Installation and User's Guide

Linear Shaft Motor

The Next Generation Ultra-Precision Brushless Linear Motor

Simple - High-Precision - Non-Contact

NPM Nippon Pulse
Your Partner in Motion Control

Linear Shaft Motor
Installation and Users Guide
June 2021
Revision L
Item Number 24135

DISCLAIMER
Nippon Pulse makes no guarantees of any kind with regard to this manual and shall not be liable for errors contained herein or for consequential or incidental damages incurred because of acting on information contained in the manual.

CUSTOMER CARE
For inquiries relating to the operation and use of the Linear Shaft Motor described in this manual, please contact your local Nippon Pulse representative.

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Important

This instruction manual is not intended to include a comprehensive list of every detail for all procedures required for installation, operation, and maintenance of the Linear Shaft Motor. This manual describes general guidelines that apply to most of the linear motor products shipped by Nippon Pulse. If you have any questions about a procedure or are uncertain about any detail, do not proceed with installation and contact your local Nippon Pulse representative for more information or clarification.

Warranty

Nippon Pulse guarantees its products are free from faulty components and defects in material or workmanship for one (1) year from the date of delivery. Nippon Pulse shall not be liable for any special, incidental, indirect, or consequential damages. Additional information regarding Nippon Pulse's warranties can be found in our Terms and Conditions of Sale, which are available upon request. All requests for repair and replacement should be directed to Nippon Pulse Inside Sales Department. The serial number of the equipment should be quoted in any communications. Nippon Pulse reserves the right to alter specifications and pricing at any time.

This guide does not include data sheets. For the most up-to-date datasheets, please see the Manuals and Literature page of the Nippon Pulse website, at: nipponpulse.com/support/manuals

Change Record

Date	REV	Page	Item	From	To
December 2007	A	All	All	Original	
June 2008	B	3	Table of Contents		Reformatted
		All	PDF Indexed		
		14	Figure 15		Updated
		15, 20	Table 1, Table 3		Added L250, L320
		17	Layout		
		31	Figure 17, 18		Added Hall diagrams
		44-70	Data Sheets		Added L250, L320
		75	Part Numbers		Added Large Air Gap Series
October 2008	C	47	S080 Data Sheet		Hall Effect Lead wire info.
		76-79	Engineering Notes		Updated
April 2009	D	44-70	Data Sheets		Removed S100, Added S605
		80	Appendix C		Updated
April 2012	E	1-3	General Info		Updated
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April 2012	F		Document Reformatted	Word Doc	Adobe InDesign
May 2015	G	31-80	Data Sheets		Updated
July 2015	H	29-30	FAQ		Updated
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March 2016	J	31-91	Data Sheets		Updated L Series
January 2019	K		Data Sheets		Removed from this document - most up-to-date versions are on the website.
June 2021	L	12, 16, 20, 35	Part Numbers		Removed L and S sizes 427 and 435

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General Information

This instruction manual contains general procedures that apply to Nippon Pulse Linear Shaft Motor products. Be sure to read and understand the Safety Notice statements in this manual. For your protection, do not install, operate, or attempt to perform maintenance procedures until you understand the Warning and Caution statements.

A 'Warning' statement indicates a condition that can cause harm to personnel. A 'Caution' statement indicates a condition that can cause damage to equipment.

Warnings

Heart Pacemakers. Linear Shaft Motors contain powerful permanent magnets. Anyone with a pacemaker or A.I.C.D. should maintain a minimum distance of 12 inches from the magnets.

Strong magnets. The magnetic attraction between the magnet shaft and other magnetic or ferrous materials is extremely high. Keep fingers and other body parts away from these objects to avoid injury by this magnetic attraction.

Electric shock. Do not touch electrical connections until you ensure that **power has been disconnected.** Electrical shock can cause serious or fatal injury.

Hot surface. Surface temperatures of up to 80°C (144°F) can be present during the commissioning and servicing of this equipment. Allow the forcer and shaft to cool before working on the equipment.

Heavy object. Use proper care and safety procedures during handling, lifting, installing, operating, and maintaining operations. Improper methods may cause muscle strain or other harm.

Crush hazard. The forcer may move unexpectedly. Always isolate all sources of electrical supply before working on the equipment.

General hazard. Follow the advice given.

Ground hazard. Be sure the system is properly grounded before applying power. **DO NOT** apply AC power before you ensure that all grounding instructions have been followed. Electrical shock can cause serious or fatal injury. National Electrical Code and local codes must be carefully followed.

CAUTION: Be careful when removing the motor from its shipping container. Slide the motor from the box onto a level, non-magnetic, flat surface to prevent bending. Bending can damage the forcer and shaft.

Receiving
Each Linear Shaft Motor is thoroughly tested at the factory and carefully packaged for shipment. When you receive your motor, there are several things you should do immediately.

1. Observe the condition of the shipping container and report any damage immediately to the commercial carrier that delivered your motor.
2. Verify that the part number of the motor you received is the same as the part number listed on your purchase order.

Storage
If the parts are not immediately put into service, store them in a clean, dry, and warm location. If the storage location is damp or humid, the exposed metal surface of the motors and windings must be protected from moisture. If the ambient temperature decreases suddenly, condensation may form. Protect all parts from moisture.

Unpacking


Each Linear Shaft Motor is packaged for ease of handling and to prevent entry of contaminants. To avoid condensation, do not unpack until the motor has reached room temperature of the room in which it will be installed. The packing provides insulation from temperature changes during transportation. When the motor has reached room temperature, remove all protective wrapping material from the forcer. It is recommended that the protective wrapping material be left on the shaft during installation. Unpack the magnet shaft and place it on a clean non-magnetic surface away from other magnet devices and any other ferrous material.
Always keep the magnet shaft at a safe distance from magnetic or ferrous material, a distance equal to the N-N magnetic pole pitch. If the magnet shaft is to be left unattended for any period of time, precautions should be taken to prevent accidents due to the strength of the magnets (it is best to leave them in their packing material to prevent injury due to magnetic attraction). Anyone who will come in contact with this assembly while receiving, transporting, storing, installing, disassembling, or at any other time, must be made aware of this danger.

Handling
Be extremely careful. Keep in mind:

The magnetic attraction between the magnet shaft and other magnetic or ferrous materials is extremely high. Keep fingers and other body parts away from these objects to avoid injury.

Use proper care and procedures that are safe during handling, lifting, installing, operating, and maintaining operations. Improper methods may cause muscle strain or other harm.

Repairs
Nippon Pulse will not share any responsibility for damage caused by customer attempt to repair or modify a motor. Any repairs or modifications attempted by the customer without first consulting Nippon Pulse will void any warranties, both implied and stated. Consult Nippon Pulse before performing any service or modification to the motor(s).

Overview

What is a Linear Shaft Motor?

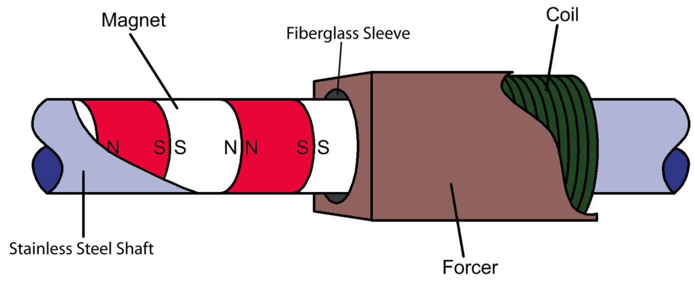


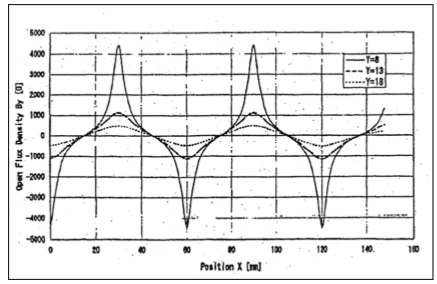
Figure 1

The Linear Shaft Motor is a high-precision direct drive linear servomotor consisting of a shaft of Neodymium-Iron-Boron Permanent (NIB) Magnets and a "forcer" of cylindrically wound coils.

Shaft Construction

- The magnetic portion 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 portion is inserted into a protective stainless steel tube. This is shown in **Figure 1**. This is a patented process which is protected by numerous patents throughout the world.
- The patented process used by the Linear Shaft Motor produces a very strong magnetic field, by kinking and redirecting, which is twice that of other linear motors. An actual measured magnetic field is shown in **Figure 2.**
- The magnetic portion is then inserted into a protective stainless steel tube. This is shown in **Figure 1**.

Figure 2



Forcer Construction

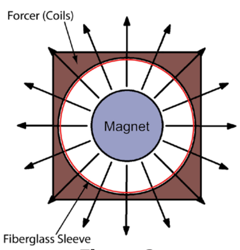


Figure 3

The coils of the Linear Shaft Motor are of a cylindrical design, thus providing a number of key advantages over other linear motors.

- The cylindrical design of the coils makes the coil assembly very stiff without the use of external stiffening materials, such as the iron used by platen style linear motors.
- The coils surround the magnets allowing for the optimal use of all the magnetic flux. (**Figure 3)**
- The above point 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.

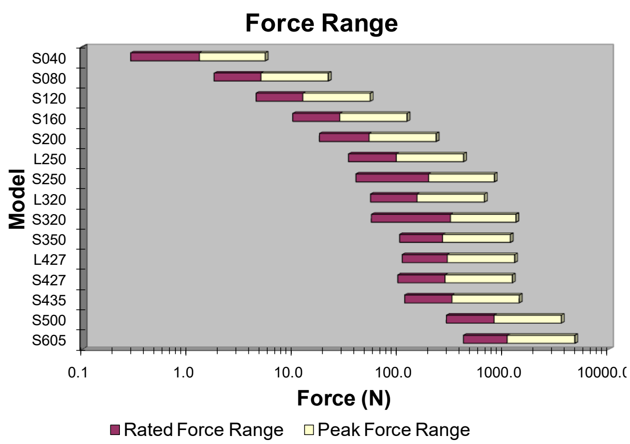
The Linear Shaft Motor requires less current and less mass to produce forces similar to traditional linear motors of comparable size. This combination makes the Linear Shaft Motor more efficient than these comparable motors.

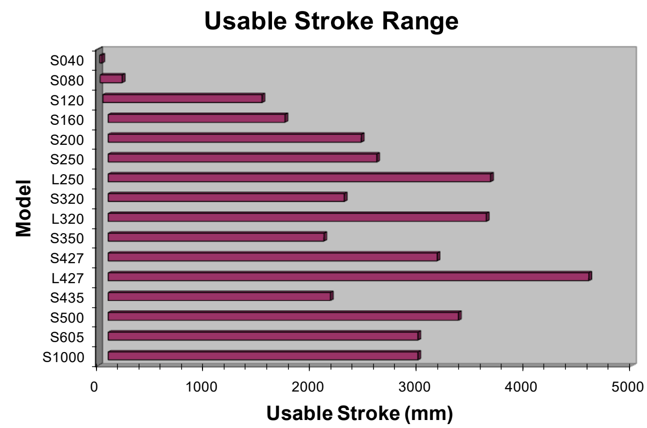
Advantages of Linear Shaft Motors

- **Very simple construction.** The Linear Shaft Motor itself consists of only two parts: the shaft (with magnets) and the forcer (coils). There is a non-critical air gap, and no physical contact between the shaft and the forcer.
- **Direct drive.** Unlike lead screws with gearheads, the Linear Shaft Motor offers high thrust (up to 20,000 Newtons/4500 pounds) without any gearheads or backlash.
- **Precision linear position control.** Linear movement resolution as small as 0.07 nanometers is achievable.
- **Precise speed control.** High speeds (up to 6.5 meters per second) and low speeds (down to 8 micrometers per second) are achievable with virtually no speed fluctuations (+/-0.006% at 100 micrometers/second).
- **Durable construction.** Capable of operating in a clean room environment, in a vacuum, or under water.
- **Quiet Operation.** The absence of friction makes the system extremely quiet. The only mechanical contact section is the linear guide.
- **Compact and lightweight.** Lightweight when compared to traditional linear motors.
- **Zero cogging.** The coreless design results in no magnetic cogging whatsoever.
- **Large Air Gap.** The non-critical 0.5mm to 5.0mm nominal annular air gap allows for easy installation and alignment.
- **Simple drive.** The Linear Shaft Motors have built-in flexibility to cater to most servo amplifiers. They can be driven by traditional three-phase brushless DC servo drives. Several units can be networked to achieve a cluster of Linear Shaft Motors that can be synchronized with a network controller or a PC.
- **Power Efficiency.** The Linear Shaft Motors extremely strong magnetic flux, cylindrical design and small moving mass provide for a very efficient linear motion. The Linear Shaft Motor is 50% more efficient than non-direct drive systems (Belt drive, ball/lead screw,

etc.) and also 50% more efficient than other direct drive systems (u-shaped linear motor, etc.).

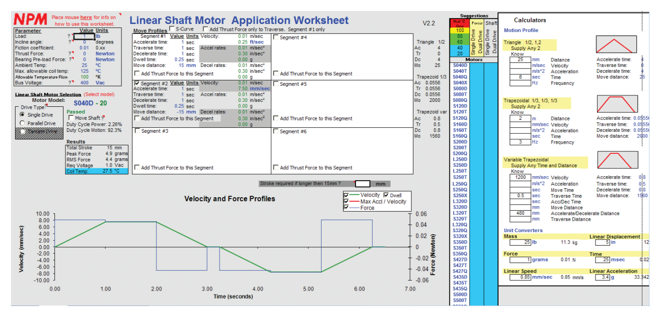
- **Enclosed magnets.** Because the magnets in the Linear Shaft Motor are enclosed by a stainless steel shaft, the motor can easily be integrated into various environmental conditions.
- **Efficient Use of Magnetic Flux.** With the motor coils encircling the magnets, the Linear Shaft Motor uses 100 percent of all magnetic flux. All magnetic flux created cuts the motor coils at 90 degrees.
- **Parallel Drive.** The design of the Linear Shaft Motor allows it to be used in a parallel configuration using only one encoder, one drive, and one amplifier.
- **Wide capability.** Thrust forces less than 0.5 Newtons and peak thrust forces up to 20,000 Newtons are available. Usable strokes from 20 mm up to 4.6 meters can be chosen from a number of available models.





Shaft Motor Application Resource Tool (SMART)

Nippon Pulse offers the Linear Shaft Motor Application Resource Tool to assist in determining the proper motor for all applications. Easy to use, SMART requires the user to plug in some basic information about the project (payload mass, effective stroke required, force required, etc.). Once project specifications are entered, the program helps determine which motor is best suited for the application.



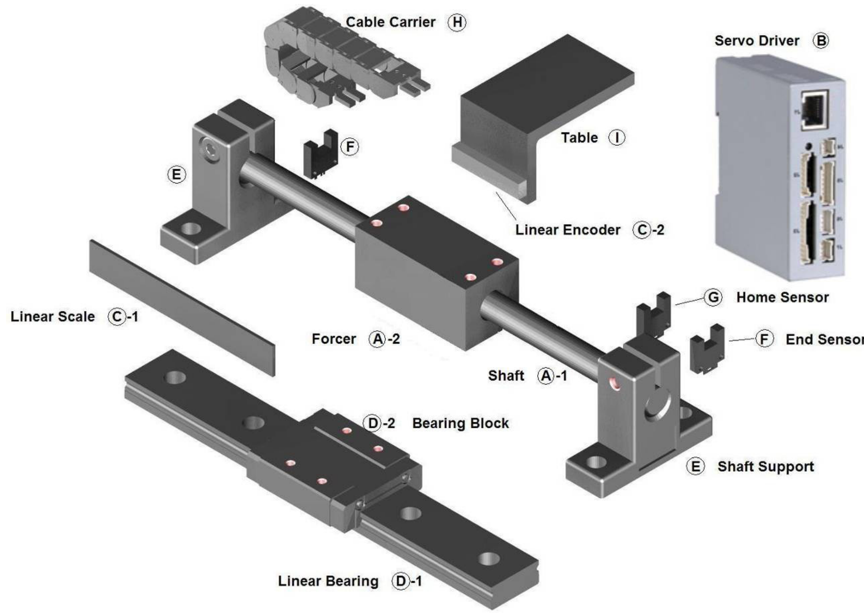
Online 3D CAD Models

For the early application design phase, Nippon Pulse offers 3D CAD drawings on our web site. After a quick and completely private registration, users are able to download CAD drawings in virtually every CAD format available.

Design Considerations

The design of the Linear Shaft Motor allows for systems replacing standard ball-screw to achieve higher speed and resolution. However, to achieve the highest performance with the Linear Shaft Motor system, the entire system structure must be optimized. There are various design considerations, which are somewhat different from traditional servo system practices. We will discuss the main components needed to make a Linear Shaft Motor system as well as what factors to consider when making your selections.

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



A. Linear Shaft Motor - There are 16 model sizes available. The correct model needs to be chosen for the application, depending on several factors including the stroke length and thrust force required.

B. Servo Driver - This is a standard three phase brushless DC (sometimes referred to as AC servo) driver.

C. Linear Scale - This is placed along the linear guide, or rail, and provides precise linear position feedback to the servo system.

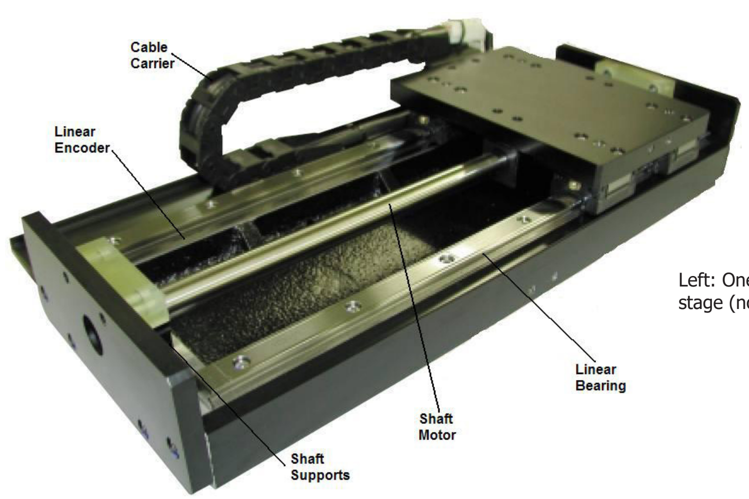
D. Bearing - These are used to guide the forcer as it moves linearly. This is the only contacting part. For totally no-contact applications, air bearings can be used.

E. Shaft Support - In applications where the shaft is stationary while the forcer moves and is attached to the load, two shaft supports (one at each end) are required.

Items B-E are necessary parts of the system and great consideration must be given to your application, demand specifications, environmental conditions, and which part will be moving — the forcer or the shaft. The other items, F through I, are optional and will need to be selected depending on your application. Other considerations include:

Motion Controller - This can be a PC or a dedicated programmable single (or multiple axis) motion controller. This is sometimes integrated into the Servo Driver.

Cable Carrier - Cable tracks will help guide and prevent damage to the motor cable, encoder cable, and any ancillary cables or hoses attached to the forcer.



Left: One version of a completed motion stage (not including electronics).

Linear Shaft Motor

With the Linear Shaft Motor there are two ways to achieve linear motion. The shaft can be held stationary while the forcer moves or the forcer can be held stationary while the shaft moves. There is no restriction on the angle or orientation at which the system can be mounted. This provides the user with a high degree of flexibility.

The Linear Shaft Motor should be mounted as closely as possible to the center of mass of the moving load and should be as close as possible to the working point of the machine. If this is not possible, than two Linear Shaft Motors can be used and should be spaced evenly from the working point.

In the majority of applications, the shaft will be fixed and the forcer will be the moving element. In this case, the forcer has been designed for the payload to be mounted via the supplied mounting holes. It is recommended that you use an adapter plate if the holes must be customized for mounting bearings, the encoder system and other specific application needs. The forcer comes with standard surface mounting holes that can be used to attach it to the load. Refer to the Data Sheet of your Linear Shaft Motor for detailed mounting dimension information.

If the application requires a moving shaft, then the surface to which the stationary forcer is mounted should have a minimum flatness of 0.01mm, and parallelism of 0.03mm.

Shaft

The magnetic field emanating from the shaft is very strong; always use extreme caution when handling.

Since the shaft contains strong magnets, its proximity to ferrous parts, or parts sensitive to magnetic fields, should be carefully considered.

A list of items to keep at a safe distance from the magnetic shaft include, but are not limited to: tools, watches, cell phones, pacemakers, precision instruments, and computers.

The shaft must be mounted so that it maintains concentricity with the central bore of the forcer. When the forcer and shaft are aligned correctly there is a nominal radial air gap of between 0.5 to 5.0mm depending on the series of Linear Shaft Motor you are using (refer to the Data Sheet to determine the exact gap size on your Linear Shaft Motor); where practical, this should be maintained along the entire length of travel. This air gap is non-critical, but the forcer should not rub against the shaft. If this occurs the amount of friction in the system is increased.

NOTE: The shaft is not a load-bearing member.
Do not us it as a bearing surface.

There are no mounting holes provided in the shaft, nor is it advisable for the customer to drill any. Therefore, the shaft must be clamped in position. As the forcer encircles the shaft and travels along its length, the shaft can only be clamp at its ends. Because all generated force is transmitted throughout the length of the shaft, users must ensure the chosen clamping method can withstand the peak force created by the Linear Shaft Motor. In order to propel the forcer only, the shaft must be prevented from moving. For applications where the shaft is to move, the forcer must be prevented from moving.

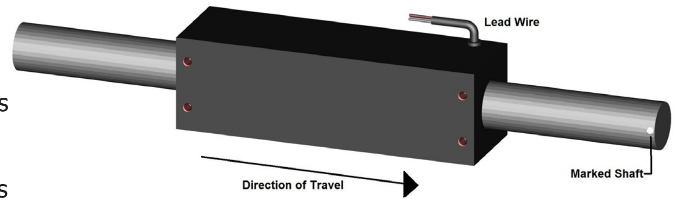
The shaft contains magnetic components whose performance can be impaired if subjected to temperatures above 80°C. With temperatures above 80°C, demagnetization of the magnets within the shaft can occur. Therefore, avoid mounting the shaft close to any direct heat source. Consideration should also be given to the continuous operating current at the applicable ambient temperature. For applications where the duty cycle is high, ensure there is good flow of air over the forcer and shaft, especially through the air gap.

To operators unfamiliar with cylindrical linear motors, the shaft appears as a solid metal bar and is often used as a handle. This may cause damage to the system, and should be avoided. Furthermore, operators are often caught unaware by the magnetic nature of these parts. Use warning labels to clearly identify the potential hazard, and when possible use a suitable physical guard or cover.

The north end of the shaft is marked with a yellow dot. It is essential, when designing systems with parallel Linear Shaft Motors driven with one servo driver, that the north ends of both shafts are in the same direction.

Forcer

For applications where the duty cycle is high, ensure there is sufficient air flow over the forcer and shaft, especially through the air gap.



The end of the Linear Shaft Motor forcer with the lead wire coming out should be toward the North end of the shaft marked with a yellow dot (**Figure 4**). This is most critical when designing systems with tandem and parallel Linear Shaft Motors driven with one servo driver. The linear encoder should also be installed to count up in this direction of travel. If it does not, the A and B encoder signals should be exchanged.

Note the forcer is electrically earth grounded through the forcer case. For CE type forcers the earth ground is also available through the motor cable.

Servo Driver

Any three phase brushless DC servomotor driver can be used to drive the Linear Shaft Motor[1]. In order to control the position of the Linear Shaft Motor, it is necessary to employ a servo controller and amplifier combination. There are many different makes and models of amplifiers available, but they tend to fall into one of three possible categories:

1. Intelligent amplifiers that have built in servo controllers
2. Velocity amplifiers capable of controlling only the velocity of the motor
3. Current/Torque amplifiers that control only the force of a linear motor (torque in a rotary motor)

Commutation

Different servo amplifiers have different commutation arrangements. The Linear Shaft Motors have built-in flexibility to cater to most servo amplifiers. The two most common methods of commutation are trapezoidal and sinusoidal. Commutation is usually started in one of three ways.

1. Digital Hall effects are used where trapezoidal commutation is required, or where sinusoidal commutation is achieved through encoder feedback and the Hall effects are used to read, on power-up, the location of the forcer in relation to the magnetic fields of the shaft.

If the servo amplifier you are using does not look at the Hall signals on power up it most likely only uses sinusoidal commutation, it starts commutation in one of two ways.

2. The driver will apply power to move the servo motor a few counts before initiating commutation, sometimes called a 'wake and shake'.

3. The other method will cause your motor to jump when power is applied to the system as the commutation sequence is typically initiated by energizing one of the motor phases. **WARNING - There can be large movements when power is applied to the system**.

Encoder

When sinusoidal encoder commutation is used, the electrical cycle of the motor is a required setting within the amplifier. The electrical cycle is normally defined in terms of encoder counts per pole pair (the distance between consecutive like poles).

Hall effect

Hall effect sensors are devices that can sense position magnetically and provide this information to the driver. Hall sensors are quite small and can be, depending on the size of Linear Shaft Motor, mounted outside or inside the forcer to sense the magnetic field of the shaft assembly. The sensors are operated only as switches, that are "ON" or "OFF" to sense the changing field direction as alternate north-south poles pass by when the forcer moves in respect to the shaft. The Hall sensors are mounted 120 electrical degrees apart. Each 60° segment has a unique set of Hall sensor outputs so that the forcer position can be resolved to any six segments over the 360 electrical degrees (**Figure 5**). The Hall effect sensors used in the Linear Shaft Motors employ an open collector output. 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 driver.

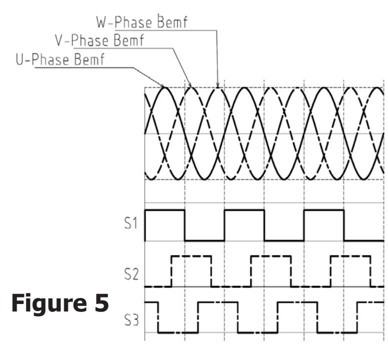


Figure 5

Linear Encoder

One of the advantages of the Linear Shaft Motor is that there is no inherent backlash in the motor. Therefore, it is possible to produce systems that can be moved to the same position from either direction without errors due to mechanical backlash. It is always desirable to use encoder systems that do not suffer from backlash (i.e. the

1. For a list of Servo Drivers which have been tested to work with the Linear Shaft Motor see Appendix C.

use of rotary encoders with conversion systems is not advisable). Basically, any type of system that can produce a measurable signal based upon distance moved can be used. The actual choice depends on a number of variables, such as repeatability required, operating environment, and signal type. The most commonly used linear encoders available consist of an encoded strip (attached to a surface parallel to the motor), and a sensor read head mounted to the moving part (motor). These are normally either optical, magnetic, or inductance based systems. For very high accuracy systems it is also possible to use a laser interferometer.

Resolution

The positioning resolution, repeatability, and smoothness of operation depend on the resolution of the encoder. The application usually determines the required resolution. In addition, the maximum response speed of the encoder may limit the maximum system speed. It is also imperative that you insure the controller is capable of counting the frequency of encoder pulses produced at your application's maximum speed. It is always important to ensure that the encoder type selected is compatible with the controller that you are intending to use. When sinusoidal encoder commutation is used, the electrical cycle of the motor is divided by the encoder resolution within the amplifier. For this reason, the smoothness of operation depends on the resolution of the encoder, it is recommended you use an encoder with a resolution that is at least equal to or finer than the north to south magnetic distance divided by 1000. See **Table 1**.

Mounting Location

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 bearings must be of sufficient stiffness to minimize dynamic deflections of the structure.

Sinusoidal Commutation Course Encoder

Coil	NS	Resolution
S040	9mm	9µm
S080	15mm	15µm
S120	24mm	24µm
S160 L160	30mm	30µm
S200	36mm	36µm
S250 L250	45mm	45µm
L250xS	60mm	60µm
S320 L320 S350	60mm	60µm
S500	90mm	90µm
S605	120mm	120µm
S1000	135mm	135µm

Table 1

Error Signal

It is recommended that a magnetic or optical encoder, which has an Error Signal, be used when using a servo drive utilizing Hall commutation. Using the encoder's error signal will allow the servo controller to detect when the system is missing pulses (drifting) or when the encoder signal is lost. Many servo drives using Hall commutation may try to apply full power to the motor when the encoder signal is lost, which will cause a highly undesirable system condition. To prevent this, the servo drive should be disabled by the servo controller or commanded to stop in a controlled manner when the encoder signal is lost.

In general, encoder errors are normally due to either:

- Incorrect sensor read head alignment with the encoder scale
- Incorrect gap between sensor read head and the encoder scale
- Damaged or dirty encoder scale, particularly optical scales
- Damaged signal wires
- Noise on the encoder signals

Magnetic Encoder

In the case of a magnetic linear encoder, ensure it is installed so the magnetic shaft does not affect the encoder. Magnetic encoder strips can be affected by the high magnetic fields produced by the shaft. It is possible for the magnetic field of the shaft to interfere with the field of the strip, or affect the read head directly; therefore, it is necessary to ensure there is sufficient distance between the components to ensure this does not occur. It is advisable that the two be separated by a distance equal to or greater than the north-to-north magnetic distance.

Bearing System

NOTE: The shaft is not a load-bearing component.
Do not use it as a bearing surface.

Like a ball-screw carriage, the forcer must be supported by a linear bearing system. The linear bearing system must be capable of supporting the load/heat sink and the forcer. Often, the linear bearing is the only moving contact type component in the system. Therefore, this component requires special attention. If the motor and feedback are far apart, the machine structure and bearings must be of sufficient stiffness to minimize dynamic deflections of the structure. Desirable bearing characteristics include high 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 **Table 2**.

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					

Table 2

Shaft Support

The shaft support along with the patented shaft design is what allows longer strokes in a Linear Shaft Motor system without excessive bending of the shaft. The shaft support should be able to support the mass of the shaft and should also be in contact with the shaft for the specified support length.

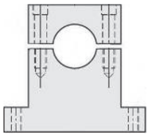


Figure 6

While the shaft support can be designed into the basic system structure of your machine, a typical shaft hanger such as the one shown in **Figure 6** can also be used. However, a few points to note are as follows:

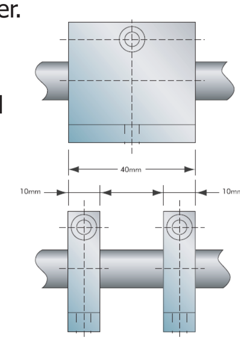
1. For optimal performance it is recommended that the shaft be supported for the support length listed on the appropriate Linear Shaft Motor data sheet.

2. 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. If using two shaft supports at each end of the shaft, confirm that the shaft supports are spaced according to the specified support length as outlined in the data sheet. See **Figure 7**.

3. There should be the capability to adjust the position of the shaft to align it with the central bore of the forcer.

4. Because of the simple support structure of the motor, on longer systems the shaft will have a tendency to sag in the middle due to gravity **(Figure 8)**. This can be overcome, to some extent, by inducing an upward bow into the shaft. Two common methods of doing this include; using shims to angle the end clamps (**Example 1**) or providing screw adjustment to angle the end clamps (**Example 2**). Verify that the shaft does not exceed the maximum bending as shown in the Data Sheet for your Linear Shaft Motor.

Figure 7



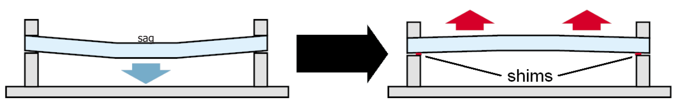
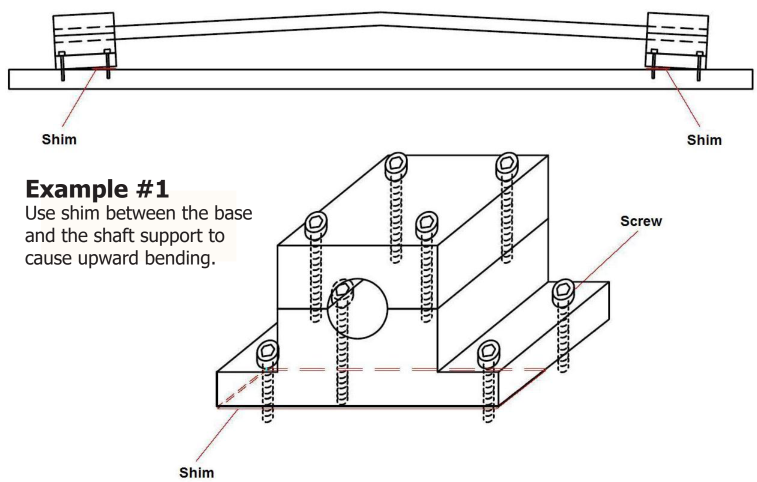
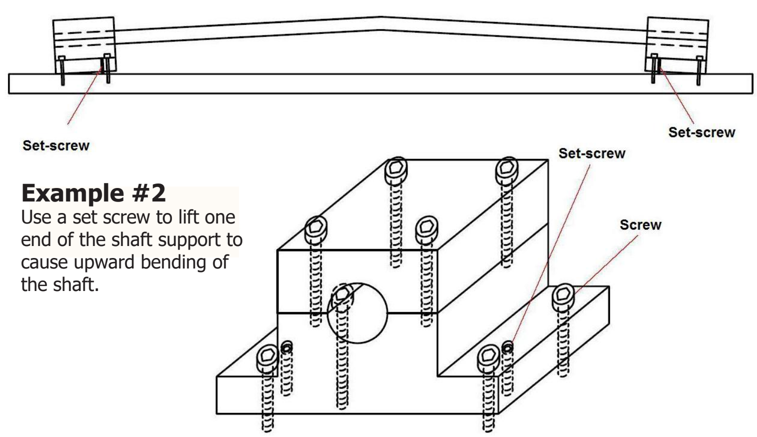


Figure 8





End Sensors

End Sensors are also called limit (end of travel) switches and are primarily safety features.

End sensors may be useful when dubugging a system or when the system is initializing, during its commissioning, and when unforeseen errors occur during normal operation. A common error (that may result in motor damage) is to leave the motor applying force against an end stop. If the limit signals are used to disable the amplifier, or to allow motion only in the direction away from the end stop, then this type of damage can be avoided. Limit switches are also helpful when the commanded positions are larger than the travel available. They can also be used as part of the homing sequence if required. There is normally one switch at either end of travel. Many quality linear encoders include limit switches.

In the event that the system starts losing counts (if the encoder stops producing them correctly or the controller counts them incorrectly) the physical position of the motor will change for the same count values. The limit switches can be used to ensure that if the motor passes a defined maximum physical position it can be disabled or even stopped, thus minimizing damage potential.

To protect from over-travel, it is highly recommended safety bumpers be installed. Bumpers on each end of the shaft can prevent damage to the system when unforeseen over-travel occurs.

Home Sensor

If an incremental encoder is used it is not possible for the controller to know the absolute position of the motor when the system is initially powered up. In order to establish a known position, it is necessary to perform a search for a home or index mark; this is often referred to as the homing sequence. For linear encoders with only one index mark it is only necessary to search for the index mark from the encoder. However, many linear encoders have index marks at regular intervals along the length of travel. In this case it is advisable to use a home sensor for the homing sequence.

Cable Carrier

It is recommended that when the Linear Shaft Motor is used with a moving forcer, a cable carrier be used. The cable carrier will help guide and prevent damage to the motor cable, encoder cable, and any ancillary cables or hoses attached to the forcer.

The forcer provides some strain relief for the cable, but when the forcer is moving it should not be relied upon as the only means of cable strain relief. Cable carriers also provide a means to relieve strain from the motor and encoder cables.

For short stroke systems, it may not be necessary to use a cable carrier. In order to achieve the rated flex-life of the motor and encoder cables, special attention should be given to the cable suppliers' recommended cable bend radius.

The cable that exits the forcer is not a high-flex type; therefore it must terminate before entering the cable carrier.

It is strongly suggested that a high-flex cable be mounted with a connector to your Linear Shaft Motor before it enters the cable carrier. This allows maintainability of the high-flex cable without having to removing the forcer. To assist with this, every Linear Shaft Motor is shipped with a connector which you can install. A good shield connection on all cabling is required for proper operation. Cables should be made in a twisted pair configuration, shielded, and grounded properly to the machine base, servo amplifier, and motor in order to reduce RFI.

Note the forcer is electrically earth grounded through the forcer case, for CE type forcers the earth ground is also available through the motor cable.

Other System Components

Each component in the moving portion of a system will increase mass, thus increasing the amount of energy needed to run it and the amount of heat generated. Systems must have the highest stiffness, with lowest possible mass, to increase resonant frequencies above the required servo bandwidth. All moving parts should also be of the lowest possible mass which will allow higher accelerations and velocities. Hollowed and ribbed components or honeycomb structures, along with special materials, will assist in reducing power requirements and system temperature. Obtaining the highest 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.

Environmental Considerations

Temperature considerations are critical when using the Linear Shaft Motor. For this reason ventilation is extremely important. Be sure to allow clearance for ventilation and access for cleaning, repair, service, and inspections. Be sure the area for ventilation is not obstructed. Obstructions limit the free passage of air. Linear Shaft Motors get warm and heat must be dissipated to prevent damage. The coil temperature rise of the ambient of any linear motor is linearly proportional to the amount of force produced. The design of the Linear Shaft Motor allows for the maximum amount of heat dissipation of any linear motor.

A temperature sensor OTL (Over Temperature Limit), which will cut power to the motor should it get too hot due to over load, can be added in series with the main power to the driver. The maximum coil temperature limit is typically 135°C. The standard temperature difference between the coil and the forcer surface is shown in **Table 3.**

Standard temp. difference between the coil winding and the forcer surface

Type	Standard Temp. Difference (°C)
S040	10
S080	10
S120	15
S160 L160	15
S200	20
S250 L250	20
S320 L320	25
S350	25
S500	40
S605	40
S1000	40

If large masses are added, values can as much as double

Table 3

Vertical Applications

If the Linear Shaft Motor is to be operated in a vertical orientation, it is recommended a counter-balance be used. If the load is not counter-balanced, the Linear Shaft Motor must always work against gravity, even when it is not moving. This should be taken into consideration when sizing the Linear Shaft Motor. The counter-balance should be designed to balance the gravitational force acting on the system, which is the weight of the forcer and the payload. If a system is properly counter-balanced, even when no power is applied to the forcer, it should remain stationary. Typical counterbalance techniques include a pneumatic cylinder, springs, or a counterweight.

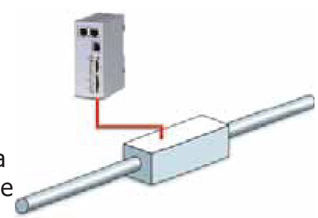
If a counter-balance mechanism is not possible, a brake should be used to prevent the load from dropping in the event of a power interruption.

Clean Room

Stages prepared for Class 10, 100 and 10,000 clean rooms can be built using standard Linear Shaft Motors. The customer must consider the bearing and other moving parts selected to confirm they are materials suitable for the specified environment. It is recommended that air bearings be used in stages for clean rooms. Linear Shaft Motors can be provided as clean room prepped if requested. The customer must perform the final cleaning. When using the Linear Shaft Motor in a clean room, Nippon Pulse recommends using a moving-shaft design (forcer stationary) to eliminate cable debris.

Single Drive System

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

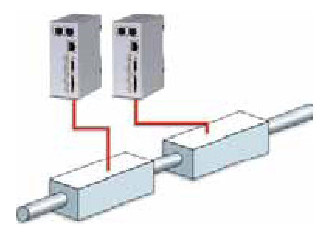


Multi-Axis Systems

The unique functionality of the Linear Shaft Motor allows for various multi-axis configurations. These range from a single axis with two or more motors on the same shaft and bearing system, to X-Y-Z gantry systems. These can be mixed and matched to achieve the desired load thrust and the complexity of the application. Typical systems can be configured in the following formats:

Multiple Forcer

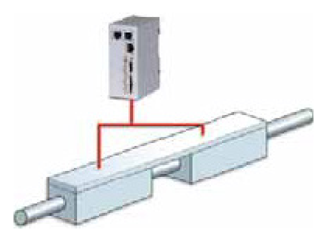
Multiple forcers on the same axis share the same bearing rail and shaft and can be synchronized, or act independently. This is a unique feature of linear motor systems and is impossible in a ball-screw system. This capability allows for greater flexibility in automated assembly applications, or test machines and provides a cost effective and space efficient solution.



Tandem Drive System

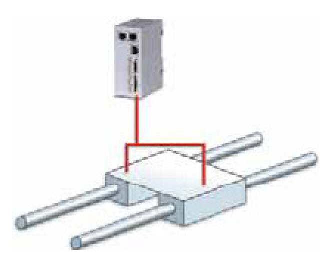
To multiple force in a linear systerm, multiple forcers can be used on the same axis while sharing the same bearing, rail, shaft, and servo driver. Locate the Dual forcer information on the data sheet and refer to Page 33 of this installation guide to learn more about using a tandem drive system.

Running the Linear Shaft Motor allows for greater flexibility in automated assembly applications, or test machines and provides a cost effective method of increasing force. Tandem drive motors must be mechanically connected together so they act as a single coil.



Parallel Drive System

The Linear Shaft Motor can be used in parallel (two or more sliders and two shafts connected to the same load), to achieve large thrusts for moving heavy objects. This is a unique feature of the Linear Shaft Motor and due to its non-critical air gap, it is very simple to implement. The Parallel Linear Shaft Motors will be synchronized when using one servo driver and one encoder. This allows the best method for providing force evenly across the load. Like a tandem drive system, a parallel drive system must be mechanically connected together so the motors are able to work as a single coil.



Installation

Unpacking

- Check packaging for signs of damage.
- Remove packaging. Do not discard. In the event items need to be returned to Nippon Pulse, it is recommended that the original packaging be used.
- Ensure the packing slip correctly reflects your order and the items delivered.
- Check equipment for signs of damage. Never use the equipment if it appears damaged in any way.
- Read and understand this Installation Guide before installing and using the equipment.

Precautions

- Since the shaft has a strong magnetic force (5000 ~ 7000G), it is recommended that you use non-magnetic material for the system structure when possible.
- If magnetic material is required, please arrange it at such a distance that it will not be affected by the magnetic attraction of the shaft.
- The magnetic force may cause bending in longer shafts. Take special care when the shaft is longer then 500mm.
- The Linear Shaft Motor assembly has no directivity, but the forcer coil does have an operating directivity when related to the shaft. The lead wires should be carefully arranged with this aspect in mind to keep the leads from being tangled.
- Physical contact between the shaft and the forcer should be avoided. Although contact between the shaft and forcer does not cause any catastrophic problems in operation, their contact does cause added intermittent friction, thereby making the setup and adjustment of the system troublesome.
- During continuous operation, the forcer will heat up. Heat radiation and insulation should be considered. Proper ventilation needs to be provided to remove the heat generated in the forcer.

Please locate the Data Sheet for your Linear Shaft Motor before continuing.

Installation should conform to the National Electrical Code as well as local codes and practices. When other devices are coupled to the motor, be sure to install protective devices to prevent accidents. Machinery that is accessible to personnel should provide protection in the form of guardrails, screening, warning signs, etc.

Mechanical Basic

The installation of your Linear Shaft Motor is very simple. Installation should be possible after reviewing these few key points.

Shaft

When using hand tools around the shaft keep in mind, the magnetic field emanating from the shaft is very strong; always use extreme caution.

Since the shaft contains strong magnets, its proximity to ferrous parts, or parts sensitive to magnetic fields, should be carefully considered.

Alignment

It is a good practice for the shaft to be mounted so it maintains concentricity with the central bore of the forcer. When the forcer and shaft are aligned correctly there is a nominal radial air gap of between 0.5 to 5.0mm depending on the series of Linear Shaft Motor you are using. Where practical, the air gap should be consistently maintained along the entire length of travel. On longer strokes the shaft may not stay concentric along the entire length of travel. As long as the shaft does not touch the central bore of the forcer the system will run correctly.

This 'large' air gap is non-critical, but the forcer should not rub against the shaft. While contact between the shaft and forcer does not cause any problems in operation, their contact causes added intermittent friction, thereby making the setup and adjustment of the system troublesome.

Due to the simply supported nature of the shaft, on longer systems the shaft will have a tendency to sag in the middle due to gravity. This can be overcome, to some extent, by inducing an upward bow into the shaft. **(Figure 9)** Two common methods of doing this include using shims to angle the end clamps or providing screw adjustment to angle the end clamps. Verify that the shaft does not exceed the maximum bending as shown in the Data Sheets for your Linear Shaft Motor.

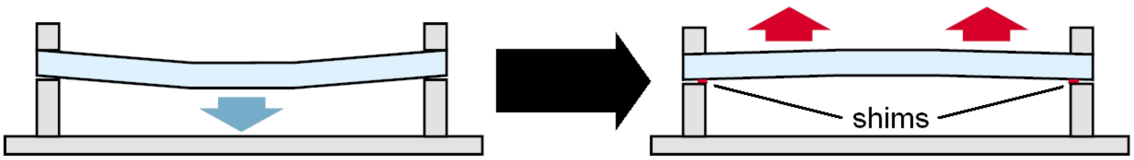


Figure 9

When using two motors in parallel, confirm both shafts and forcers are installed the same direction and they are parallel to each other.

NOTE: The shaft is not a load-bearing component.
Do not use it as a bearing surface.

The shaft is not intended to withstand radial loading. An accompanying linear bearing should always be used.

Forcer

It is good practice for the forcer to be electrically earth grounded through the forcer case. For CE type forcers the earth ground is available through the motor cable.

The end of the Linear Shaft Motor forcer where the lead wire exits should be toward the North end of the shaft marked with a yellow dot (**Figure 10**). This is most critical when designing systems with tandem and parallel Linear Shaft Motors driven with one servo driver. The linear encoder should also be installed to count up in this direction of travel. If it does not, the A and B encoder signals should be exchanged.

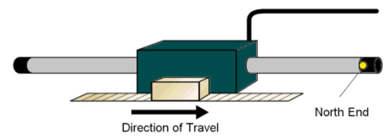
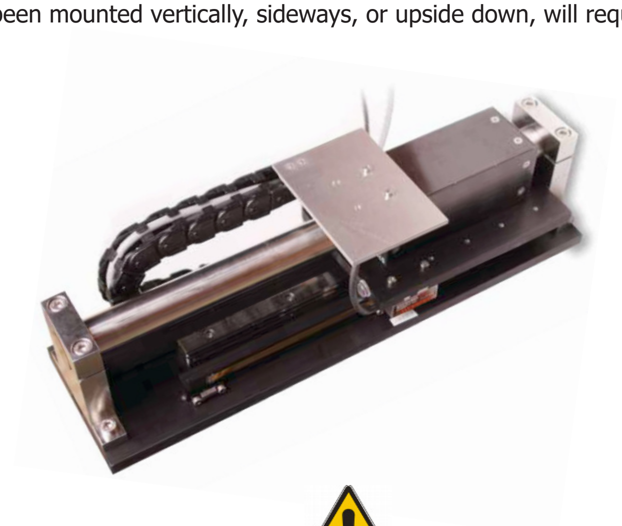


Figure 10

If you need more explanation the procedures outlined in the "Advanced" section can serve as a general guideline to your Linear Shaft Motor installation and alignment.

Mechanical Advanced

The procedures outlined in the advanced section can serve as a general guideline to your Linear Shaft Motor installation and alignment. This is not, and is not intended to be, a step-by-step installation guide. Individual application requirements will vary depending on the design of your system. These guidelines should provide a general starting point for basic designs. The guidelines assume the system has been mounted in a horizontal plane. Systems that have been mounted vertically, sideways, or upside down, will require a slightly modified procedure.



Note: Before carrying out these procedures, ensure there are non-ferrous (cardboard, wood, aluminum, etc.) packing pieces available to insert between the shaft and bearing rail. These packing pieces must be non-ferrous due to the magnetic nature of the shaft. The use of these packing pieces is essential, as the shaft is attracted to the bearing rail; the force with which they will 'snap' together is great. This situation may cause personal injury, and is likely to cause irreparable damage to the shaft or other structures. It is recommended the protective wrapping material be left on the shaft during installation. Unpack the magnet shaft and place it on a clean, non-magnetic surface away from other magnet devices and any other ferrous material.

Shaft Support

It is recommended at least one shaft support, the width of the recommended support length on the Linear Shaft Motor data sheet, be used. If using two shaft supports at each end of the shaft, confirm that the shaft supports are spaced according to the specified support length as outlined in the data sheet. **(Figure 11)**

The shaft support system should allow for adjustability, so the shaft may be aligned with the central bore of the forcer.

Because of the simple support structure of the motor, on longer systems the shaft will have a tendency to sag in the middle due to gravity. The shaft support system should allow for the ability to adjust for the bow. Common methods of doing this include the use of shims or providing screw adjustment to angle the end clamps. This is discussed in more detail in the "Shaft Alignment" section.

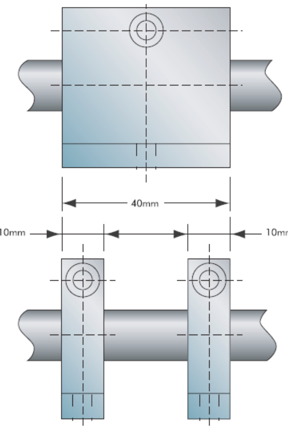


Figure 11

Forcer/Shaft Installation

Single Drive System

The end of the Linear Shaft Motor forcer with the lead wire exiting should be toward the direction of the marked end of the shaft. See **Figure 12**. The linear encoder should also be installed to count up in this direction of travel. If it does not, the A and B encoder signals should be exchanged.

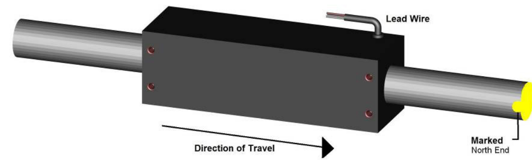


Figure 12

Tandem Forcers

Locate the Tandem forcer information on the data sheet. Please note the forcer spacing and if the second forcer needs to be flipped. If the second forcer has to be flipped, it will need to be installed on the shaft in a direction reversed from the first forcer **(Figure 13).** The U and V leads from the second forcer will also need to be swapped. The forcer with the lead wire and serial number away from the marked end of the shaft will be considered the second forcer.

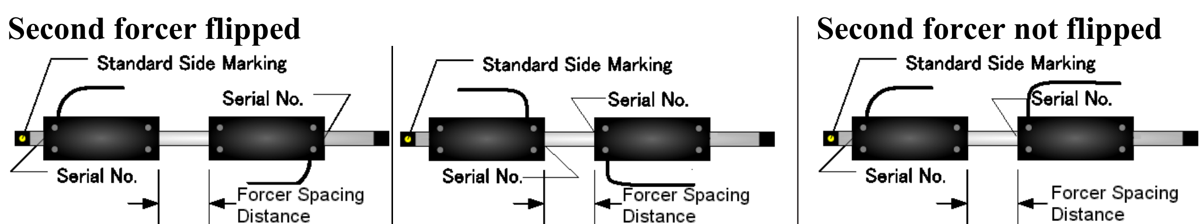


Figure 13

Note: Tandem forcers must be mechanically tied together.

Parallel Forcers

The Linear Shaft Motor can be set up in a parallel configuration with relative ease. It can be run in a parallel system using only one encoder, one drive, and one amplifier. When used in a parallel system, the Linear Shaft Motor will greatly increase force in any application. Motors used in parallel must be mechanically connected together.

Users of the Linear Shaft Motor in parallel must keep in mind some simple design considerations. The motors must be aligned in the same direction, meaning the yellow marks are on the same end of the system. Linear Shaft Motors must be physically coupled with a mechanism, which when applied, allows the axis to realize only one-degree-of-freedom of movement.

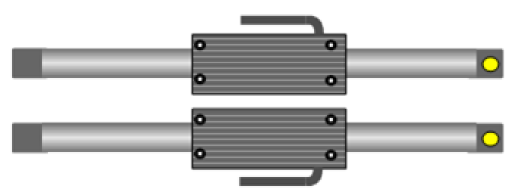


Figure 14

Both forcers must be oriented the same direction on their shafts. Nippon Pulse recommends the Serial Numbered end of the forcer be pointing toward the end of the shaft which is marked with yellow paint. If the orientation of the coils is different, it is possible to have a totally inoperable system, a runaway system, or significant loss of thrust. The standard for parallel drive system is for mirrored cable exit locations **(Figure 14)**. Like tandem forcers, Linear Shaft Motors in a parallel configuration must be mechanically tied together **(Figure 15)**.

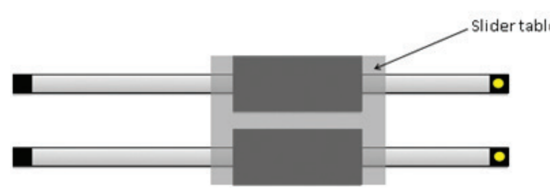


Figure 15

1 - This procedure can serve as a general guideline to your Linear Shaft Motor installation and alignment. This is not, and is not intended to be, a step-by-step installation guide since your system components will be very dependent on your design and may be very different from what is described here; however, our hope is that these guidelines will be helpful. The guidelines assume that the system has been mounted in a horizontal plane. Systems that have been mounted vertically, sideways, or upside down, will require a slightly modified procedure.

Offset Motors

Multiple motors can also be aligned in an off-set configuration but must follow the specifications in **Tables 4/5** and **Figures 14/15**.

Model	Δx (mm)
S040	0.25
S080	0.42
S120	0.67
S160	0.83
S200	1.00
S250	1.25
S320	1.67
S350	1.67
S500	2.50
S605	3.33

Table 4

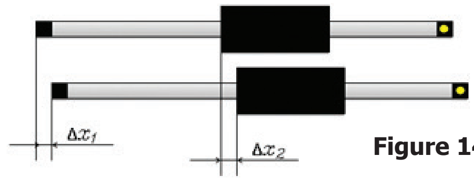


Figure 14

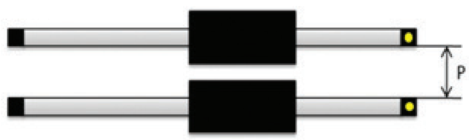


Figure 15

Model	P (mm)
S040	18
S080	30
S120	48
S160	60
S200	72
S250	90
S320	120
S350	120
S500	180
S605	240

Table 5

Short Strokes

When installing the Linear Shaft Motor it is necessary to adjust the position of the shaft in relation to the central bore of the forcer.

An example of a procedure that has been used is detailed to the right.
After both supports have been adjusted, remove the packing pieces and move the forcer, by hand, along the whole length of travel, visually checking the alignment of the shaft in relation to the central bore of the forcer.

On systems over 1m, there may be some deviation from concentricity, but as long as the shaft does not touch the central bore of the forcer, over the whole length of travel, the system will run correctly. When the shaft touches the central bore of the forcer there may be an increase in resistance to the movement of the forcer.

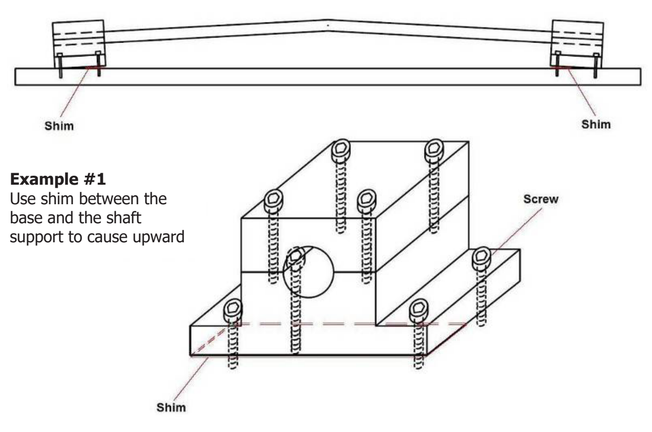
Sample short stroke forcer/shaft alignment[2]:

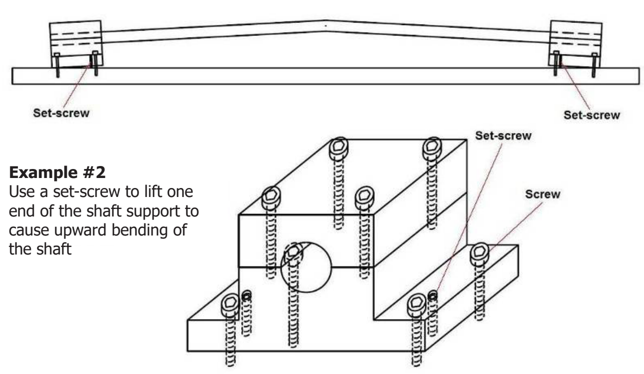
1. First, ensure the packing pieces are inserted between the shaft and bearing rail. These pieces do not need to be a tight fit but should be spaced no further than 500mm apart.
2. Temporarily tighten one of the supports; loosely tightening the base bolts and fully tightening the shaft clamp bolt.
3. Slide the forcer to approximately 50mm from this support; removing and replacing the packing pieces as required.
4. Adjust the position of the support so that the shaft is aligned concentrically with the central bore of the forcer. The correct position can be determined by eye alone.
5. Tighten the base bolts, ensuring the position of the support does not change while doing so.
6. Repeat the procedure for the other shaft support.

Long Strokes

Because of the simple support structure of the motor, on longer systems the shaft will have a tendency to sag in the middle due to gravity. This can be overcome, to some extent, by inducing an upward bow into the shaft. Two common methods of doing this include; using shims (**Example #1**) to angle the end clamps or providing screw adjustment (**Example #2**) to angle the end clamps. Verify that the shaft does not exceed the maximum bending as shown in the Data Sheets for your Linear Shaft Motor.

Both of these alignment methods of the shaft requires the 'simultaneous' adjustment of both of the shaft supports. Below is an example of an adjustment using shims[3].





2 - This procedure can serve as a general guideline to your Linear Shaft Motor installation and alignment. This is not, and is not intended to be, a step-by-step installation guide since your system components will be very dependent on your design and may be very different from what is described here; however our hope is that these guidelines will be helpful. The guidelines assume that the system has been mounted in a horizontal plane. Systems that have been mounted vertically, sideways, or upside down, will require a slightly modified procedure.

3 - This procedure can serve as a general guideline to your Linear Shaft Motor installation and alignment. This is not, and is not intended to be, a step-by-step installation guide since your system components will be very dependent on your design and may be very different from what is described here; however our hope is that these guidelines will be helpful. The guidelines assume that the system has been mounted in a horizontal plane. Systems that have been mounted vertically, sideways, or upside down, will require a slightly modified procedure.

Sample long stroke forcer/shaft alignment

Stage 1: When installing the shaft supports and Linear Shaft Motor, start by using a temporary shim. The size of the final shim will vary depending on the length of system, and therefore how much bow needs to be induced into the shaft to overcome the natural sag due to gravity. The shim size will normally be between 0.3mm and 1.0mm (a 0.8mm shim is a good starting point).

Insert a shim below both inner bolts, on each of the supports, between the support and the bottom plate. Please see the illustration on the previous page with example #1 for clarification. Tighten the bolts, on each support, enough to hold the shims in place and force the support against the bottom plate. Tighten the top bolts both to hold the shaft rigidly in the supports.

Stage 2: Position the whole shaft support.

1. First, ensure packing pieces are inserted between the shaft and bearing rail. These pieces do not need to be a tight fit but should be spaced no greater than 500mm apart.
2. Temporarily tighten one of the supports; loosely tightening the base bolts and fully tightening the shaft clamp bolt.
3. Slide the forcer to approximately 50mm from this support; removing and replacing the packing pieces as required.
4. Adjust the position of the support so that the shaft is aligned concentrically with the central bore of the forcer. The correct position can be determined by eye alone.
5. Tighten the base bolts, ensuring that the position of the support does not change while doing so.
6. Repeat the procedure for the other shaft support.

Stage 3: After both supports have been adjusted, move the forcer to the middle of travel, and remove the packing pieces (The forcer is moved to the middle of travel, to stop the shaft from 'snapping' down onto the bearing rail, in the event of an error being made during the shaft support adjustment). Move the forcer, by hand, along the whole length of travel, visually checking the position of the shaft in relation to the central bore of the forcer. The shaft will not stay concentric along the whole length of travel, but as long as the shaft does not touch the central bore of the forcer the system will run correctly. The shaft will look similar to the one shown in **Figure 18**.

If the shaft touches the central bore of the forcer, it will be evident by an increase in resistance to the movement of the forcer. If this occurs, the shaft will need to be realigned. Minor adjustments can be made by repositioning of the whole support; larger adjustments will require different size shims to be used in stage 1 of the adjustment. Rubbing in the center will require larger shims, while rubbing at 1/3 from ends will require smaller shims. Always remember, before undoing any of the shaft support bolts, packing pieces should be inserted between the shaft and the bearing rail.

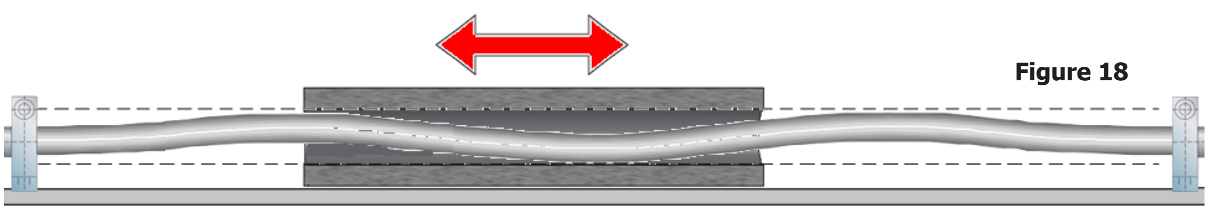


Figure 18

Encoder Installation

Encoders should be installed according to the encoder manufacturer's installation information. Attention should be given to the proximity of the encoder to the shaft, due to the shaft's strong magnetic field. This is particularly important when using magnetic type encoders.
The direction of count of a two-channel (Quadrature decoded) incremental encoder is defined such that a signal denoted as channel A should lead channel B when the motor is moving in the forward direction. It is sometimes impossible to mount the encoder systems so that the counts will conform to this convention. Under these circumstances, it is necessary to reverse the direction of count as seen by the controller. There are two possible methods of reversing the direction of the count from an incremental encoder, both described below.

- If a channel is inverted (i.e. A wired to A- and vice versa) then the signal from channel A will then lag behind channel B. This will cause the controller to reverse the count as perceived from the encoder.
- If the signals from channel A and channel B are swapped completely with one another (i.e. A+ wired to B+, A- wired to B-, and vice versa), this will result in channel B leading channel A, and reverses the count.

4 - This procedure can serve as a general guideline to your Linear Shaft Motor installation and alignment. This is not, and is not intended to be, a step-by-step installation guide since your system components will be very dependent on your design and may be very different from what is described here; however, our hope is that these guidelines will be helpful. The guidelines assume that the system has been mounted in a horizontal plane. Systems that have been mounted vertically, sideways, or upside down, will require a slightly modified procedure.

Magnetic encoders

If the rod and strip come into contact, or are in very close proximity with one another, then the magnetic profile in the strip will be permanently damaged. The magentic encoder must be shielded from the motor's shaft or must be at least one N-N magnetic pole pitch from the shaft.

Cable Carrier

When the Linear Shaft Motor is used with a moving forcer, it is recommended a cable carrier is used. The cable carrier will help guide and prevent damage to the motor cable, encoder cable, and any accompanying cables or hoses attached to the forcer.

For short stroke systems it may not be necessary to use a cable carrier, but the use of strain relief is recommended.

The cable that exits the forcer is not a high-flex type; therefore, it must terminate before entering the cable carrier. Cable undergoing dynamic movement should be protected and have a method of strain relief, ideally protected within a cable carrier. It is important to lay any cables, or conduit, neatly within the cable carrier to prevent damage to them, and to minimize the friction of the system due to the cable carrier binding. All static cables should be routed in such a way that they are protected from being damaged by parts of the machine or secondary moving parts.

Operation Considerations

The motor must always be operated within the specified operating parameter limits. Exceeding those limits will permanently damage the motor. The following steps must be completed to ensure safe and proper operation.

Verify that all electrical wiring and cables are properly connected. Refer to the manual provided with the driver for this information.

1. Adjust the servo driver current to match the motor's current specification. See the data sheet.
2. Refer to the motor specifications for operating parameters. Adjust the control parameters to the motor data specifications as necessary.
3. Adjust the control for the proper P.I.D. loop tuning. Begin at a low gain setting and increase the gain as necessary.
4. Strain relieve the wires prior to operating.

The cable that exits the forcer is not a high-flex type; therefore it must terminate before entering the cable carrier.

Cable undergoing dynamic movement should be protected and have a method of strain relief, ideally cable should be protected within a cable carrier. It is important to lay any cables, or conduit, neatly within the cable carrier to prevent damage to them, and to minimize the friction of the system due to the cable carrier binding. All static cables should be routed in such a way that they are protected from being damaged by parts of the machine or secondary moving parts.

Using the supplied connector provided with the Linear Shaft Motor, connect cables before entering the cable carrier. This connector attaches to the high-flex cable in the cable carrier. This allows maintainability of the high-flex cable without have to removing the forcer. Required for proper operation, is a good shield connection on all cabling. Cables should be tied together in a twisted pair configuration, shielded, and grounded properly to the machine base, servo amplifier, and motor in order to reduce RFI.

Note the forcer is electrically earth-grounded through the forcer case, for CE type forcers the earth ground is also available through the motor cable.

Mounting Orientation

There is no restriction on the angle or orientation at which the system can be mounted. If the system is to be mounted in a vertical orientation, it is recommended a counter-balance be used. If the load is not counter-balanced, the motor must always work against gravity, even when it is not moving. This should be taken into consideration when sizing the motor. The counter-balance should be designed to balance the gravitational force acting on the system, which is the weight of the forcer and the payload. If a system is properly counter-balanced, when no power is applied to the forcer it should remain stationary.

Electrical Installation

Note: The lead wire supplied with the Linear Shaft Motor is not intended for use in a cable carrier. It is suggested you use the supplied connectors for connection to a suitable cable for continuous operation.
All connections to the motor are made through the flying leads exiting on the side of the motor. High voltages can be present. Ensure all power is removed from the motor before connecting or disconnecting the motor.

Power and Control Connections

All the power and control connections are made through the Linear Shaft Motor's forcer assembly. For an example of an integrated configuration using the Linear Shaft Motor and amplifier / controllers, refer to **Figure 19**.

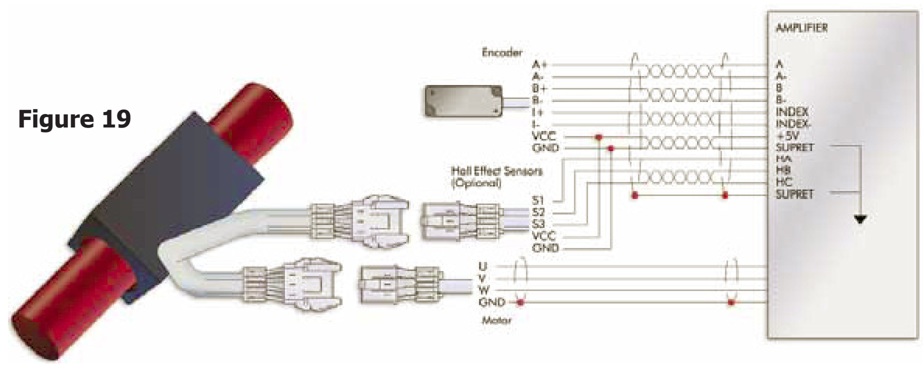


Figure 19

The data sheet for your Linear Shaft Motor identifies the color, function, and length of the wire in the forcer assembly. Connect the three wire (U, V and W) flying leads exiting on the side of the motor to the Servo amplifier. For correct operation, the flying leads on the end of your motor cable should be connected as detailed in your servo amplifier instructions. These wiring connections may be indicated on your servo drive connector as; U, V, and W; or R, S and T; or M1, M2, and M3, or A, B and C; or simply 1, 2 and 3.

Hall effects

If your Linear Shaft Motor has the Hall effect option, connect S1, S2, S3, GND, and VCC connection for the Hall effects to the respected input terminals of the driver. Suitable cable should be selected for use between the Linear Shaft Motor and the driver. Consideration should be given to shielding and bending radius cable when used in a cable carrier.

The Linear Shaft Motor uses EW500 Hall Sensor. The circuit is shown in **Figure 20**.

As shown in **Figure 21**: S1 – U, S2 – V, S3 – W

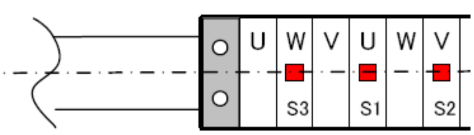
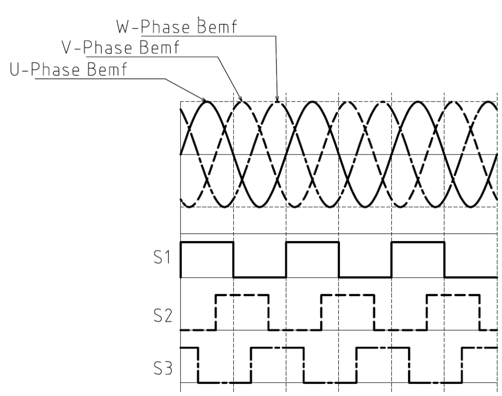


Figure 20



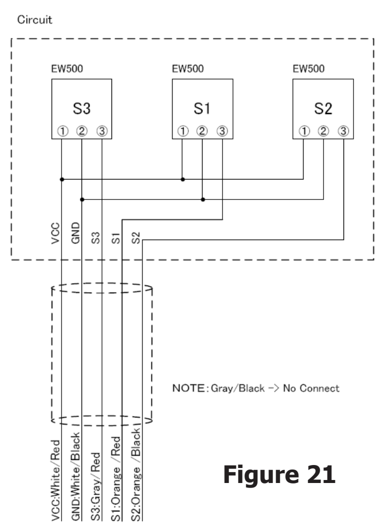


Figure 21

Tandem Forcers
If your system makes use of Tandem forcers, locate the tandem forcer information on the data sheet (**Table 4)**. Please note the forcer spacing and if the second forcer is to be flipped. If the second forcer is to be flipped, it will need to be installed on the shaft reversed from the first forcer. The U and V leads from the second forcer also need to be swapped.

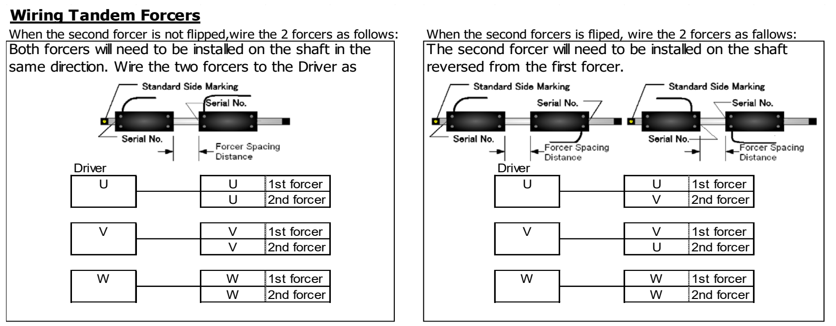


Table 4

Encoder and other Sensors
Connect the encoder and other sensors -- OTL (Over Temperature Limit), Limit Switches, and Air Sensors-- to the driver. Please refer to the instruction manual of the driver and device being connected to confirm correct connection.

Grounding
The motor-ground must be connected at both the servo amplifier's earth-ground terminal and the body of the forcer. When using a CE type motor, the motor-ground is available through a ground screw. Always keep the connection between motor and the earth-point as short as possible. For best results, use a heavy gauge, multi-strand earth strap.

Electromagnetic Compatibility (EMC)
The ultimate responsibility for ensuring the Electromagnetic Compatibility of a system lies with the OEM.

Motor
All motor windings are contained within the aluminum housing of the forcer. This housing provides very effective screening from the noise immited by the high switching currents associated with a pulse width modulated amplifier, and is also very effective at preventing external sources of noise from affecting the electronics contained in the termination pocket.

Hall Effect Devices
Digital Hall effect devices have built in noise immunity that comes from using digital electronics.

General Precautions
Although the motor's EMC performance is very good, it is still advisable to take precautions to minimize the risk of any Electromagnetic Interference (EMI) in your application. These precautions include:

- Keep all cable routing as short and direct as possible
- Avoid routing signal cables alongside power cables or close to "noisy" components like mechanical relays.
- Where shielded cables are provided, ensure that the shield termination is as short and direct as possible. Do not use "pig tails" to terminate shields.

Servo Driver

The following information can serve as a general guideline to your servo driver installation and alignment. This is not, and was not intended to be, a step by step installation guide since your system components will be very dependent on your design and may be very different from what is described here; however our hope is that these guidelines should be helpful.

Basic PID(F) Servo Controller Setup

PID(F) controllers use the error between the desired position of the motor and its current position to control the force that the motor will produce. PID refers to proportional, integral and derivative terms applied to this error (referred to as the following error) that are used in this type of control system. Many of these controllers will also have feed-forward terms (F) to help reduce the response times of the system. In order for the controller to move the system to the desired position it is necessary to set values to these terms. The process of selecting the value to which these parameters should be set is called tuning. In order to tune a system it is necessary to understand the effect of each of the terms. Refer to your servo tuning guide for detailed information.

Proportional gain

The proportional gain in a system causes the motor to produce a force directly proportional to the following error. The further away from the desired position the motor, the greater the following error and the greater the amount of correcting force produced. As this value is increased the position error is reduced. It is possible to use too large a value of proportional gain, as the system can become unstable. This parameter also provides stiffness when in position.

Derivative/Velocity feedback gain

One method of stabilizing a system requiring a high proportional gain is to introduce a velocity feedback factor into the loop. This parameter reduces the force that is available to the motor as the speed of the motor increases. Although this allows higher gains to be used, there is still a limit to the maximum value, as the system will still become unstable if very large values of velocity feedback are used.

Integral gain

When the above two terms have been set there may still be an unacceptable following error in the system. This integral term is combined with the following error in a continuously incrementing accumulation to produce a force to drive the motor. Because of the time dependency of this term, it tends to have a much slower response rate when compared to the above two terms. For most systems, a quick response is required, and so a high value for this gain is tried. Unfortunately, even at fairly low values this term can cause the system to become unstable. For linear systems this term is generally very small, or set to zero.

Feed-forward gains

There are several different types of feed-forward gains that are available, depending on the controller type. Velocity, acceleration, deceleration and friction feed-forward compensation are a few of the common ones. During a move, feed-forward terms allow the controller to produce a force based upon the commanded move rather than on the following error. An example would be to consider the acceleration feed-forward term. Using Newton’s law of motion, F=MA, it is possible to assume that if an acceleration is required, then a certain current needs to flow in the motor windings (force is directly proportional to current). An acceleration feed-forward term would produce a command signal that could be expected to achieve this acceleration. This does, however, mean that the feed-forward terms are open-loop in nature. Just as with all the other gains, if any feed-forward terms are too large the system will be unstable. In general, the feed-forward terms are used to minimize following errors and improve system response time. Unfortunately, there is no universal method of tuning, or predetermined gain values, that can be used on all servo controllers commercially available. Each servo controller has specific control algorithms and scaling.

Maintenance and Service

When correctly installed, the Linear Shaft Motor system requires little maintenance. The Linear Shaft Motor systems contain no parts that undergo frictional contact. When incorporating a Linear Shaft Motor system, care should be taken to allow access for routine maintenance of the bearing and encoder systems and any other additional equipment. The Linear Shaft Motor itself is entirely maintenance free. It does not have any parts that can wear out.

Nippon Pulse recommends you periodically perform minimal inspections.

Periodically:

- Check that the forcer can move freely over the entire stroke
- Clean any accumulated debris from the shaft surface (ferrous material in particular can be attracted to the shaft)
- Check the bending of the shaft
- Check all parts are tight and secure
- Check all flexing cables for signs of wear and/or damage

The forcer contains the stator coils; these are potted into the aluminum housing with an epoxy resin. The aluminum housing and the coils are therefore, in effect, a single piece and there is no maintenance needed. If, however, wear has been noted on the shaft, then the central bore (internal diameter of the coils) should be inspected for wear, or excessive ingress of foreign matter. The shaft will need to be removed from the bore of the forcer to do this.

The shaft is NOT a bearing surface, and should NOT be oiled or greased. When correctly set up there should be no maintenance requirements for the shaft. However, on long systems where the possibility of the shaft rubbing on the central bore of the forcer is high, regular checks should be made for correct alignment.

The only contact and source of friction is in the external linear bearing. The external linear bearing must be lubricated from time-to-time according to the slide manufacturer's specifications. Please consult the bearing manufacturer for recommendations on lubrication types and lubrication intervals.

If a roller bearing or an air bearing system is used to guide the load, there may not be any maintenance at all.

Service

The Linear Shaft Motor is not designed to be serviced in the field. In the rare event of a malfunction, please contact Nippon Pulse for return authorization.

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Phone: 1-540-633-1677
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Web: www.nipponpulse.com

Troubleshooting Guide

This section covers symptoms, probable causes and solutions related to the Linear Shaft Motor. It lists the most common symptoms of irregular operation, and the possible causes and solutions for these faults. Most problems encountered during installation can be traced to a few basic mechanical alignment problems, or incorrect/noisy wiring. A logical and methodical approach to trouble-shooting is essential to isolating and resolving these problems. Common problems include:

- Mechanical alignment of the shaft
- Incorrect tuning of the servo controller and/or drive
- Motor power and Hall effect devices incorrectly wired
- Encoder feedback failure
- Motor over-temperature
- Motor over-current
- Improper setting of current in drive

The magnetic attraction between the magnet shaft and other magnetic or ferrous materials is extremely high. Keep fingers and other body parts away from these objects to avoid injury.

Before performing the tests described in this section, be aware that lethal voltages may exist on the motor connections. A qualified service technician or electrician should perform these tests.

Symptom	Probable cause	Corrective Action
Linear Shaft Motor does not move freely by hand when power is not applied to the system	Forcer rubbing against shaft	Realign forcer so its bore is concentric with the forcer per the instructions the Installation Section (page 18)
Encoder counts when motor is not moving	Encoder shield not connected	Connect encoder shield
	Amplifier/motor noise	Check shields and earth grounds (See Installation Section page 32)
		Route encoder cables away from motor cable at controller
Encoder feedback failure or intermittent feedback	Encoder not set up correctly	Adjust encoder per encoder manual
	Encoder scale dirty	Clean scale
	Encoder strip scratched (optical)	Replace encoder strip
	Encoder strip damaged (magnetic)	
	Encoder read head failed	Replace Encoder Sensor
Linear Shaft Motor runs unevenly	Incorrect number of encoder counts per pole pitch for commutation	Recalculate counts per pole pitch (See Engineering Notes page 23)
	Servo gains set incorrectly	Re-tune system
	Current offsets in drive amplifier	Contact drive supplier
	Shaft damaged due to excessive heat	Replace shaft (contact Nippon Pulse)
	Earth ground/shields not connected correctly	Check connections (See Section Installation page 31, 32)
	Incorrect pole pitch set up or phase offset between position sensor and forcer back EMF	Check drive or controller set up

Linear Shaft Motor stalls on power up	Hall effects not connected correctly	Check Hall effects connections (See Section Installation page 31)
	Motor power not connected correctly	Check motor connections
Linear Shaft Motor runs away (Positive Feedback)	Polarity of control signal and encoder count direction are opposite	Ensure a positive force or velocity command from the servo controller yields an increase in the reported encoder position (See Section Installation page 26)
Amplifier fails to enable	Faulty Wiring	Check and correct wiring
	Limit switches active	Move motor away from limits, or disable limits at controller
Linear Shaft Motor drifting	Exceeding encoder frequency specifications of amplifier	Reduce linear motor speed
	Electrical noise affecting read head	Check for grounding loops
The shaft is discolored	Motor exceeded rated temperature	Check continuous current setting
		Measure motor phase resistances
Linear Shaft Motor fails to phase align on power-up	Motor/encoder/Halls not wired correctly	Check connections (See Chapter Installation page 22)
	Insufficient travel available to complete phase sequencing	Clear obstruction
		Replace shaft with longer shaft (contact Nippon Pulse)
	Insufficient phase search current	Check amplifier setting
Forcer locks into certain positions on the shaft	Hall effect signal missing	Check connections
	Motor phase not connected	
Linear Shaft Motor feels coggy	Ferrous materials used in stage	Replace ferrous parts with non-ferrous materials.
	Phase wires shorted out	Unshort phase wires
Shaft pitted or scarred	Forcer rubbing on shaft	Realign forcer so its bore is concentric with the forcer per the instructions in Installation Section
RMS over-current fault	Move regimen too strenuous for payload being carried, and the motor’s capabilities	Reduce commanded accelerations and or velocity
		Reduce payload
	Incorrect drive settings for motor	Correct drive settings
Following error	System can not follow commanded move velocity and/or acceleration.	Reduce commanded speed and/or acceleration
	Encoder signal failure, or intermittent encoder signal	Check encoder signal with drive disabled
	Following Error Window set too tight	Increase following error window
	System not tuned properly	Adjust tuning parameters per your servo control’s instructions
System is not repeatable	Servo system is not tuned properly for application	Adjust tuning parameters
	Settling time is not sufficient to meet settling window requirements	Increase allowable settling time
System vibrates when servo loop closed	Servo controller gains set too high, or incorrectly	Reduce gains and retune system

Linear Shaft Motor moves the wrong direction	Polarity of control signal and encoder count direction are opposite	Ensure a positive force or velocity command from the servo controller yields an increase in the reported encoder position (See Section Installation page 26)
	Control's direction sense is not set correctly for your application	Switch direction sense
Linear Shaft Motor does not move and produces no force	Drive not powered	Check all connections to make sure they are tight and secure, and the power is turned on.
	Linear Shaft Motor phase is not connected to drive	Check phase connections to the drive
	Over-temperature sensor setup but not connected	Check settings and connection of over-temperature sensor and the drive
	Linear Shaft Motor is over-temperature	Allow forcer to cool (see symptom below)
Linear Shaft Motor does not move but does produce force	One or more of the motor phase connections are missing or connected improperly	Check phase connections to the drive make sure they are tight and secure.
	One or more of the position sensor connections are missing or connected improperly	Check position sensor connections to the drive make sure they are tight and secure
	The Linear Shaft Motor is mechanically blocked	Check to see that the Linear Shaft Motor is free to move
Linear Shaft Motor gets too hot	The Linear Shaft Motor is being driven beyond its designed load carrying capacity	Turn off the machine and call Nippon Pulse to double check the proper sizing
Linear Shaft Motor moves but the commanded position is not what it is supposed to be	There is improper reading of position from the encoder by the driver	Align the encoder's linear scale properly so that it is exactly parallel to the rail guide, linear bearing, or air bearing being used

FAQ

Q. What is a Linear Shaft Motor?
A. Linear Shaft Motors are direct drive linear servomotors that consist of a shaft with permanent magnets and a forcer of cylindrically wound coils.

Q. What routine maintenance is required for Linear Shaft Motors?
A. The Linear Shaft Motor itself is entirely maintenance-free. Because of its simple structure, the Linear Shaft Motor does not have any parts that can wear out. However, Nippon Pulse recommends you perform periodic inspections on all systems, including the bearings and supports. See the Maintenance and Service section of the Installation and User's Guide for details about the recommended inspections.

Q. What is the reliability of the Linear Shaft Motor?
A. The Linear Shaft Motor is a non-contact device. As such, it does not have any parts that can wear out. If the system is designed properly and the operating parameter limits are not exceeded, the Linear Shaft Motor should last indefinitely.

Q. What advantages does the Linear Shaft Motor offer over traditional linear motion systems?
A. The Linear Shaft Motor is the first linear servomotor designed for a the ultra high-precision market and, as a result, has several advantages over traditional linear systems. The Linear Shaft Motor is compact and lightweight, has no cogging issues, is up to 50 percent more energy-efficient than traditional linear motors, and features a non-critical air gap, which reduces maching costs.

Q. Are there 3D CAD models of the Linear Shaft Motor available?
A. Yes. There are 3D models of the Linear Shaft Motor available on the Nippon Pulse web site (www.nipponpulse.com). The models are available in practically every CAD format on the market.

Q. Can the shaft of the Linear Shaft Motor transmit a rotary force?
A. Yes, this is possible. To determine which Linear Shaft Motor is best suited for your application, contact an applications engineer to review your specifications.

Q. Do magnets ever lose their magnetism over time?
A. The Linear Shaft Motors use rare-earth magnets, which are the strongest magnets available and produce magnetic fields that are significantly stronger than any other type of magnets. However, when operating at high ambient temperatures (>80°C), these magnets can lose strength. Lower temperatures have no effect on the magnets.

Q. How accurate are Linear Shaft Motors?
A. The Linear Shaft Motor is a high-performance, accurate motor. There is no need to convert rotary motion to linear motion, which is a major source of positioning error among rotary-to-linear systems. While the Linear Shaft Motor does not have inherent resolution, position accuracy is ultimately determined by the linear encoder feedback accuracy and the core stiffness of the motor. Testing has shown that, with encoder resolutions less then 10nm, the Linear Shaft Motor will, at worst, enable a position accuracy of ±1.2 pulses of encoder resolution. This position accuracy is not affected by the expansion and contraction of the shaft.

Q. How fast can the Linear Shaft Motor go?
A. The maximum speed is a two-step calculation. First, max acceleration is calculated by (acceleration = accl force / mass). Second, the maximum speed is calculated by (velocity = acceleration * time). Outside of this, the Linear Shaft Motor itself does not have inherent speed limitations.

There are several factors that can limit the maximum speed of a Linear Shaft Motor system. The control must provide sufficient bus voltage to support the speed requirements. The encoder must be able to respond to that speed, and its output frequency must be within the controller's capability. Finally, the speed rating of the stage's bearing system must not be exceeded.

Q. What is cogging?
A. Cogging is a resistive torque or force caused by the interaction of a magnetic field with a ferrous (magnetic, iron-containing) material, even when there is no current present. Cogging causes jerky, uneven motion in servo systems. Because our Linear Shaft Motor contains no ferrous material, it does not experience cogging effects.

Q. What happens if the system loses power or velocity feedback?
A. If a power loss occurs, the system loses all stiffness. So, if the payload is moving, it will continue to move until it hits a stop or until friction brings it to a stop. If the feedback loop is lost, it may lead to a runaway situation. This condition can be avoided with the use of soft and hard stops as well as braking systems.

Q. Are linear motors difficult to integrate into a machine?
A. One of the key design aspirations of the Linear Shaft Motor is simplicity. That simplicity extends to the integration process. As all systems are different, it is generally difficult to make specific statements about machine integration that hold true. A Nippon Pulse applications engineer would be happy to assist you with integration questions relevant to your individual project.

Q. What is RMS Current?
A. RMS stands for "Root Mean Square." It is the effective average current. It is most commonly used when referring to AC current.

$$I_{RMS} = \sqrt{\frac{(I_{accel}^2 \cdot T_{accel}) + (I_{@vel}^2 \cdot T_{@vel}) + (I_{decel}^2 \cdot T_{decel}) + (I_{settle}^2 \cdot T_{settle}) + \ldots}{(T_{accel} + T_{@vel} + T_{decel} + T_{settle} + \ldots)}}$$

Q. What is motor power duty cycle for a linear motor?
A. Duty cycle for a linear motor is different than for other types of systems. While it is defined as (time on) / (time on + time off) per cycle, in servo systems the motor can be on even when not in motion. Thus, for a servo motor, the duty cycle is based upon the time the motor is actually working (when current is applied) and NOT the percentage of time the motor is moving. It is possible for motor power duty to be 100 percent while the motor is not moving, or for the motor's motion duty to be nearly 100 percent with very low motor power duty.

Q. Do standard rotary motor electronics work with linear motors?
A. Yes they do. In most cases, the only differences between the two is the terms used in the software and manuals. For example, torque will become force; RPM will become velocity. A Nippon Pulse applications engineer would be happy to assist you in understanding the corresponding terms in your case.

Q. Can a Linear Shaft Motor be mounted vertically?
A. Yes, a linear motor provides the same performance when mounted vertically or horizontally. However, it is recommended that a vertically mounted Linear Shaft Motor be counterbalanced to reduce RMS and counteract the impact of gravity on the motion system.

Q. Can more than one forcer be used with a single shaft?
A. Yes, more than one forcer can be used in conjunction with a single shaft as long as the forcers do not physically interfere with each other. Two forcers may also be tied together and driven with one drive to double the output force.

Q. Are versions of the Linear Shaft Motor available for use in waterproof, vacuum or clean room environments?
A. Yes, the Linear Shaft Motor can be built for a variety of operating environments. To determine which Linear Shaft Motor is suitable for your application, contact an applications engineer to review your specifications.

Q. What are the advantages of the Linear Shaft Motor over a lead screw?
A. The advantages of the Linear Shaft Motor include higher velocities [>240 in/sec (>6 m/s)], non-wear moving part, free movement when power is off, no backlash because there are no mechanical linkages, easier alignments, and easier manufacturing.

Q. What is the MTBF (Mean Time Between Failure) for the Linear Shaft Motor?
A. The Linear Shaft Motor components operate in a passive manner when properly designed into your system. As such, there is no MTBF on the motor.

Any installation that causes any component of the motor to be active (example: flexing of supplied lead wires, using shaft or forcer as load-bearing member, etc.) is beyond the intended design of the Linear Shaft Motor. This will void the warranty and is done at your own risk.

With the proper settings, the Linear Shaft Motor will not wear out.

Q. In a tandem or parallel drive-application, do both motors need Halls?
A. In the case where both forcers are connected to the same drive, no; only one motor needs Hall effects. In an application where two forcers are connected to the same drive, the same phase of each forcer must be above a like magnetic pole in order to run. As such, only one set of Halls is needed by the servo drive.

In the case of each forcer being connected to separate servo drives that require Halls, yes; you will need Halls on both motors.

Q. In certain tandem forcer applications, why does one motor need to be physically flipped?
A. The physical flipping of one of the two forcers in a tandem configuration is sometimes used to reduce the overall footprint while maintaining the magnetic alignment of the two forcers.

Glossary

A

Abbe Error
Motion errors caused by angular moments between the measuring feedback element and the point of interest.

Abbe Offset
The linear distance between the measuring feedback element and the point of interest.

Absolute Move
A move referenced from a fixed zero position.

Acceleration
Change in velocity as a function of time, going from slower to faster.

Accereration Current
The current that can be applied for short periods of time for accelerating or decelerating. The peak current can be safely applied the Linear Shaft Motor for a maximum of 40 seconds, before the motor phases reach their maximum operating temperature when the ambient temperature is 25°C, the motor is not moving, and there is no additional heat sinking.

Accuracy
Difference between expected position and achieved position.

B

Back EMF
The peak phase-to-phase voltage generated when the motor is moving.

Backlash
The non-responsive lost motion between a drive screw and its nut that occurs at the point of change in rotation direction.

Brushless Servomotor
A class of servomotors, which operates using electronic commutation of phase currents rather than electromechanical (brushes) commutation.

C

Cantilevered Load
A load that has its center of mass offset from the balance point of a bearing system.

Closed Loop
Implementing feedback to regulated position and/or velocity with respect to commanded.

Cogging
Changes in force, caused by magnetic "detenting" forces created by relative motion between a motor's permanent magnets and a ferrous material. The ferrous material is attracted to the magnetic poles of the permanent magnets. Cogging appears as jerkiness, especially at low speeds.

Commutation
The switching sequence of drive voltage into motor phase windings necessary to ensure continuous motor movement. A brushed motor relies upon brush/bar contact to switch the windings mechanically. A brushless Linear Shaft Motor requires a device that senses forcer position information relative to the shaft, and then feeds that data to a drive, which determines the next switching sequence.

Commutation, Sinusoidal
The three phase currents applied to a motor closely follow the sine wave shape of the motor's natural back EMF waves, thereby providing the lowest velocity ripple and the smoothest possible motion. Sinusoidal commutation is electronically generated at the servo controller. This is a very important factor for scanning applications.

Commutation, Trapezoidal
The three phase currents applied to a motor resemble a 9-step profile. Slight force ripple is present due to the mismatch between the three phase trapezoidal shape and the motor's back EMF sine wave profile. Trapezoidal commutation is typically generated by Hall effect sensors secured near the motor's moving coils. Trapezoidal commutation is suitable for most high-speed motion applications.

Continuous Current
The current required to heat the motor phases to their maximum operating temperature when the ambient temperature is 25°C, the motor is not moving, and there is no cooling.

Continuous Force
Continuous force is the force produced when the continuous current is applied to the motor. It is the product of the force constant and the continuous current. The motor is not moving and there is no cooling.

Continuous Working Voltage
The maximum allowable continuous voltage between any two phases or between any phase and the motor safety earth.

Counts per Meter
Counts per Meter is equal to 1 divided by the encoder resolution
(Example for 50nm encoder:
Pulses per Meter = $1/(50*10^{-9})$=20,000,000)

Coefficient of Kinetic Friction (μ_k)
It is the proportional value of the force required to maintain motion to the normal force of the mass being moved.

Coefficient of Static Friction (μ_s)
It is the proportional value of the force required to overcome static friction to the normal force of the mass to be moved.

Cosine Error
The result of a parallel misalignment between a linear bearing system and the linear feedback element.

Current
The flow of electric charge through a medium. This charge is typically carried by moving electrons in a conductor such as wire. The SI unit for measuring the rate of flow of electric charge is the ampere, which is charge flowing through some surface at the rate of one coulomb per second.

Current/Torque Amplifiers
Current/Torque amplifiers produce a force proportional to the command signal. The speed with which the motor will move is therefore controlled entirely by the external servo controller.

D

Deceleration
Change in velocity as a function of time, going from faster to slower.

Duty Cycle, Motion
The percentage of the time in motion to the total time (motion time ÷ total time) x 100%.

Duty Motor Power
The percentage of the application process power to a motor's continuous power limits [$(I_{RMS} \div I_{Cont})^2 \times 100\%$]. This value should not exceed 100% for a prolonged period of time.

E

Electrical Time Constant
The time taken for a step current input to the motor to reach 63.2% of its value.

Encoder
A position-sensing device that translates mechanical motion into electronic signals used for monitoring position or velocity.

F

Flatness
The deviation from the theoretically perfect line of travel, and is measured as displacement in the vertical plane. (Note the frame or mounting surface to which the module or gantry system is fixed will affect the flatness of the system)

Friction
Resistance to motion of two surfaces that touch.

Force Constant
Force constant is the amount of force produced when 1 ampere flows through the motor.

Forcer
The coil assembly of the Linear Shaft Motor. It is typically available with one to eight sets windings (see Appendix A).

H

Hall Sensors
A feedback device, which is used in some brushless servo systems to provide information for the amplifier to electronically commutate the motor. In a Linear Shaft Motor, the Hall sensors detect the position of the forcer and send a signal to the driver to switch on the next sequential winding in the forcer, which causes linear movement.

Hysteresis
The non-responsive lost motion which may occur at the point of change in direction. The composite error results from many contributing factors (backlash, elasticity of structure, etc.).

I

Incremental Move
A move referenced from the current position.

Inductance
The property of an electric circuit by which an electromotive force is induced in it as the result of a changing magnetic flux. This electrical characteristic is an indicator of how fast the current can rise and fall when voltage is applied to the windings.

Inertia
The property of an element's mass and shape that resists changes in velocity when exposed to an outside force. The larger an object's mass, the greater its inertia and the greater the magnitude of force required to accelerate it at a given rate.

Intelligent Amplifiers
Servo amplifiers which do not require external control signals in order to position the motor. Depending on the unit, they can perform very simple point to point moves up to very sophisticated moves with external synchronization and I/O handling. Generally, they can operate in either position/velocity or force control modes.

L

Limits or Limit Switches
A sensor or switch which alerts the control electronics the physical end of travel is being approache. These are safety devices at each end of the movement to prevent damage due to over travel.

Linear Bearing
A support device that controls alignment and supports the load when two surfaces are loaded against each other.

M

Magnetic Pitch (Pole Pitch)
The length of one complete electrical cycle (between like magnetic poles). Example: North-to-North.

Maximum Phase Temperature
The maximum operating temperature for the motor phases. It is limited to provide a safe operating temperature for the coil.

O

Open Loop
A motion system which does not utilize a feedback element.

Orthogonality
The degree to which stages are aligned with their motion at right angles to one another. Motion of an X-Y system is typically 90° apart in a single plane. X-Y-Z systems are all mutually at a 90° relationship in a 3D space. The specification is typically the angle measured between the best-fit-straight-line of X-axis motion and the best-fit-straight-line of Y-axis motion.

P

Parallelism
The deviation between the perpendicular distance between axes (with one being the reference axis).

Peak Current
Maximum amount of current instantaneously applied to the motor.

Peak Force
The force produced when the peak current is applied to a motor. It is the product of force constant and peak current. The motor is not moving, there is no cooling and no additional heat sinking.

Pulses per Meter
Pulses per Meter is equal to 1 divided by the encoder resolution divided by 4 (Example for 50nm encoder:
Pulses per Meter = $[1/(50*10^{-9})]/4=5000000$)

Repeatability, Bi-directional
The error from nominal when repeatedly approaching a position from opposite directions.

Repeatability, Uni-directional
The error from nominal when repeatedly approaching a position from the same direction.

Resistance
The opposition to the flow of charge through a conductor.

Resonance
Oscillatory behavior in a mechanical body when subjected to a periodic force occurring at its natural frequency.

Resolution, Electrical
The smallest increment that can be commanded by a servo system. The value results from the feedback's precision (encoder, laser, etc.) and the controller's logic multiplication factor.

Resolution, Mechanical
The smallest increment that can be controlled by a motion system. The value is affected by friction, static friction, driving mechanism precision, etc.

S

Scale Error
Errors associated with the precision of the feedback elements.

Settling Time
The time it takes after a move completes to settle to within a specified tolerance band (ie. to within ±1μm).

Servo Driver
A brushless DC servomotor driver used to drive and control the position of a servomotor. There are many different makes and models of amplifiers available, but they tend to fall into one of three possible categories:

1. Intelligent amplifiers that have built in servo controllers
2. Velocity amplifiers capable of controlling only the velocity of the motor
3. Current/Torque amplifiers that control only the force of a linear motor (torque in a rotary motor)

Shaft
The magnetic assembly of the Linear Shaft Motor. It is typically a stainless steel tube and is not designed to be load bearing.

Straightness
The deviation from the theoretical perfect line of travel. It is measured as displacement in the horizontal plane.

Static Friction (Stiction)
Frictional resistance to initial motion.

T

Thermal Resistance
The ratio of the temperature rise of the motor as compared to the total power consumed. It is meaured in °C/W.

V

Velocity
A change in position as a function of time (speed).

Velocity amplifiers
Capable of controlling only the velocity of the motor.

W

Weight
The force of gravity acting on a body. Weight equals mass x acceleration due to gravity.

Working Envelope
The effective area available for the system to operate, without interfering with other parts of the system.

Y

Yaw
Angular motion of a linear stage, about an axis which is between to the bearing system and which is at right angles to the direction of travel.

Appendix A

A typical Linear Shaft Motor consists of one forcer plus one magnet shaft. In a given Linear Shaft Motor series the magnet shafts are compatible with all forcer coil models. Note that the effective motor travel length is track length minus coil length. Non-standard shaft lengths are available in 1mm increments.

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

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

# of Forcers (XX): Two or more forcers

Options:

Blank	Standard
FO	Forcer Only
SO	Shaft Only

Options:

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

Usable Stroke:

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

Parallel Option:

Blank	Standard
PL	Parallel Motors

Forcer Size (A):

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

Shaft Size (D):

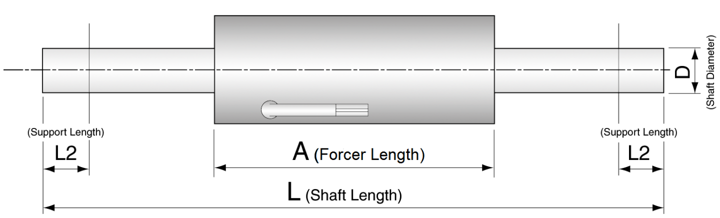
XX	Shaft diameter in mm x10

S / L:

S	Standard Air Gap
L	Large Air Gap

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

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

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

You can order the Linear Shaft Motor from Nippon Pulse directly at:
4 Corporate Dr.
Radford, VA 24141, USA
Phone: 1-540-633-1677
E-mail: info@nipponpulse.com
Web: http://www.nipponpulse.com

Appendix B

Selection guide for Linear Shaft Motor

One of the most straightforward 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 that is required by the mechanical design. This often the most overlooked aspect of a linear motion system design. Making the motor the most costly aspect of the system, is not only from the perspective of the initial purchase cost but also from the aspect of service maintenance and energy costs.

The unique properties of the Linear Shaft Motor make its sizing for applications slightly different than that of other linear motors. Nevertheless, the proper sizing of a Linear Shaft Motor is rather straightforward. 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.

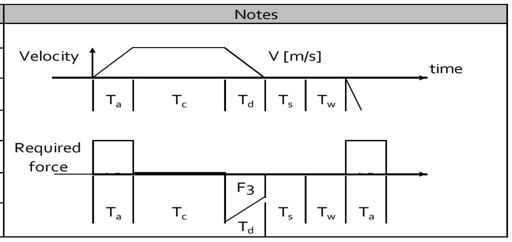
1. Operation Condition

Item	Symbol	Value	Unit	Notes
Load mass	M_L		Kg	Mass of the moving part of your system less the mass of the motor.
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.
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.
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	

Example: Table, Encoder
Example of use: As the motor moves, it needs to maintain 10 lbs of force on an object.
Example: Cable Chain, Bearing wipers, Preloaded Guide, springs

Next is to define what motion if any your system will be making.

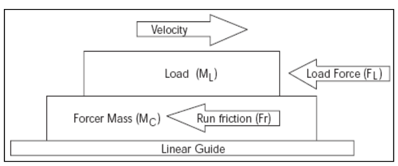
2. Motion Profile

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 that for the best sizing of a Linear Shaft Motor, a complete cycle should be used for sizing. Stroke out and back. The NPA SMART sizing software allows for sizing with up to 6 segments.

3. Selection Flow

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 (F_C) are run friction and treated as load force.
   For your initial calculations, it is suggested that you use 1/10 the load mass, as the value for Forcer mass (M_C).



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. "α" is the angle of incline. For Vertical or incline moves use Fr for against gravity moves and Frd for with gravity moves.

F_i	Force (Inertia)	$F_i = (M_L + M_C) * (V / T_a)$
F_f	Force (Friction)	$F_f = (M_L + M_C) * g * [\sin(\alpha) + \mu * \cos(\alpha)] + F_r$
F_{fd}	Force (Friction) down	$F_{fd} = (M_L + M_C) * g * [\sin(\alpha) + \mu * \cos(\alpha) * -1] + F_r$

F1	acceleration force	$F1 = Fi + F_L + F_r$	Inertia force + external force
F2	continuous force	$F2 = F_L + F_f$	load of external force
F3	deceleration force	$F3 = Fi -(F_L + Fr)$	inertia force - external force
F4	dwell force	$F4 = (M_L + M_C) * g * [\sin(\alpha)] +FL$	

3. Temporary selection
   The largest thrust value calculated in section 2, must be less then 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 that M_C (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 M_C value.

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. motor whose the rated force (Frated) is met in the equation.

$$F_{eff} = \sqrt{\frac{(F1^2 * T_a) + (F2^2 * T_c) + (F3^2 * T_d) + (F4^2 * \{T_s + T_w\})}{(T_a + T_c + T_d + T_s + T_w)}}$$

Useful formulas

Amplifier Sizing

Voltage due to Back EMF	V_{BEMF} = Back EMF x Velocity
Voltage due to R x I	V_{ri} = 1.225 x Resistance x Peak Current
Voltage due to Inductance	$V_L = \frac{7.695 \text{ x velocity x inductance x peak current}}{\text{Magnetic pitch}}$
Minimum bus voltage needed in application	$V_{bus} = 1.15 \{(V_{BEMF} + V_n)^2 + V_L^2\}$
Peak Current (rms value)	I_{pmrs} = Peak Current x 1.2
Continuous current (rms value)	I_{Crms} = Continuous current x 1.2
These formulas add a 20% safety margin for current and a 15% safety margin for voltage	

Encoder

Encoder resolution	$E_r = \frac{\text{Scale Pitch}}{\text{4 x Interpolation}}$
Encoder output frequency (A-B phase)	$E_{OF} = \frac{\text{Velocity x } 10^6}{\text{4 x Encoder resolution}}$
Encoder output frequency (sine - cosine)	$E_{OF} = \frac{\text{Velocity x } 10^6}{\text{Scale Pitch}}$
Encoder pulses per meter	$E_{lm} = \frac{1}{\text{Encoder resolution}} /4$
Encoder counts per meter	$E_{OF} = \frac{\text{Velocity x } 10^6}{\text{Scale Pitch}}$
Encoder lines per meter	$E_{OF} = \frac{\text{Velocity x } 10^6}{\text{4 x Encoder resolution}}$

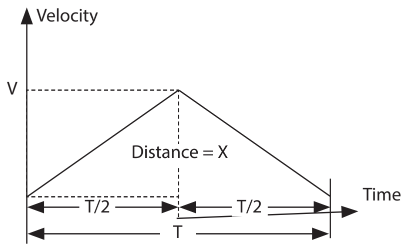
Conversions

Force			
newton	to	pound force	0.2248
newton	to	gram force	101.97
newton	to	ounce force	3.5969
pound force	to	newton	4.4482
gram force	to	newton	0.0098
ounce force	to	newton	0.2780
Length			
mm	to	inch	0.0394
mm	to	foot	0.0033
mm	to	cm	0.1
micron	to	inch	0.00003937
nanometer	to	inch	0.00000003937
meter	to	foot	3.2808
inch	to	mm	25.4
foot	to	mm	304.8
cm	to	mm	10
foot	to	meter	0.3048
inch	to	micron	25,400
inch	to	nanometer	25,400,000
Temperature			
C	to	F	1.8 then +32
F	to	C	-32 then /1.8

Mass			
kilogram	to	pound	2.2046
kilogram	to	gram	1,000
kilogram	to	ounce	35.274
pound	to	kilogram	0.4536
gram	to	kilogram	0.0010
ounce	to	kilogram	0.0283
Velocity			
mm/sec	to	inch/sec	0.0394
m/sec	to	inch/sec	39.370
inch/sec	to	mm/sec	25.4
inch/sec	to	m/sec	0.0254
mm/sec	to	m/sec	0.001
m/sec	to	mm/sec	1,000
Acceleration			
g	to	m/sec^2	9.8067
g	to	mm/sec^2	9806.7
g	to	$inch/sec^2$	386.09
g	to	$foot/sec^2$	32.144
m/sec^2	to	g	0.1020
mm/sec^2	to	g	0.0001
$inch/sec^2$	to	g	0.0026
$foot/sec^2$	to	g	0.0311

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.

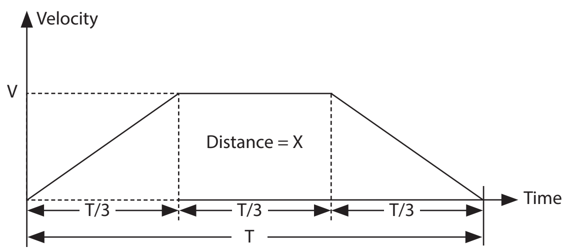


Solve for \ Have	X (m) T (sec)	V (m/sec) T (sec)	A (m/sec^2) T (sec)	A (m/sec^2) V (m/sec) X (m)
Distance X (m)		X = (1/2) * V * T	X = (1/4) * A * T^2	X = V^2/A
Velocity V (m/sec)	V = 2 * (X/T)		V = (A*T)/2	V = √A * X
Acceleration A (m/sec2)	A = 4 * (X/T^2)	A = 2 * (V/T)		A = V^2/X

Trapezoidal Profile

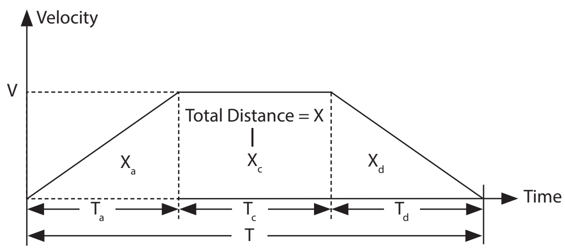
Accelerate to constant speed, travel at that constant speed, and then decelerate back to original speed or zero. This is common in applications such as scanning inspection. There are two types:

1/3rd Trapezoidal Profile 1/3, 1/3, 1/3



Solve for \ Have	X (m) T (sec)	V (m/sec) T (sec)	A (m/sec^2) T (sec)	A (m/sec^2) V (m/sec) X (m)
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 = √(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



Solve for \ Have	X (m) T (sec)	V (m/sec) T (sec)	A (m/sec^2) T (sec)	A (m/sec^2) V (m/sec) X (m)
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 = √(2 * A)/X
Acceleration A (m/sec2)	A = (2 * X)/T^2	A = V/T		A = V^2/(2 * X)

Motor Sizing Example

Assume you want to move horizontally a mass of 6kg point to point for a distance of 100mm (X) in 160msec including settling time (T_m) to +/- 1 micron. Total travel is 400mm with a dwell time of 200msec needed after each move.

Move Profile

We will assume an estimated settling time of 10msec (T_s).
So 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/sec^2 (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	α	0	°
Available Voltage	V	120	Vac
Available Current	I	7	Amp_{rms}
Max. Allowable Temperature		110	°C

Item	Symbol	Value	Unit
Stroke	X	100	mm
Velocity	V	1	m/s
Acceleration Time	T_a	0.05	s
Continuous Time	T_c	0.05	s
Deceleration Time	T_d	0.05	s
Settling Time	T_s	0.01	s
Waiting Time	T_w	0.2	s

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_{ta} (N) = 178 + 20.4 = 198.4N
Total Constant Velocity Force	F_{tcv} (N) = 20.4N
Total Deceleration Force	F_{td} (N) = 178 – 20.4 = 157.6N
Total Dwell Force	F_{tdw} (N) = 0N
RMS Force	F_{rms} (N) = √[{198.4^2*0.05)+(20.4^2*0.025)+(157.6^2*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 Back 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 + 4.23] = 118.8Vac

More information on Linear shaft motor sizing can be found in the "Linear Shaft Motor sizing Application Note" and accompanying "LSM Sizing Example" Excel file.

Appendix C

Any three-phase brushless servomotor drive can drive the Linear Shaft Motor. There are many different makes and models of servomotor drives available, but the ones listed below have been tested by Nippon Pulse, the driver manufacturers, and/or Nippon Pulse customers.

When selecting a servomotor drive, always confirm it is compatible with your controller and feedback system. 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 drive.

The following servo drives have been tested and certified by their respective manufacturers to work with the Linear Shaft Motor series of products.

Manufacturer	Model(s)	Hall Required
Elmo Motion Control	BAS, CEL, COR, HAR, TUB, TWE, WHI (All SimplIQ Digital Drives)	NO
Hitachi	AD Series	NO

The following servo drives have been tested by their respective manufacturers to work with the Linear Shaft Motor series of products.

Manufacturer	Model(s)	Hall Required
ADVANCED Motion Controls (AMC)	DigiFlex® Performance™ series digital drivers (DPC,DPQ, DPR and DZ), DPRALTE-015B200	NO
G.E. Fanuc	*contact Fanuc for more information	
Panasonic	A4L, A5, A5L	
Performance Motion Devices (PMD)	ION	
Teknic	All 5, 6, and 7-series Eclipse	Recommended
Yaskawa	Sigma FSP	NO

The following servo drives have been tested by customers and are reported to work with the Linear Shaft Motor series of products.

Manufacturer	Model(s)	Hall Required
Allen-Bradley	Ultra 3000 servo drives, K300, K350, K6000	YES
Baldor	Mint, Flex drives	
Beckhoff	AX2003-B110-00z	NO
Copley	Xenus, Xenus Jr, Accelnet	NO
Delta Tau	P-MAC, U-MAC	NO
Emerson	Digitax, UniDrive SP	NO
Emerson	EP	YES
Technosoft	All manufactured drives	Recommended
Kollmorgen	S200, S300, S600, CD drives	NO
Parker	Compax3	NO
Servoland	SVDM 40P, SVDM 2P, SVDM 5P	NO

CE DECLARATION OF CONFORMITY

We, GMC HILLSTONE CO., LTD., 4466-1, Daimyojin, Tomizawa, Mogami-machi, Mogami-gun, Yamagata 999-6105 Japan, declare in our sole responsibility that the following product conforms to all the relevant provisions.

Product Name : Shaft Motor

Models Covered :
S080D followed by D, T or Q
S120D followed by D, T or Q
S160D followed by D, T or Q
S200D followed by T or Q
S250D followed by D, T, Q, H or X
S320D followed by D, T, Q or X
S427D followed by D, T or Q
S350P

Applicable Standards : EN60034-1 (1998)

Year to begin affixing CE Marking : 2005

Signature: Yoichi Ishiyama
Full Name: Yoichi Ishiyama
Position: President

Date: 28 December 2005

Nippon Pulse

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.

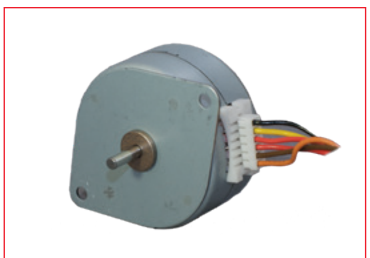
INDUSTRIES WE SERVE

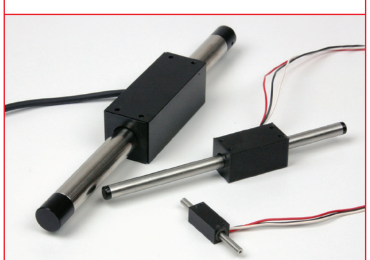
Automation
Bio-Medical & Medical
Equipment Manufacturing
Instrumentation
Machine Tooling
OEM
Packaging
Pharmaceutical
Photonics
Semiconductor

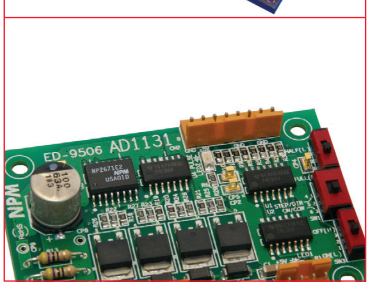
Your Partner in Motion Control

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.

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.

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