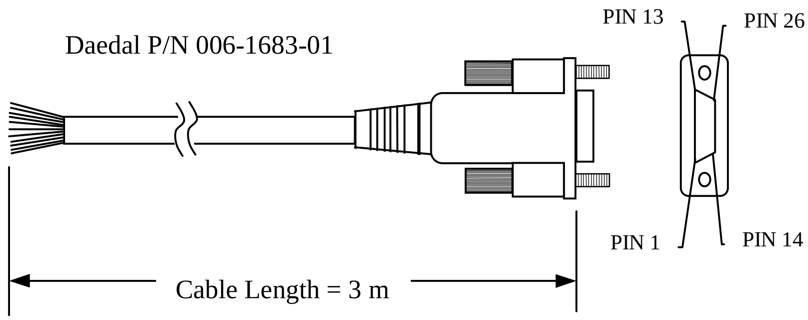




Gemini Adapter Cable

- Use this cable to connect the Encoder and Hall Effect signals from an electrical panel strip to the Gemini's 26 pin Motor Feedback connector.

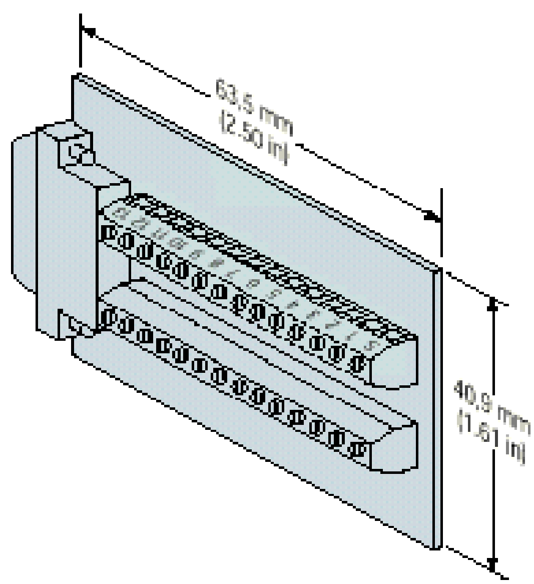
Function	Wire Color	Pin #
	Encoder Wires	
Ch A+	White	5
Ch A-	Yellow	6
Ch B+	Green	7
Ch B-	Blue	8
Ch Z+	Orange	9
Ch Z-	Brown	10
Ground	Black	3,4
+5 VDC	Red	1,2
	Hall Signal Wires	
Hall Gnd	White/Green	15
Hall +5V	White/Blue	14
Hall 1	White/Brown	16
Hall 2	White/Orange	17
Hall 3	White/Violet	18
	Temperature Switch	
Temp Switch	Yellow/Orange	12
Temp Switch	Yellow/Red	13
Shield	Yellow/Green	Shield Cover



Gemini Plug-in Connection Module

- Use this module to directly connect the 412LXR's Encoder and Hall Effect cables to the Gemini Drive.

Function	Wire Color	Pin #
	Encoder Wires	
Ch A+	White	5
Ch A-	Yellow	6
Ch B+	Green	7
Ch B-	Blue	8
Ch Z+	Orange	9
Ch Z-	Brown	10
Ground	Black	3,4
+5 VDC	Red	1,2
Shield	Green/Yellow	Shield Cover
	Hall Signal Wires	
Hall Gnd	White/Green	15
Hall +5V	White/Blue	14
Hall 1	White/Brown	16
Hall 2	White/Orange	17
Hall 3	White/Violet	18
Shield	Green/Yellow	Shield Cover
	Temperature Switch	
Temp Switch	Yellow	12
Temp Switch	Yellow	13

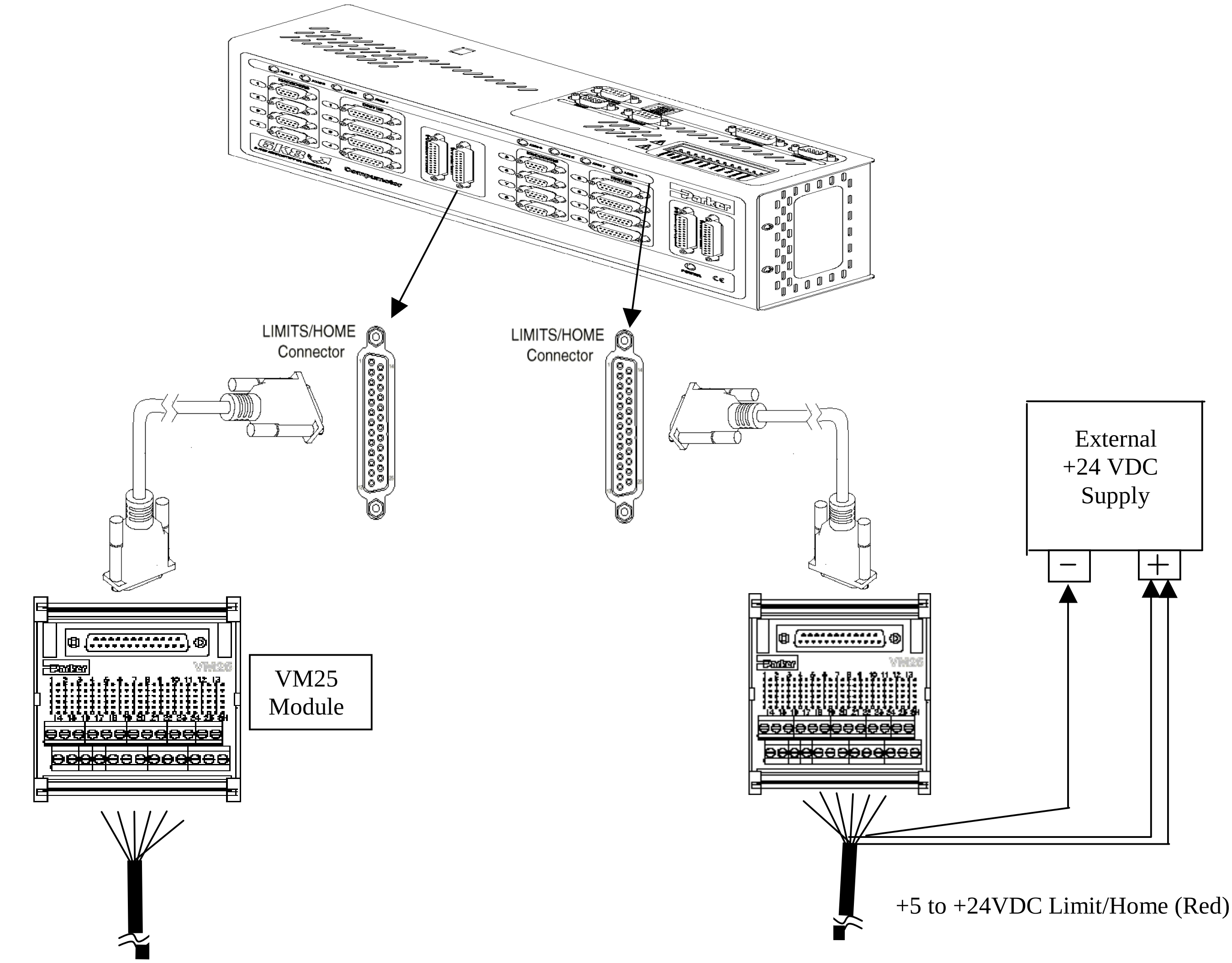


Gemini Motor Phase Connections

- Use these Connections to connect the LXR's Fork Terminal Motor Phase Cable to the Gemini Drive.

Function	Wire Color	Pin #
	Motor Phase	
Phase A	M.W. White #1	U
Phase B	M.W. White #1	V
Phase C	M.W. White #1	W
Ground	Green/Yellow	Grd
Shield	Shield	Shield Cover

Note: For Maximum Noise Immunity It is recommended that the end of the Motor Cable be strip back and connected to the Ground clamp located on the side of the Gemini. See Gemini Hardware manual for grounding details.



LXR Limit/Home Cable
P/N 006-1742-0X

VM25 Pin Outs** 6K Axis Number								Function	Wire Color*	LXR Pin #
1	2	3	4	5	6	7	8			
Connect to external power supply (see above)								+5 to +24VDC	Red	A
21	15	9	3	21	15	9	3	(-) Limit	Blue	B
23	17	11	5	23	17	11	5	(+) Limit	Orange	C
19	13	7	1	19	13	7	1	Home	Green	D
All even pins are connected to logic ground.								Ground	Black	E

* Color scheme of the flying leads from the Limit/Home Cable. P/N 006-1742-0X.

** Axes 1-4 use the first 25-pin limits/home connector and axes 5-8 use the second limits/home connector on the 6K.

Chapter 6 - Maintenance and Lubrication

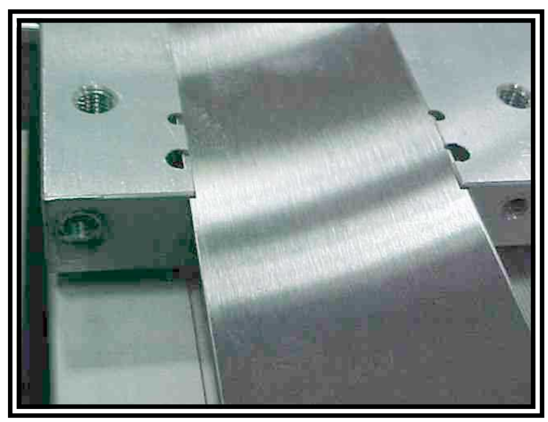
Internal Access Procedure

The following procedure outlines the steps required to access the interior of the positioner.

- Remove carriage end caps by removing eight (8) M6 Socket Head Cap Screws (4pc/carriage side).

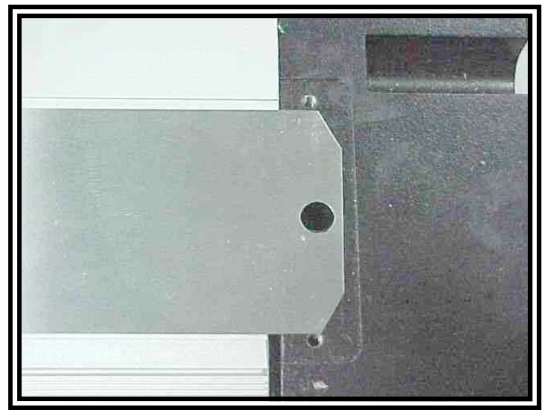
- Pull carriage end caps off. Carriage end caps on both sides of carriage must be removed.

- Remove the two (2) strip seal cover plates.

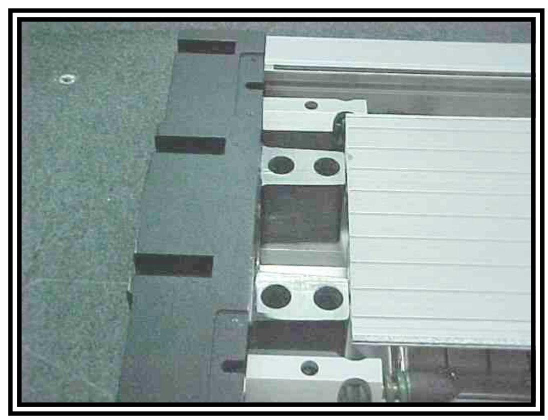


- Remove the four (4) strip seal clamps by removing eight (8) M3 Socket Head Cap Screws (2pc/clamp).

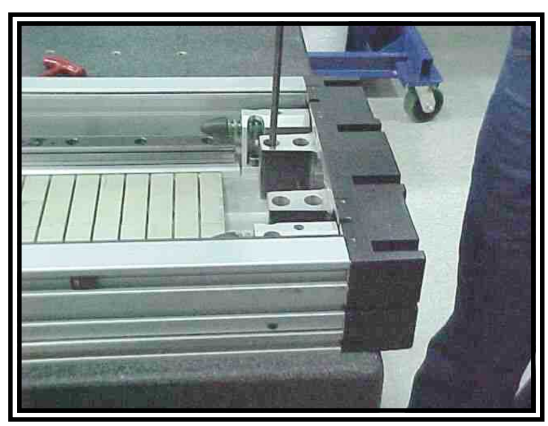
- Carefully pull the strip seal through the carriage.
- Caution: The strip seal ends are VERY SHARP.



- Carefully lift one end of the top cover so that it clears the edge of the end block. Push the top cover through the carriage and set aside.

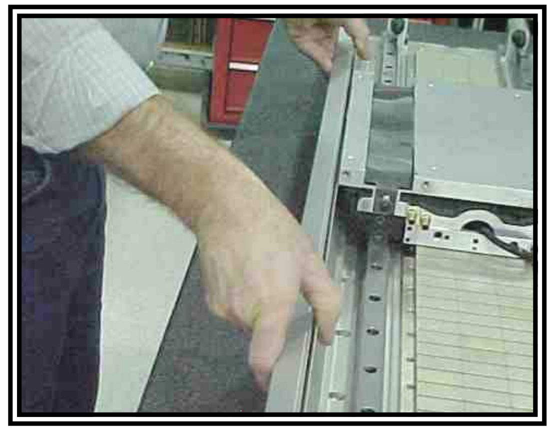


- Remove one end block by removing four (4) M6 Socket Head Cap Screws.



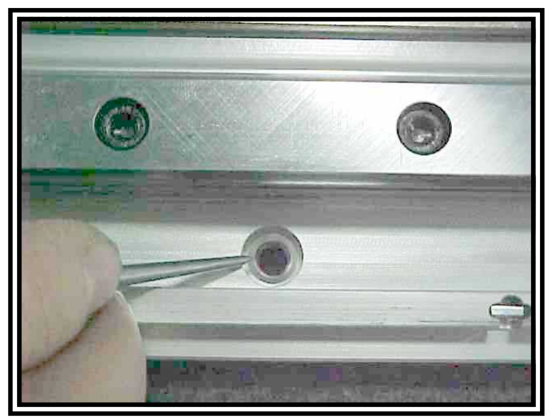
- Remove the M3 Button Head Cap Screws that attach the side covers to the base.

- Slide the side cover off the base.



- The base mounting holes can now be accessed.

- Great care should be used when inserting and tightening screws on the side with the encoder tape scale. If the tape is damaged the linear encoder will not function properly and the table may “run away.”



Reassemble positioner by reversing steps.

Note: When installing the strip seals to the unit, completely tighten one clamp while the leaving the other side loose. Thread, but do not tighten the screws on the other end. Pull the clamp away from the carriage and tighten the screws to ensure the strip seal is pulled taught.

Square Rail Bearing Lubrication

See Section on *Internal Access* for procedure to access interior of positioner.

Materials Required: Daedal Grease type #1, Isopropyl Alcohol, Clean Cloth, Small Brush

- Lubrication Type:

  Daedal grease type #1, model number G1. Lithium 12 hydoxstearate soap base containing additives to enhance oxidation resistance and rust protection (viscosity, 70/80 CST at 100 degrees C) is recommended for grease lubrication.

- Lubricant Appearance:

  Blue and very tacky.

- Maintenance Frequency:

  Square rail bearing blocks are lubricated at our facility prior to shipment. For lubrication inspection and supply intervals following shipment, apply grease every 1000 hours of usage. The time period may change depending on frequency of use and environment. Inspect for contamination, chips, etc, and replenish according to inspection results.

- Lubricant Application:

  Locate the two grease fittings on the side of the carriage. Apply one pump of grease into each fitting. Move the carriage 700 mm to ensure the grease is evenly dispersed. After bearings are relubricated, check encoder tape scale located on inside wall of table. If the tape scale is dirty, clean with lint free cloth, removing all dirt and grease. Using a lint free cloth, wipe down linear tape scale with isopropyl alcohol. Check to make sure the encoder is clean and getting proper encoder counts by moving the carriage by hand.

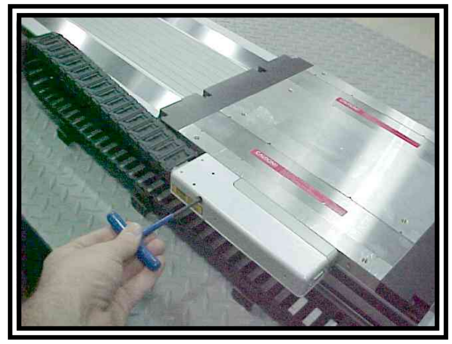
- Note: Do not use/mix petroleum base grease with synthetic base grease at any time. For lubrication under special conditions consult factory.

Cable Management Module Replacement

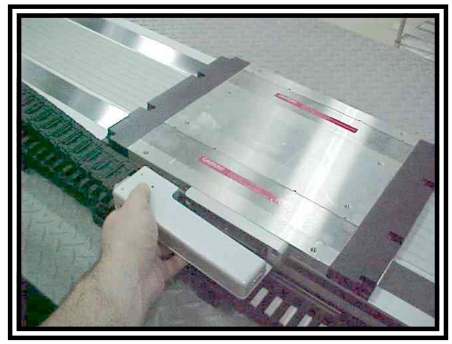
- Order replacement Cable Management Module Below:

Travel Code	Replacement Part Number	Travel Code	Replacement Part Number	Travel Code	Replacement Part Number
T01	006-1744-01	T05	006-1744-05	T09	006-1744-09
T02	006-1744-02	T06	006-1744-06	T10	006-1744-10
T03	006-1744-03	T07	006-1744-07	T11	006-1744-11
T04	006-1744-04	T08	006-1744-08	T12	006-1744-12

- Remove one (1) M3 Socket Head Cap Screw from the side of the carriage connector.

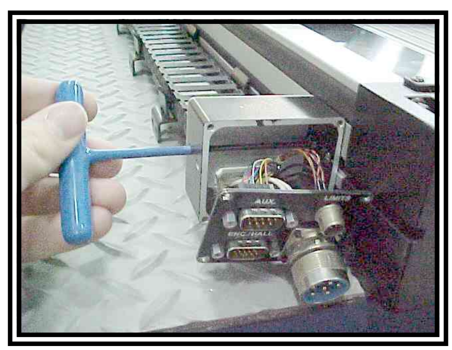


- Pull the carriage connector off, taking care to pull straight off to avoid bending the connectors.



- Disconnect all of the cables attached to the transport module and locate the four (4) M2 Button Head Screws at the corners of the cover plate. Remove the screws and gently pull on the cover plate to reveal the internal wiring.

- Remove two (2) M3 Button Head Cap Screws that attach the module to a T-nut. The T-nut secures the module to the table.

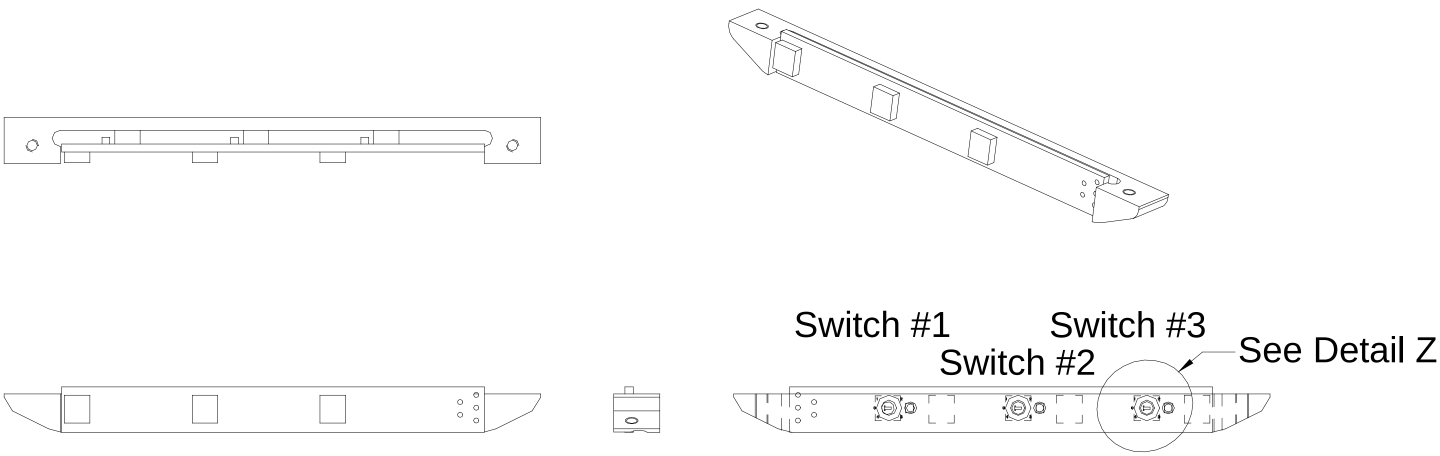


Replacement modules are mounted by reversing steps.

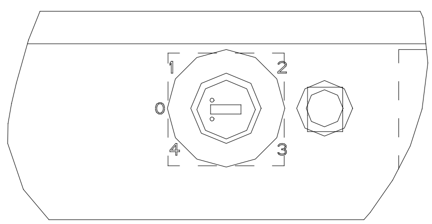
Limit and Home Sensor Module Adjustment

Materials Required: Small flathead screwdriver.

- See switch location table below.



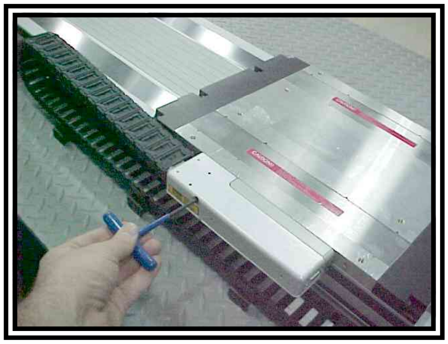
Shown in 'Zero' Position



Detail Z

Limit and Home Option	Switch #1 Position	Switch #2 Position	Switch #3 Position		Limit and Home Option	Switch #1 Position	Switch #2 Position	Switch #3 Position
H2L2-412LXR	1	1	1		H4L2-412LXR	1	2	1
H2L3-412LXR	4	1	4		H4L3-412LXR	4	2	4
H2L4-412LXR	2	1	2		H4L4-412LXR	2	2	2
H2L5-412LXR	3	1	3		H4L5-412LXR	3	2	3
H3L2-412LXR	1	4	1		H5L2-412LXR	1	3	1
H3L3-412LXR	4	4	4		H5L3-412LXR	4	3	4
H3L4-412LXR	2	4	2		H5L4-412LXR	2	3	2
H3L5-412LXR	3	4	3		H5L5-412LXR	3	3	3

- Remove one (1) M3 Button Head Screw from the side of the carriage connector.

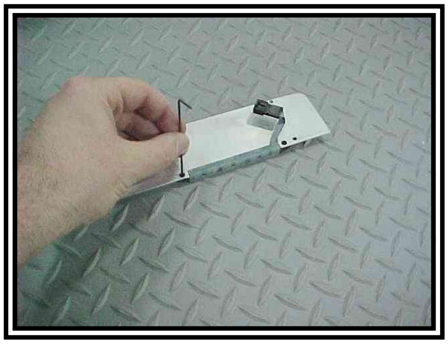


- Pull the carriage connector off, taking care to pull straight off to avoid bending the connectors.

- Remove the four (4) M2 Button Head Screws that attach the connector housing top to its base.

- Locate the limit/home wire connection. Press on the release tab to disengage the connector.

- Remove the two (2) M2 Flat Head Screws that attach the limit/home switch to the cable carrier.



Replacement switches are mounted by reversing steps.

Appendix A – Understanding Linear Motors

The Linear Motor Concept

Linear Motors are basically a conventional rotary servo motor unwrapped. So now what was the stator is now called a forcer and the rotor becomes a magnet rail. With this design, the load is connected directly to the motor. No more need for a rotary to linear transmission device.

Linear Motor Benefits

- **High speeds:** Only the bus voltage and the speed of the control electronics limit the maximum speed of a linear motor. Typical speeds for linear motors are 3 meters per second with 1 micron resolution and over 5 meters per second with courser resolution.
  Note: Motors must be sized for specific loading conditions.

- **High Precision:** The feedback device controls the accuracy, resolution, and repeatability of a linear motor driven device. And with the wide range of linear feedback devices available today, resolution and accuracy are primarily limited to budget and control system bandwidth.

- **Fast Response:** The response rate of a linear motor driven device can be over 100 times faster than some mechanical transmissions. This is simply because there is no mechanical linkage. This means faster accelerations and settling times, thus more throughput.

- **Stiffness:** Because there is no mechanical linkage in a linear motor, increasing the stiffness is simply a matter of gain and current. Thus the spring rate of a linear motor driven system can be many times that of a ball screw driven device. However it must be noted that this is limited by the motor's peak force, the current available, and the resolution of the feedback.

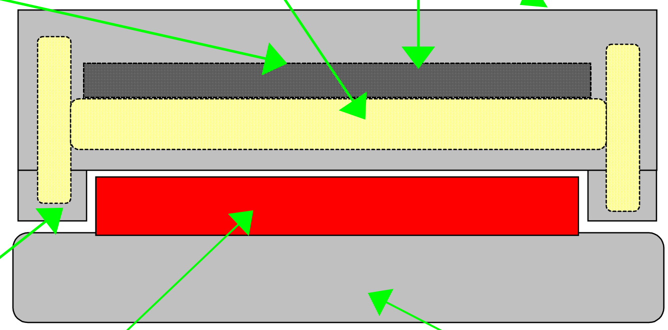
- **Zero Backlash:** Since there are no mechanical components there is no backlash. There are however, resolution considerations which effect the repeatability of the positioner (See Chapter 2, *General Table Specifications*, Chapter 3, *Setting Home Sensor* and *Z Channel Position Reference*)

- **Maintenance Free Drive Train:** Because linear motors of today have no contacting parts, in contrast with screw and belt driven positioners, there is no wear on the drive mechanism.

Slotless Linear Motor Design

The Linear Motor inside the 412LXR is a Slotless Linear Motor. The following will give a brief description of the motor design and construction:

- **Construction:** Designed by the Compumotor and Daedal Divisions of Parker Hannifin, the motor takes its operating principle from Parker's slotless rotary motors which have grown popular over the past few years. The magnetic rail is simply a flat iron plate with magnets bonded to it. The forcer is unique. It begins with a coil and a "backiron" plate, which is placed behind the coil. This assembly is placed inside an aluminum housing with an open bottom. The housing is then filled with epoxy, securing the winding and "backiron" into the housing. The thermal sensors and hall effect sensors are mounted to the housing.



Advantages/Disadvantages of Slotless Linear Motors

- **Lower Weight Magnetic Rail:** Since this is a single magnet rail the weight is less then half of dual magnet rail motors. This means less load and higher throughput in multi-axis systems.

- **Structurally Strong Forcer:** With the body of the forcer being made of aluminum and the windings being bonded to this housing, the strength of the forcer is much greater than that of the epoxy only housed motors. Thus reducing the possibility of motor fatigue failures.

- **Light Weight Forcer:** Because of its aluminum body construction, the slotless linear motor forcer weight is approximately 2/3 that of an equivalent iron core linear motor. Thus resulting in higher throughput in light load applications.

- **Lower Attractive Forces:** The slotless design has a "backiron" causing attractive forces between the forcer and the rail. However, this attractive force is significantly less than other linear motors. Thus significantly reducing loading on the linear guide bearings and increasing bearing life.

- **Lower Cogging:** Due to the larger magnetic gap between the magnets and forcer "backiron" the slotless design has lower cogging. This enables the slotless design to operate in applications that require very good velocity control.

- **Heat Dissipation:** The slotless design, with the coil resting across the "backiron", which is in direct contact with the aluminum housing, has very good heat transfer characteristics and is easy to manage.

Appendix B - Internal Protection

The 412LXR is protected from its environment via a magnetically retained protective seal. Daedal has conducted testing to determine the *degree* to which the positioner is protected by using a British standard called an **Ingress Protection Rating (IP Rating)**.

Definition

Reference: British standard EN 60529 : 1992

This standard describes a system of classifying degrees of protection provided by enclosures of electrical equipment. Standardized test methods and the establishment of a two digit numeric rating verify the extent of protection provided against access to hazardous parts, against ingress of solid foreign objects, and against the ingress of water.

First Number – The first number indicates protection of persons against access to dangerous parts and protection of internal equipment against the ingress of solid foreign objects.

1 - Protection against access to hazardous parts with the back of a hand, and protected against solid foreign objects of 50 mm diameter and larger.

2 - Protection of fingers against access to dangerous parts, and protection of equipment against solid foreign objects of 12.5 mm diameter and larger.

3 - Protection against access to hazardous parts with a tool, and protection against solid foreign objects of 2.5 mm diameter and larger.

Second Number – The second number indicates protection of internal equipment against harmful ingress of water.

0 - No special protection provided.

Note: Number Indicators above represent only a partial list of IP Rating specifications.

Warnings (Points of Clarity)

- The specification applies to protection of particles, tools, parts of the body, etc., against access to hazardous parts inside the enclosure. This does not cover external features such as switch pinch points, pinch points causes by the motion of the carriage, or cable carrier assemblies.
- The testing method as specified in the standard uses a solid steel rod of the appropriate diameter at a specified force. The specification does not consider soft or pliable particles. Due to the design of the table and sealing method, a soft particle can compress due to the motion of the table, and reduce its cross-section. This can allow particles to enter the unit.
- In application, shavings or chips commonly created in a machining operation are a greater concern. If any edge or dimension of the “chip” is under the appropriate diameter, it can wedge under and start to the lift the seals. This action will allow larger particles to do the same until failure is reached.

Product Rating

All standard configurations will pass IP30 specifications with the following exception:

- The cable carrier is not covered by the specification.

All standard configurations, (less cable carrier), can be configured to pass IP30 specifications by utilizing the “IP ship kit” supplied with each unit as follows:

- Using the supplied *aluminum foil disks*, cover all *counter-bored base mounting holes* that are not covered by your mounting surface. The disks should be installed from the outside of the unit. Depending on the travel length, some disks will not be used.

- Using the supplied *aluminum foil disks*, plug all unused *carriage mounting holes* that are not covered by the load or load plate.

- Using the supplied *aluminum foil disks*, plug all *threaded base mounting holes* that are not covered by your mounting surface. Depending on the travel length, some disks will not be used.

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