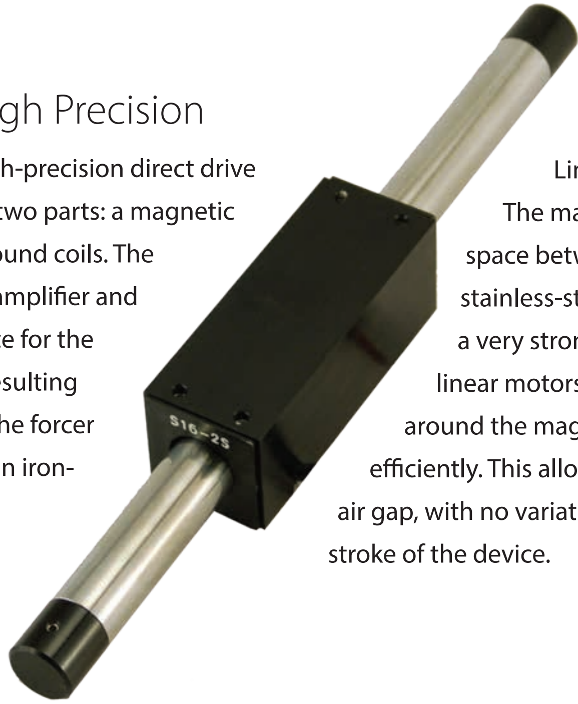
Linear Shaft Motor Overview

Simple, Non-Contact, High Precision

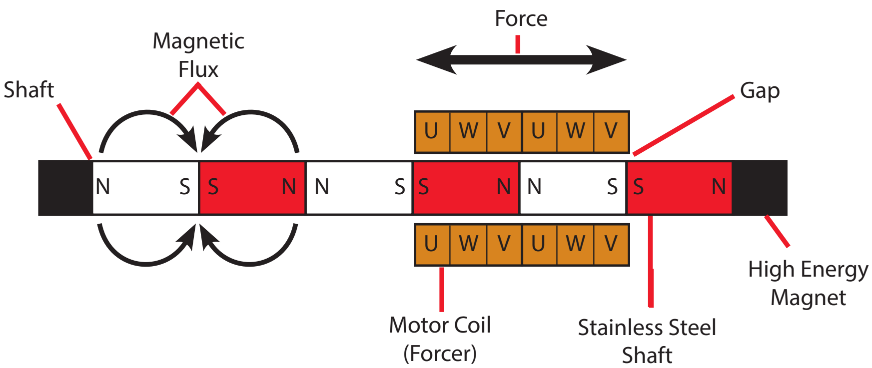
The Linear Shaft Motor is an ultra-high-precision direct drive linear servomotor consisting of only two parts: a magnetic shaft and a "forcer" of cylindrically wound coils. The forcer assembly, combined with the amplifier and control electronics, produces the force for the motor. The motor contains no iron, resulting in zero cogging, though the coils of the forcer provide the stiffness expected from an iron-core motor.



Linear Shaft Motors are also non-contact. The magnetic shaft is built such that there is no space between the magnets within the cylindrical stainless-steel tube. The patented process produces a very strong magnetic field twice that of other linear motors. Since the forcer coil completely wraps around the magnets, all the magnetic flux is used efficiently. This allows for a large (0.5 to 5.0mm) non-critical air gap, with no variation in force as the gap varies over the stroke of the device.

Advantages of the Linear Shaft Motor

- Compact, lightweight design requires less power while producing a comparable force to that of a similar-sized traditional linear motor.
- High precision (0.07nm)[1] and precise micropositioning.
- Capable of high thrust (up to 100,000N), stroke of up to 4.6 meters and virtually no speed fluctuation (±0.006% at 100mm/s).
- No heat sinks required. All sides of the forcer coil are positioned to allow for maximum heat dissipation and efficiency.
- Easy installation, alignment and system integration.
- Quiet operation, due to the absence of friction; the only mechanical contact is the linear guide (though fully non-contact operation is possible using an air slider).
- Durable construction, capable of operation even in a vacuum, in a harsh environment, or underwater.
- Available in shaft diameters as small as 4mm and as large as 60mm.



[1] Repetitive positioning precision is dependent on the resolution of the linear encoder. It is also necessary to have sufficient machine rigidity. 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.

Applications

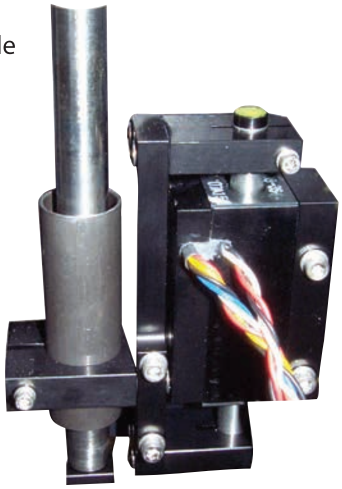
Lab Automation	Equipment Manufacturing	Medical/Biomedical	Other Automation
Microscope Automation Liquid Handling Robots Sample Handling Pick and Place Robotic Grippers	Laser Processing Welding/Heat Treating Engraving/Etching/Stamping Shaping/Grinding Electrical Discharge Machining Cutting/Punching Inspection Equipment	Pharmaceutical Packaging Automated Injecting Scanner Constant-Speed Drug Dispensing Medical Imaging	Industrial Sewing Machine Transfer Lines Semiconductor Equipment High-Precision Conveying Line-Head Drives in High-Speed Printers

Please visit nipponpulse.com/support for complete product specifications.

Motor Configurations

Hall Effect Sensors

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.



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.

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 larger, the sensors fit inside the motor and no additional space is needed in your design.

Cooling Methods

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

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

Orientation Options

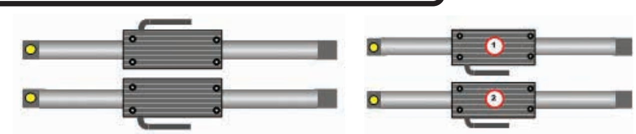
In a horizontal application, Linear Shaft Motors typically will have the load attached to the forcer so as to achieve simple and precise linear movements. The shaft is supported at both shaft supports, and the load moves along slide rails, linear bearings, or air bearings. A linear encoder scale is attached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

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. This can also reduce the net load on the motor by supporting it against gravity. Typical counterbalance techniques include a pneumatic cylinder, springs, or a counterweight.

Linear Shaft Motor in Parallel Systems

Parallel drive systems are any application that has two or more linear motors in parallel. In parallel applications, the wires extend from the shaft on opposite sides, whereas in non-parallel applications, other motor locations are not accounted for in the wiring.

Parallel Linear Shaft Motor Design



Parallel Option

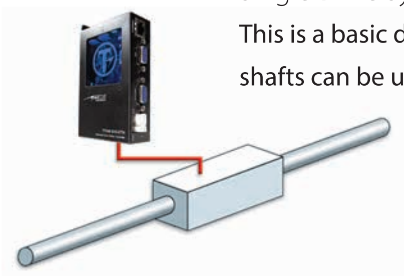
Non-Parallel Option

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, but you can't put both 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.

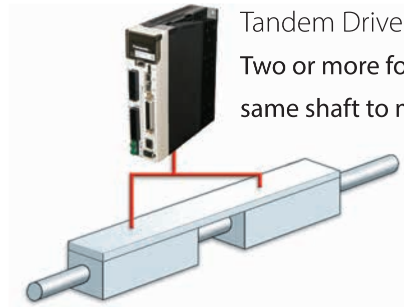
Drive Setup and Configuration Examples

Drive Systems for Linear Shaft Motor



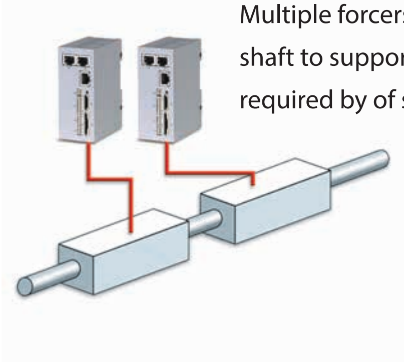
Single Drive System

This is a basic drive system. The X and Y shafts can be used to create an X-Y stage.



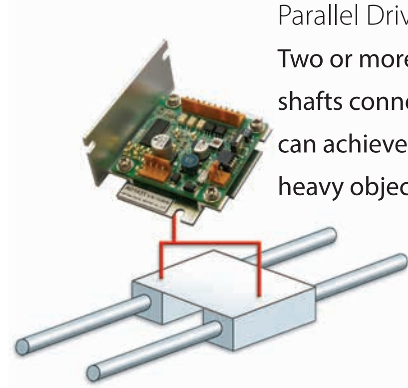
Tandem Drive System

Two or more forcers can be used on the same shaft to multiply the thrust.



Multi-Drive System

Multiple forcers can be used with a single shaft to support complex movements required by of some applications.



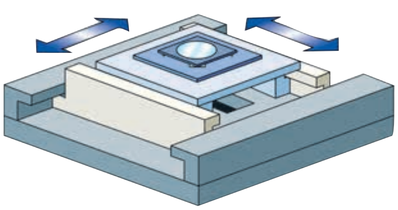
Parallel Drive System

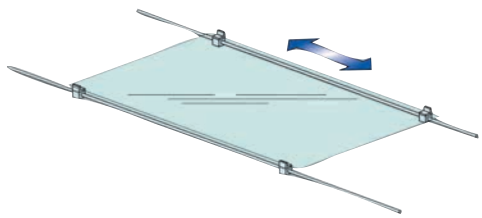
Two or more forcers and two or more shafts connected to the same load can achieve large thrusts for moving heavy objects.

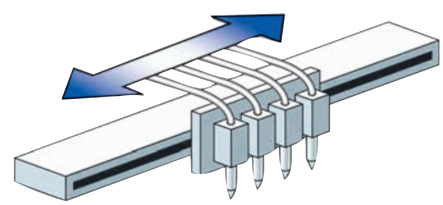
Allows for parallel drive using only one encoder and one driver

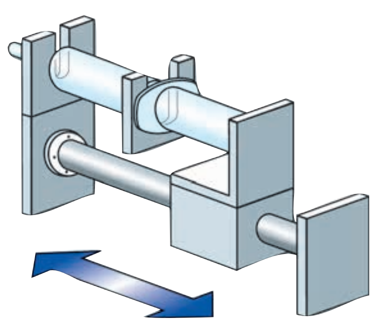
The mechanism must allow for 1-degree freedom of motion between the two motors.

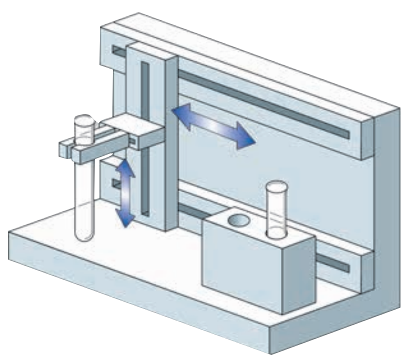
Examples of Linear Shaft Motor Configurations and Axes of Movement

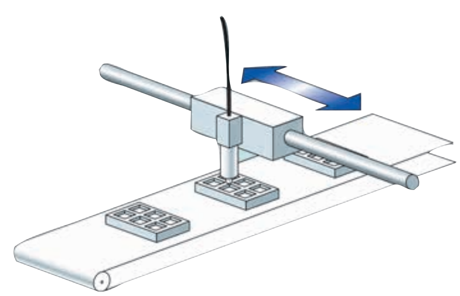


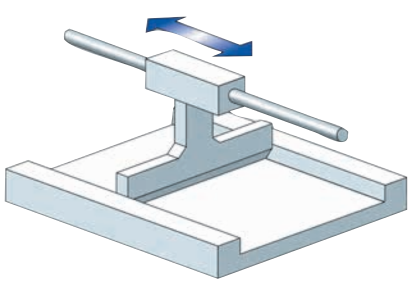












Fast and Slow Controllable Speeds — as fast as 15 meters/second and as slow as 8μm/second have been documented. Maximum shaft lengths of 6 meters.

Linear Shaft Motor Part Numbering Guide (S and L Series)

S | Shaft Size (D) | Forcer Size (A) X | Alt. Winding __XX | Parallel Option XX | Usable Stroke XXXXst | Options XX | Options XX

Series:
- S Standard Air Gap
- L Large Air Gap

Shaft Size (D): 040, 080, 160, 200, 250, 320, 350, 500, 605*

XX Shaft diameter in mm *10

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

Forcer Size (A):
- D Double (2) windings
- T Triple (3) windings
- Q Quadruple (4) windings
- X Octuple (8) windings

Alt. Winding:
- Blank Standard
- _S Alternate Winding

Assigned by factory based on customer needs

Parallel Option:
- Blank Standard
- PL Parallel Motors

Usable Stroke:
XX Usable stroke in millimeters
only needed if ordering shaft

Options:
- WP Waterproof
- HA Digital Hall Effect
- CE CE type motor
- FG Frameground

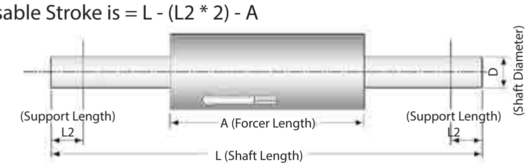
only needed if ordering forcer

Options:
- Blank Standard
- FO Forcer Only
- SO Shaft Only

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

Alternate standard windings are available to meet your available voltage and performance needs. For more information, contact an applications engineer or review the datasheets available on nipponpulse.com/support.

Usable Stroke is = L - (L2 * 2) - A



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

Other Linear Shaft Motor Options

Large Air Gap Linear Shaft Motors (L series)

Available on 16, 25 and 32mm-size Linear Shaft Motors, the L series indicates a larger non-critical, non-contact air gap. Compared to standard models in the same sizes, the L series has an air gap upwards of 60 percent larger with minimal force lost.

Short-Forcer Shaft Motors (SS series)

The SS series Linear Shaft Motors have smaller sized forcers than other standard Linear Shaft Motors. In this series, the size of the motor coil in the forcer has been dramatically reduced, which makes this series perfect for compact applications. The SS series forcer measures 50mm in length, and multiple forcers can be added to a single shaft.

Multiple Form Factors

The Linear Shaft Motor's forcer can be manufactured in different lengths depending on your application's space and power requirements. Nippon Pulse offers 12 different frame sizes, and each is available in multiple lengths, for multiple frame size options with the same amount of force.

Please visit nipponpulse.com/support for complete product specifications.