

1. Linear Motor

A linear motor or linear induction motor is an alternating current (AC) electric motor that has had its stator "unrolled" so that instead of producing a torque (rotation) it produces a linear force along its length. The most common mode of operation is as a Lorentz-type actuator, in which the applied force is linearly proportional to the current and the magnetic field ($F = qv \times B$).

Many designs have been put forward for linear motors, falling into two major categories,

- i) low-acceleration and
- ii) high-acceleration linear motors.

Low-acceleration linear motors are suitable for maglev trains and other ground-based transportation applications. **High-acceleration** linear motors are normally quite short, and are designed to accelerate an object up to a very high speed and then release the object, like roller coasters.

They are usually used for studies of hypervelocity collisions, as weapons, or as mass drivers for spacecraft propulsion. The high-acceleration motors are usually of the linear induction design (LIM) with an active three-phase winding on one side of the air-gap and a passive conductor plate on the other side. The low-acceleration, high speed and high power motors are usually of the linear synchronous design (LSM), with an active winding on one side of the air-gap and an array of alternate-pole magnets on the other side. These magnets can be permanent magnets or energized magnets. The Transrapid Shanghai motor is an LSM.

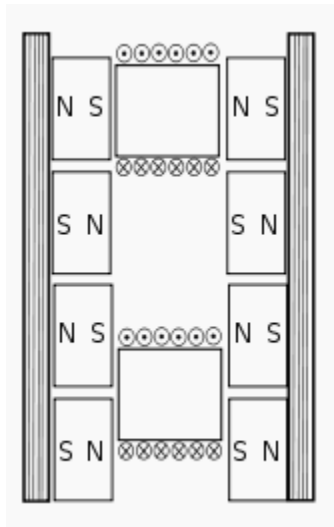
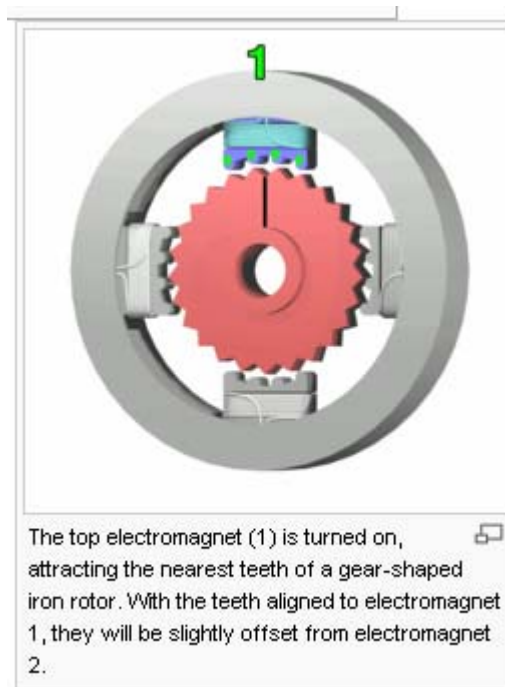


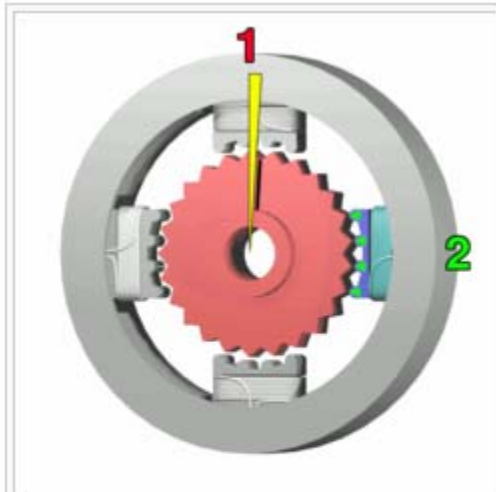
Fig. 1 U-channel linear motor

2. Stepper motor

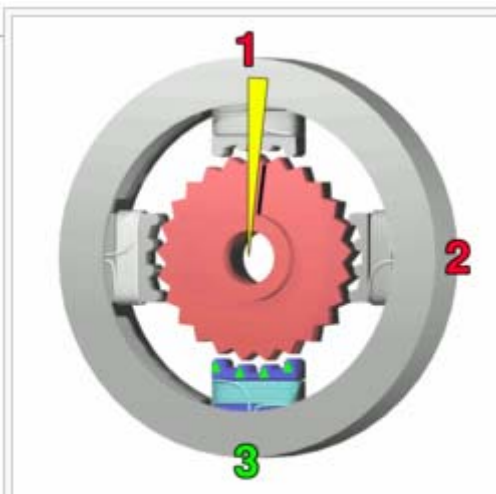
A stepper motor (or step motor) is a brushless, synchronous electric motor that can divide a full rotation into a large number of steps. The motor's position can be controlled precisely, without any feedback mechanism (see open loop control). Stepper motors are similar to switched reluctance motors (which are very large stepping motors with a reduced pole count, and generally are closed-loop commutated.)

Because of power requirements, induction of the windings, and temperature management, motors cannot be powered directly by most digital controllers. Some circuitry that can handle more power — a motor controller such as an H-bridge — must be inserted between digital controller and motor's windings. The above image shows the basic circuit of a motor controller that can also sense motor current. The circuitry to control one winding of a motor is shown; a stepper motor would use a circuit that could control four windings, and a normal DC motor would need circuitry to control two windings. All of this circuitry is typically incorporated in an integrated H-bridge chip.

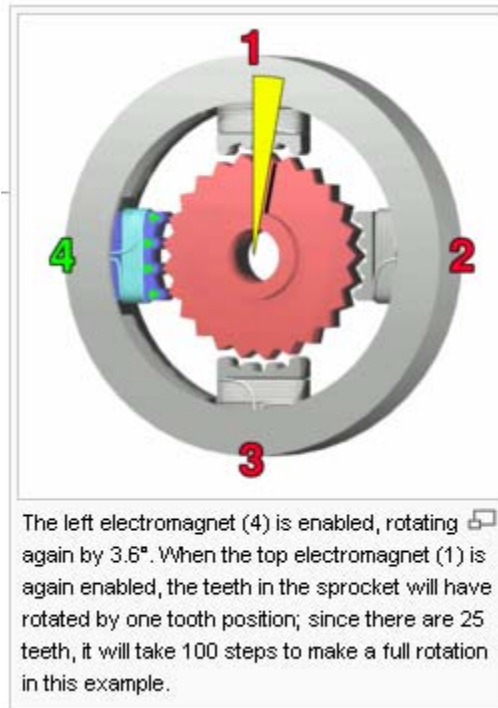




The top electromagnet (1) is turned off, and the right electromagnet (2) is energized, pulling the nearest teeth slightly to the right. This results in a rotation of 3.6° in this example.



The bottom electromagnet (3) is energized; another 3.6° rotation occurs.



The bottom electromagnet (3) is energized; another 3.6° rotation occurs. The left electromagnet (4) is enabled, rotating again by 3.6° . When the top electromagnet (1) is again enabled, the teeth in the sprocket will have rotated by one tooth position; since there are 25 teeth, it will take 100 steps to make a full rotation in this example.

2.1 Fundamentals of Operation

Stepper motors operate differently from normal DC motors, which rotate when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor shaft turn, first one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are thus aligned to the first electromagnet, they are slightly offset from the next electromagnet. So when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a "step," with an integral number of steps making a full rotation. In that way, the motor can be turned by a precise angle.

2.2 Stepper motor characteristics

Stepper motors are constant power devices. As motor speed increases, torque decreases. The torque curve may be extended by using current limiting drivers and increasing the driving voltage.

Steppers exhibit more vibration than other motor types, as the discrete step tends to snap the rotor from one position to another. This vibration can become very bad at some speeds and can cause the motor to lose torque. The effect can be mitigated by accelerating quickly through the problem speed range, physically damping the system, or using a micro-stepping driver. Motors with a greater number of phases also exhibit smoother operation than those with fewer phases.

2.3 Open-loop versus closed-loop commutation

Steppers are generally commutated open loop, ie. the driver has no feedback on where the rotor actually is. Stepper motor systems must thus generally be over engineered, especially if the load inertia is high, or there is widely varying load, so that there is no possibility that the motor will lose steps. This has often caused the system designer to consider the trade-offs between a closely sized but expensive servomechanism system and an oversized but relatively cheap stepper.

A new development in stepper control is to incorporate a rotor position feedback (eg. an encoder or resolver), so that the commutation can be made optimal for torque generation according to actual rotor position. This turns the stepper motor into a high pole count brushless servo motor, with exceptional low speed torque and position resolution. An advance on this technique is to normally run the motor in open loop mode, and only enter closed loop mode if the rotor position error becomes too large -- this will allow the system to avoid hunting or oscillating, a common servo problem.

2.4 There are three main types of stepper motors:

- Permanent Magnet Stepper
- Hybrid Synchronous Stepper
- Variable Reluctance Stepper
- Two-phase stepper motors

There are two basic winding arrangements for the electromagnetic coils in a two phase stepper motor: bipolar and unipolar.

Unipolar motors

A unipolar stepper motor has logically two windings per phase, one for each direction of magnetic field. Since in this arrangement a magnetic pole can be reversed without switching the direction of current, the commutation circuit can be made very simple (eg. a single transistor) for each winding. Typically, given a phase, one end of each winding is made common: giving three leads per phase and six leads for a typical two phase motor. Often, these two phase commons are internally joined, so the motor has only five leads.

Bipolar motor

Bipolar motors have logically a single winding per phase. The current in a winding needs to be reversed in order to reverse a magnetic pole, so the driving circuit must be more complicated, typically with an H-bridge arrangement. There are two leads per phase, none are common.

A step motor can be viewed as a synchronous AC motor with the number of poles (on both rotor and stator) increased, taking care that they have no common denominator. Additionally, soft magnetic material with many teeth on the rotor and stator cheaply multiplies the number of poles (reluctance motor). Modern steppers are of hybrid design, having both permanent magnets and soft iron cores.

Applications

Computer-controlled stepper motors are one of the most versatile forms of positioning systems. They are typically digitally controlled as part of an open loop system, and are simpler and more rugged than closed loop servo systems.

Industrial applications are in high speed pick and place equipment and multi-axis machine CNC machines often directly driving lead screws or ballscrews. In the field of lasers and optics they are frequently used in precision positioning equipment such as linear actuators, linear stages, rotation stages, goniometers, and mirror mounts. Other uses are in packaging machinery, and positioning of valve pilot stages for fluid control systems.

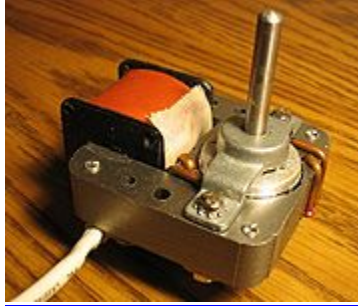
Commercially, stepper motors are used in floppy disk drives, flatbed scanners, computer printers, plotters and many more devices.

3. Shaded-pole motor

A shaded-pole motor is a type of AC single-phase induction motor. As in other induction motors the rotating part is a squirrel-cage rotor. All single-phase motors require a means of producing a rotating magnetic field for starting. In the shaded-pole type, a part of the face of each field pole carries a copper ring called a shading coil. Currents in this coil delay the phase of magnetic flux in that part of the pole enough to provide a rotating field. The effect produces only a low starting torque compared to other classes of single-phase motors.

These motors have only one winding, no capacitor nor starting switch, making them economical and reliable. Because their starting torque is low they are best suited to driving fans or other loads that are easily started. Moreover, they are compatible with triac-based variable-speed controls, which often are used with fans. They are built in power sizes up to about 1/6 hp or 125 watts output. For larger motors, other designs offer better characteristics.

The first photo is of a common C-frame motor. With the shading coils positioned as shown, this motor will start in a clockwise direction as viewed from the long shaft end. The second photo shows detail of the shading coils.



Small shaded-pole motor



Shading coils

4.1 Amplydynes and Metadyne

A Metadyne is an electrical machine with three, or more, brushes. It can be used as an amplifier or rotary transformer. It is similar to a third brush dynamo but much more complex, having additional regulator or "variator" windings. The technical description is "a cross-field direct current machine designed to utilize armature reaction". A metadyne can convert a constant-voltage input into a constant current, variable voltage, output.

Metadynes have been used to control the aiming of large guns and for speed control in electric trains, e.g. London Underground O Stock. The equipment in the latter case weighed three tons.

Amplydyne

An amplidyne is an electromechanical amplifier invented during World War II by Ernst Alexanderson

Synchro

Early systems just moved indicator dials, but with the advent of the amplidyne , as well as motor-driven high-powered hydraulic servos.

Source: www.en.wikipedia.org