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GSM SERIES

INTEGRATED SERVO MOTOR AND ACTUATOR

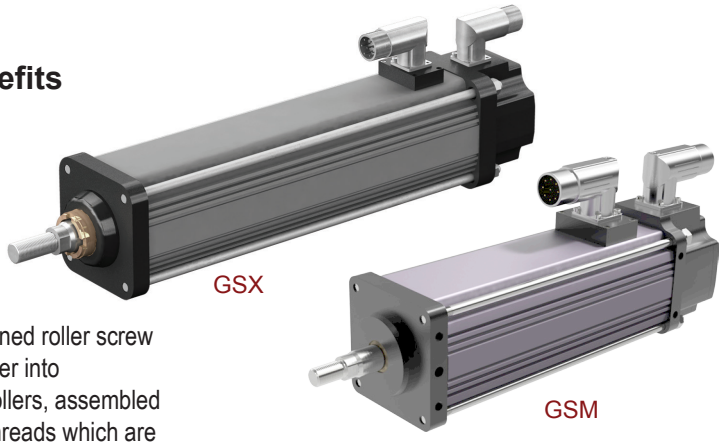
Economical alternative to GSX

Standard capacity screw

GS Series

GSX and GSM Common Benefits

The GS Series linear actuators by Exlar offers you two grades of actuator to provide cost effective options in order to meet your application's requirements. View the chart below to compare the GSX and GSM models.



All GS Series actuators use a specially designed roller screw mechanism for converting electric motor power into linear motion within the actuator. Planetary rollers, assembled around the actuator's extending rod, follow threads which are precisely machined on the inside surface of the actuator's hollow armature. Linear motion is produced in precise synchronization with the armature rotation. Because roller screw mechanism has an inherently larger cumulative contact surface, these actuators have a much longer working life, and can handle heavier loads at higher speeds than is possible from a similarly sized ball screw system.

Exlar's T-LAM segmented lamination stator technology delivers higher continuous motor torque than in traditionally wound motors. T-LAM technology consists of stator segments, each containing individual phase wiring for maximum motor performance. The improved efficiencies of the GSX Series are a result of the limited heat generation qualities inherent in the segmented stator design (see diagram). The elimination of end turns in the stator, and the use of thermally conductive potting removes the parts most susceptible to failure in a traditional stator. Other design advantages include:

- Neodymium-iron-boron magnets provide high flux density and maximum motor torque.
- Thermally conductive potting of the entire stator provides increased heat dissipation and protection from contamination in oil-cooled units.
- Each stator segment contains individual phase wiring. External winding of individual segments provides maximum slot fill for maximum motor performance.
- Class 180 H insulation systems compliant with UL requirements.
- UL recognized component.
- CE compliant.

Integrated Motor and Actuator in One Compact Unit

With other actuator technologies, customers are usually responsible for engineering the linear motion system. This process usually includes purchasing the motor, gear reducer, timing belt, mounting hardware, flexible couplings, etc. separately. Then these components must be assembled to perform properly for a given application.

GS Series actuators eliminate all this systems engineering. These units are single, fully integrated component packages that are much smaller than traditional rotary-to-linear conversion mechanisms.

Designed for Closed Loop Servo Systems

Their brushless servo design means GS Series units can be used in advanced closed-loop servo systems when velocity regulation and position control are required. Position feedback can be delivered in a number of different forms. These include resolvers, encoders, or internally mounted linear position feedback sensors.

GSX and GSM Differences	GSX (pg 5)	GSM (pg 36)
Frame Sizes	**20, 30, 40, 50, 60**	**20, 30, 40**
Roller Screw Option	High Capacity	Standard Capacity
Ingress Protection	IP65S	IP54S (IP65S optional)
Motor Stacks	1, 2, 3	1, 2
Life vs. Ball Screw	15X	2 to 5X
Oil Cooling Option	Yes	No
Rated Force (lbf)	92 - 15,000	92 - 3,966
Speeds (ips)	5 - 40	5 - 37.5
Backlash (in)	0.004	0.008

GSM Series

Standard Capacity Roller Screw Technology

Description

This design incorporates superior roller screw technology with an integral brushless servo motor for medium to high performance motion control applications. The GSM Series offers 5 times the travel life and a smaller package with higher speed and higher load capacity than ball screws and other traditional rotary-to-linear conversion mechanisms. These features make the GSM Series an excellent replacement for ball screw actuators.

Selection of the proper feedback configuration allows GSM Series actuators to be powered by nearly any brand of brushless motor amplifier on the market. This flexibility allows these actuators to be incorporated into the highest performance single and multi-axis motion control systems in use today. In applications varying from food and beverage packaging, to multi-axis turning centers, to aircraft assembly, the GSM Series shows incredible performance and durability.

Feature	Standard	Optional
External anti-rotate mechanism	No	Yes
Internal Anti-rotate Mechanism	No	Yes
Pre-loaded follower	No	Yes
Electric brake	No	Yes
External End Switches	No	Yes
Connectors	Right Angle, Rotatable	Custom Connectors
Mounting Style	Extended Tie Rods, Side Tapped Mounting Holes, Trunnion, Rear Clevis, Front or Rear Flange	Custom Mountings
Rod End	Male or Female: U.S. Standard or Metric	Specials Available To Meet OEM Requirements
Lubrication	Greased, Oil Connection Ports are Built-in for Customer Supplied Recirculated Oil Lubrication	Specials Available To Meet OEM Requirements
Primary Feedback	Standard Encoders or Resolvers to Meet Most Amplifier Requirements	Custom Feedback

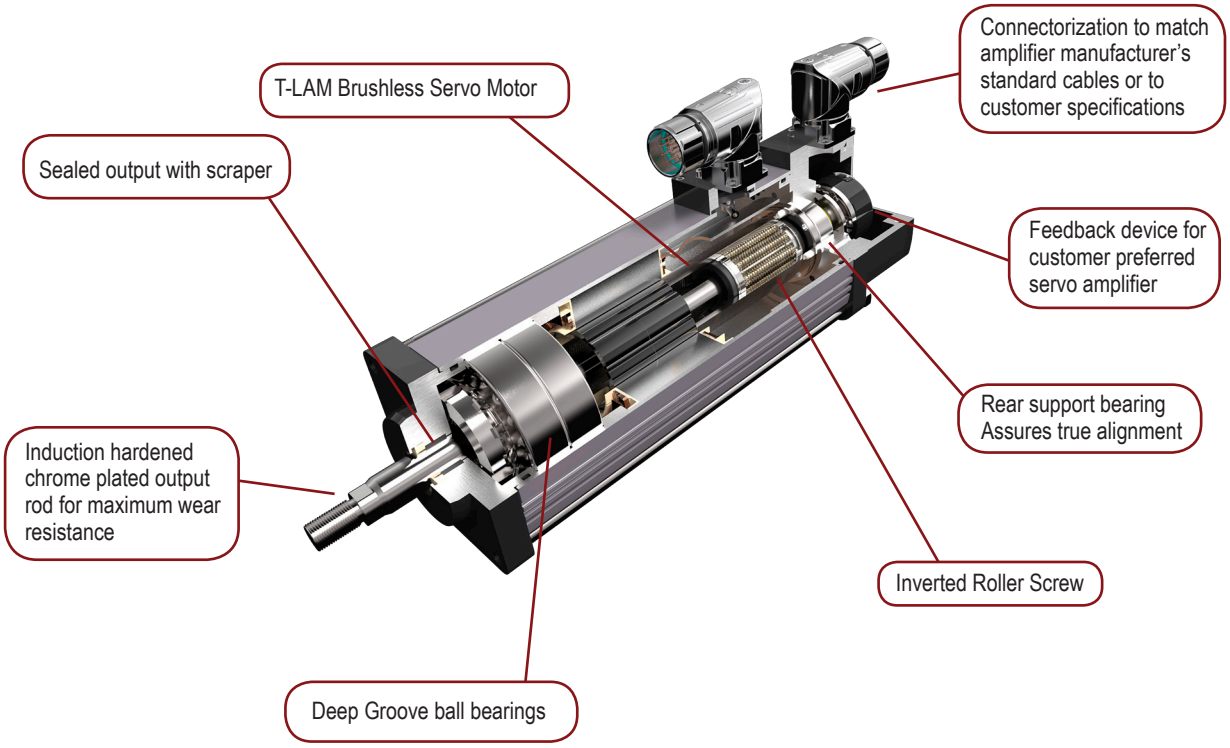
Technical Characteristics	
Frame Sizes in (mm)	2.25 (60), 3.3 (80), 3.9 (100)
Screw Leads in (mm)	0.1 (2.54), 0.2 (5.08), 0.4 (10.16), 0.5 (12.7), 0.75 (19.05)
Standard Stroke Lengths in (mm)	3 (76), 4 (102), 6 (152), 8 (203), 10 (254), 12 (305), 14 (356), 18 (457)
Force Range	103 to 3,457 lbf (458 to 15.3 kN)
Maximum Speed	Up to 37.5 in/sec (952 mm/sec) linear speeds

Operating Conditions and Usage		
Accuracy:		
Screw Lead Error	in/ft (µm / 300 mm)	0.001 (25)
Screw Travel Variation	in/ft (µm / 300 mm)	0.0012 (30)
Screw Lead Backlash	in	0.008 maximum
Ambient Conditions:		
Standard Ambient Temperature	°C	0 to 65
Extended Ambient Temperature*	°C	-30 to 65
Storage Temperature	°C	-40 to 85
IP Rating		IP54S
Vibration**		3.5 grms; 5 to 500 hz

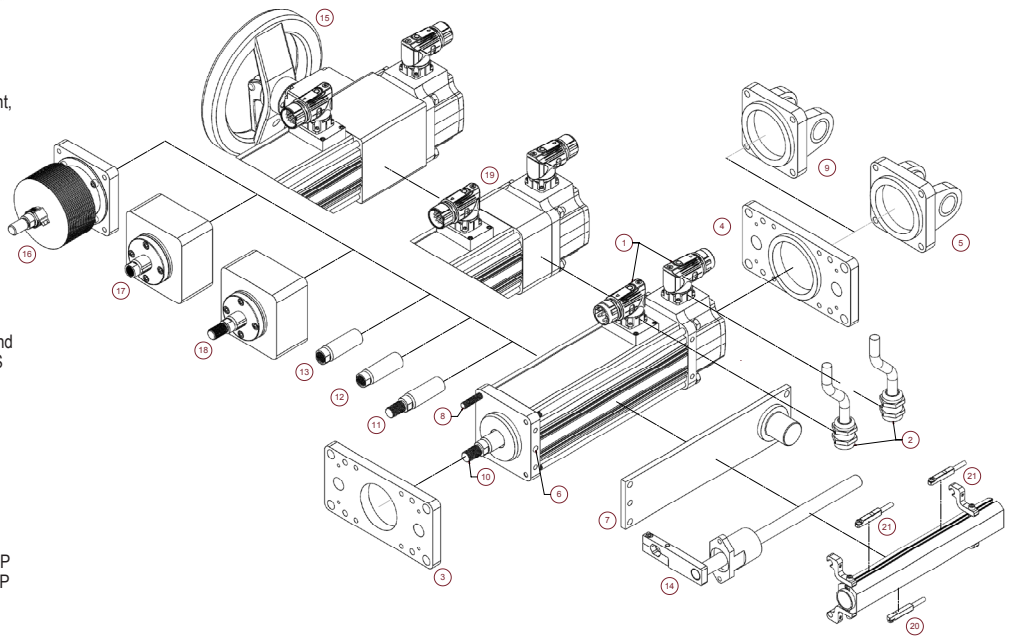
* Consult Exlar for extended temperature operations
** Resolver feedback

Ratings at 25°C, operation over 25°C requires de-rating.

Product Features



1 - Exlar standard M23 style and manufacturer's connector
2 - Embedded leads 3 ft. standard*
3 - Front flange and rear flange*
4 - Male metric thread SS and female, metric thread
5 - Rear clevis
6 - Side mount*, double side mount, metric side mount*, and metric double side mount
7 - Side trunnion and metric side trunnion
8 - Extended tie rods and metric extended tie rods
9 - Metric rear clevis
10 - Male, US standard thread and male, US standard thread SS
11 - Male, metric thread and male metric thread SS
12 - Female, US standard thread and female, US standard thread SS
13 - Female, metric thread and female, metric thread SS
14 - External anti-rotate
15 - Manual drive, handwheel with interlock switch
16 - Protective bellows
17 - Splined main rod- Female
18 - Splined main rod - Male
19 - Rear brake
20 - External limit switch - N.O., PNP
21 - External limit switch - N.C., PNP



* Consult Factory

Industries and Applications:

Hydraulic cylinder replacement
Ball screw replacement
Pneumatic cylinder replacement

Automotive
- Parts Clamping
- Automated Assembly

Food Processing
- Sealing
- Dispensing
- Forming
- Pick and Place Systems
- Fillers
- Cutting / Slicing / Cubing

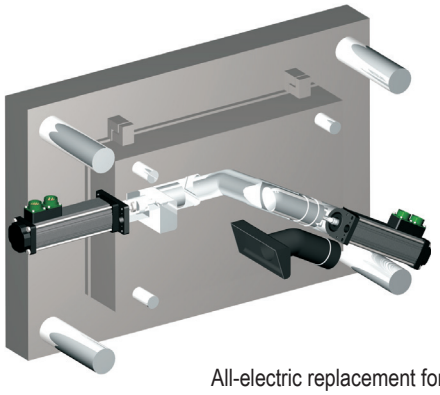
Process Control
- Control Valves
- Conveyor Diverters / Gates
- Dampers
- Pilot Valves

Entertainment / Simulation
- Robot Manipulator Arms
- Test Stands

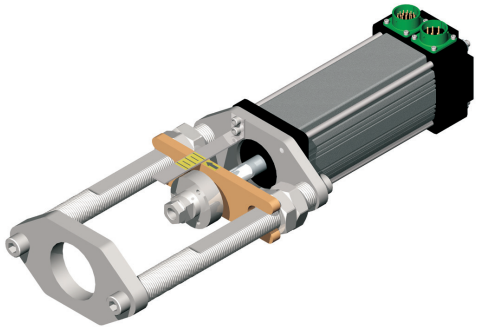
Medical Equipment
- Volumetric Pumps
- Patient Positioning

Plastics
- Cutoffs
- Die Cutters
- Molding
- Formers

Material Handling
- Open / Close Doors
- Automated Flexible Fixturing
- Automatic Tool Changers
- Tension Control
- Web Guidance
- Wire Winding



All-electric replacement for hydraulic cylinders improves throughput with servo control and lower maintenance for core-pull cylinders.



A typical 3 inch stroke GSM Series actuator used in a valve-modulating application can control position to +/– 0.5% and fully open or close in less than 200 mSec.

Mechanical Specifications

GSM20

Model No. (Motor Stacks)		1 Stack			2 Stack		
Screw Lead Designator		**01**	**02**	**04**	**01**	**02**	**04**
Screw Lead	in	0.1	0.2	0.4	0.1	0.2	0.4
	mm	2.54	5.08	10.16	2.54	5.08	10.16
Continuous Force *(Motor Limited)*	lbf	367	195	103	578	307	163
	N	1632	867	459	2571	1366	723
Max Velocity	in/sec	8.3	16.8	33.3	8.3	16.8	33.3
	mm/sec	211.7	423.3	846.7	211.7	423.3	846.7
Friction Torque *(standard screw)*	in-lbf	1.0			1.1		
	N-m	0.12			0.12		
Friction Torque *(preloaded screw)*	in-lbf	1.25			1.25		
	N-m	0.14			0.14		
Back Drive Force [1]	lbf	110	60	30	110	60	30
	N	490	270	135	490	270	135
Min Stroke	in	3			3		
	mm	76			76		
Max Stroke	in	12			12		
	mm	305			305		
C_a (Dynamic Load Rating)	lbf	1568	1219	738	1568	1219	738
	N	6970	5422	3283	6970	5422	3283
Inertia *(zero stroke)*	lb-in-s^2	0.0007758			0.0008600		
	Kg-m^2	0.00008766			0.00009717		
Inertia Adder *(per inch of stroke)*	lb-in-s^2/in	0.00004667					
	Kg-m^2/in	0.000005273					
Weight *(zero stroke)*	lb	4.5			5.0		
	Kg	2.04			2.27		
Weight Adder *(per inch of stroke)*	lb	0.5					
	Kg	0.23					

GSM30

Model No. (Motor Stacks)		1 Stack			2 Stack		
Screw Lead Designator		**01**	**02**	**05**	**01**	**02**	**05**
Screw Lead	in	0.1	0.2	0.5	0.1	0.2	0.5
	mm	2.54	5.08	12.7	2.54	5.08	12.7
Continuous Force *(Motor Limited)*	lbf	792	449	190	1277	724	306
	N	3521	1995	845	5680	3219	1363
Max Velocity	in/sec	5.0	10.0	25.0	5.0	10.0	25.0
	mm/sec	127.0	254.0	635.0	127.0	254.0	635.0
Friction Torque *(standard screw)*	in-lbf	1.5			1.7		
	N-m	0.17			0.19		
Friction Torque *(preloaded screw)*	in-lbf	1.75			1.75		
	N-m	0.20			0.20		
Back Drive Force [1]	lbf	180	80	40	180	80	40
	N	800	360	180	800	360	180
Min Stroke	in	3			3		
	mm	75			75		
Max Stroke	in	18			18		
	mm	457			457		
C_a (Dynamic Load Rating)	lbf	3310	3570	3016	3310	3570	3016
	N	14724	15880	13416	14724	15880	13416
Inertia *(zero stroke)*	lb-in-s^2	0.002655			0.002829		
	Kg-m^2	0.0003000			0.0003196		
Inertia Adder *(per inch of stroke)*	lb-in-s^2/in	0.0001424					
	Kg-m^2/in	0.00001609					
Weight *(zero stroke)*	lb	6.5			7.65		
	Kg	2.95			3.47		
Weight Adder *(per inch of stroke)*	lb	1.1					
	Kg	0.50					

[1] Back drive force is nominal value only. Operating conditions can cause wide variations in back drive force. Exlar cannot assure that an actuator will or will not back drive.

GSM40

Model No. (Motor Stacks)		1 Stack				2 Stack			
Screw Lead Designator		**01**	**02**	**05**	**08**	**01**	**02**	**05**	**08**
Screw Lead	in	0.1	0.2	0.5	0.75	0.1	0.2	0.5	0.75
	mm	2.54	5.08	12.7	19.05	2.54	5.08	12.7	19.05
Continuous Force *(Motor Limited)*	lbf	2089	1194	537	358	3457	1975	889	593
	N	9293	5310	2390	1593	15377	8787	3954	2636
Max Velocity	in/sec	5.0	10.0	25.0	37.5	5.0	10.0	25.0	37.5
	mm/sec	127.0	254.0	635.0	953.0	127.0	254.0	635.0	953.0
Friction Torque *(standard screw)*	in-lbf	2.7				3.0			
	N-m	0.31				0.34			
Friction Torque *(preloaded screw)*	in-lbf	3.0				3.0			
	N-m	0.34				0.34			
Back Drive Force [1]	lbf	380	150	60	50	380	150	60	50
	N	1700	670	270	220	1700	670	270	220
Min Stroke	in	4				6			
	mm	102				102			
Max Stroke	in	18			12	18			12
	mm	457				457			
C_a (Dynamic Load Rating)	lbf	4736	4890	4218	3328	4736	4890	4218	3328
	N	21067	21751	18763	14804	21067	21751	18763	14804
Inertia *(zero stroke)*	lb-in-s^2	0.01132				0.01232			
	Kg-m^2	0.0012790				0.001392			
Inertia Adder *(per inch of stroke)*	lb-in-s^2/in	0.0005640							
	Kg-m^2/in	0.00006372							
Weight *(zero stroke)*	lb	8.0				11.3			
	Kg	3.63				5.13			
Weight Adder *(per inch of stroke)*	lb	2.0							
	Kg	0.91							

[1] Back drive force is nominal value only. Operating conditions can cause wide variations in back drive force. Exlar cannot assure that an actuator will or will not back drive.

DEFINITIONS:

Continuous Force: The linear force produced by the actuator at continuous motor torque.

Max Velocity: The linear velocity that the actuator will achieve at rated motor rpm.

Friction Torque (standard screw): Amount of torque required to move the actuator when not coupled to a load.

Friction Torque (preloaded screw): Amount of torque required to move the actuator when not coupled to a load.

Back Drive Force: Amount of axial force applied to the rod end of the actuator that will produce motion with no power applied to the actuator.

Min Stroke: Shortest available stroke length.

Max Stroke: Longest available stroke length.

C_a (Dynamic Load Rating): A design constant used when calculating the estimated travel life of the roller screw.

Inertia (zero stroke): Base inertia of an actuator with zero available stroke length.

Inertia Adder (per inch of stroke): Inertia per inch of stroke that must be added to the base (zero stroke) inertia to determine the total actuator inertia.

Weight (zero stroke): Base weight of an actuator with zero available stroke length.

Weight Adder (per inch of stroke): Weight adder per inch of stroke that must be added to the base (zero stroke) weight to determine the total actuator weight.

Electrical Specifications

GSM20

Motor Stator		118	138	158	168	218	238	258	268
RMS SINUSOIDAL COMMUTATION									
Continuous Motor Torque	lbf-in	7.6	7.3	7.0	7.0	11.9	11.5	11.0	11.3
	Nm	0.86	0.83	0.79	0.79	1.34	1.30	1.25	1.28
Torque Constant (Kt) (+/– 10% @ 25˚C)	lbf-in/A	2.5	5.2	7.5	9.5	2.5	5.2	8.6	10.1
	Nm/A	0.28	0.59	0.85	1.07	0.28	0.59	0.97	1.15
Continuous Current Rating	A	3.4	1.6	1.0	0.8	5.4	2.5	1.4	1.2
Peak Current Rating	A	6.9	3.1	2.1	1.6	10.8	4.9	2.9	2.5
O-PK SINUSOIDAL COMMUTATION									
Continuous Motor Torque	lbf-in	7.6	7.3	7.0	7.0	11.9	11.5	11.0	11.3
	Nm	0.86	0.83	0.79	0.79	1.34	1.30	1.25	1.28
Torque Constant (Kt) (+/– 10% @ 25˚C)	lbf-in/A	1.7	3.7	5.3	6.7	1.7	3.7	6.1	7.2
	Nm/A	0.20	0.42	0.60	0.76	0.20	0.42	0.69	0.81
Continuous Current Rating	A	4.9	2.2	1.5	1.2	7.6	3.5	2.0	1.8
Peak Current Rating	A	9.7	4.5	2.9	2.3	15.2	7.0	4.1	3.5
MOTOR STATOR DATA									
Voltage Constant (Ke) (+/– 10% @ 25˚C)	Vrms/Krpm	16.9	35.5	51.5	64.8	16.9	35.5	58.6	69.3
	Vpk/Krpm	23.9	50.2	72.8	91.7	23.9	50.2	82.9	98.0
Pole Configuration		8	8	8	8	8	8	8	8
Resistance (L-L)(+/– 5% @ 25˚C)	Ohms	2.6	12.5	28.8	45.8	1.1	5.3	15.5	20.7
Inductance (L-L)(+/– 15%)	mH	4.6	21.4	47.9	68.3	2.5	10.2	28.3	39.5
Brake Inertia	lbf-in-sec^2	0.00012							
	Kg-cm^2	0.135							
Brake Current @ 24 VDC	A	0.33							
Brake Holding Torque	lbf-in	19							
	Nm	2.2							
Brake Engage/Disengage Time	ms	14/28							
Mechanical Time Constant (tm), ms	min	4.7	5.1	5.5	5.6	2.0	2.1	2.3	2.2
	max	6.6	7.2	7.9	7.9	2.8	3.0	3.3	3.1
Electrical Time Constant (te)	ms	1.8	1.7	1.7	1.5	2.2	1.9	1.8	1.9
Bus Voltage	Vrms	115	230	400	460	115	230	400	460
Speed @ Bus Voltage	rpm	5000							
Insulation Class		180 (H)							

Test data derived using NEMA recommended aluminum heatsink 10" x 10" x 1/4" at 25°C

Specifications subject to change without notice.

GSM30

Motor Stator		118	138	158	168	218	238	258	268
RMS SINUSOIDAL COMMUTATION									
Continuous Motor Torque	lbf-in	16.9	16.8	16.3	16.0	26.9	27.1	26.7	27.0
	Nm	1.91	1.90	1.84	1.81	3.04	3.06	3.01	3.05
Torque Constant (Kt) (+/– 10% @ 25˚C)	lbf-in/A	4.4	8.7	15.5	17.5	4.4	8.7	15.5	17.5
	Nm/A	0.49	0.99	1.75	1.97	0.49	0.99	1.75	1.97
Continuous Current Rating	A	4.3	2.2	1.2	1.0	6.9	3.5	1.9	1.7
Peak Current Rating	A	8.6	4.3	2.4	2.0	13.8	6.9	3.8	3.4
O-PK SINUSOIDAL COMMUTATION									
Continuous Motor Torque	lbf-in	16.9	16.8	16.3	16.0	26.9	27.1	26.7	27.0
	Nm	1.91	1.90	1.84	1.81	3.04	3.06	3.01	3.05
Torque Constant (Kt) (+/– 10% @ 25˚C)	lbf-in/A	3.1	6.2	11.0	12.4	3.1	6.2	11.0	12.4
	Nm/A	0.35	0.70	1.24	1.40	0.35	0.70	1.24	1.40
Continuous Current Rating	A	6.1	3.0	1.7	1.4	9.7	4.9	2.7	2.4
Peak Current Rating	A	12.2	6.1	3.3	2.9	19.5	9.8	5.4	4.9
MOTOR STATOR DATA									
Voltage Constant (Ke) (+/– 10% @ 25˚C)	Vrms/Krpm	29.8	59.7	105.8	119.3	29.8	59.7	105.8	119.3
	Vpk/Krpm	42.2	84.4	149.7	168.7	42.2	84.4	149.7	168.7
Pole Configuration		8	8	8	8	8	8	8	8
Resistance (L-L)(+/– 5% @ 25˚C)	Ohms	2.7	10.8	36.3	47.9	1.1	4.4	14.1	17.6
Inductance (L-L)(+/– 15%)	mH	7.7	30.7	96.8	123.0	3.7	14.7	46.2	58.7
Brake Inertia	lbf-in-sec^2	0.00033							
	Kg-cm^2	0.38							
Brake Current @ 24 VDC	A	0.5							
Brake Holding Torque	lbf-in	70							
	Nm	8							
Brake Engage/Disengage Time	ms	19/29							
Mechanical Time Constant (tm), ms	min	4.9	4.9	5.2	5.4	2.0	2.0	2.0	2.0
	max	9.4	9.5	10.1	10.5	3.9	3.8	3.9	3.8
Electrical Time Constant (te)	ms	2.9	2.8	2.7	2.6	3.3	3.4	3.3	3.3
Bus Voltage	Vrms	115	230	400	460	115	230	400	460
Speed @ Bus Voltage	rpm	3000							
Insulation Class		180 (H)							

Test data derived using NEMA recommended aluminum heatsink 10" x 10" x 3/8" at 25°C

Specifications subject to change without notice.

GSM40

Motor Stator		118	138	158	168	218	238	258	268
RMS SINUSOIDAL COMMUTATION									
Continuous Motor Torque	lbf-in	47.5	47.5	45.9	45.4	75.1	78.6	78.7	79.5
	Nm	5.37	5.36	5.19	5.13	8.49	8.89	8.89	8.99
Torque Constant (Kt) (+/– 10% @ 25˚C)	lbf-in/A	4.1	8.2	14.5	16.8	4.1	8.2	14.5	16.8
	Nm/A	0.46	0.93	1.64	1.90	0.46	0.93	1.64	1.90
Continuous Current Rating	A	12.9	6.5	3.5	3.0	20.5	10.7	6.0	5.3
Peak Current Rating	A	25.9	12.9	7.1	6.0	40.9	21.4	12.1	10.6
O-PK SINUSOIDAL COMMUTATION									
Continuous Motor Torque	lbf-in	47.5	47.5	45.9	45.4	75.1	78.6	78.7	79.5
	Nm	5.37	5.36	5.19	5.13	8.49	8.89	8.89	8.99
Torque Constant (Kt) (+/– 10% @ 25˚C)	lbf-in/A	2.9	5.8	10.3	11.9	2.9	5.8	10.3	11.9
	Nm/A	0.33	0.66	1.16	1.34	0.33	0.66	1.16	1.34
Continuous Current Rating	A	18.3	9.1	5.0	4.3	28.9	15.1	8.5	7.5
Peak Current Rating	A	36.6	18.3	10.0	8.6	57.9	30.3	17.1	15.0
MOTOR STATOR DATA									
Voltage Constant (Ke) (+/– 10% @ 25˚C)	Vrms/Krpm	28.0	56.0	99.3	114.6	28.0	56.0	99.3	114.6
	Vpk/Krpm	39.6	79.2	140.5	162.1	39.6	79.2	140.5	162.1
Pole Configuration		8	8	8	8	8	8	8	8
Resistance (L-L)(+/– 5% @ 25˚C)	Ohms	0.42	1.7	5.7	7.8	0.2	0.72	2.26	3.0
Inductance (L-L)(+/– 15%)	mH	3.0	11.9	37.5	49.9	1.2	5.4	18.2	23.1
Brake Inertia	lb-in-sec^2	0.00096							
	Kg-cm^2	1.08							
Brake Current @ 24 VDC	A	0.67							
Brake Holding Torque	bf-in	97							
	Nm	11							
Brake Engage/Disengage Time	ms	20/29							
Mechanical Time Constant (tm), ms	min	4.5	4.5	4.8	4.9	2.1	1.9	1.9	1.9
	max	6.0	6.0	6.4	6.6	2.8	2.6	2.6	2.5
Electrical Time Constant (te)	ms	7.0	7.0	6.6	6.4	5.9	7.5	8.0	7.8
Bus Voltage	Vrms	115	230	400	460	115	230	400	460
Speed @ Bus Voltage	rpm	3000							
Insulation Class		180 (H)							

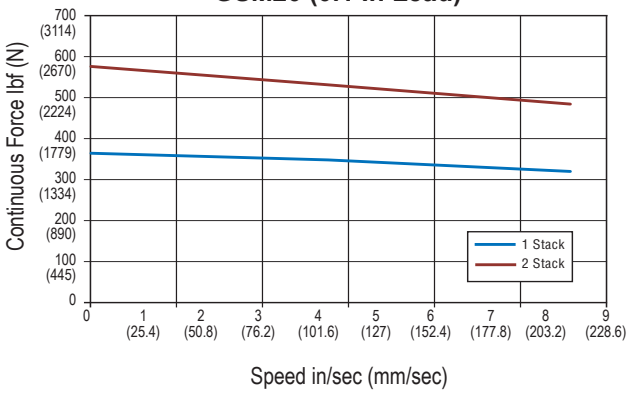
Test data derived using NEMA recommended aluminum heatsink 12" x 12" x 1/2" at 25°C

Specifications subject to change without notice.

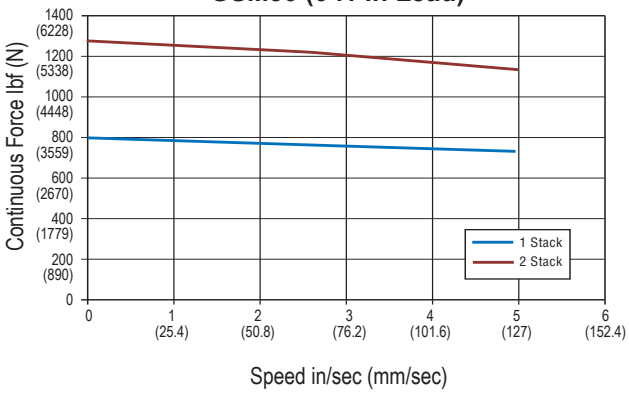
Performance Curves

The below speed vs. force curves represent approximate continuous thrust ratings at indicated linear speed. Different types of servo amplifiers will offer varying motor torque and actuator thrust. These values are at constant velocity and do not account for motor torque required for acceleration.

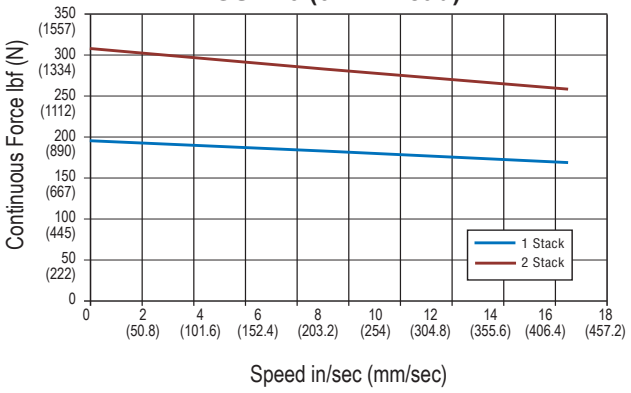
GSM20 (0.1 In Lead)



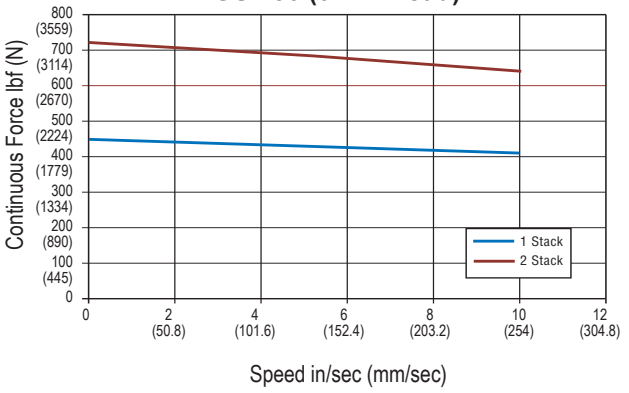
GSM30 (0 .1 In Lead)



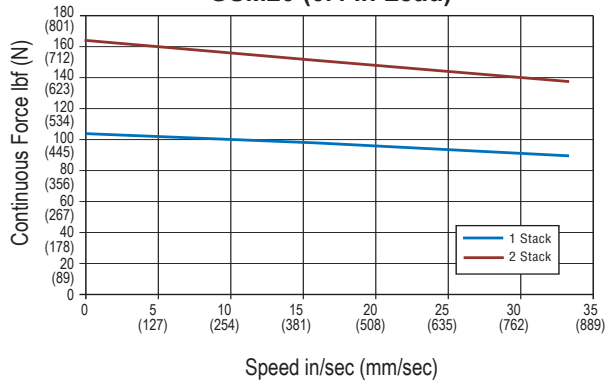
GSM20 (0.2 In Lead)



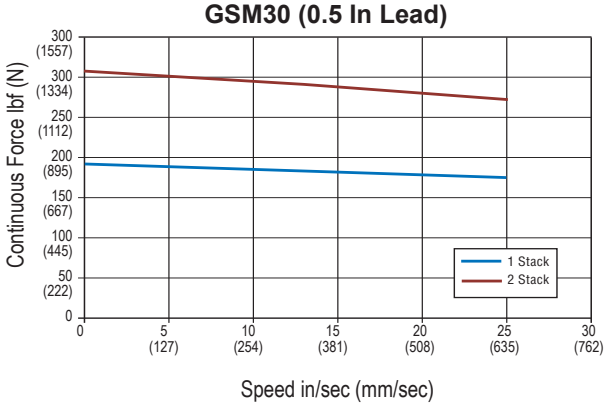
GSM30 (0.2 In Lead)



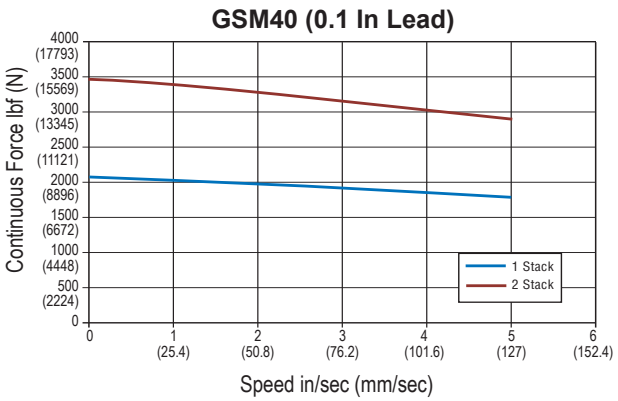
GSM20 (0.4 In Lead)

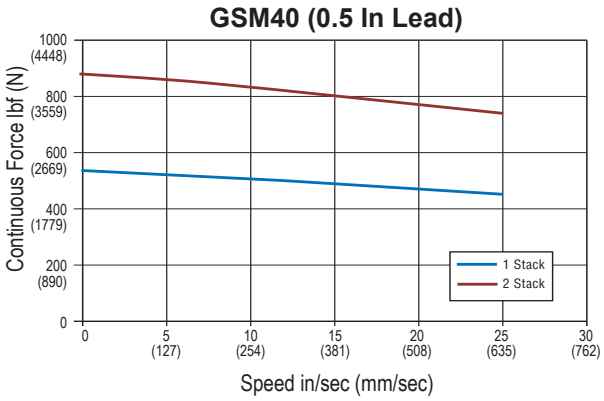


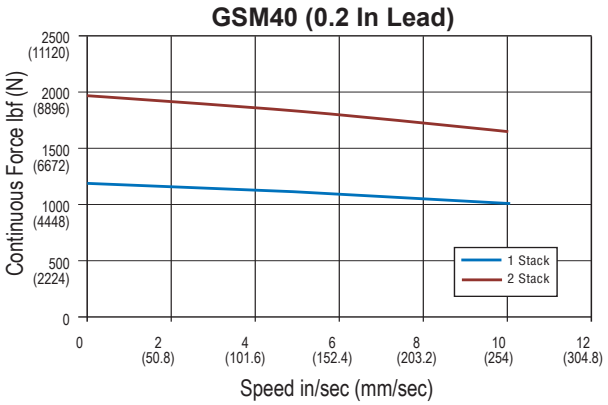
GSM30 (0.5 In Lead)

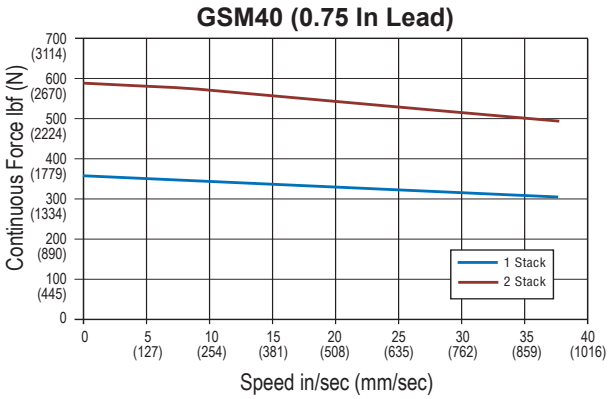


Test data derived using NEMA recommended aluminum heatsink 10" x 10" x 1/4"on GSM20 and 10" x 10" x 3/8" on GSM30



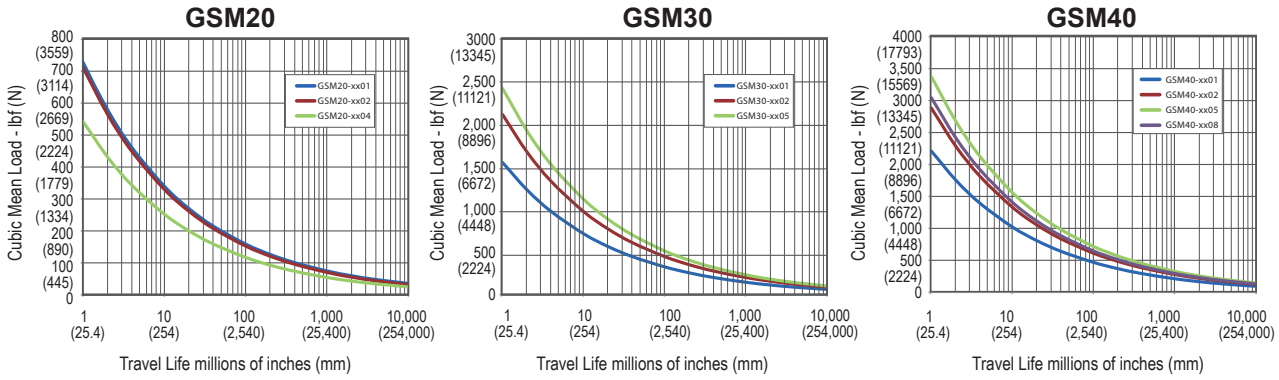






Test data derived using NEMA recommended aluminum heatsink 12" x 12" x 1/2" on GSM40

Life Curves Estimated L_{10} Travel Life



See page 17 for Life Curve Information.
If your application requires high force over a stroke length shorter than the length of the nut, please contact Exlar for derated life calculations.
You may also download the article “Calculating Life Expectancy” at www.exlar.com.

Options

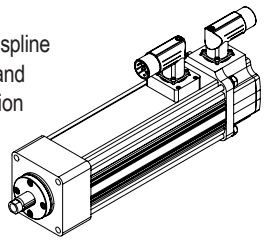
AR = External Anti-rotate Assembly

This option provides a rod and bushing to restrict the actuator rod from rotating when the load is not held by another method. Shorter actuators have single sided anti-rotation attachments. Longer lengths require attachments on both sides for proper operation. For AR dimensions, see page 30.

RB = Rear Electric Brake

This option provides an internal holding brake for the GSM Series actuators. The brake is spring activated and electrically released.

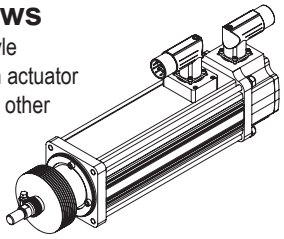
SR = Splined Main Rod



A ball spline shafting main rod with a ball spline nut that replaces the standard front seal and bushing assembly. This rod restricts rotation without the need for an external mechanism. The rod diameter will be the closest metric equivalent to our standard rod sizes. Since this option is NOT sealed, it is not suitable for environments in which contaminants may enter the actuator.

Note: Adding this option affects the overall length and mounting dimensions. Due to the reduced diameter of the splined main rod on GSX50 actuators, the standard A, F and B rod ends are not available. In this case, an "X" should be used in the rod end location. If not otherwise specified, an M24x2 male rod end will be used.

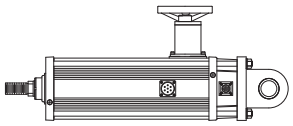
PB = Protective Bellows



This option provides an accordion style protective bellows to protect the main actuator rod from damage due to abrasives or other contaminants in the environment in which the actuator must survive. The standard material of this bellows is S2 Neoprene Coated Nylon, Sewn Construction. This standard bellows is rated for environmental temperatures of -40 to 250 degrees F. Longer strokes may require the main rod of the actuator to be extended beyond standard length. Not available with extended tie rod mounting option. Please contact your local sales representative.

HW = Manual Drive, Handwheel

This option provides a manual drive handwheel on the side of the actuator. The handwheel has an engage/disengage lever that is tied to an interrupt switch. Not available on GSM20. Also not available with holding brake unless application details have been discussed with your local sales representative.



L1, L2, L3 = Adjustable External Travel Switches

This option allows up to 3 external switches to be included with the GSM Series Actuator. These switches provide travel indication to the controller and are adjustable. See drawing on page 54. Must purchase external anti-rotate with this option.

Motor Speed

All Exlar T-LAM motors and actuators carry a standard motor speed designator (see chart). This is representative of the standard base speed of the motor for the selected bus voltage.

Designator	Base Speed	Actuator/ Motor Series
-50	5000 rpm	GSM20
-30	3000 rpm	GSM30, GSM40
01-99	Special Speed, consult your local sales representative	

If the model number is created and the location for the motor speed designator is left blank, this is the base speed to which the motor will be manufactured. The model number can also be created including this standard speed designator.

Exlar also provides the flexibility to manufacture all of its T-LAM products with special base speeds to match your exact application requirements. This may be a higher than standard speed motor, or lower base speed than standard which will allow you to get the required torque at a speed optimized to your application and use the minimum amount of current from your amplifier.

The call out for a special speed is configured in the model number by using a two digit code from 01-99. This code represents the number, in hundreds, of RPM that is the base speed for the particular motor.

For example, a GSM30-0301-MFM-EM2-138-30 motor that normally has a 3000 RPM standard winding can be changed to a 3300 RPM winding by changing the -30 to a -33. Similarly, it can be changed to a 5000 RPM winding by changing the -30 to a -50.

Changing this speed designator changes the ratings of the motor; these must be obtained from your local sales representative. Also, it is not possible to produce every possible speed from -01 to -99 for each motor at each voltage so please contact your local sales representative for confirmation of the speed that is desired for the application.

Feedback

Due to the variability in size of some feedback devices, especially absolute feedback devices which are often very large relative to the size of the actuator motor, the actual size of the actuator may differ in length and width from these drawings for feedback types other than standard resolvers and standard encoders. Please consult your local sales representative. In the event that you order an actuator that differs from these standard dimensions, you will be sent a drawing of the final configuration of your actuator for approval.

Motor Stators

GSM motor options are described with a 3 digit code. The first digit calls out the stack length, the second digit signifies the rated bus voltage, and the third digit identifies the number of poles of the motor. Refer to the mechanical/electrical specifications for motor torque and actuator rated force.

118	1 stack	115 Vrms	8 Pole	Class 180 H
138		230 Vrms		
158		400 Vrms		
168		460 Vrms		
1A8*		24 VDC		
1B8*		48 VDC		
1C8*		120 VDC		
218	2 stack	115 Vrms	8 Pole	Class 180 H
238		230 Vrms		
258		400 Vrms		
268		460 Vrms		
2A8*		24 VDC		
2B8*		48 VDC		
2C8*		120 VDC		

Note: 3 stack not available in GSM Series

* Low voltage stators may be limited to less than catalog rated torque and/or speed. Please contact your local sales representative when ordering this option.

Rod End Attachments

Rear Clevis Pin **Spherical Rod Eye**
Rod Eye **Rod Clevis**

See drawings on pages 53-54.
Attachments ordered separate from actuator.

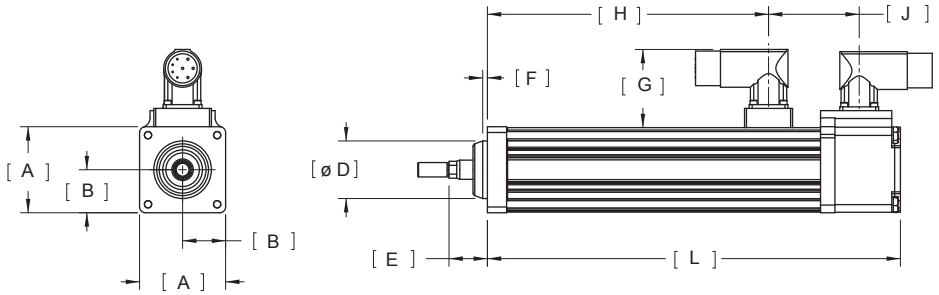
Housing Options

P5 = IP65S Sealing Option

Please read full description of IP Ratings in the engineering reference in the back of the book.

Dimensions

Base Actuator



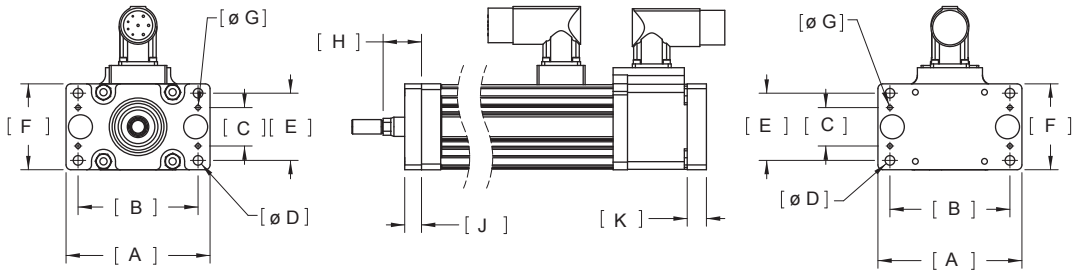
		GSM20	GSM30	GSM40
A	in	2.24	3.05	3.90
	mm	56.9	77.4	99.1
B	in	1.12	1.52	1.95
	mm	28.4	38.7	49.5
Ø D	in	1.500 +0.000/-0.003	2.000 +0.000/-0.003	2.500 +0.000/-0.003
	mm	38.10 0.00/0.08	50.80 0.00/0.08	63.50 0.00/0.08
E [5]	in	1.00	1.32	1.65
	mm	25.4	33.5	41.9
F	in	0.12	0.31	0.10
	mm	3.1	8.0	2.5
G	in	2.04	2.04	2.04
	mm	51.7	51.7	51.7
H (zero stroke)	in	1.3	1.5	2.9
	mm	34	38	73
J [4]	in	2.36	2.63	2.63
	mm	60.0	66.7	66.7
L [4] **(zero stroke)**	in	4.8	5.2	6.6
	mm	122	133	167

1. Dimensions shown are for referencing only and are subject to change
2. Dimensions reflect Exlar standard M23 style connectors (option I)
3. Dimensions may vary based on options selected. Consult Exlar for details or refer to drawings provided after receipt of order
4. If ordering a brake, add the following to dimensions J and L:
   GSM20 add 1.78 in (45.2 mm)
   GSM30 add 1.60 in (40.6 mm)
   GSM40 add 2.33 in (59.2 mm)
5. If ordering bellows add 2 in (50.8 mm) to dimension E.

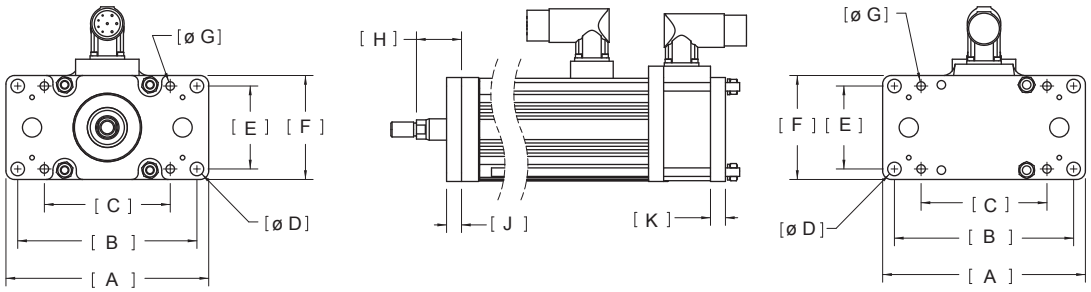
Pre-sale drawings and models are representative and are subject to change. Certified drawings and models are available for a fee. Consult your local Exlar representative for details.

Front or Rear Flange Mount

GSM20



GSM30, GSM40

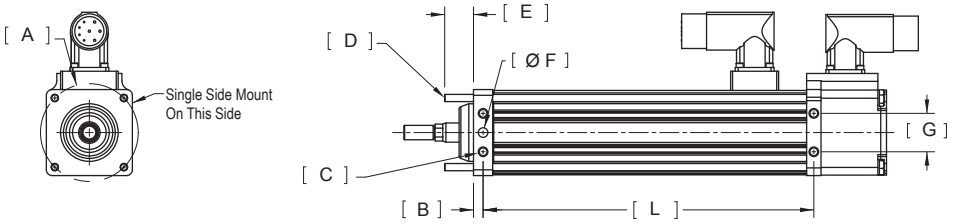


		GSM20	GSM30	GSM40
A	in	3.75	5.94	7.68
	mm	95.3	150.9	195.1
B	in	3.13	5.25	6.80
	mm	79.4	133.4	172.7
C	in	1.00	3.69	5.25
	mm	25.4	93.7	133.4
Ø D	in	0.250	0.397	0.516
	mm	6.35	10.08	13.10
E	in	1.75	2.43	2.92
	mm	44.5	61.7	74.2
F	in	2.24	3.05	3.80
	mm	56.8	77.4	96.5
Ø G	in	0.125 +0.001/-0.000	0.250 ±0.0005	0.250 ±0.001
	mm	3.18 +0.03/0.00	6.35 ±0.13	6.35 ±0.025
H [1]	in	1.00	1.32	1.65
	mm	25.4	33.5	41.9
J [1]	in	0.44	0.44	0.63
	mm	11.1	11.1	15.9
K	in	0.50	0.44	0.63
	mm	12.7	11.1	15.9

1. If ordering a splined main rod, add the following to dimensions H and J:
   GSM20 add .50 in (12.7 mm)
   GSM30 add 1.20 in (30.5 mm)
   GSM40 add 1.77 in (45.0 mm)

Pre-sale drawings and models are representative and are subject to change. Certified drawings and models are available for a fee. Consult your local Exlar representative for details.

Side Mount or Extended Tie Rod Mount

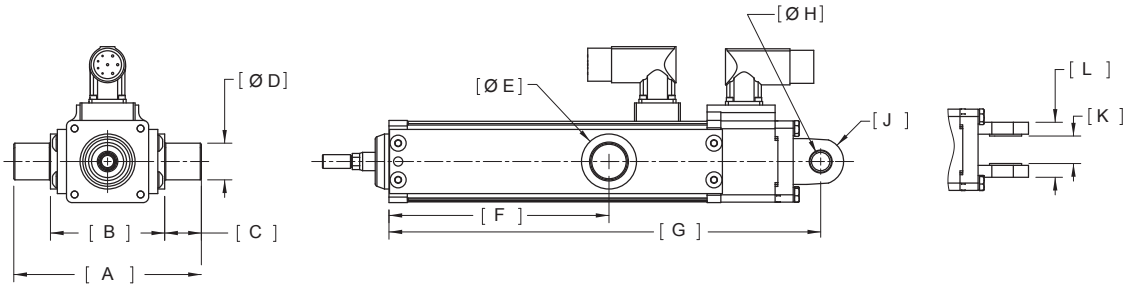


		GSM20	GSM30	GSM40
Ø A	in	2.546	3.536	4.243
	mm	64.66	89.80	107.76
B [2]	in	0.25	0.25	0.31
	mm	6.4	6.4	7.9
C [1]	in	1/4-20 UNC	1/4-20 UNC	3/8-16 UNC
	mm	M6 x 1.0	M6 x 1.0	M10 x 1.5
D	in	10-24 UNC	1/4-20 UNC	3/8-16 UNC
	mm	M5 x 0.8	M6 x 1.0	M8 x 1.25
E	in	0.75	0.96	1.38
	mm	19.1	24.4	35.1
Ø F	in	0.2500 +0/-0.0005↧0.25	0.2500 +0/-0.0005↧0.25	0.3750 +0/-0.0005↧0.44
	mm	6 M7↧9.0	6 M7↧9.5	8 M7↧12.0
G	in	1.00	1.75	1.75
	mm	25.4	44.5	44.5
L (zero stroke)	in	2.6	3.1	4.3
	mm	67	80	109

1. Side mount options S and J = 4X, D and K = 8X for dimension C
2. If ordering a splined main rod, add the following to dimension B:
   GSM20 add .50 in (12.7 mm)
   GSM30 add 1.20 in (30.5 mm)
   GSM40 add 1.77 in (45.0 mm)

Pre-sale drawings and models are representative and are subject to change. Certified drawings and models are available for a fee. Consult your local Exlar representative for details.

Side Trunnion Mount of Rear Clevis Mount

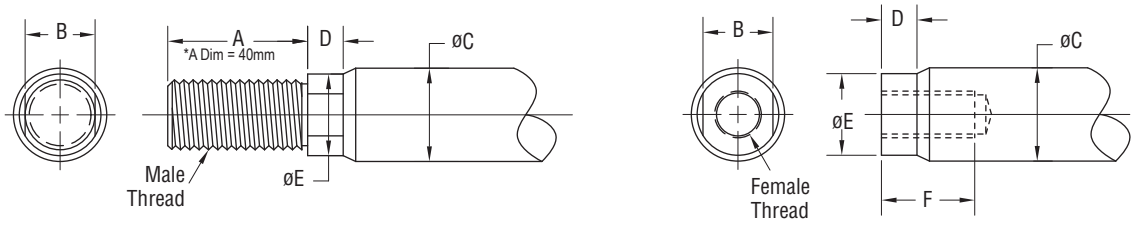


		GSM20	GSM30	GSM40
A	in	5.12	5.92	6.90
	mm	129.9	150.4	175.2
B	in	3.12	3.92	4.90
	mm	79.1	99.6	124.4
C	in	1.00	1.00	1.00
	mm	25.4	25.4	25.4
Ø D	in	1.000 +/-0.001	1.000 +/-0.001	1.500 +/-0.001
	mm	25 h7	25 h7	35 h7
Ø E	in	1.50	1.50	2.00
	mm	38.1	38.1	50.8
F (3" stroke)	in	3.0	5.4	NA
	mm	76	137	NA
F (4" stroke)	in	NA	NA	4.0
	mm	NA	NA	102
F (6" stroke)	in	6.0	8.0	6.0
	mm	152	203	152
F (8" stroke)	in	NA	NA	8.0
	mm	NA	NA	203
F (10" stroke)	in	10.0	10.0	10.0
	mm	254	254	254
F (12" stroke)	in	12.0	12.0	12.0
	mm	305	305	305
F (14" stroke)	in	NA	14.0	NA
	mm	NA	406	NA
F (18" stroke)	in	NA	18.0	18.0
	mm	NA	457	457
G [1] (zero stroke)	in	5.8	6.5	8.3
	mm	147	165	210
Ø H	in	0.500 +0.002/-0.001	0.750 +0.002/-0.001	0.750 +0.002/-0.001
	mm	12 +0.01/-0.06	20 +0/-0.07	20 +0/-0.07
J	in	0.63	0.75	0.75
	mm	15.9	19.1	19.1
K	in	0.75	1.25	1.25
	mm	19.1	31.8	31.8
L	in	1.50	2.50	2.50
	mm	38.1	63.5	63.5

1. If ordering a brake, add the following to dimension G: GSM20 add 1.78 in (45.2 mm), GSM30 add 1.60 in (40.6 mm), GSM40 add 2.33 in (59.2 mm)

Pre-sale drawings and models are representative and are subject to change. Certified drawings and models are available for a fee. Consult your local Exlar representative for details.

Actuator Rod End Options



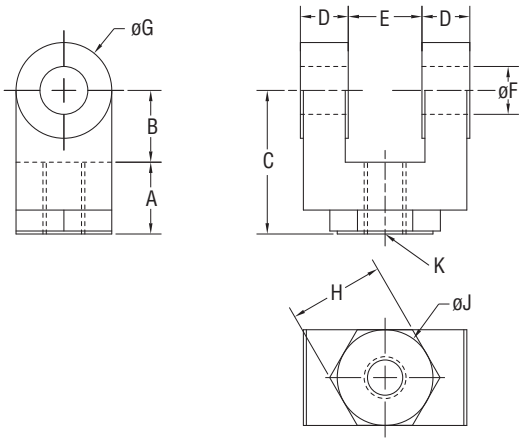
Standard Rod Ends

	A	B	ØC	D	ØE	F	Male U.S.	Male Metric	Female U.S.	Female Metric
GSM20 in (mm)	0.813 (20.7)	0.375 (9.5)	0.500 (12.7)	0.200 (5.1)	0.440 (11.2)	0.750 (19.1)	3/8 – 24 UNF – 2A	M8 x 1 6g	5/16 – 24 UNF – 2B	M8 x 1 6h
GSM30 in (mm)	0.750 (19.1)	0.500 (12.7)	0.625 (15.9)	0.281 (7.1)	0.562 (14.3)	0.750 (19.1)	7/16 – 20 UNF– 2A	M12 x 1.75* 6g	7/16 – 20 UNF – 2B	M10 x 1.5 6h
GSM40 in (mm)	1.500 (38.1)	0.750 (19.1)	1.000 (25.4)	0.381 (9.7)	0.875 (22.2)	1.000 (25.4)	3/4 – 16 UNF – 2A	M16 x 1.5 6g	5⁄8 – 18 UNF – 2B	M16 x 1.5 6h

Part numbers for rod attachment options indicate the through hole size or pin diameter. Before selecting a spherical rod eye please consult the information on the anti-rotation option for the GSM actuators. Spherical rod eyes will allow the rod to rotate if the load is not held.

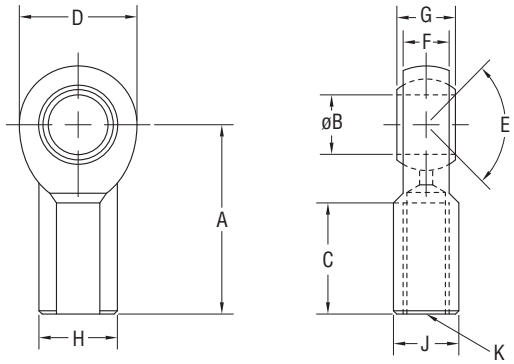
For Rod End with Splined Main Rod, see pg 32

Rod Clevis Dimensions



in (mm)	GSM20 - RC038	GSM30 - RC050	GSM40 - RC075
A	0.810 (20.6)	0.75 (19.1)	1.125 (28.58)
B	0.785 (19.9)	0.75 (19.1)	1.25 (31.75)
C	1.595 (40.5)	1.50 (38.1)	2.375 (60.3)
D	0.182 (4.6)	0.50 (12.7)	0.625 (15.88)
E	0.386 (9.8)	0.765 (19.43)	1.265 (32.13)
ØF	0.373 (9.5)	0.50 (12.7)	0.75 (19.1)
ØG	0.951 (24.2)	1.00 (25.4)	1.50 (38.1)
H	NA	1.00 (25.4)	1.25 (31.75)
ØJ	NA	1.00 (25.4)	1.25 (31.75)
K	3/8-24	7/16-20	3/4-16

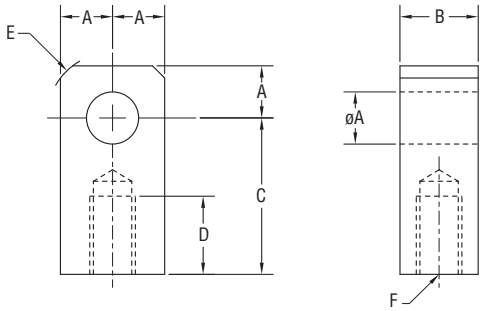
Spherical Rod Eye Dimensions



in (mm)	GSM20 - SRM038	GSM30 - SRM044	GSM40 - SRM075
A	1.625 (41.3)	1.81 (46.0)	2.88 (73.2)
ØB	0.375 (9.525)	0.438 (11.13)	0.75 (19.1)
C	0.906 (23.0)	1.06 (26.9)	1.72 (43.7)
D	1.0 (25.4)	1.13 (28.7)	1.75 (44.5)
E	6 deg	14 deg	14 deg
F	0.406 (10.3)	0.44 (11.1)	0.69 (17.5)
G	0.500 (12.7)	0.56 (14.2)	0.88 (22.3)
H	0.688 (17.4)	0.75 (19.1)	1.13 (28.7)
J	0.562 (14.3)	0.63 (16.0)	1.00 (25.4)
K	3/8-24	7/16-20	3/4-16

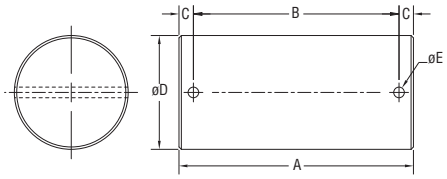
Pre-sale drawings and models are representative and are subject to change. Certified drawings and models are available for a fee. Consult your local Exlar representative for details.

Rod Eye Dimensions



in (mm)	GSM20 - RE038	GSM30 - RE050	GSM40 - RE075
ØA	0.50 (12.7)	0.50 (12.7)	0.75 (19.1)
B	0.560 (14.2)	0.75 (19.1)	1.25 (31.8)
C	1.00 (25.4)	1.50 (38.1)	2.06 (52.3)
D	0.50 (12.7)	0.75 (19.1)	1.13 (28.7)
E	0.25 x 45°	0.63 (16.0)	0.88 (22.3)
F	3/8 - 24	7/16 - 20	3/4 - 16

Rod Clevis Pin Dimensions



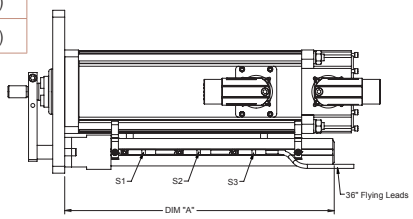
in (mm)	A	B	C	ØD	ØE
CP050[1]	2.28 (57.9)	1.94 (49.28)	0.17 (4.32)	0.50 -0.001/-0.002 (12.7 +0.00/-0.05)	0.106 (2.69)
CP075[2]	3.09 (78.5)	2.72 (69.1)	0.19 (4.82)	0.75 -0.001/-0.002 (19.1 +0.00/-0.05)	0.14 (3.56)

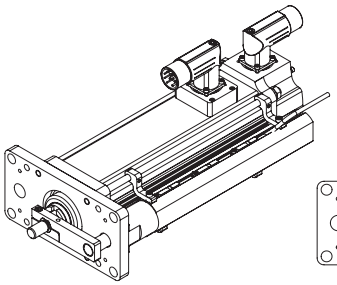
[1] Fits GSM30 rear clevis, RC050 and RE050
[2] Fits GSM30, 40 and RC075, RE075 and SRM075

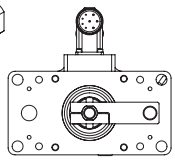
GSM20, GSM30 and GSM40 External Limit Switch Extension Options

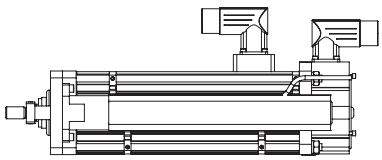
Dim A	3 inch (76 mm) stroke in (mm)	6 inch (152 mm) stroke in (mm)	8 inch (203 mm) stroke in (mm)	10 inch (254 mm) stroke in (mm)	12 inch (305 mm) stroke in (mm)	18 inch (457 mm) stroke in (mm)
GSM20	5.515 (140.1)	8.515 (216.3)	NA	12.5 (317.5)	14.515 (368.7)	NA
GSM30	6.932 (176.1)	9.832 (249.7)	NA	13.832 (351.3)	15.832 (402.1)	21.832 (554.5)
GSM40	NA	9.832 (249.7)	11.83 (300.5)	13.832 (351.3)	15.832 (402.1)	21.832 (554.5)

** Dimensions for Anti rotate option can be seen on page 30.*









The external limit switch option (requires anti-rotate option) provides the user with 1, 2, or 3 externally mounted adjustable switches for use as the end-of-travel limit switches or home position sensors.

The number of switches desired is selected by ordering the L1, L2, or L3 option, in which 1, 2, or 3 switches will be provided, respectively.

The switches are 9-30 VDC powered, PNP output, with either normally open or normally closed logic operation depending on the switch configuration ordered. Switches are supplied with 1 meter of 3-wire embedded cable. Below is a chart that shows which logic operation will be provided for each switch, based on the option that is ordered.

Option	SW1	SW2	SW3
L1	Not Supplied	Normally Open	Not Supplied
L2	Normally Closed	Not Supplied	Normally Closed
L3	Normally Closed	Normally Open	Normally Closed

Switch Type	Exlar Part Number	Turck Part Number
Normally Closed Switch	43404	BIM-UNT-RP6X
Normally Open Switch	43403	BIM-UNT-AP6X

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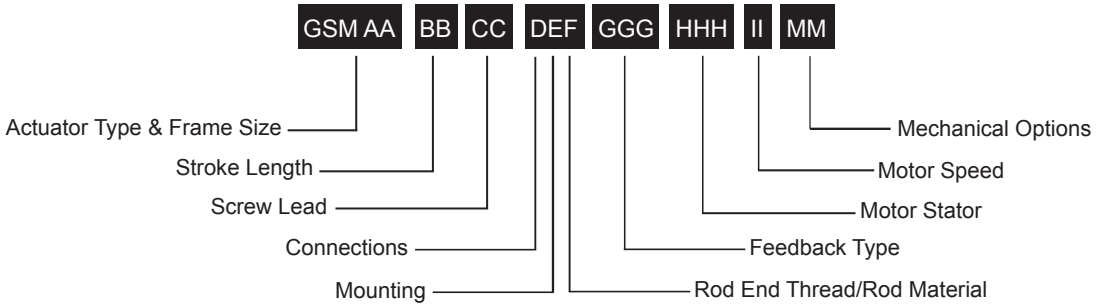


Commonly Ordered Options Shown in BOLD

AA = GSM Actuator Size (nominal)
20 = 2 in (60 mm) frame
30 = 3 in (80 mm) frame
40 = 4 in (100 mm) frame

BB = Stroke Length
03 = 3 in (76 mm) GSM20 and GSM30
04 = 4 in (102 mm) GSM40
06 = 6 in (152 mm) all models; 5.9 in (150 mm) GSM30
08 = 8 in (203 mm) GSM40
10 = 10 in (254 mm) GSM20, GSM30 and GSM40
12 = 12 in (305 mm) GSM20, GSM30 and GSM40
18 = 18 in (457 mm) GSM30 and GSM40

CC = Lead
01 = 0.1 in (2.54 mm) (all models)
02 = 0.2 in (5.08 mm) (all models)
04 = 0.4 in (10.16 mm) (GSM20)
05 = 0.5 in (12.7 mm) (GSM30 and GSM40)
08 = 0.75 in (19.05 mm) (GSM40) [3]

D = Connections
I = Exlar standard M23 style
M = Manufacturer's connector [1]
J = Embedded leads with "I" plug, 3 ft. standard

E = Mounting
C = Rear clevis
F = Front flange
R = Rear flange
D = Double side mount [11]
T = Side trunnion
E = Extended tie rods
K = Metric double side mount [11]
Q = Metric side trunnion
M = Metric extended tie rods
G = Metric rear clevis

F = Rod End Thread / Rod Material
M = Male, US standard thread
A = Male, metric thread
F = Female, US standard thread
B = Female, metric thread
W = Male, US standard thread SS [10]
R = Male metric thread SS [10]
V = Female, US standard thread SS [10]
L = Female, metric thread SS [10]

GGG = Feedback Type
See page 207 for detailed information.

HHH = Motor Stator [2] – All 8 Pole [8]
118 = 1 stack, 115 Vrms
138 = 1 stack, 230 Vrms
158 = 1 stack, 400 Vrms
168 = 1 stack, 460 Vrms

218 = 2 stack, 115 Vrms
258 = 2 stack, 230 Vrms
238 = 2 stack, 400 Vrms
268 = 2 stack, 460 Vrms

II = Motor Speed
30 = 3000 rpm, GSM30, GSM40
50 = 5000 rpm, GSM20

MM = Mechanical Options [12]
AR = External anti-rotate [7]
HW = Manual drive, Handwheel with interlock switch [5, 9]
PB = Protective bellows [6]
SR = Splined main rod
RB = Rear brake
L1/L2/L3 = External limit switch [4]
P5 = IP65S sealing option[13]

NOTES:
1. Available as described in Feedback Types.
2. Stator voltage and pole options allow for catalog rated performance at varying amplifier bus voltages and pole configuration requirements.
3. 0.75 lead not available over 12 inch stroke
4. Requires AR option
5. Not available on GSM20.
6. Not available with extended tie rod mounting option.
7. A second anti-rotate arm is used on GSM 20, 30 & 40 for 10 inch and longer stroke.
8. See page 48 for optimized stators.
9. N/A with holding brake unless application details are discussed with your local ales representative.
10. Consult with your local sales representative when ordering splined stainless steel main rod.
11. Anti-rotate with D or K mounting N/A on 10 inch or longer stroke.
12. For extended temperature operation consult factory for model number.
13. Not available with splined main rod option

For cables and accessories, see page 202.

For options or specials not listed above or for extended temperature operation, please contact Exlar

Commonly Ordered Options Shown in BOLD

Elmo Motion Control:
EL1 = Standard Resolver
EL2 = Standard Incremental Encoder
EL3 = EnDat Heidenhain EQN1125 multi-turn absolute encoder

Emerson/Control Techniques:
EM2 = Std Incremental Encoder – NT motor wiring w/MS connectors for 'M' option
EM5 = Encoder 5000 line, with commutation, 5 VDC – NT motor wiring w/MS connectors for 'M' option

Elau:
EU1 = Hiperface Stegmann SRM050 multi-turn absolute encoder – 40-50-60 Frame Size. SH motor wiring w/MS connectors for 'M' option
EU4 = Hiperface Stegmann SKM036 multi-turn absolute encoder – 20-30 Frame Size. SH motor wiring w/MS connectors for 'M' option.

Exlar:
EX4 = Standard Resolver
EX5 = Standard Resolver with KTY84 thermistor
EX6 = EnDat Heidenhain EQN1125 multi-turn absolute encoder
EX7 = Incremental encoder, 5000 line with commutation, 5Vdc
EX8 = Hiperface Stegmann SRM50 multi-turn absolute encoder

Indramat/Bosch-Rexroth:
IN6 = Std Resolver – MKD/MHD motor wiring w/M23 euro connectors for 'M' option
IN7 = Hiperface Stegmann SKM036 multi-turn absolute encoder – MSK motor wiring w/M23 euro connectors for 'M' option – plug & play option
IN8 = Indradrive EnDat Heidenhain EQN1125 multi-turn absolute w/M23 connectors

Kollmorgen/Danaher:
KM4 = EnDat Heidenhain EQN1325 multi-turn absolute encoder (Sine Encoder)– AKM motor wiring w/M23 Intercontec euro connectors for 'M' option
KM5 = Standard Resolver – AKM motor wiring w/M23 Intercontec euro connectors for 'M' option
KM6 = Standard Incremental Encoder – AKM motor wiring w/ M23 Intercontec euro connectors for 'M' option

Lenze/AC Tech:
LZ1 = Hiperface Stegmann SRM050 multi-turn absolute encoder – MCS motor wiring w/M23 euro connectors for 'M' option
LZ5 = Standard Resolver – MCS motor wiring w/ M23 euro connectors for 'M' option
LZ6 = Standard Incremental Encoder – MCS motor wiring w/ M23 euro connectors for 'M' option

Mitsubishi[2]:
MT2 = DSL Stegmann MR-J4 compatible

Parker Compumotor:
PC6 = Std Incremental Encoder – SMH motor wiring w/M23 connectors for 'M' option – European only
PC7 = Std Resolver – SMH motor wiring w/M23 connectors for 'M' option – European only
PC8 = Standard Incremental Encoder – MPP series motor wiring w/PS connectors for 'M' option – US Only
PC9 = Hiperface Stegmann SRM050 multi-turn absolute encoder – MPP motor wiring w/PS connectors for 'M' option – US Only
PC0 = Standard Resolver – MPP motor wiring w/PS connectors for 'M' option – US Only

Schneider Electric:
SC2 = Hiperface Steamann SKM036 multi-turn absolute encoder – BSH motor wiring w/M23 euro connectors for 'M' option

Stober Drives:
SB3 = EnDat Heidenhain EQN1125 multi-turn absolute encoder – ED/EK motor wiring w/M23 euro connectors for 'M' option
SB4 = Standard Resolver ED/EK motor wiring W/23 connector for "M" option

Siemens:
SM2 = Standard Resolver – 1FK7 motor wiring w/M23 connectors for 'M' option
SM3 = EnDat Heidenhain EQN1325 multi-turn absolute encoder – 40-50-60 Frame Size. 1FK7 motor wiring w/M23 euro connectors for 'M' option
SM4 = EnDat Heidenhain EQN1125 multi-turn absolute encoder – 20-30 Frame Size. 1FK7 motor wiring w/M23 euro connectors for 'M' option
SM9 = Siemens Heidenhain EQN1325 4096 (12 bits) multi-turn absolute w/M23 connectors

SEW/Eurodrive:
SW1 = Standard Resolver – CM motor wiring w/ M23 euro connectors for 'M' option
SW2 = Standard Incremental Encoder
SW3 = Hiperface Stegmann SRM050 multi-turn absolute encoder – CM motor wiring w/ M23 euro connectors for 'M' option

Yaskawa:
YS5 = Yaskawa Sigma V absolute encoder

NOTES:
1. Not compatible with Kinetix 300 Drives.
2. N/A with holding brake unless application details are discussed with your local sales representative.
3. All rotary motors to be used with Kinetix or Sercos based systems will require prior approval from Rockwell Automation.

Sizing and Selection of Exlar Linear and Rotary Actuators

Move Profiles

The first step in analyzing a motion control application and selecting an actuator is to determine the required move profile. This move profile is based on the distance to be traveled and the amount of time available in which to make that move. The calculations below can help you determine your move profile.

Each motion device will have a maximum speed that it can achieve for each specific load capacity. This maximum speed will determine which type of motion profile can be used to complete the move. Two common types of move profiles are trapezoidal and triangular. If the average velocity of the profile, is less than half the maximum velocity of the actuator, then triangular profiles can be used. Triangular Profiles result in the lowest possible acceleration and deceleration. Otherwise a trapezoidal profile can be used. The trapezoidal profile below with 3 equal divisions will result in 25% lower maximum speed and 12.5% higher acceleration and deceleration. This is commonly called a 1/3 trapezoidal profile.

The following pages give the required formulas that allow you to select the proper Exlar linear or rotary actuator for your application. The first calculation explanation is for determining the required thrust in a linear application.

The second provides the necessary equations for determining the torque required from a linear or rotary application. For rotary applications this includes the use of reductions through belts or gears, and for linear applications, through screws.

Pages are included to allow you to enter your data and easily perform the required calculations. You can also describe your application graphically and fax it to Exlar for sizing. Reference tables for common unit conversions and motion system constants are included at the end of the section.

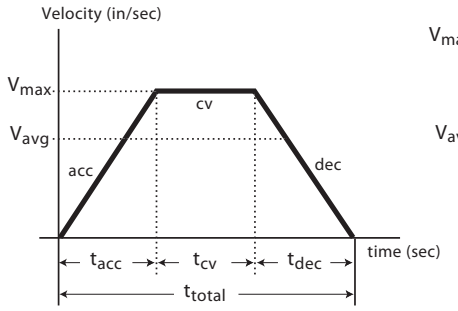
Linear Move Profile Calculations

Vmax = max.velocity-in/sec (m/sec)
Vavg = avg. velocity-in/sec (m/sec)
tacc = acceleration time (sec)
tdec = deceleration time (sec)
tcv = constant velocity (sec)
ttotal = total move time (sec)
acc = accel-in/sec^2 (m/sec^2)
dec = decel-in/sec^2 (m/sec^2)
cv = constant vel.-in/sec (m/sec)
D = total move distance-in (m)
or revolutions (rotary)

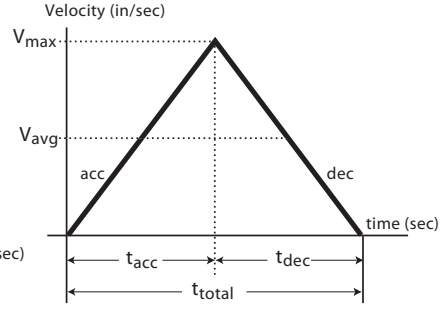
Standard Equations

Vavg = **D** / ttotal
If tacc = **t**dec **Then: V**max =
(**t**total/(**t**total-tacc)(**V**avg)
and
D = Area under profile curve
D = (1/2(**t**acc+**t**dec)+**t**cv)(**V**max)

Trapezoidal Move Profile



Triangular Move Profile



Trapezoidal Equations

If tacc = **t**cv = **t**dec **Then:**
Vmax = 1.5 (**V**avg)
D = (2/3) (**t**total) (**V**max)
acc = dec = $\frac{\mathbf{V}max}{\mathbf{t}acc}$

Triangular Equations

If tacc = **t**total/2 **Then:**
Vmax = 2.0 (**V**avg)
D = (1/2) (**t**total) (**V**max)
acc = dec = $\frac{\mathbf{V}max}{\mathbf{t}acc}$

Terms and (units)

THRUST = Total linear force-lbf (N)
Ø = Angle of inclination (deg)
Ffriction = Force from friction-lbf (N)
tacc = Acceleration time (sec)
Facc = Acceleration force-lbf (N)
v = Change in velocity-in/sec (m/s)
Fgravity = Force due to gravity-lbf (N)
μ = Coefficient of sliding friction
Fapplied = Applied forces-lbf (N)
(refer to table on page 136 for different materials)
WL = Weight of Load-lbf (N)
g = 386.4: Acceleration of gravity - in/sec^2 (9.8 m/sec^2)

Thrust Calculation Equations

THRUST = **F**friction + [**F**acceleration] + **F**gravity + **F**applied

THRUST = **W**Lμcosø + [(**W**L /386.4) (**v**/tacc)] + **W**Lsinø + **F**applied

Sample Calculations: Calculate the thrust required to accelerate a 200 pound mass to 8 inches per second in an acceleration time of 0.2 seconds. Calculate this thrust at inclination angles(ø) of 0˚, 90˚ and 30˚. Assume that there is a 25 pound spring force that is applied against the acceleration.

WL = 200 lbm, v = 8.0 in/sec., **t**a = 0.2 sec., **F**app. = 25 lbf, μ = 0.15

ø = 0˚

THRUST = **W**Lμcosø + [(**W**L /386.4) (**v**/tacc)] + **W**Lsinø + **F**applied
= (200)(0.15)(1) + [(200/386.4)(8.0/0.2)] + (200)(0) + 25

= 30 lbs + 20.73 lbs + 0 lbs + 25 lbs = **75.73 lbs force**

ø = 90˚

THRUST = **W**Lμcosø + [(**W**L /386.4) (**v**/tacc)] + **W**Lsinø + **F**applied
= (200)(0.15)(0) + [(200/386.4)(8.0/0.2)] + (200)(1) + 25

= 0 lbs + 20.73 lbs + 200 lbs + 25 lbs = **245.73 lbs force**

ø = 30˚

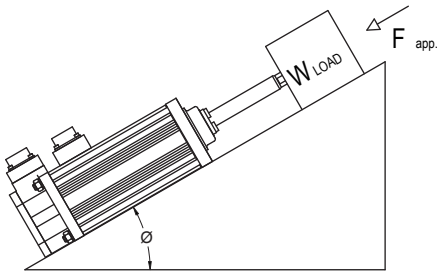
THRUST = **W**Lμcosø + [(**W**L /386.4) (**v**/tacc)] + **W**Lsinø + **F**applied
= (200)(0.15)(0.866) + [(200/386.4)(8.0/0.2)] + (200)(0.5) + 25

= 26 lbs + 20.73 lbs + 100 + 25 = **171.73 lbs force**

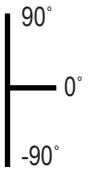
Thrust Calculations

Definition of thrust:

The thrust necessary to perform a specific move profile is equal to the sum of four components of force. These are the force due to acceleration of the mass, gravity, friction and applied forces such as cutting and pressing forces and overcoming spring forces.



Angle of Inclination



Note: at ø = 0˚
cosø = 1; sinø = 0
at ø = 90˚
cosø = 0; sinø = 1

It is necessary to calculate the required thrust for an application during each portion of the move profile, and determine the worst case criteria. The linear actuator should then be selected based on those values. The calculations at the right show calculations during acceleration which is often the most demanding segment of a profile.

Motor Torque Calculations

When selecting an actuator system it is necessary to determine the required motor torque to perform the given application. These calculations can then be compared to the torque ratings of the given amplifier and motor combination that will be used to control the actuator's velocity and position.

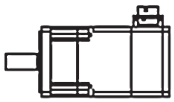
When the system uses a separate motor and screw, like the FT actuator, the ratings for that motor and amplifier are consulted. In the case of the GSX Series actuators with their integral brushless motors, the required torque divided by the torque constant of the motor (Kt) must be less than the current rating of the GSX or SLM motor.

Inertia values and torque ratings can be found in the GSX, FT, and SLM/SLG Series product specifications.

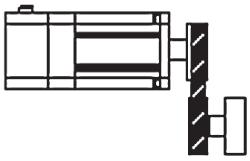
For the GSX Series the screw and motor inertia are combined.

Motor with screw (GSX, GSM, FT, & EL)

Motor & motor with reducer (SLM/SLG & ER)



Motor with belt and pulley



Terms and (units)

λ	=	Required motor torque, lbf-in (N-m)
λa	=	Required motor acceleration torque, lbf-in (N-m)
F	=	Applied force load, non inertial, lbf (kN)
S	=	Screw lead, in (mm)
R	=	Belt or reducer ratio
TL	=	Torque at driven load lbf-in (N-m)
vL	=	Linear velocity of load in/sec (m/sec)
ωL	=	Angular velocity of load rad/sec
ωm	=	Angular velocity of motor rad/sec
η	=	Screw or ratio efficiency
g	=	Gravitational constant, 386.4 in/s^2 (9.75 m/s^2)
α	=	Angular acceleration of motor, rad/s^2
m	=	Mass of the applied load, lb (N)
JL	=	Reflected Inertia due to load, lbf-in-s^2 (N-m-s^2)
Jr	=	Reflected Inertia due to ratio, lbf-in-s^2 (N-m-s^2)
Js	=	Reflected Inertia due to external screw, lbf-in-s^2 (N-m-s^2)
Jm	=	Motor armature inertia, lbf-in-s^2 (N-m-s^2)
L	=	Length of screw, in (m)
ρ	=	Density of screw material, lb/in^3 (kg/m^3)
r	=	Radius of screw, in (m)
π	=	pi (3.14159)
C	=	Dynamic load rating, lbf (N)

Velocity Equations

Screw drive: $\mathbf{V}_L = \omega m * S/2\pi$ in/sec (m/sec)

Belt or gear drive: $\omega m = \omega_L * R$ rad/sec

Torque Equations

Torque Under Load

Screw drive (GS, FT or separate screw): $\lambda = \frac{S \bullet F}{2 \bullet \pi \bullet \eta}$ lbf-in (N-**m**)

Belt and Pulley drive: $\lambda = \mathbf{T}_L / R\,\eta$ lbf-in (N-**m**)

Gear or gear reducer drive: $\lambda = \mathbf{T}_L / R\,\eta$ lbf - in (N-**m**)

Torque Under Acceleration

$\lambda a = (\mathbf{J}_m + \mathbf{J}_R + (\mathbf{J}_s + \mathbf{J}_L)/R^2)\alpha$ lbf-in

α = angular acceleration = ((RPM / 60) x 2π) / $\mathbf{t}_{acc}$, rad/sec^2.

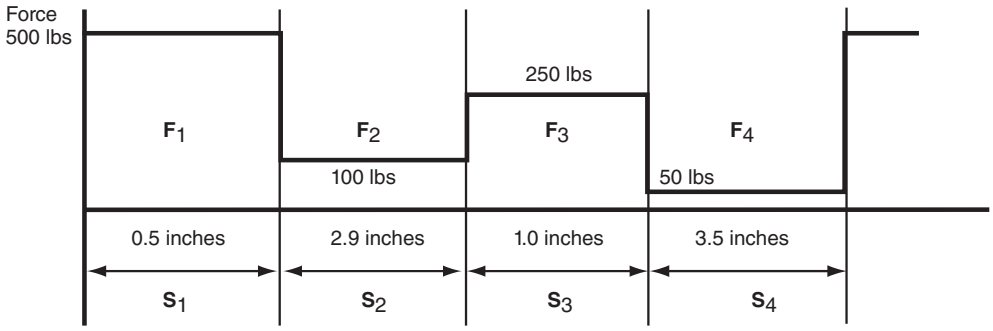
$\mathbf{J}_S = \frac{\pi \bullet \mathbf{L} \bullet \rho \times r^4}{2 \bullet g}$ lb - in - s^2 (N - **m** - s^2)

Total Torque per move segment

$\lambda T = \lambda a + \lambda$ lbf-in (N-m)

Mean Load Calculations

For accurate lifetime calculations of a roller screw in a linear application, the cubic mean load should be used. Following is a graph showing the values for force and distance as well as the calculation for cubic mean load. Forces are shown for example purposes. Negative forces are shown as positive for calculation.



S = Distance traveled during each move segment

Cubic Mean Load Equation

$$F_{cml} = \sqrt[3]{\frac{F_1^3 S_1 + F_2^3 S_2 + F_3^3 S_3 + F_4^3 S_4}{S_1 + S_2 + S_3 + S_4}}$$

Value from example numbers is 217 lbs.

Lifetime Calculations

The expected L_{10} life of a roller screw is expressed as the linear travel distance that 90% of the screws are expected to meet or exceed before experiencing metal fatigue. The mathematical formula that defines this value is below. The life is in millions of inches (mm). This standard L_{10} life calculation is what is expected of 90% of roller screws manufactured and is not a guarantee. Travel life estimate is based on a properly maintained screw that is free of contaminants and properly lubricated. Higher than 90% requires de-rating according to the following factors:

95% x 0.62 96% x 0.53
97% x 0.44 98% x 0.33
99% x 0.21

Single (non-preloaded) nut:

$$L_{10} = \left(\frac{C_a}{F_{cml}} \right)^3 \times \ell$$

If your application requires high force over a stroke length shorter than the length of the nut, please contact Exlar for derated life calculations. You may also download the article “Calculating Life Expectency” at www.exlar.com.

Note: The dynamic load rating of zero backlash, preloaded screws is 63% of the dynamic load rating of the standard non-preloaded screws. The calculated travel life of a preloaded screw will be 25% of the calculated travel life of the same size and lead of a non-preloaded screw for the same application.

Total Thrust Calculations

Terms and (units)

THRUST = Total linear force-lbf (N)

$\mathbf{F}_{friction}$ = Force from friction-lbf (N)

$\mathbf{F}_{acc}$ = Acceleration force-lbf (N)

$\mathbf{F}_{gravity}$ = Force due to gravity-lbf (N)

$\mathbf{F}_{applied}$ = Applied forces-lbf (N)

386.4 = Acceleration of gravity - in/sec^2 (9.8 m/sec^2)

Variables

Ø = Angle of inclination - deg..... = _____

tacc = Acceleration time - sec..... = _____

v = Change in velocity - in/sec (m/s)..... = _____

μ = Coefficient of sliding friction ..... = _____

$\mathbf{W}_L$ = Weight of Load-lbm (kg)..... = _____

$\mathbf{F}_{applied}$ = Applied forces-lbf (N) ..... = _____

Thrust Calculation Equations

THRUST = [$\mathbf{F}_{friction}$] + [$\mathbf{F}_{acceleration}$] + $\mathbf{F}_{gravity}$ + $\mathbf{F}_{applied}$

THRUST = [$\mathbf{W}_L$ x μ x cosø] + [($\mathbf{W}_L$ /386.4) x (**v** / $\mathbf{t}_{acc}$)] + $\mathbf{W}_L$sinø + $\mathbf{F}_{applied}$

THRUST = [( )x( )x( )] + [(/386.4) x (/)] + [( ) ( )] + ( )

THRUST = [ ] + [( ) x ( )] + [ ] + ( )

= _____ lbf.

Calculate the thrust for each segment of the move profile. Use those values in calculations below.
Use the units from the above definitions.

Cubic Mean Load Calculations

$$\sqrt[3]{\frac{F_1^3 S_1 + F_2^3 S^2 + F_3^3 S_3 + F_4^3 S_4}{S_1 + S_2 + S_3 + S_4}}$$

F_1= _____ S_1= _____ $F_1^3 S_1$ = _____

F_2= _____ S_2= _____ $F_2^3 S_2$ = _____

F_3= _____ S_3= _____ $F_3^3 S_3$ = _____

F_4= _____ S_4= _____ $F_4^3 S_4$ = _____

Move Profiles may have more or less than four components. Adjust your calculations accordingly.

Torque Calculations

Terms and (units)

λ = Torque, lb-in (N-m) ..... = ----------

F = Applied Load, non inertial, lbf (N) ..... = ----------

S = Screw lead, in (m) ..... = ----------

η = Screw or ratio efficiency (~85% for roller screws) ..... = ----------

g = Gravitational constant, 386 in/s2 (9.8 m/s2) ..... = ----------

α = Acceleration of motor, rad/s2 ..... = ----------

R = Belt or reducer ratio ..... = ----------

$\mathbf{T_L}$ = Torque at driven load, lbf-in (N-m) ..... = ----------

$\mathbf{V_L}$ = Linear velocity of load, in/sec (m/sec) ..... = ----------

ω_L = Angular velocity of load, rad/sec ..... = ----------

ω_m = Angular velocity of motor, rad/sec ..... = ----------

m = Mass of the applied load, lbm (kg) ..... = ----------

$\mathbf{J_R}$ = Reflected Inertia due to ratio, lb-in-s2 (N-m-s2) ..... = ----------

$\mathbf{J_S}$ = Reflected Inertia due to screw, lb-in-s2 (N-m-s2) ..... = ----------

$\mathbf{J_L}$ = Reflected Inertia due to load, lb-in-s2(N-m-s2) ..... = ----------

$\mathbf{J_M}$ = Motor armature inertia, lb-in-s2 (N-m-s2) ..... = ----------

π = pi ..... = 3.14159

$\mathbf{K_t}$ = Motor Torque constant, lb-in/amp (N-m/amp) ..... = ----------

* For the GS Series J_S and J_M are one value from the GS Specifications.

Torque Equations

Torque From Calculated Thrust.

$\lambda = \frac{SF}{2 \cdot \pi \cdot \eta}$ lb - in (N - m) = ( ) x ( )/2π (0.85) = ( ) x ( )/5.34 = ----------

Torque Due To Load, Rotary.

Belt and pulley drive: $\lambda = T_L / R \eta$ lbf-in (N-m)

Gear or gear reducer drive: $\lambda = T_L / R\eta$ lbf-in (N-m)

Torque During Acceleration due to screw, motor, load and reduction, linear or rotary.

$I = (\mathbf{J_m} + (\mathbf{J_S} + \mathbf{J_L}) / \mathbf{R}^2) \alpha$ lb-in (N-**m**) = [( ) + (+) / ( )] ( ) = ----------

Total Torque = Torque from calculated Thrust + Torque due to motor, screw and load

( ) + ( ) + ( ) = _____

Motor Current = $\lambda / \mathbf{K_t}$ = ( ) / ( ) = _____

Exlar Application Worksheet

FAX to:
Exlar Actuation Solutions
(952) 368-4877
Attn: Applications Engineering

Date: _____ Company Name: _____

Address: _____

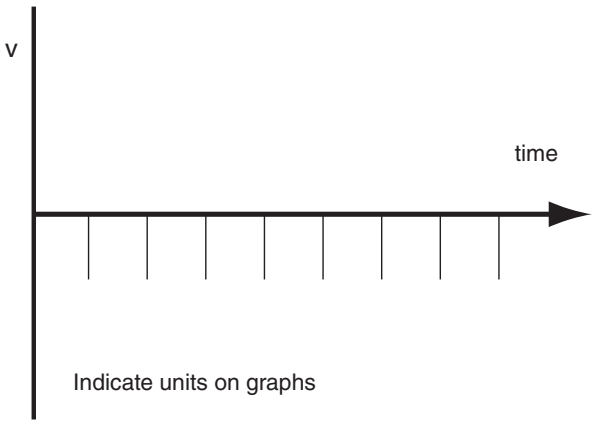
City: _____ State: _____ Zip Code: _____

Phone: _____ Fax: _____

Contact: _____ Title: _____

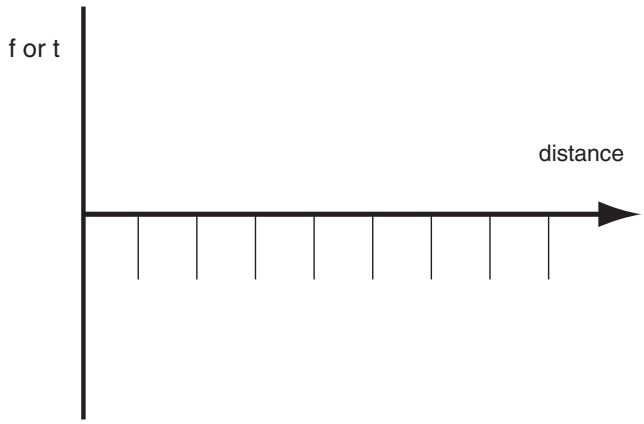
Sketch/Describe Application

Velocity vs. Time



Indicate units on graphs

Force or Torque vs. Distance



Exlar Application Worksheet

Date: _____ Contact: _____ Company: _____

Stroke & Speed Requirements

Maximum Stroke Needed	_____	inches (mm), revs
Index Stroke Length	_____	inches (mm), revs
Index Time	_____	sec
Max Speed Requirements	_____	in/sec (mm/sec), revs/sec
Min Speed Requirements	_____	in/sec (mm/sec), revs/sec
Required Positional Accuracy	_____	inches (mm), arc min

Load & Life Requirements

Gravitational Load	_____	lb (N)
External Applied Load	_____	lbf (N)
Inertial Load	_____	lbf (N)
Friction Load	_____	lbf (N)
Rotary Inertial Load	_____	lbf-in-sec^2 (Kg-m^2)
or rotary mass, radius of gyr. lb (kg)	_____	in (mm)
Side Load (rot. or lin. actuator)	_____	lb (N)

Force Direction _____ Extend _____ Retract _____ Both

Actuator Orientation _____ Vertical Up _____ Vertical Down _____ Horizontal

_____ Fixed Angle _____ Degrees from Horizontal

_____ Changing Angle _____ to _____

Cycling Rate	_____	Cycles/min/hr/day
Operating Hours per Day	_____	Hours
Life Requirement	_____	Cycles/hr/inches/mm

Configuration

Mounting: _____ Side _____ Flange _____ Ext Tie Rod _____ Clevis _____ Trunnion

Rod End: _____ Male _____ Female _____ Sph Rod Eye _____ Rod Eye _____ Clevis

Rod Rotation Limiting: _____ Appl Inherent _____ External Required

Holding Brake Required: _____ Yes _____ No

Cable Length: _____ ft (m)

Rotary Inertia To obtain a conversion from A to B, multiply by the value in the table.

B	Kg-m²	Kg-cm²	g-cm²	kgf-m-s²	kgf-cm-s²	gf-cm-s²	oz-in²	ozf-in-s²	lb-in²	lbf-in-s²	lb-ft²	lbf-ft-s²
A												
Kg-m²	1	10^4	10^7	0.10192	10.1972	$1.01972x10^4$	$5.46745x10^4$	$1.41612x10^2$	$3.41716x10^3$	8.850732	23.73025	0.73756
Kg-cm²	10^{-4}	1	10^3	$1.01972x10^5$	$1.01972x10^3$	1.01972	5.46745	$1.41612x10^{-2}$	0.341716	$8.85073x10^{-4}$	$2.37303x10^{-3}$	$7.37561x10^{-5}$
g-cm²	10^{-7}	10^{-3}	1	$1.01972x10^{-8}$	$1.01972x10^{-6}$	$1.01972x10^{-3}$	$5.46745x10^{-3}$	$1.41612x10^{-5}$	$3.41716x10^{-4}$	$8.85073x10^{-7}$	$2.37303x10^{-6}$	$7.37561x10^{-8}$
kgf-m-s²	9.80665	$9.80665x10^4$	$9.80665x10^7$	1	10^2	10^5	$5.36174x10^5$	$1.388674x10^3$	$3.35109x10^4$	86.79606	$2.32714x10^2$	7.23300
kgf-cm-s²	$9.80665x10^{-2}$	$9.80665x10^2$	$9.80665x10^5$	10^{-2}	1	10^5	$5.36174 x10^3$	13.8874	$3.35109x10^{-2}$	0.86796	2.32714	$7.23300x10^{-2}$
gf-cm-s²	9.80665x10-5	0.980665	$9.80665x10^2$	10^{-5}	10^{-3}	1	5.36174	$1.38874 x10^{-2}$	0.335109	$8.67961x10^{-4}$	$2.32714x10^{-3}$	$7.23300x10^{-5}$
oz-in²	$1.82901x10^{-5}$	0.182901	$1.82901x10^2$	$1.86505x10^{-6}$	$1.86505x10^{-4}$	0.186506	1	$2.59008 x10^{-3}$	$6.25 x10^{-2}$	$1.61880x10^{-4}$	$4.34028x10^{-4}$	$1.34900x10^{-3}$
oz-in-s²	$7.06154x10^{-3}$	70.6154	$7.06154x10^4$	$7.20077x10^4$	$7.20077x10^{-2}$	72.0077	$3.86089x10^2$	1	24.13045	$6.25 x10^{-2}$	0.167573	$5.20833x10^{-4}$
lb-in²	$2.92641x10^{-4}$	2.92641	$2.92641x10^3$	$2.98411x10^5$	$2.98411x10^3$	2.98411	16	$4.14414 x10^2$	1	$2.59008x10^{-3}$	$6.94444x10^{-3}$	$2.15840x10^{-4}$
lbf-in-s²	0.112985	$1.129x10^3$	$1.12985x10^6$	$1.15213x10^2$	1.15213	$1.51213 x10^3$	$6.1774 x10^3$	16	$3.86088x10^2$	1	2681175	$8.3333x10^{-2}$
lbf-ft²	$4.21403x10^{-2}$	$4.21403x10^2$	$4.21403x10^5$	$4.29711x10^3$	0.429711	4.297114	$2.304 x10^3$	5.96755	144	0.372971	1	$3.10809x10^{-2}$
lbf-ft-s²	1.35583	$1.35582x10^4$	$1.35582x10^7$	0.138255	13.82551	$1.38255x10^4$	$7.41289x10^4$	192	$4.63306x10^3$	12	32.17400	1

Torque To obtain a conversion from A to B, multiply A by the value in the table.

B	N-m	N-cm	dyn-cm	Kg-m	Kg-cm	g-cm	oz-in	ft-lb	in-lb
A									
N-m	1	10^{-2}	10^7	0.109716	10.19716	$1.019716 x10^4$	141.6199	0.737562	8.85074
N-cm	102	1	10^5	$1.019716 x10^3$	0.1019716	$1.019716 x10^2$	1.41612	$7.37562 x10^{-3}$	$8.85074 x10^{-2}$
dyn-cm	10-7	10^{-5}	1	$1.019716 x10^{-8}$	$1.019716 x10^{-6}$	$1.019716 x10^{-3}$	$1.41612 x10^{-5}$	$7.2562 x10^{-8}$	$8.85074 x10^{-7}$
Kg-m	9.80665	$980665x10^2$	$9.80665 x10^7$	1	10^2	10^5	$1.38874 x10^3$	7.23301	86.79624
Kg-cm	9.80665x10-2	9.80665	$9.80665 x10^5$	10^{-2}	1	10^3	13.8874	$7.23301 x10^{-2}$	0.86792
g-cm	9.80665x10-5	$9.80665x10^{-3}$	$9.80665 x10^2$	10^{-5}	10^{-3}	1	$1.38874 x10^{-2}$	$7.23301 x10^{-5}$	$8.679624 x10^{-4}$
oz-in	7.06155x10-3	0.706155	$7.06155 x10^4$	$7.20077 x10^{-4}$	$7.20077 x10^{-2}$	72,077	1	$5.20833 x10^{-3}$	$6.250 x10^{-2}$
ft-lb	1.35582	$1.35582x10^2$	$1.35582 x10^7$	0.1382548	13.82548	$1.382548 x10^4$	192	1	12
in-lb	0.113	11.2985	$1.12985 x10^6$	$1.15212 x10^{-2}$	1.15212	$1.15212 x10^3$	16	$8.33333 x10^{-2}$	1

Common Material Densities

Material	oz/in³	gm/cm³
Aluminum (cast or hard drawn)	1.54	2.66
Brass (cast or rolled)	4.80	8.30
Bronze (cast)	4.72	8.17
Copper (cast or hard drawn)	5.15	8.91
Plastic	0.64	1.11
Steel (hot or cold rolled)	4.48	7.75
Wood (hard)	0.46	0.80
Wood (soft)	0.28	0.58

Coefficients of Sliding Friction

Materials in contact	μ
Steel on Steel (dry)	0.58
Steel on Steel (lubricated)	0.15
Aluminum on Steel	0.45
Copper on Steel	0.36
Brass on Steel	0.44
Plastic on Steel	0.20
Linear Bearings	0.001

Standard Ratings for Exlar Actuators

The standard IP rating for Exlar Actuators is IP54S or IP65S. Ingress protection is divided into two categories: solids and liquids.

For example, in IP65S the three digits following "IP" represent different forms of environmental influence:

- The first digit represents protection against ingress of solid objects.
- The second digit represents protection against ingress of liquids.
- The suffix digit represents the state of motion during operation.

Digit 1 - Ingress of Solid Objects	
The IP rating system provides for 6 levels of protection against solids.	
1	Protected against solid objects over 50 mm e.g. hands, large tools.
2	Protected against solid objects over 12.5 mm e.g. hands, large tools.
3	Protected against solid objects over 2.5 mm e.g. large gauge wire, small tools.
4	Protected against solid objects over 1.0 mm e.g. small gauge wire.
5	Limited protection against dust ingress.
6	Totally protected against dust ingress.

Digit 2 - Ingress of Liquids	
The IP rating system provides for 9 levels of protection against liquids.	
1	Protected against vertically falling drops of water or condensation.
2	Protected against falling drops of water, if the case is positioned up to 15 degrees from vertical.
3	Protected against sprays of water from any direction, even if the case is positioned up to 60 degrees from vertical.
4	Protected against splash water from any direction.
5	Protected against low pressure water jets from any direction. Limited ingress permitted.
6	Protected against high pressure water jets from any direction. Limited ingress permitted.
7	Protected against short periods (30 minutes or less) of immersion in water of 1m or less.
8	Protected against long durations of immersion in water.
9	Protected against high-pressure, high-temperature wash-downs.

Suffix			
S	Device standing still during operation	M	Device moving during operation

Notes

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1. OFFER AND ACCEPTANCE: These terms and conditions constitute Seller's offer to Buyer and acceptance by Buyer and any resulting sale is expressly limited to and conditioned upon Seller's terms and conditions as set forth below. If Buyer objects to any of Seller's terms and conditions, such objections must be expressly stated and brought to the attention of Seller in a written document which is separate from any purchase order or other printed form of Buyer. Such objections, or the incorporation of any additional or different terms or conditions by Buyer into a resulting order shall constitute non-acceptance of these Terms and Conditions, releasing Seller from any obligation or liability hereunder and a proposal for different terms and conditions which shall be objected to by Seller unless expressly accepted in writing by an authorized representative of Seller. Acknowledgment copy, if any, shall not constitute acceptance by Seller of any additional or different terms or conditions, nor shall Seller's commencement of effort, in itself, be construed as acceptance of an order containing additional or different terms and conditions.

2. PRICES: Published prices and discount schedules are subject to change without notice. They are prepared for the purpose of furnishing general information and are not quotations or offers to sell on the part of the company.

3. TRADE TERMS: Shipment terms are FCA, shipping point (Exlar, Chanhassen, MN). FCA (Free Carrier) per Incoterms 2010 means the Seller delivers the goods, cleared for export into the custody of the first carrier named by the buyer at the named place, above. This term is suitable for all modes of transport, including carriage by air, rail, road, and containerized/multi-modal transport. Title of the merchandise transfers from Exlar Corporation to the Buyer when it is received from Exlar by the carrier. Where allowable, Exlar will arrange the transportation via the carrier specified by the Buyer. The Buyer is responsible for all costs associated with the shipment.

4. PAYMENT TERMS: Subject to approval of Buyer's credit, the full net amount of each invoice is due and payable in cash within thirty (30) days of shipment. No payment discounts are offered, and minor inadvertent administrative errors contained in an invoice are subject to correction and shall not constitute reason for untimely payment. If, in the judgment of the Seller, the financial credit of Buyer at any time does not justify continuance of production or shipment of any product(s) on the payment terms herein specified, Seller may require full or partial payment prior to completion of production or shipment, or may terminate any order, or any part thereof, then outstanding. Custom products and blanket orders are subject to payment terms: 30% due at time of order, 70% due net 30 days from shipment.

5. MINIMUM BILLING: Minimum billing will be $50.00.

6. DELAYS: Exlar shall not be liable for any defaults, damages or delays in fulfilling any order caused by conditions beyond Seller's control, including but not limited to acts of God, strike, lockout, boycott, or other labor troubles, war, riot, flood, government regulations, or delays from Seller's subcontractors or suppliers in furnishing materials or supplies due to one or more of the foregoing clauses.

7. CANCELLATIONS: All cancelled orders for standard products are subject to order cancellation charges. The minimum cancellation charge will be 20% of the order total. Standard products, if unused may be returned in accordance with the current return policy. All returns are subject to prior approval by Exlar, and return charges may apply. No return credit for any product will be issued or authorized prior to evaluation of the product by Exlar. Custom product is not returnable. Orders for custom product are not cancelable.

8. QUANTITY PRICING AND BLANKET ORDER PRICING TERMS: Blanket order quantity pricing requires a complete delivery schedule for the volume being ordered, with all units scheduled to deliver within a 15 month period from the placement of the purchase order to the final scheduled shipment. Any requests to change the delivery schedule of a blanket order must be received in writing 60 days prior to the requested change. Failure to take delivery of the entire ordered volume will result in back charges equal to the difference in quantity price between the volume ordered and the volume received times the number of units received. A cancellation charge in accordance with the cancellation policy (item 7) will apply to any reduction in delivered volume from the original ordered quantity.

For orders receiving quantity discounts, but not as scheduled blanket orders, the same quantity pricing rules apply. Failure to take delivery of the entire quantity ordered will result in back charges equal to the difference in quantity price between the volume ordered and the volume received times the number of units received. Cancellation charges in accordance with the cancellation policy (item 7) will apply to any reduction in delivered volume from the original ordered quantity. For either blanket orders or quantity orders, in addition to any applicable cancellation charges, the customer is responsible for the value of any additional inventory allocated specifically to their order. Charges for this inventory will be invoiced in addition to cancellation charges, along with any back charges for quantity variance.

9. DESTINATION CONTROL STATEMENT: Exlar products, technology or software are exported from the United States in accordance with the Export Administration Regulations (EAR) or International Traffic in Arms Regulations (ITAR) as applicable. Diversion, transfer, transshipment or disposal contrary to U.S. law is prohibited.

10. EXPORT CONTROL AND SHIPMENT REGULATIONS: Purchaser agrees at all times to comply with all United States laws and regulations as well as International Trade Laws, as they may exist from time to time, regarding export licenses or the control or regulation of exportation or re-exportation of products or technical data sold or supplied to Distributor. Seller may terminate or suspend this order, without remedy, should the Purchaser become an entity identified on any US export denial listing. Products ordered may require authorization and/or validated export license from a U.S. government agency. Seller may terminate or suspend this order, without remedy, should a government agency approval be denied.

11. GOVERNING LAW AND VENUE: This order shall be governed by, and construed in accordance with the laws of the State of Minnesota, U.S.A. All disputes shall be resolved by a court of competent jurisdiction in the trial courts of Carver County, in the State of Minnesota.

12. ATTORNEY FEES: Reasonable attorney's fees and other expenses of litigation must be awarded to the prevailing party in an action in which a remedy is sought under this order.

13. NON-WAIVER: The failure by the Seller to require performance of any provision shall not affect the Seller's right to require performance at any time thereafter, nor shall a waiver of any breach or default of this Order constitute a waiver of any subsequent breach or default or a waiver of the provision itself.

14. MERGER AND INTEGRATION: These Terms and Conditions contain the entire agreement of the parties with respect to the subject matter of this order, and supersede all prior negotiations, agreements and understandings with respect thereto. Purchase orders may only be amended by a written document duly executed by buyer and seller.

15. INDEMNITY: Buyer agrees to indemnify, defend and hold harmless Exlar from any claims, loss or damages arising out of or related to Seller's compliance with Buyer's designs, specifications or instructions in the furnishing of products to Buyer, whether based on infringement of patents, copyrights, trademark or other right of others, breach of warranty, negligence, or strict liability or other tort.

WARRANTY AND LIMITATION OF LIABILITY: Products are warranted for two years from date of manufacture as determined by the serial number on the product label. Labels are generated and applied to the product at the time of shipment. The first and second digits are the year and the third and fourth digits represent the manufacturing week. Product repairs are warranted for 90 days from the date of the repair. The date of repair is recorded within the Exlar database and tracked by individual product serial number.

Exlar Corporation warrants its product(s) to the original purchaser and in the case of original equipment manufacturers, to their original customer to be free from defects in material and workmanship and to be made only in accordance with Exlar standard published catalog specifications for the product(s) as published at the time of purchase. Warranty or performance to any other specifications is not covered by this warranty unless otherwise agreed to in writing by Exlar and documented as part of any and all contracts, including but not limited to purchase orders, sales orders, order confirmations, purchase contracts and purchase agreements. In no event shall Exlar be liable or have any responsibility under such warranty if the product(s) has been improperly stored, installed, used or maintained, or if Buyer has permitted any unauthorized modifications, adjustments and/or repairs to such product(s). Seller's obligation hereunder is limited solely to repairing or replacing (at its opinion), at the factory any product(s), or parts thereof, which prove to Seller's satisfaction to be defective as a result of defective materials, or workmanship and within the period of time, in accordance with the Seller's stated product warranty (see Terms and Conditions above), provided, however, that written notice of claimed defects shall have been given to Exlar within thirty (30) days from the date of any such defect is first discovered. The product(s) claimed to be defective must be returned to Exlar, transportation prepaid by Buyer, with written specification of the claimed defect. Evidence acceptable to Exlar must be furnished that the claimed defects were not caused by misuse, abuse, or neglect by anyone other than Exlar.

Components such as seals, wipers, bearings, brakes, bushings, gears, splines, and roller screw parts are considered wear parts and must be inspected and serviced on a regular basis. Any damage caused by failure to properly lubricate Exlar products and/or to replace wear parts at appropriate times, is not covered by this warranty. Any damage due to excessive loading is not covered by this warranty.

The use of products or components under load such that they reach the end of their expected life is a normal characteristic of the application of mechanical products. Reaching the end of a product's expected life does not indicate any defect in material or workmanship and is not covered by this warranty.

Costs for shipment of units returned to the factory for warranty repairs are the responsibility of the owner of the product. Exlar will return ship all warranty repairs or replacements via UPS Ground at no cost to the customer.

For international customers, Exlar will return ship warranty repairs or replacements via UPS Expedited Service and cover the associated shipping costs. Any VAT or local country taxes are the responsibility of the owner of the product.

The foregoing warranty is in lieu of all other warranties (except as Title), whether expressed or implied, including without limitation, any warranty of merchantability, or of fitness for any particular purpose, other than as expressly set forth and to the extent specified herein, and is in lieu of all other obligations or liabilities on the part of Exlar.

Seller's maximum liability with respect to these terms and conditions and any resulting sale, arising from any cause whatsoever, including without limitation, breach of contract or negligence, shall not exceed the price specified of the product(s) giving rise to the claim, and in no event shall Exlar be liable under this warranty otherwise for special, incidental or consequential damages, whether similar or dissimilar, of any nature arising or resulting from the purchase, installation, removal, repair, operation, use or breakdown of the product(s) or any other cause whatsoever, including negligence.

The foregoing warranty shall also apply to products or parts which have been repaired or replaced pursuant to such warranty, and within the period of time, in accordance with Seller's stated warranty.

NO PERSON INCLUDING ANY AGENT OR REPRESENTATIVE OF EXLAR CORPORATION IS AUTHORIZED TO MAKE ANY REPRESENTATION OR WARRANTY ON BEHALF OF EXLAR CONCERNING ANY PRODUCTS MANUFACTURED BY EXLAR, EXCEPT TO REFER PURCHASERS TO THIS WARRANTY.