Linear Shaft Motor

NPM **Nippon Pulse**
Your Partner in Motion Control

Linear Shaft Motor

Linear Shaft Motor - The Next Generation Actuator

Nippon Pulse's family of Linear Shaft Motors are the next generation linear brushless motor. When reliability, zero maintenance, zero cogging, and precision are paramount, the Linear Shaft Motors from Nippon Pulse are an ideal component choice, offering the user uncompromised performance, ease of use, compact package size, and high value.

What is a Linear Shaft Motor?

The Linear Shaft Motor is a high precision direct drive linear servomotor consisting of a shaft of rare Earth-Iron-Boron Permanent Neodymium Magnets and a "forcer" of cylindrically wound coils which can be supplied with optional Hall effect devices. The shaft supplies the magnetic field which the forcer acts upon. The forcer assembly, combined with the amplifier and control electronics, produces the force for the motor. The Hall effect devices can be supplied, if they are required by your selected servo driver for proper commutation of a brushless linear motor, and are integrated into the forcer assembly.

The Linear Shaft Motor was designed with three basic design concepts:

- Simple - High Precision - Non Contact -

Linear Shaft Motors are simple. They consist of only two parts, a magnetic shaft and a "forcer" of cylindrically wound coils.

Linear Shaft Motors provide ultra high precision. They have no iron in the forcer or shaft, giving you the precision and zero cogging expected in a coreless design. The coils of the Linear Shaft Motor form the core, giving you the stiffness expected in an iron-core motor.

Linear Shaft Motors are non-contact. Since the coil completely wraps around the magnets, all the magnetic flux is efficiently used. This allows for a large (0.5 to 5.0mm) nominal annular air gap. This air gap is non-critical, meaning there is no variation in force as the gap varies over the stroke of the device.

Shaft   Magnet   Coil   Forcer

Magnetic Flux   Gap   Magnet
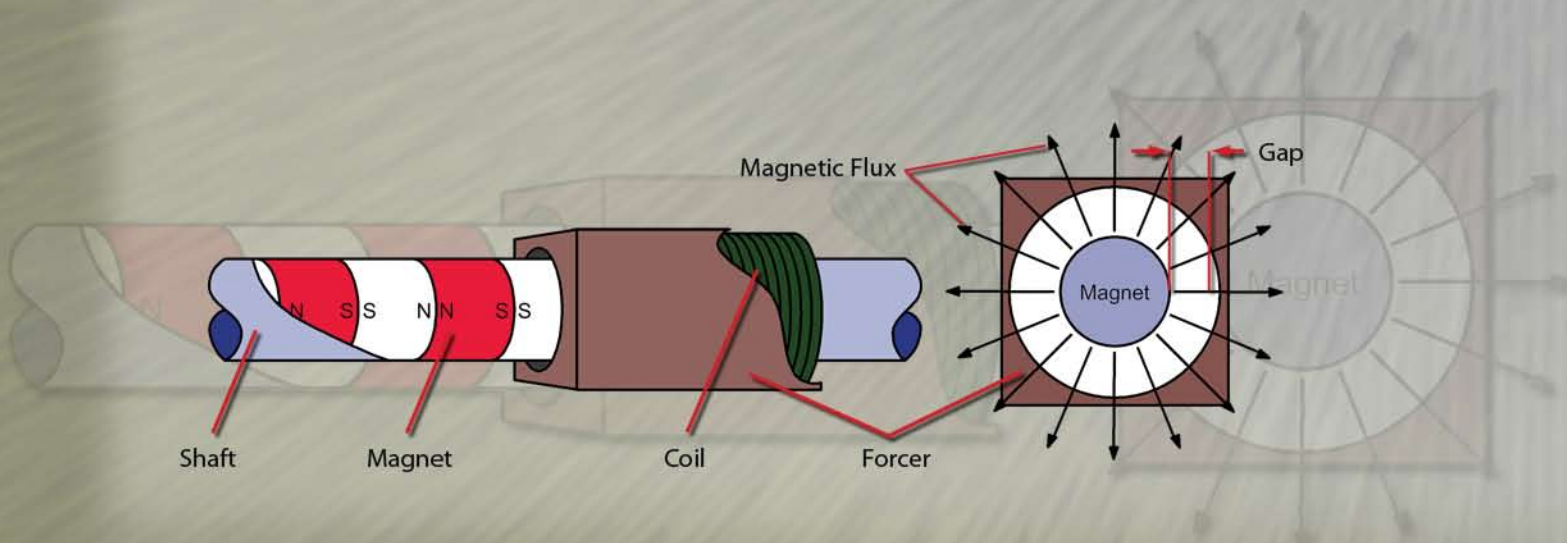
The Next Generation of Linear Motors
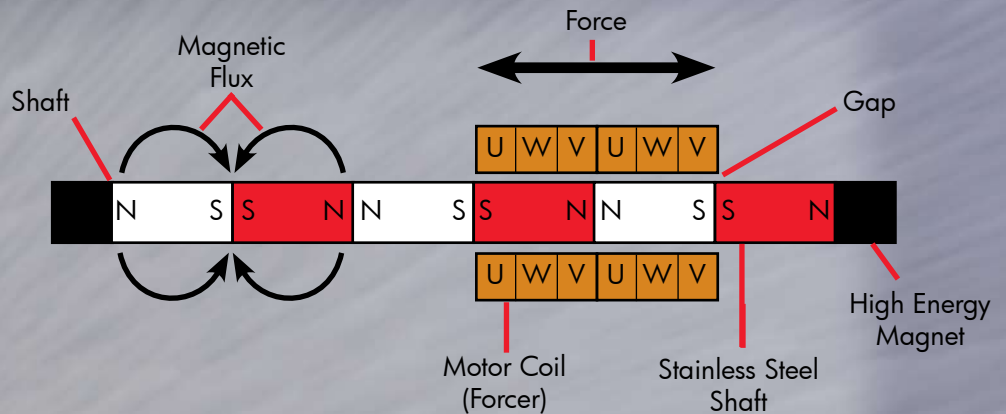
Basic Structure of a Linear Shaft Motor

The magnetic structure of the Shaft is built in such a manner that there is no space between each magnet and is fully supported within itself. The magnetic structure is then inserted into a protective stainless steel tube. This process is protected by numerous patents throughout the world. This patented process used produces a very strong magnetic field which is twice that of other linear motors.

Forcer Construction

The coils of the Linear Shaft Motor are of a cylindrical design, providing a number of key advantages over other linear motors.
- The cylindrical design of the coil assembly is very stiff without external stiffening materials (i.e. iron used by platen style linear motors).
- The coils surrounding the magnets allow for the optimal use of all the magnetic flux. This makes the air gap non-critical. As long as the forcer does not come in contact with the shaft there is no variation in the linear force.
- The magnetic flux cuts motor windings at right angles for maximum efficiency.
- All sides of the coil are positioned to allow for maximum dissipation of heat.
- The more efficient Linear Shaft Motor requires less power in a compact design while producing a comparable force to that of a similarly-sized traditional linear motor.

Features of Linear Shaft Motors

- Capable of high thrust (up to 100,000N)
- Quiet due to the absence of friction, the only mechanical contact section is the linear guide
  (Fully non-contact operation is possible using an air slider)
- Simplified unit construction allows a stroke of up to 4.6 meters
- High precision (0.07nm[1])
- High speed drive (greater than 10m/s) with acceleration up to 20G
- Low speed drive (8μm/s)
- Allows for parallel drive using only one encoder and one driver[2]
- Virtually no speed fluctuation (±0.006% at 100mm/s)
- Durable construction, capable of operation even underwater or in a vacuum

[1]-The precision of repetitive positioning is dependent on the resolution of the linear encoder. In addition, it is necessary to have sufficient machine rigidity. Also, absolute positioning precision is fundamentally dependent on the linear encoder. It is not dependent on the expansion or contraction caused by the heat of the Linear Shaft Motor.
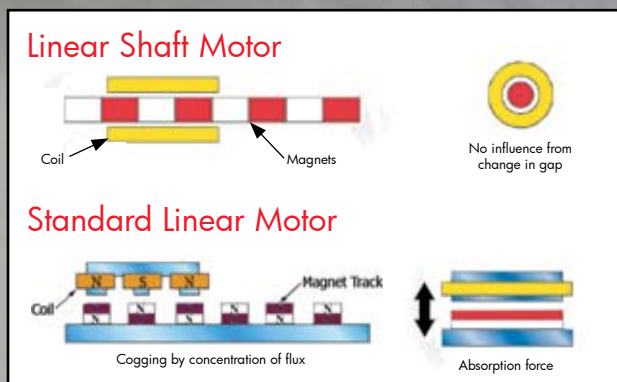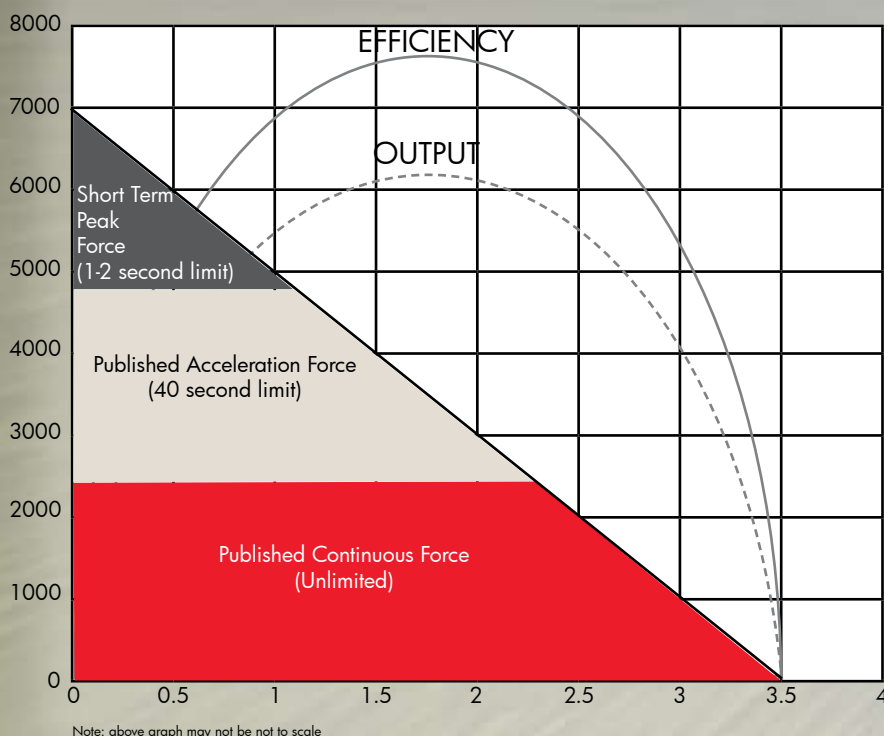[2] - The mechanism must allow for 1-degree of freedom of motion between the two motors.

Linear Shaft Motor

Traditionally, linear electric motors have been designed by "opening out flat" their rotary counterparts. For every rotary motor there is a linear motion counterpart, although the opposite of this statement may not always be true. Thus, corresponding to the DC motor and AC induction, stepper and synchronous motor, we have the Linear DC Motor (DCLM), Linear Induction Motor (LIM), Linear Pulse Motor (LPM), and Linear Synchronous Motor (LSM), respectively. Although this does provide a solution, a number of inherent disadvantages arise.

Like the voice coil motor, the force velocity (FV) curve of the Linear Shaft Motor is a straight line from peak velocity to peak force. The Linear Shaft Motor's FV curves are split into three regions. Published in Nippon Pulse literature as Continuous Force, it is the region were the motor can operate indefinitely without the need for any external cooling, including heat sinks. The second is the published Acceleration Force (refered to as Peak Force by other motor manufacturers). It is the amount of force which can be delivered by the motor for 40 seconds without the need for any external cooling, including heat sinks. The third region (not published) is limited only by the power which can be supplied and the duty cycle. It is the Peak Force and is limited to 1 to 2 seconds. Your local Nippon Pulse application engineer can help you map this for your particular application.

The Linear Shaft Motor is a very simple design which consists of a coil assembly (forcer), which encircles a patented round magnetic shaft. This design offers a number of advantages when compared to other types of linear motion systems:

Linear Shaft Motor

Coil   Magnets

No influence from change in gap

Standard Linear Motor

Coil   Magnet Track

Cogging by concentration of flux

Absorption force

No Need for Precision Air Gap

Unlike other types of linear motor technologies the cylindrical design of the Linear Shaft Motor contains a very large (0.5 to 5.0mm) non-critical air gap. This allows for a constant linear force, which is not effected by the alignment or misalignment of the forcer (coil) to the shaft (magnets). This allows for quick and simple assembly into the final product without the need for extensive machining and alignment time.

High Efficiency

The patented shaft design and resulting magnetic field allow for an unparalleled magnetic field strength. This allows a small amount of current to produce large amounts of force. Along with the cylindrical design which allows for 100% of the copper, current, and magnetic field to produce force only in the direction of travel.

EFFICIENCY

OUTPUT

Short Term Peak Force (1-2 second limit)

Published Acceleration Force (40 second limit)

Published Continuous Force (Unlimited)

Note: above graph may not be not to scale

Coreless Design with Ultra-High Stiffness

Platen style linear motors rightly boast high levels of stiffness due to their iron core. This iron also results in the creation of eddy currents which generate large amounts of heat while allowing moderate amounts of heat dissipation. The iron core also introduces large amounts of absorption forces, between the stator and armature, and cogging into the linear motion. U-shaped linear motors on the other hand use epoxy as their core which does not create eddy currents or any absorption force. This type of motor has a stiffness that is, at best, 1/125 that of a similar iron-cored motor. The sandwiching of the coil between the magnetic track and the very low thermal conductivity of epoxy produce a very thermally limited motor. The Linear Shaft Motor is designed to have a motor stiffness which is 100 times better than that of the u-shaped motor, while having a heat dissipation which is over four times greater than that of similar sized Platen style linear motors.

Linear Shaft Motor Advantages

- Compact & Lightweight: Lower weight when compared to traditional type of linear motors
- Zero Cogging: The coreless, ironless design results in no magnetic cogging
- Large Air Gap: The non-critical 0.5 to 5.0mm nominal annular air gap allows for easy installation and alignment
- Highly Efficient: Some of the highest efficiencies of any linear motor[1]
- Enclosed Magnets: Easy integration into a number of environments
- Efficient Use of Magnetic Flux: Forcer encircles the magnets allowing full use of the magnetic flux

1 - An independent study by the University of Virginia (Oct. 2010) proves, when all factors are equal, the Linear Shaft Motor is at least 50 percent more efficient than u-shaped linear motors. See www.nipponpulse.com for complete detail.
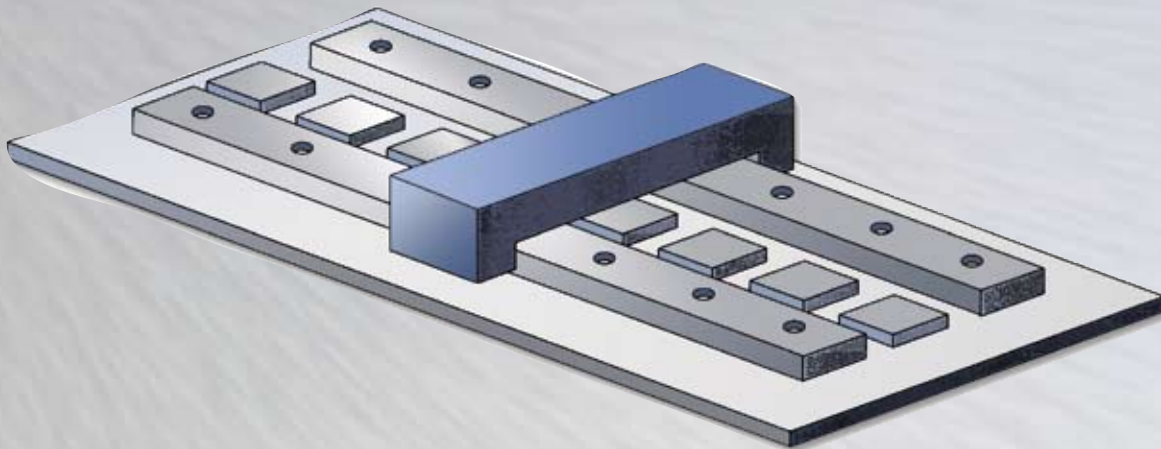
Linear Stepping Motors
- Open loop or low servo stiffness
- Limited force/speed

Platen-Style Linear Motors
- Precision air gap required
- Large force between stator and armature
- Exposed magnet track

Piezo Motors
- Side loading
- Constant contact results in wear
- Audible noise generated
- Custom electronics needed

Linear Induction Motors
- Large physical size
- High power consumption
- Complex cooling typically required
- Large force between stator/armature

U-shaped Linear Motors
- Restricted heat dissipation from sandwiched armature coils
- Partial use of magnetic flux in design
- Limited mechanical stiffness

Linear Shaft Motors provide direct thrust for the positioning of the payload.
It eliminates the need for a rotary-to-linear conversion mechanism.
Example: ball-screw, rack and pinion, toothed belt.
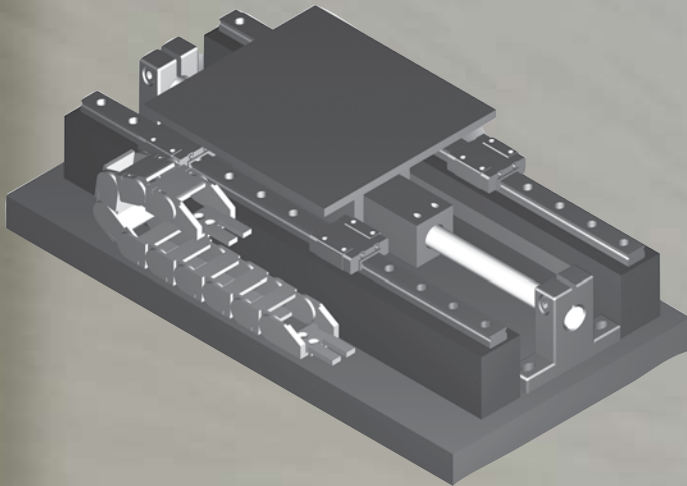
## No Lubrication/
Adjustment Maintenance Necessary

The Linear Shaft Motor requires no greasing, as is necessary with a ball-screw, and has no performance degradation because of wear/aging as with ball-screw and belt drive systems. Because the Linear Shaft Motor is maintenance-free, there is significant cost reduction throughout its life-span. The air gap between the shaft and the forcer eliminates the need for adjustments such as positioning of the guide or concentric adjustment, which are all required for ball-screws.
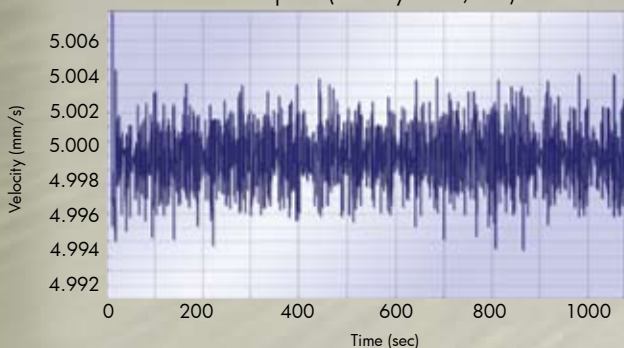
No Noise/No Dust Operation

Dust and noise, inevitable in ball-screw and pneumatic systems, does not exist in the non-contact Linear Shaft Motor. This is not only applicable for clean room environments, but it also greatly improves the work environment by reducing noise

Speed Fluctuation

High Speed (Velocity: 100mm/Sec)
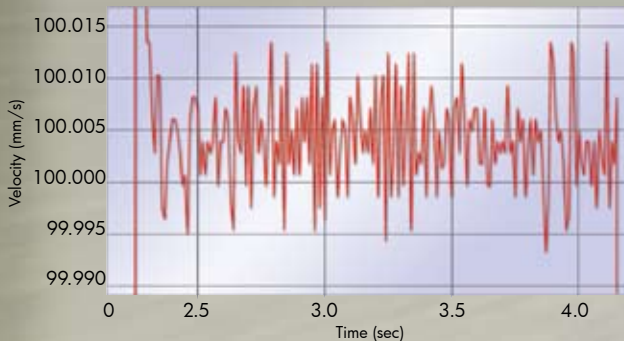
### Low Speed (Velocity: 5mm/Sec)

The Linear Shaft Motor is coreless and as a result is able to provide uniformity of speed over a wide range of speeds.

Advantages of Linear Shaft Motors

• Simple mechanical arrangement	Minimal number of moving parts
• Direct thrust motor	No backlash, no wear
• Wide speed range	$8\mu m/sec$ to >10m/sec
• Smooth	Virtually no speed fluctuation
• Quiet	Virtually silent motion
• Maintenance-free motor	No internal moving parts
• Lower inertia	Less mass to move
• Lower power requirements	Direct drive systems are more efficient than coupled systems
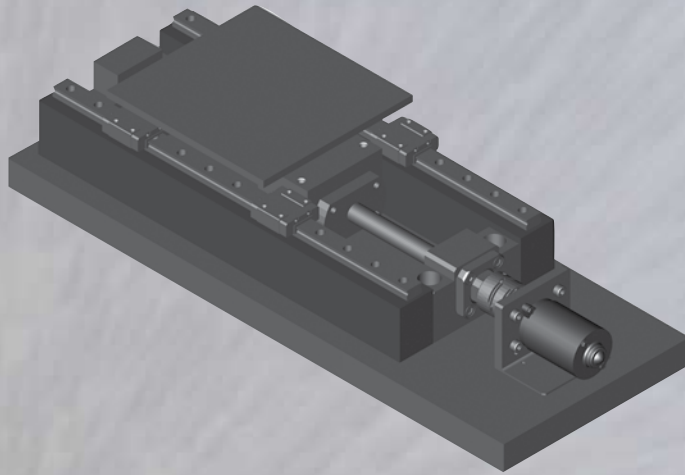
Extremely High Precision [1]/Low Speed Uniformity/High Repeatability

The Linear Shaft Motor enables a level of precision not achievable in ball-screws, and allows you to drastically improve the yield of high precision process, which is limited by other linear mechanisms.

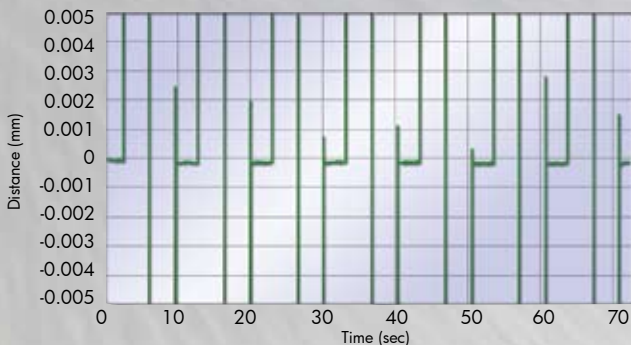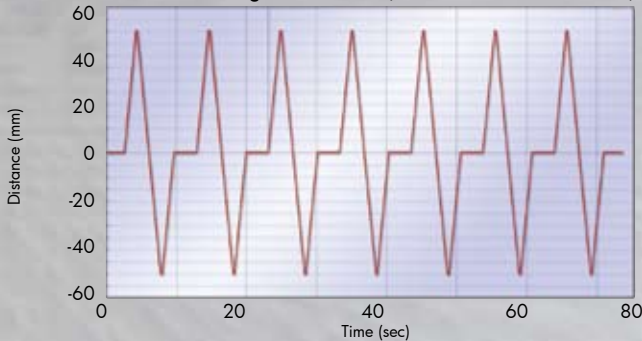## Realizes High Speed Motions while Retaining High Precision

The Linear Shaft Motor's high precision in high-speed operation shortens the travel time required by ball-screws.

Good Resistance Against Environmental Changes such as Temperature

For precision operation, other linear mechanisms require strict control of work environment including temperature. The Linear Shaft Motor, which operates without direct contact, allows constant precision that is unaffected by environmental changes and facilitates a large reduction in climate control cost.

Using Linear Shaft Motors can

- Reduce the number of parts

- Save space

- Eliminate the need to adjust with locating

  guides and concentrics

- Reduce base machining costs and time

- Lower design costs and time

[1] The precision of repetitive positioning is dependent on the resolution of the linear encoder. In addition, it is necessary to have sufficient machine rigidity. Also, absolute positioning precision is fundamentally dependent on the linear encoder. It is not dependent on the expansion or contraction caused by the heat of the Linear Shaft Motor.

Precision

Static Positioning Performance (encoder resolution 8.6nm)

This is the center section of the top graph displayed at 10,000X magnification.

A wide range of applications are possible by utilizing one or more of the features
of the Linear Shaft Motor listed on these two pages.
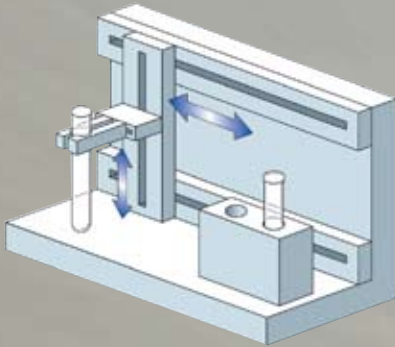
Friction free and quiet
The Linear Shaft Motor's moving parts are all
non-contact. All sources of noise and friction are
eliminated, allowing use in quiet and clean room
surroundings, such as test laboratories
or medical facilities.

High thrust
Peak thrust of up to 100,000 Newtons is achievable.
Can be used for precisely conveying heavy loads such
as clinical equipment or transfer
lines on a factory floor.
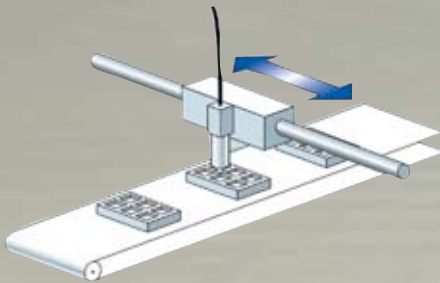
Environmental compatibility
Operates well in production locations where oil or water
are used, or in a vacuum.
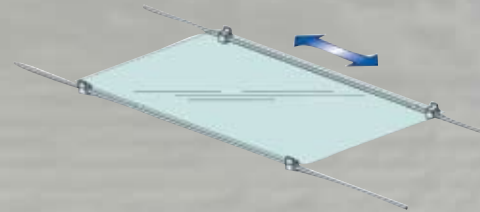
Large stroke lengths
Stroke lengths up to 4.6 meters. Ideal for high-precision
conveying, such as LCD's over relatively long distances.
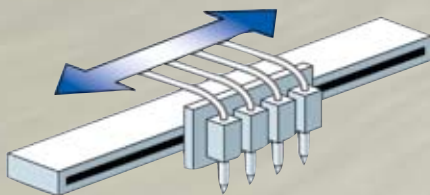
High controllable speed
Speeds of greater than 10 meters/sec have been
documented. Ideal for line head drives in
high-speed printers.
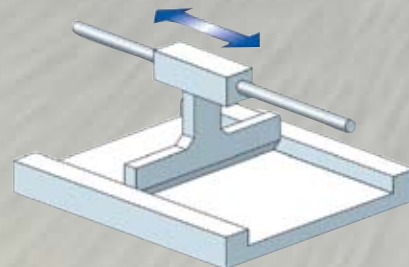
Low speed drives
Speeds as low as 8µm/sec have been documented.
Ideal for equipment, in life sciences for example, which
may be difficult to handle with ball-screws.

The Linear Shaft Motor can be mixed and matched to achieve the desired load thrust, based upon the complexity of the application.
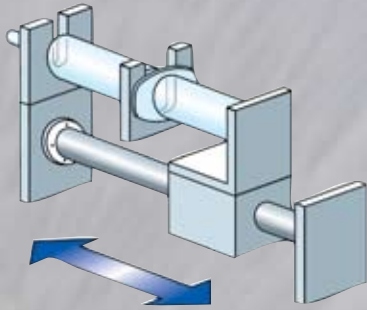
No speed fluctuation
Ideal for constant speed drug dispensing which may be difficult to achieve with lead-screws or ball-screws.
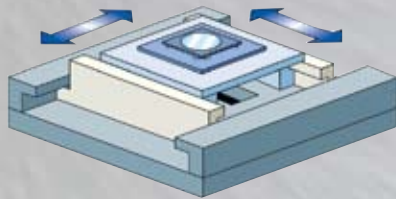
High resolution
Useful for precise micro positioning required in semiconductor equipment.
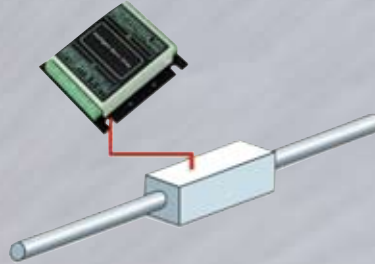
Single Drive System
This is a basic drive system. The X and Y shafts can be used to create an X-Y stage.
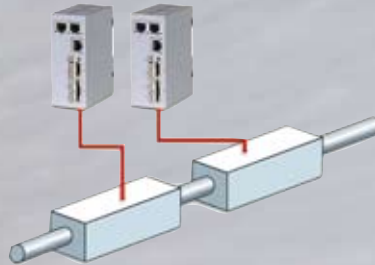
Multi-Drive System
Multiple forcers can be used with a single shaft to support complex movements required by of some applications.
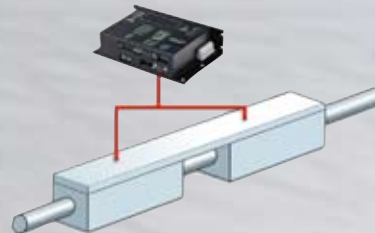
Tandem Drive System
Two or more forcers can be used on the same shaft to multiply the thrust.
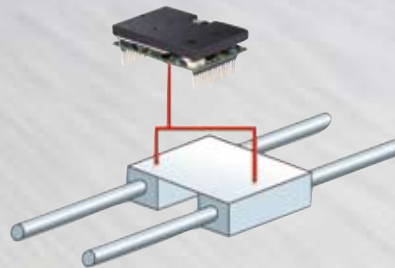
Parallel Drive System
Linear Shaft Motors can be used in parallel (two or more forcers and two or more shafts connected to the same load), to achieve large thrusts for moving heavy objects.

Linear Slider

In this application, a single Linear Shaft Motor was used with a servo driver, motion controller, linear encoder, and linear guide (bearing).

- Linear Shaft Motor: S160T
- Stroke: 300mm
- Thrust: 15N
- Resolution: 0.082μ to 5μ
  (settable in eight levels within this range)
- Maximum operating speed:
  7.2 meters per second

A Linear Shaft Motor was selected because of it's high speed and acceleration along with high precision.

Linear Station

In this application, two Linear Shaft Motors were used in blood testing equipment. A single Linear Shaft Motor with two sliders, for two independent movements, was used on the X-axis and a single Linear Shaft Motor was used on the Y-axis. A dedicated controller controlled the axes.

- Linear Shaft Motors:
  - X axis   S160T
  - Y axis   S200T
- Stroke: X axis   350mm
  - Y axis   200mm
- Thrust: X axis   15N
  - Y axis   28N
- Resolution: 4 micrometers
- Stepping motors were used on the other axes for specimen aspiration/dispensing, aspiration tip disposal, test tube chucking and test tube position control
- Controller: Motionnet® (see Nippon Pulse's Motion Control/ Serial Communcation catalog) for multi-axis control and cable saving
- Processing time: One specimen every 35 seconds
- Maximum operating speed:
  0.5 meters per second

The Linear Shaft Motor was selected because of its ability to have two heads running at the same time.

High Precision Stage

In this application, a single Linear Shaft Motor was used for a high precision granite stage.

- Linear Shaft Motor: S320D
- Stroke: 40mm
- Thrust: 56N
- Resolution: 0.14nm
- Controller: UMAC made by Delta-Tau Data Systems, Inc.
- Servo driver: SVDH5-A made by Servoland
- Linear Encoder: Laser scale P/N BS55A made by Sony Manufacturing System (±0.04 micrometers on 40 mm effective length)
- Interpolator: BD95-T12 by Sony Manufacturing System (Resolution is 0.14nm)
- Linear guide: Air slider

The Linear Shaft Motor was selected because of its high motor stiffness and its ability to achieve ultra high precision.
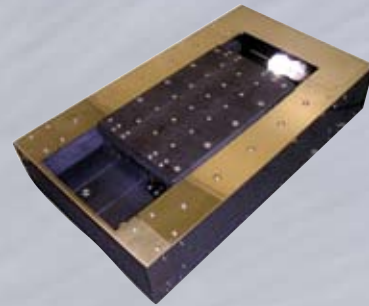
Vertical Slider

In this application, a single Linear Shaft Motor was used for smooth vertical movement and for quiet operation.

- Linear Shaft Motor: S250D
- Stroke: 50mm
- Thrust: 46N
- Resolution: 100μm
- Maximum operating speed: 1.3m per second

A Linear Shaft Motor was selected because of its totally quiet operation.
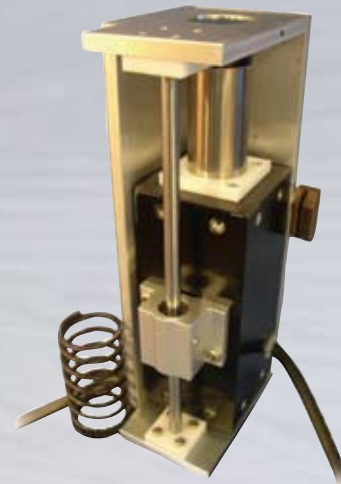
Clean Room Pick and Place

In this application, a single Linear Shaft Motor was used in a non-contact stage suitable for a class-10,000 clean room.

- Linear Shaft Motor: S200T
- Stroke: 500mm
- Thrust: 28N
- Maximum operating speed: 1.0m per second

A Linear Shaft Motor was selected because of its non-contact construction, and because it does not require maintenance.
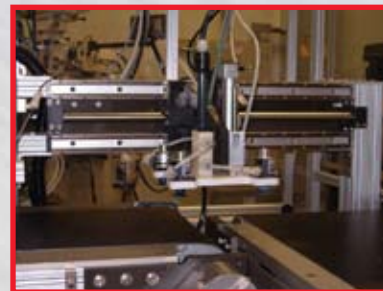
The design of the Linear Shaft Motor allows you to replace the standard ball screw system with the Linear Shaft Motor and achieve higher speed and resolution. However, to achieve the highest performance with the Linear Shaft Motor system, the entire system structure must be optimized. Please be aware there are various design considerations which are somewhat different from traditional servo system practices. These are the main components needed to make a Linear Shaft Motor system, as well as factors to consider when designing a system.

B Servo Driver

F Cable Carrier

G Table

E Shaft Support

A -1 Shaft

C -2 Linear Encoder

C -1 Linear Scale

A -2 Forcer

D -2 Bearing Block

D -1 Linear Rail

E Shaft Support
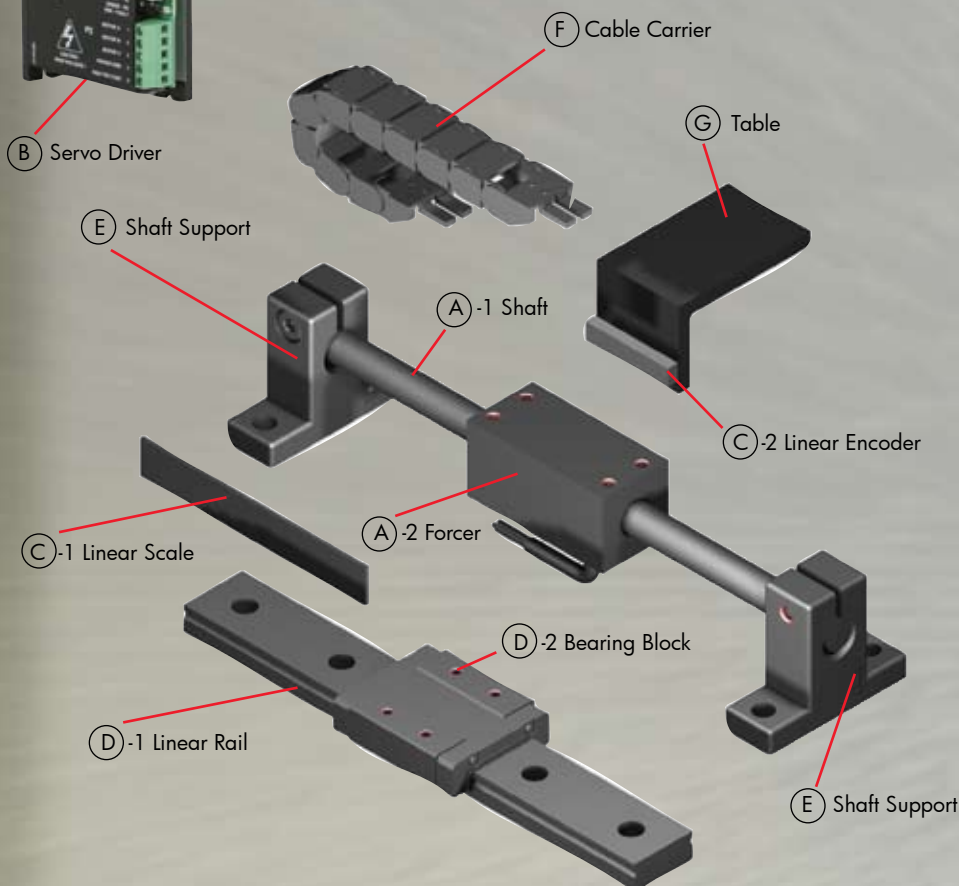
Steps to putting together a Linear Shaft Motor System

Choose the Linear Shaft Motor based on force and stroke requirements.

⬇

Choose the shaft supports based on design and motor specifications.

⬇

Choose the linear guide (bearings) based on cost and smoothness (performance) constraints.

⬇

Choose the linear encoder to achieve the required position resolution.

⬇

Choose the servo driver to match the power requirements of the Linear Shaft Motor.

⬇

Choose the OTL, limit switches/other components and assemble the Linear Shaft Motor system.

Configuring the Linear Shaft Motor

To configure a system using the Linear Shaft Motor, the following peripheral devices are required:

- A. Linear Shaft Motor
- B. Servo Driver
- C. Linear encoder (optical or magnetic)

Item D (Linear Guide) is a necessary part of a system, but consideration must be given to the application, demand specifications, environmental conditions, and which will be moving–the forcer or the shaft.

The other items, E through G, are optional and will need to be selected depending on the application.

Choose the Linear Shaft Motor Based on Force and Stroke Requirements

For assistance in selecting the correct Linear Shaft Motor, use the Selection Guide in the Engineering Notes section and the "SMART" (Linear Shaft Motor Application Resource Tool) which can be found of the Nippon Pulse website (www.nipponpulse.com). The Linear Shaft Motor should be mounted as closely as possible to the center of gravity of the moving load and to the working point of the machine.

If the motor and feedback are far apart, the machine structure and linear guide (bearings) must be of sufficient mechanical stiffness to minimize dynamic deflections of the structure. Be sure to allow clearance for ventilation and access for cleaning, repair, service, and inspections. Ventilation is extremely important. Be 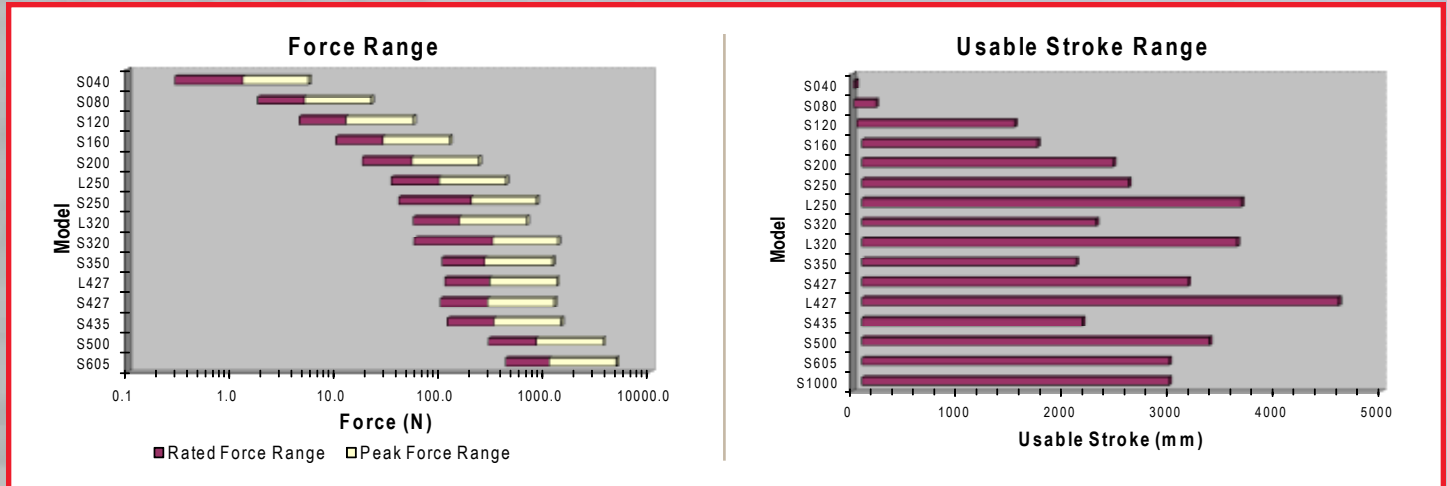sure the area for ventilation is not obstructed. Obstructions limit the free passage of air. Motors get warm and the heat must be dissipated to prevent damage.

Force Range

Usable Stroke Range

Choose the Shaft Supports Based on Force and Stroke Requirements

Select a shaft support as outlined in the data sheet of your selected Linear Shaft Motor. The shaft support is what allows longer strokes in a Linear Shaft Motor system without excessive bending of the shaft. The shaft support should not only be able to support the mass of the shaft, but also be in contact with the shaft for the specified support length. While a single shaft support will provide better security and easier alignment, a lower cost option is to space two smaller shaft supports for the specified support length. The drawing to the right illustrates these two different options.
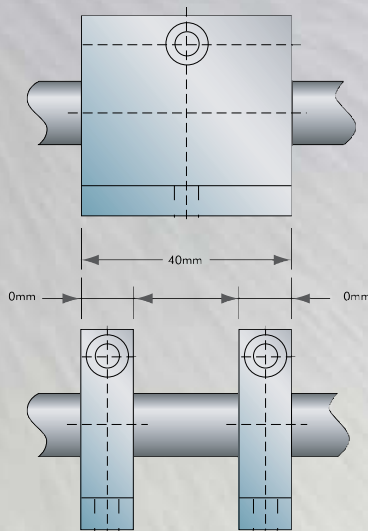
Choose the Linear Guide (bearings) Based on Cost and Smoothness (performance) Constraints

The linear guide (bearings) must be selected to support the moving load. Often, the linear guide (bearings) is the only moving contact type component in the system. Therefore, this component requires special attention. Desirable bearing characteristics include high mechanical stiffness (for increased natural frequency) and low friction. Because the Linear Shaft Motor can provide high velocities, the speed and acceleration limitations of the bearings need to be considered. Some common bearing choices are compared in the table below. Air bearings are most desirable from the standpoint of smoothness, but they are also the most costly. Mechanical slide rails on the other hand are the least expensive, but they are least desirable with respect to load carrying capability.

	Slide Rails	Cam Follower	Crossed Roller	Recirculating Element	Air
Travel	◉	◉	●	◉	◐
Stiffness	●	●	◉	◉	◐
Speed	●	◉	◐	○	◐
Smoothness	●	◐	◐	◉	○
Precision	●	●	◐	◐	○
Load	◐	●	◐	◉	●
Cost	○	○	◐	◐	●

Least Desirable ● ◐ ◉ ○ Most Desirable

Choose the Linear Encoder to Achieve the Required Position Resolution

The linear encoder is one of the most important parts of your Linear Shaft Motor system. A processed signal from the linear encoder is used to precisely measure the actual position of the system. The positioning resolution, repeatability, and smoothness of operation depend on the resolution of the encoder. For this reason, it is recommended you use an encoder with 1μm resolution or better. In addition, the maximum response speed of the encoder may limit the maximum system speed. Select a linear encoder that will supply 10 times your required resolution. To assist in selecting the correct encoder, use the Encoder formula in the Engineering Notes section. Either an optical or a magnetic encoder can be used.

In the case of a magnetic linear encoder, take care it is installed so the magnetic shaft does not affect the encoder. Ensure your driver supports the output mode of the selected encoder. The linear encoder should be mounted as close as possible to the working point of the machine. If the motor and feedback are far apart, the machine structure and linear guide (bearings) must be of sufficient mechanical stiffness to minimize dynamic deflections of the structure.
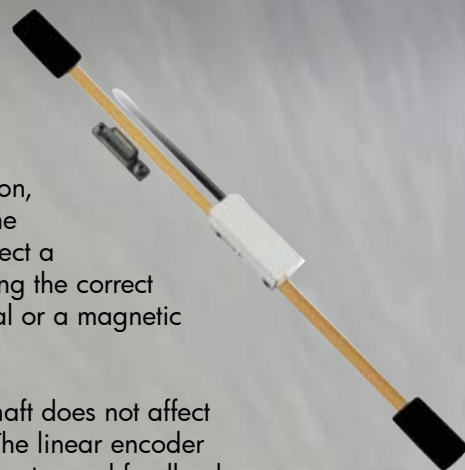
Choose the Servo Amplifier/Driver to Match the Power Requirements of the Linear Shaft Motor

Select a servo driver that can meet the power requirements of your selected Linear Shaft Motor. To assist in selecting the correct servo driver, use the Amplifier/Driver Sizing Guide in the Engineering Notes section (note: this information is also calculated in the SMART sizing program). Any three phase brushless DC servomotor driver can be used to drive the Linear Shaft Motor. In selecting a servo driver, check the method in which the magnetic position is detected.

Since the Linear Shaft Motor does not come with hall effect sensors in its standard configuration, they will need to be added as an option, if required by your selected servo driver. If the servo driver does not require the use of hall effect sensors, you may use the Linear Shaft Motor in its standard configuration.

Most servo drivers use peak (DC) units for voltage and current ratings while most servomotors (like the Linear Shaft Motor) use RMS (AC) units. Please pay attention to the units when selecting a servo driver. The Engineering Notes section has formulas for converting peak values to RMS values.

Choose the OTL, Limit Switches, and Other Components and Assemble the Linear Shaft Motor System

Temperature Sensor
A temperature sensor OTL (Over Temperature Limit), which will cut power to the motor should it get too hot due to overload, can be added in series with the main power to the driver. The maximum coil temperature limit of the Linear Shaft Motor is 135°C.

Limit Switches
Limit switches can be added on either side of the load on the shaft to prevent the load from overshooting and causing harm. Many quality linear encoders include limit switches.

Cabling & Cable Carrier
The Linear Shaft Motor is typically operated with a stationary shaft and a moving forcer (it can be operated with a stationary forcer and moving shaft). With such an arrangement, you will have moving cables. A provision must be provided in the machine to carry the cables. A connector is provided with the Linear Shaft Motor to allow you to connect cables for proper flex life at the designed bend radius in the locations were the cable will move. Cables should be made in a twisted pair configuration, shielded, and grounded properly to the machine base, servo driver, and motor in order to reduce RFI.
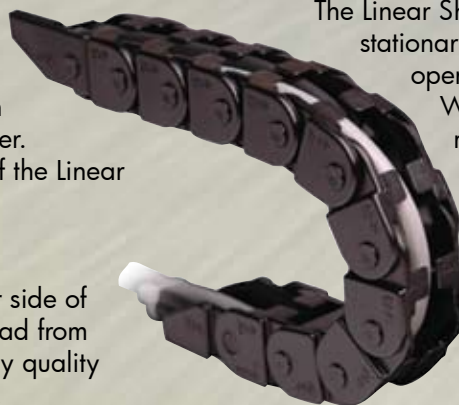
Hall Effect Sensors

Hall effect sensors are devices able to sense position magnetically and provide this information to the servo driver. Some servo drivers require Hall sensor feedback for commutation. The Hall effect sensors are used by some servo drivers to obtain forcer position information relative to the shaft for commutation. Other servo drivers are able to obtain information for commutation from the linear encoder.
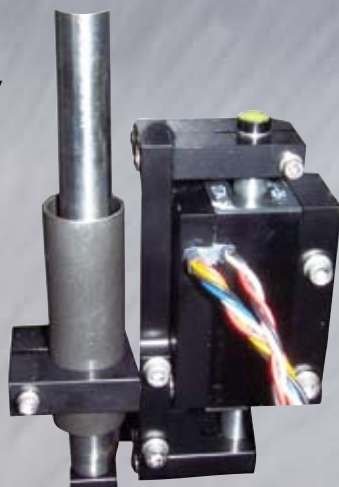
For most horizontal applications using servo drivers, there is no need for digital Hall effects. The commutation is based on a commutation table built during the tuning process, and is derived from the linear encoder. For most vertical applications, it is best to use digital Hall effects. The Linear Shaft Motor does not come with Hall effect sensors in its standard configuration; they will need to be selected as an option if required by your selected servo driver.

Because of the size of Hall effect sensors, they are not available on our 4mm Linear Shaft Motor. On the 8-20mm motors, the dimensions of your project must be expanded to include the sensors, which must be connected externally to the motor. On the 25mm series and above, the sensors fit inside the motor and no additional space is needed in your design.

Other Components

Each component must be of the lowest mass and highest mechanical stiffness possible in order to decrease settling times. Hollowed and ribbed components or honeycomb structures, along with special materials, are often utilized to achieve this. Obtaining the highest mechanical stiffness with the lowest mass requires that the linear motor be treated as an integral element to a motion system and not an add-on part.
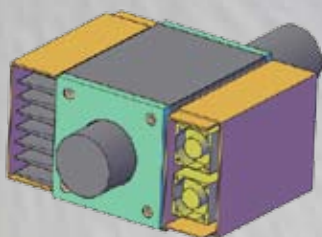
Cooling Methods

Depending on the application, Nippon Pulse sales engineers can suggest a variety of options, including several cooling methods, if cooling is necessary in your design.

Although the Linear Shaft Motor inherently runs cooler than other linear motors, using heat dissipation can improve the ratings of the LSM by 30-40%. Cooling methods include, but are not limited to, heat routing, heat fins (above, left), heat fans (above, right), forced air, and water cooling.

Attached to a S080D, a 200mm x 100mm x 12mm heat sink improved the rated current by 75%. The same heat sink improved the rated current of a S160D by 30%.

At right is an example of a water-cooled S500D Linear Shaft Motor.

Linear Shaft Motor in Parallel Systems

Parallel drive systems are most commonly thought of as being used in Cartesian/Gantry robots. Nippon Pulse defines the parallel drive system as any application that has two or more linear motors in parallel.

Parallel Linear Shaft Motor Design

Parallel Option   Non-Parallel Option
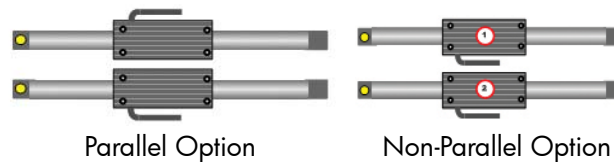
Advantages of Using Linear Shaft Motor in a Parallel Alignment

In high-precision single axis robot applications, truly accurate positioning is only possible when the feedback is directly in the center of mass of the work point. You also want your force generation from the motor directly in the center of mass of the work point as well; however, it is impossible to have the motor and feedback in the exact same location.

By putting an encoder in the center of mass, and using parallel Linear Shaft Motors equally spaced off the center of mass, you, in effect, are getting the desired feedback and force generation in the center of mass. You also are able to remove the heat source from the center of mass in high precision applications. This is impossible for other types of parallel drive systems which require two sets of encoders and servo drives to provide this parallel drive functionality.

Multiple Motors, One Encoder, One Amplifier

In the past, systems may have had two different motors driving separate ball-screws using two different controllers electronically connected together. Now that same system can be accomplished with two shaft motors, one encoder, and one amplifier, as long as the stiffness in the system itself is sufficiently high (see image at left).

Examples of Parallel Systems
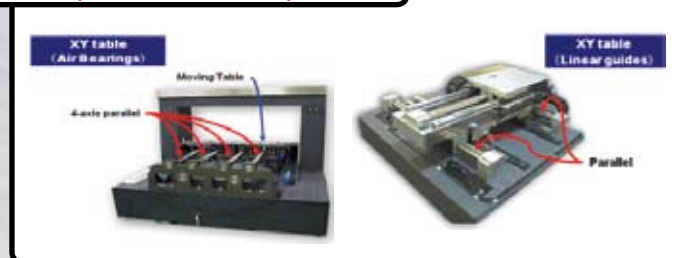
Unlimited Linear Shaft Motors Connected Together

This is also is an advantage for applications where extremely high amounts of force are needed. It is possible to connect any number of Linear Shaft Motors together, thus allowing their forces to be added together.

When used in a horizontal application, Linear Shaft Motors typically will have the load attached to the forcer so as to achieve very simple and precise linear movements. In a Linear Shaft Motor system, the shaft is supported at both shaft supports and the load moves along slide rails, linear bearings or air bearings. A linear encoder scale is attached to the guide rails to provide linear position feedback for servo control.

Moving Forcer

Table
Linear Encoder
Shaft Support
Bearing Blocks
Linear Scale
Linear Rail
Forcer
Shaft
Shaft Support

Moving Shaft

Table
Bearings
Linear Scale
Linear Encoder
Forcer
Shaft Support
Shaft Support
Shaft
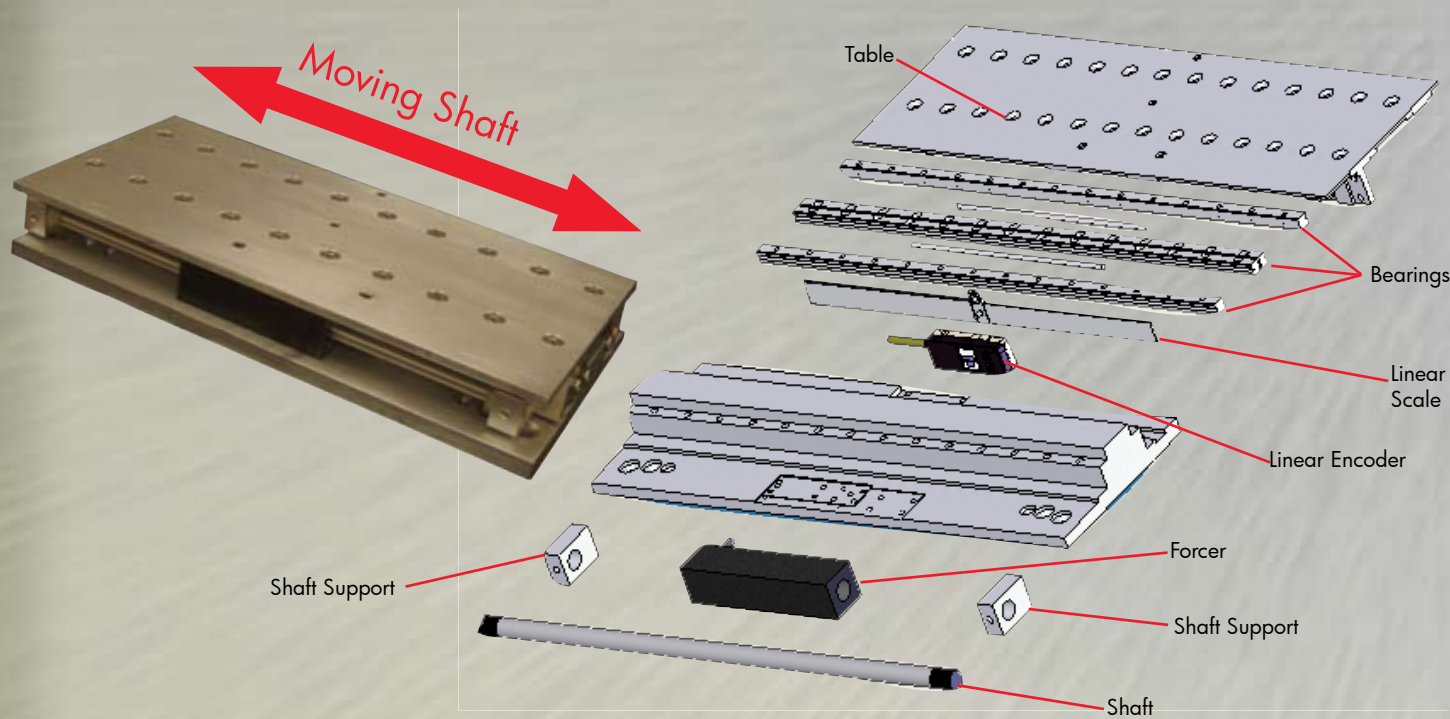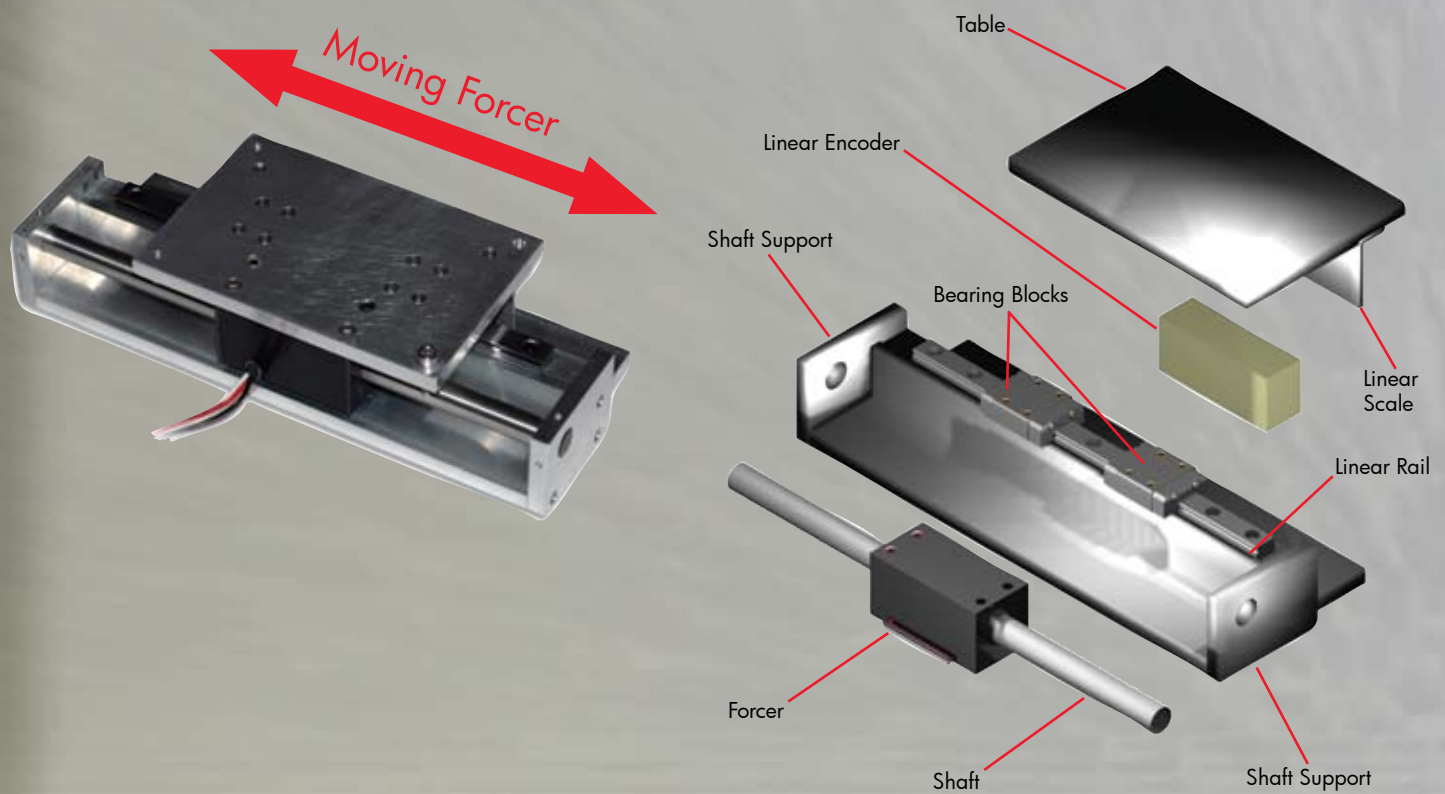
When used in a vertical application, Linear Shaft Motors typically require a counterbalance mechanism, or brake, to prevent the load from dropping in the event of a power interruption. The counter balance can also reduce the net load on the motor by supporting the load against gravity. Typical counterbalance techniques include a pneumatic cylinder, springs, or a counterweight.

Moving Forcer

Shaft Support

Linear Rail

Bearing Block

Cable Carrier

Forcer

Encoder

Tables

Linear Scale

Shaft

Shaft Support

Moving Shaft

Linear Pillow Block Bearing

Forcer

Linear Encoder

Baseplate

Linear Scale

Shaft

Shaft Support
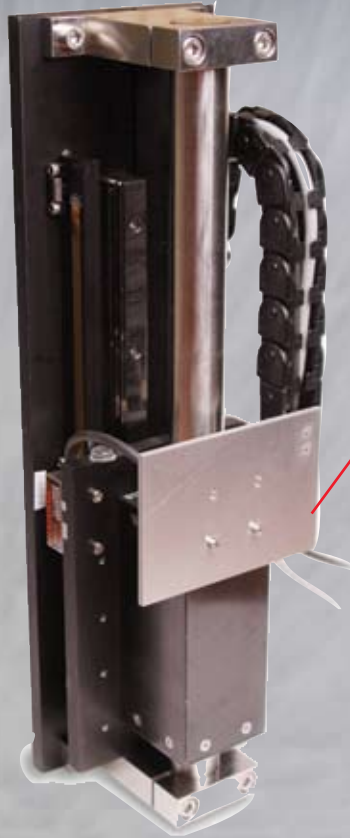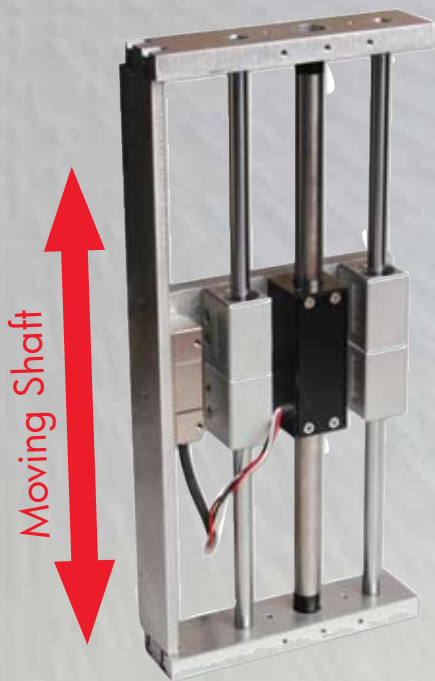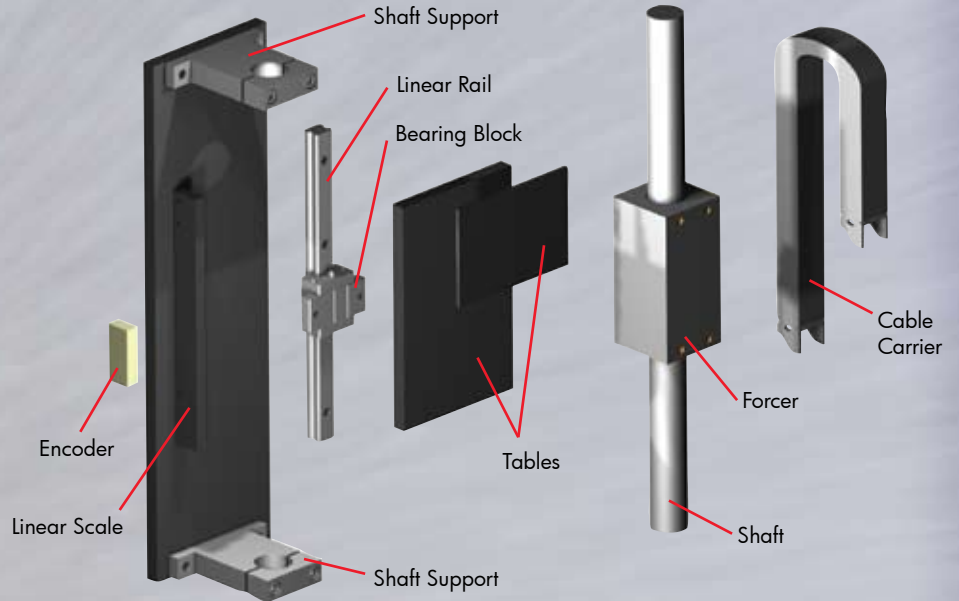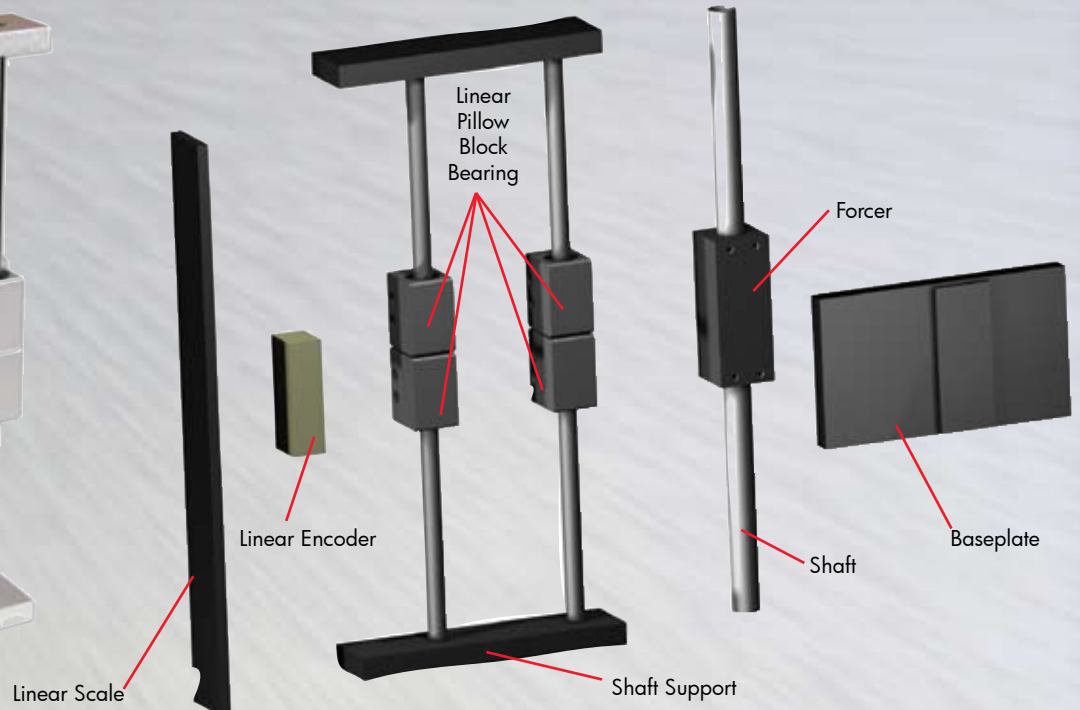
Linear Shaft Motor Part Numbering Guide

Shaft Size (D)	Forcer Size (A)	Parallel Option	Usable Stroke	Options	Options	# of Forcers
S	X	— XX —	XXXXst	— XX —	XX —	XX

Shaft Size (D):
- 040
- 080
- 160
- 200
- 250
- 320
- 350
- 427
- 435
- 500
- 605
- 1000*

Two or more forcers

Blank	Standard
FO	Forcer Only
SO	Shaft Only

WP	Waterproof
HA	Digital Hall Effect
CE	CE type motor (only needed if ordering forcer)

XX	Usable stroke in millimeters (only needed if ordering shaft)

Blank	Standard
PL	Parallel Motors

S	Single winding
D	Double (2) windings
T	Triple (3) windings
Q	Quadruple (4) windings
X	Octuple (8) windings
SS	Single winding small forcer
DS	Double winding small forcer
TS	Triple winding small forcer

XX	Shaft diameter in mm *10

S	Standard Air Gap
L	Large Air Gap

* - Larger shaft sizes are available on a custom basis. Contact Nippon Pulse for more details

Usable Stroke is = L - (L2 * 2) - A
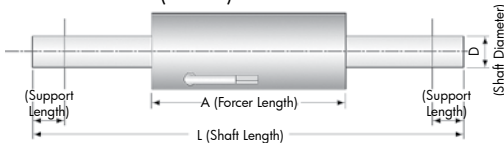
Example: For a S080D-250
L = 310
L2 = 10
A = 40
Stroke = 310 - (10*2) - 40
Stroke = 310 - 20 - 40
Stroke = 250

Part Numbering Examples

1. S160T-200st: 16mm shaft diameter, triple winding, stroke of 200mm

2. S200D-250st-HA: 20mm shaft diameter, double winding, stroke of 250mm, Hall effects

3. L250Q-1000st: Large air gap, 25mm shaft diameter, quadruple winding, stroke of 1000mm

4. L320T-2500st-02: Large air gap, 32mm shaft diameter, triple winding, stroke of 2500mm, two forcers

5. S200D-FO: 20mm shaft diameter, double winding, forcer only

6. S120Q-200st-SO: 12mm diameter, quadruple winding, stroke of 200mm, shaft only

7. S350QPL-500st: 35mm shaft diameter, quadruple winding, parallel motors, stroke of 500mm

8. L350SS-1500st-03: Large air gap, 35mm shaft diameter, single winding, small forcer, stroke of 1500mm, three forcers

Linear Shaft Motor Dimension Guide

* S040 ~ S435
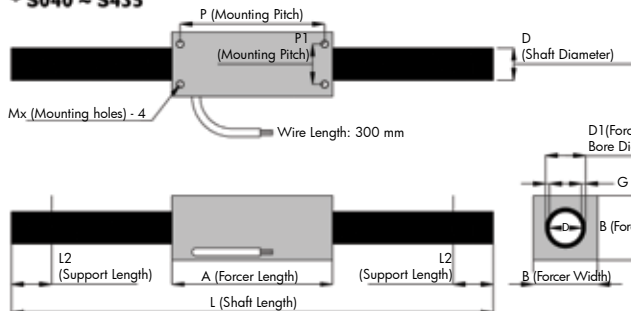
* S500 ~ S1000
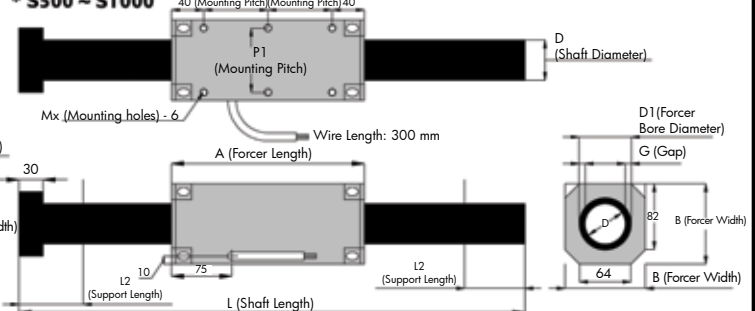
Notes:
- The dimension S (Stroke) should be used for limit switch spacing.
- The total length of the shaft (L) can be calculated using the following formula: L (Total Length) = S (Stroke) + A (Forcer Length) + 2 * L2 (Support Length)

| Model Number	Continuous Force N	Continuous Current A rms	Acceleration Force N	Accel. Current A rms	Force Constant (Kf) N/A rms	Back EMF V rms/m/s	Resistance Ω	Inductance mH	Forcer Length mm	Forcer Weight kg	Air Gap mm	Model Number	
S040D	0.29	0.3	1.2	1.1	1.0	0.4	11.2	0.5	25	0.01	0.50	S040D	4mm shaft diameter
S040T	0.45	0.3	1.8	1.1	1.6	0.5	16.8	0.7	34	0.01	0.50	S040T	
S040Q	0.58	0.3	2.3	1.1	2.1	0.7	22.4	1.0	43	0.01	0.50	S040Q	
S080D	1.8	0.8	7.2	3.4	2.1	0.7	4.7	0.7	40	0.05	0.50	S080D	8mm shaft diameter
S080T	2.7	0.8	10.7	3.4	3.2	1.1	6.8	1.0	55	0.06	0.50	S080T	
S080Q	3.5	0.8	14	3.4	4.2	1.4	9.0	1.3	70	0.08	0.50	S080Q	
S120D	4.5	0.4	18	1.6	11	3.7	37.0	12.0	64	0.09	0.50	S120D	12mm shaft diameter
S120T	6.6	0.4	27	1.6	17	5.5	54.0	18.0	88	0.12	0.50	S120T	
S120Q	8.9	0.4	36	1.6	22	7.4	73.0	24.0	112	0.16	0.50	S120Q	
S160D	10	0.6	40	2.5	16	5.4	21.0	8.2	80	0.15	0.50	S160D	16mm shaft diameter
S160T	15	0.6	60	2.5	24	8.1	33.0	12.0	110	0.20	0.50	S160T	
S160Q	20	0.6	81	2.5	33	11	43.0	16.0	140	0.30	0.50	S160Q	
L160D	8.8	0.55	35	2.2	16	5.4	21	7.3	80	0.15	0.80	L160D	Large Air Gap Series
L160T	13	0.55	53	2.2	24	8.0	31	11	110	0.23	0.80	L160T	
L160Q	18	0.55	70	2.2	32	11	41	15	140	0.30	0.80	L160Q	
S200D	18	0.6	72	2.4	31	10	28.7	19.3	94	0.30	0.75	S200D	20mm shaft diameter
S200T	28	0.6	112	2.4	47	16	43.0	29.0	130	0.50	0.75	S200T	
S200Q	38	0.6	152	2.4	64	21	56.0	39.0	166	0.70	0.75	S200Q	
S250D	40	1.3	160	5.1	31	10.4	7.8	9.8	120	0.80	0.75	S250D	25mm shaft diameter
S250T	60	1.3	240	5.1	47	16	12.0	15.0	165	1.1	0.75	S250T	
S250Q	75	1.3	300	5.1	59	20	15.0	19.0	210	1.5	0.75	S250Q	
S250X	140	2.4	560	9.6	58	19	7.5	9.5	390	2.9	0.75	S250X	
L250D	34	1.3	138	5.2	27	8.8	8.4	9.2	120	0.77	2.0	L250D	Large Air Gap Series
L250T	52	1.3	207	5.2	40	13	13	14	165	1.1	2.0	L250T	
L250Q	69	1.3	276	5.2	53	18	17	18	210	1.5	2.0	L250Q	
L250SS	17	1.3	69	5.1	13	4.5	6.5	11.4	50	0.43	2.0	L250SS	
L250DS	34	1.3	137	5.1	27	9.0	13.0	22.7	80	0.8	2.0	L250DS	
L250TS	51	1.3	206	5.1	40	13.5	19.5	34.1	110	1.1	2.0	L250TS	
S320D	56	1.2	226	5.0	45	15	11.0	17.0	160	1.2	1.00	S320D	32mm shaft diameter
S320T	85	1.2	338	5.0	68	23	17.0	26.0	220	1.7	1.00	S320T	
S320Q	113	1.2	451	5.0	91	30	23.0	34.0	280	2.2	1.00	S320Q	
L320D	55	1.3	218	5.0	44	15	12	14.0	160	1.3	2.50	L320D	Large Air Gap Series
L320T	82	1.3	327	5.0	65	22	17	21.0	220	1.9	2.50	L320T	
L320Q	109	1.3	436	5.0	87	29	23	28.0	280	2.6	2.50	L320Q	
S350D	104	1.5	416	6.0	69	23	13.8	21.8	160	1.3	1.00	S350D	35mm shaft diameter
S350T	148	1.5	592	6.0	99	33	20.2	33.0	220	1.9	1.00	S350T	
S350Q	190	2.7	760	10.8	70	23	6.9	10.9	280	2.4	1.00	S350Q	
S427D	100	3.0	400	12.0	33	11	2.7	7	220	3.0	1.65	S427D	42.7mm shaft diameter
S427T	150	3.0	600	12.0	50	17	3.9	11	310	4.2	1.65	S427T	
S427Q	200	3.0	800	12.0	67	22	5.2	15	400	5.4	1.65	S427Q	
S435D	116	3.0	464	12.0	39	13	2.7	7	220	3.0	1.25	S435D	43.5mm shaft diameter
S435T	175	3.0	700	12.0	58	19	3.9	11	310	4.2	1.25	S435T	
S435Q	233	3.0	932	12.0	78	26	5.2	15	400	5.4	1.25	S435Q	
S500D	289	3.8	1156	15.2	76	25	4.4	27	240	10	1.75	S500D	50mm shaft diameter
S500T	440	5.8	1760	23.2	76	25	3.3	20	330	13	1.75	S500T	
S500Q	585	7.7	2340	30.8	76	25	2.2	13	420	15	1.75	S500Q	
S605D	420	8.8	1000	35	47	16	1.1	7	310	16	1.75	S605D	60.5mm shaft diameter
S605T	610	8.6	2400	34.0	71	24	1.7	10	430	21	1.75	S605T	
S605Q	780	8.4	3100	34.0	93	31	2.2	13	550	27	1.75	S605Q	

Common Motion Profile Formulas

Triangular Profile 1/2, 1/2

Accelerate to speed and decelerate back to original speed or zero, rest and repeat the process as needed. This is very simple and is common in applications such as pick & place.
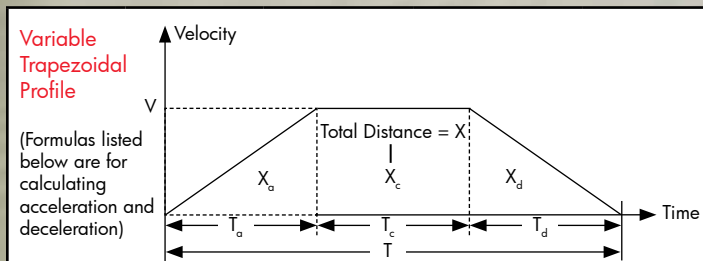

Triangular Profile
1/2
1/2
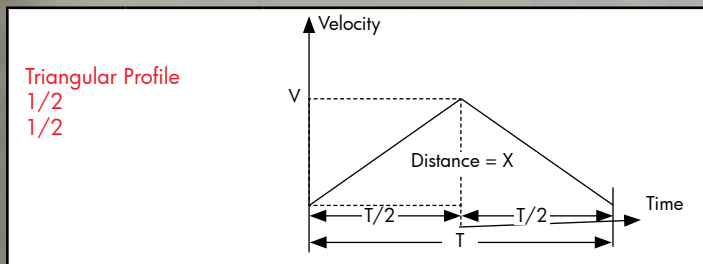
Have / Solve For	X (m) T (sec)	V (m/sec) T (sec)	A (m/sec²) T (sec)	A (m/sec²) V (m/sec)
Distance X(m)		$X = (1/2) * V * T$	$X = (1/4) * A * T^2$	$X = (V^2/A)$
Velocity V (m/sec)	$V = 2 * (X/T)$		$V = (A*T)/2$	$V = \sqrt{(A*X)}$
Acceleration A (m/sec²)	$A = 4 * (X/T^2)$	$A = 2 * (V/T)$		$A = V^2/X$

Trapezoidal Profile

Accelerate to constant speed, travel at that constant speed, and then decelerate back to original speed or zero. This is common in applications such as scanning inspection. There are two types, the 1/3 Trapezoidal Profile and the Variable Trapezoidal Profile.

Trapezoidal Profile
1/3
1/3
1/3
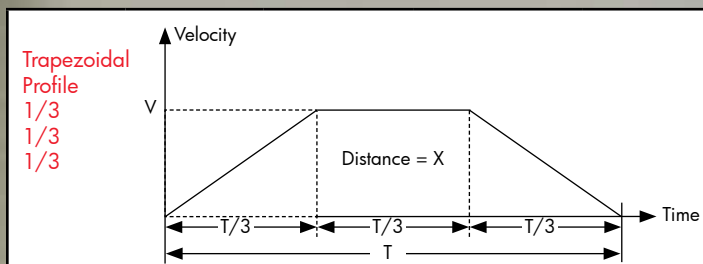
Have / Solve For	X (m) T (sec)	V (m/sec) T (sec)	A (m/sec²) T (sec)	A (m/sec²) V (m/sec)
Distance X(m)		$X = (2/3) * V * T$	$X = (1/4.5) * A * T^2$	$X = 2 * (V^2/A)$
Velocity V (m/sec)	$V = 1.5 * (X/T)$		$V = (A*T)/3$	$V = \sqrt{(A*X)/2}$
Acceleration A (m/sec²)	$A = 4.5 * (X/T^2)$	$A = 3 * (V/T)$		$A = 2 * (V^2/X)$

Variable Trapezoidal Profile

(Formulas listed below are for calculating acceleration and deceleration)

Have / Solve For	X (m) T (sec)	V (m/sec) T (sec)	A (m/sec²) T (sec)	A (m/sec²) V (m/sec)
Distance X (m)		$X = (V * T)/2$	$X = (A * T^2)/2$	$X = V^2/(2 * A)$
Velocity V (m/sec)	$V = (2 * X)/T$		$V = A * T$	$V = \sqrt{(2*A)/X}$
Acceleration A (m/sec²)	$A = (2 * X)/T^2$	$A = V/T$		$A = V^2/(2 * X)$

Useful Formulas

General Formulas

Acceleration G	$ACCG = A \ (m/sec^2)/9.81$
Gravity	$g = 9.81$
Friction Coefficient	Friction Coefficient can be calculated in the following way. The mass of the load to be moved being M1, and the amount of force required to move the mass being M2. Friction Coefficient (FC) = M2/M1
Voltage	$V = I*R$
Current	$I = V/R$
Resistance	$R = V/I$

Voltage and Current RMS vs. Peak

RMS (AC)	Peak * 0.707
Peak (DC)	RMS * 1.414

Examples:

	Voltage	Resistance	Current
RMS Values	5	25	0.2
Peak Values	3.535	25	0.1414

Please ensure your units remain constant when calculating RMS or Peak Values.

Encoder Formulas

Encoder Resolution $\quad Er = \dfrac{\text{Scale Pitch}}{(4 * \text{Interpolation})}$

Enc. Output Freq. (A-B Phase) $\quad E_{OF} = \dfrac{\text{Velocity} * 10^6}{(4 * \text{Encoder Resolution})}$

Enc. Output Freq. (Sine-Cosine) $\quad E_{OF} = \dfrac{\text{Velocity} * 10^6}{(\text{Scale Pitch})}$

Amplifier/Driver Sizing Formulas

Voltage due to Back EMF $\quad V_{BEMF} = \text{Back EMF} * \text{Velocity}$

Voltage due to R * I $\quad V_{ri} = 1.225 * \text{Resistance} * \text{Peak Current}$

Voltage due to Inductance $\quad V_L = \dfrac{7.695 * \text{Velocity} * \text{Inductance} * \text{Peak Current}}{\text{Magnetic Pitch}}$

Min. Bus Voltage needed $\quad V_{bus} = 1.15\sqrt{[\ (V_{bemf} + V_{ri})^2 + V_L^2\ ]}$

Peak Current (rms value) $\quad I_{prms} = \text{Peak Current} * 1.2$

Continuous Current (rms value) $I_{Crms} = \text{Continuous Current} * 1.2$

These formulas add a 20% safety margin for current and a 15% safety margin for voltage.

Linear Shaft Motor Selection Guide

One of the most straight forward tasks in the design of a linear motion system is to specify a motor and drive combination that can provide the force, speed and acceleration required. This is often the most overlooked aspect of the linear motion system design, making the motor the most costly part of the system, not only from the perspective of the initial cost, but also in relation to service maintenance and energy cost.

The unique properties of the Linear Shaft Motor make its sizing for applications slightly different than that of other liner motors. Nevertheless, the proper sizing of a Linear Shaft Motor is rather straight forward. Nippon Pulse provides the SMART sizing software to assist in the selection of a proper motor and drive combination for your mechanical design. Please use the following chart to assist in organizing the operation conditions for your system.

Item	Symbol	Value	Unit	Notes	Examples
Load mass	M_L		kg	Mass of the moving part of your system less the mass of the motor.	Example: Table, Encoder
Load (thrust) Force	F_L		N	Thrust Force is added to all segments of the motion profile. This is in addition to force needed to overcome mass, acceleration, and friction.	Example: As the motor moves, it needs to maintain 10 lbs of force on an object.
Run (pre-load) Friction	F_r		N	Pre-load Force is considered in all moving segments of the motion profile. Keep in mind all external forces that disturb the movement.	Example: Cable Chain, Bearing wipers, Preloaded Guide, springs
Moving Motor Mass	M_c		kg	If you are not sure which motor you are going to need, start with a value of 1/10 of Load mass	
Friction coefficient	μ				
Incline Angle	α		°	0° is Horizontal while 90° is Vertical	
Available Voltage	V		Vac		
Available Current	A		Arms		
Max Allowable temperature			°C		

Next, define what movements, if any, your system will be making using the following chart for assistance:

Item	Symbol	Value	Unit	Notes
Stroke	X		mm	
Velocity	V		m/s	
Acceleration time	T_a		s	
Continuous time	T_c		s	
Deceleration time	T_d		s	
Settling time	T_s		s	
Waiting time	T_w		s	

Note: This application note walks you through sizing with only one segment. It is recommended for the best sizing of a Linear Shaft Motor, a complete cycle should be used for sizing. Stroke out and back. The SMART sizing software allows for sizing with up to six (6) segments.

1. Calculations for Load Condition
The chart shown here helps to calculate a load force. The frictional load of the linear guide and the resistance force of the cable carrier (FC) are run friction and treated as pre-load force. For your initial calculations, it is suggested you use 1/10 the load mass, as the value for Forcer mass (MC).

2. Calculations for Required Thrust -
You will need to calculate a thrust value for each section of the motion profile. In these equations, "μ" is the coefficient of friction on the guide. "g" is as the acceleration of gravity. g = 9.81 m/sec2. "∝" is the angle of incline. For vertical or incline moves use F_r for moves against gravity and F_{rd} for moves with gravity.

3. Temporary Selection -
The largest thrust value calculated in section 2, must be less than peak thrust of the selected Linear Shaft Motor. It is good practice to add 20 to 50% to the peak thrust as a safety margin. Please note that the peak thrust of the Linear Shaft Motor may vary with operation speed.

4. Confirm MC
(forcer mass) is smaller than the value used in section 1. If it is larger, please return to section 1 to recalculate using the new MC value.
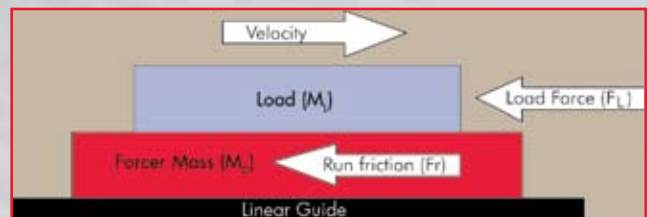

F_i	Force (Inertia)	$F_i = (M_L + M_c) * (V / T_a)$	
F_f	Force (Friction)	$F_f = (M_L + M_c) * g * [\sin(\propto) + \mu * \cos(\propto)] + F_r$	
F_{fd}	Force (Friction) down	$F_{fd} = (M_L + M_c) * g * [\sin(\propto) + \mu * \cos(\propto) * -1] + F_r$	
F_1	Acceleration force	$F_1 = F_i + F_L + F_r$	Inertia force + external force
F_2	Constant velocity force	$F_2 = F_L + F_f$	load of external force
F_3	Deceleration force	$F_3 = F_i - (F_L + F_r)$	inertia force - external force
F_4	Dwell force	$F_4 = (M_L + M_c) * g * [\sin(\propto)] + F_L$	

5. Confirm Effective thrust (F_{eff}) -
Please confirm that effective force (Feff) is less than the continuous rated force (Frated) of the motor plus a safety factor (SF) of 30% to 50%.

6. If the effective force (F_{eff})
is larger, please select a new motor where the rated force (F_{rated}) is met in the equation.

$$F_{eff} = \sqrt{\frac{(f1^2 * t1) + (F2^2 * t2) + (F3^2 * t3)}{(t1 + t2 + t3 + t4 + t5)}} < SFrated + SF$$

Nippon Pulse SMART (Shaft Motor Application Resource Tool)

Nippon Pulse offers the Linear Shaft Motor Application Resource Tool (SMART) to assist in determining the proper Linear Shaft Motor. It requires Microsoft Excel 98, or a newer version. SMART is available at www.nipponpulse.com as part of the Linear Shaft Motor design toolkit.

Motor Sizing Example

Let's assume you want to move horizontally a mass of 6kg point-to-point over a distance of 100 mm (X) in 160 msec, including settling time (Tm) to +/- 1 micron. Total travel is 400mm, and a dwell time of 200msec is needed after each move.

Move Profile

We will assume an estimated settling time of 10msec (T_s).
The move cycle time (T_c) is 160 + 200 = 360msec
Using previous move formula:
T (msec) = T_m – (T_s)
T (msec) = 160 – 10 = 150msec
We will assume an efficient trapezoidal profile (1/3, 1/3, 1/3)

Acceleration needed here (see previous move formula):
A = (4.5)*(0.1*0.15^2)
A = 20m/sec2 (about 2 "g")

V = (1.5)*(0.1/0.15)
V = 1m/sec
The acceleration and deceleration time becomes (150/3)= 50msec
The time at constant speed is (150/3) = 50msec
We can estimate the acceleration force of the load only (see previously mentioned formula) at 2g*9.81*6kg = 117N.

Based on this we can select S350T (peak force = 592N, continuous force = 148N) assuming a coil mounting plate of 1kg.
Total moving mass: 6kg (load) + 1kg (plate) + 1.9kg (coil mass) = 8.9kg
Coil resistance = 20.2ohm, Coil Force constant 99N/Ap, Thermal Resistance 2.4°C/W, Back Emf 33Vp/m/sec, Inductance p-p 33mH, Electrical cycle length 120mm
We assume a good set of linear bearings with μ=0.005 and 20N of friction.

Item	Symbol	Value	Unit
Load Mass	M_L	7	kg
Load (Thrust) Force	F_L	0	N
Run (Pre-Load) Friction	F_r	20	N
Moving Motor Mass	M_c	1.9	kg
Friction Coefficient	μ	0.005	
Incline Angle	∝	0	°
Available Voltage	V	120	Vac
Available Current	A	7	Arms
Max Allowable Temperature		110	°C

Friction Force: F_f (N) = 8.9*9.81*[sin(0) + 0.005*cos(0)] + 20 = 20.4N
Inertial Force: F_i (N) = 8.9*20 = 178N
Total Acceleration Force: F_1 (N) = 178 + 20.4 = 198.4N
Total Constant Velocity Force: F_2 (N) = 20.4N
Total Deceleration Force: F_3 (N) = 178 – 20.4 = 157.6N
Total Dwell Force: F_4 (N) = 0N
RMS Force: F_{rms} (N) = √[{198.42*0.05)+(20.42*0.025)+(157.62*0.05)/0.36}]
F_{rms} (N) = 94.7N
RMS Current: I_{ca} = 94.7/99 = 0.96 Amp rms
Peak Current: I_{pa} = 198.4/99 = 2 Amp rms
Motor Resistance Hot: R_{hot} = 20.2 * 1.423 = 28.7Ω
Voltage due B EMF: V_{bemf} = 33 * 1 = 33Vac
Voltage due I*R: V_{ir} = 1.225 * 28.7 *2 = 70.32Vac
Voltage due Inductance: V_L = 7.695 * 1 * 33 * 2 / 120 = 4.23Vac
Bus Voltage needed: V_{bus} = 1.15 * √ [(33 + 70.3)^2 + 4.232] = 118.8Vac

Item	Symbol	Value	Unit
Stroke	X	100	mm
Velocity	V	1	m/s
Acceleration Time	T_a	0.05	s
Constant velocity force	T_c	0.05	s
Deceleration Time	T_δ	0.05	s
Settling Time	T_σ	0.01	s
Waiting Time	T_w	0.2	s

For More Information

For further assistance in sizing and selecting a motor, a more detailed step-by-step guide is available as part of the Linear Shaft Motor Design Toolkit on our website, www.nipponpulse.com.

About Nippon Pulse

Nippon Pulse provides a wide array of motion control solutions to meet the needs of its current and future customers. This includes industry-leading stepper motors, the innovative Linear Shaft Motor, controllers, drivers and networks. With several customization options, we can provide products that can be utilized in an extensive number of applications.

Your Partner in Motion Control

At Nippon Pulse, we approach customer applications from an overall project standpoint. This enables us to provide the best electro-mechatronic solutions that help you design and build your motion control systems. Our system engineering services include complete design, engineering and manufacturing. Applications we have worked on range from various pick-and-place machines to large scale sorting and distributing systems, biomedical handling equipment, healthcare products, and more. Our sales engineers have extensive product knowledge and can help you determine the best solution for your particular motion control application.

INDUSTRIES WE SERVE	COMPANIES WE SUPPLY
Automation	Boeing
Bio-Medical & Medical	Caterpillar
Equipment Manufacturing	EXFO
Instrumentation	Fresinius
Machine Tooling	Hydro-Quebec
OEM	Hospiria, Inc.
Packaging	Siemens
Pharmaceutical	Smiths Medical
Photonics	Trimble Navigation Limited
Semiconductor	Yokogawa

From standard industrial sectors to the high-level electronics, Nippon Pulse optimizes development and manufacturing and provides many high-performance product groups. In order to provide the most efficient products and facilities, we are always conscious of a smooth flow from planning to design and manufacturing. This efficient flow makes it possible to create a wide variety of products which meet customers' needs.

It is essential that we provide products exceeding customer expectations, so they are able to use them with complete confidence. Maintaining excellent quality while ensuring a stable supply chain for each of our products is achieved by thorough quality control methods. These methods guarantee reliability above industry standards, even on mass-produced items, such as motors and controllers.

Whether we provide entire systems or just one motor, ensuring those products have exceeded expectations is part of our methodology. In-depth communications with the customer from the design phase through delivery and beyond installation guarantees this.

We strive to ensure all aspects of our process allow us to meet and exceed customer expectations through communication, support and by providing reliable products.
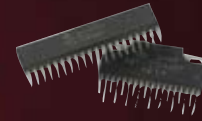
In-House Model Shop

The Nippon Pulse model shop provides quick turnaround on prototype requests for our tin-can stepper motors. Most requests can be shipped within 24 hours, allowing you to test the product in your application before committing to a purchase order. Nippon Pulse sales engineers work closely with you to understand your project so we are able to suggest the best solution possible and get a high-quality prototype to you as quickly as possible. Nippon Pulse offers the flexibility to ship just one piece, if that is all you need, to make sure our product is the correct fit for your project. In addition to the tin-can type stepper motors, we have various linear step motors, hybrid motors, controllers, and drivers in stock for quick prototyping.

The Nippon Pulse Advantage

For sixty years, Nippon Pulse has built state-of-of-the-art products based on a solid foundation of advancing technology and thorough product research.

Nippon Pulse faithfully provides these high-quality products to a wide range of industries in North and South America and Europe. We have established ourselves as a leader in stepper motor, driver and controller technology while introducing innovative products such as the Linear Shaft Motor and Motionnet®. At Nippon Pulse, we believe by bringing products to market which meet the customers' requirements, and impress them, we contribute to the progression of technology and its positive impact on our society. We pride ourselves on the reputation of our high-quality products that provide that impact. A wholly owned subsidiary of Nippon Pulse Motor Co., Ltd., Nippon Pulse America is headquartered in Radford, Va.

We have representatives throughout North and South America and Europe to assist customers directly. Limited quantities of stock on standard motors and electronics are available to allow faster response to customer needs. In addition, Nippon Pulse has a model shop in its North American headquarters for quick turnaround on custom prototypes and special orders. Our mission is to faithfully create the new products sought by its customers and to contribute to the development of society from a global viewpoint.

When you choose a Nippon Pulse motor, driver, controller, network or stage, you're doing more than just buying a quality product. You're benefitting from what we call the Nippon Pulse Advantage. This includes superior prototyping, complete system engineering, proper compliance and certification according to international guidelines and exceptional tailoring to your needs. It also includes unmatched support.

Our biggest asset at Nippon Pulse is our people, both our employees and our customers, so we ensure that we have the best people working for us so that we build loyalty among those buying from us. It's an advantage you won't find at any of our competitors and why we pride ourselves on our products and our service.
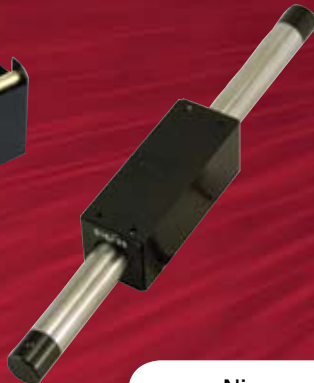
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