ABEC - U.S. standards that define tolerance classes for major dimensions and characteristics of steel ball bearings. Normal ABEC ratings are single digit odd numbers from 1-9. ABEC 1 has the loosest tolerances and ABEC 9 has the closest tolerances. Here are also special cases where the ABEC number is followed by a letter to define special requirements. ABEC ratings do not specify radial clearance of a bearing.

Acceleration/Angular Acceleration - The time rate of the change of velocity. The rotor will accelerate due to the torque developed within the motor. Rotor inertia and load will resist the torque and decelerate the system.

Accuracy - The measure of difference between the expected angular shaft position and the actual angular shaft position of a motor.

A wheel of radius $R = 28.2$ cm, mass $M = 2.11$ kg, and moment of inertia $I$ is mounted on a frictionless, horizontal axle as in the figure. A light cord wrapped around the wheel supports an object of mass $m = 0.504$ kg. Calculate the angular acceleration of the wheel, the linear acceleration of the object, and the tension in the cord.

Ampere - Unit of electrical current equal to one coulomb per second.

Ampere-turns - Unit of magneto-motive force. It is proportional to how much torque can be generated from a motor.
**AmpsPeak** - Maximum value of the current waveform being provided to the motor from the driver/controller. The peak amplitude is equal to 1.414 times the root mean square amplitude.

**Amps/Phase** - The root mean square amplitude of current provided by the driver/controller. This is a statistical measurement of the current magnitude when the values are always changing, and tells how much current each winding can handle without heating up and burning the motor. This is equal to the rated current for the motor.

**Angular transmission error** - The difference between the actual angular position and the theoretical angular position of the motor or gears.

**Angular velocity** - Rate of change of angular position of a rotating object. The units are radians per second.

**Automation** - The use of automated equipment to manufacture or produce a product.

**Axial Play** - The shaft displacement due to an axial force on the end of the shaft. Also called end play.

**AWG** - American Wire Gauge, quantifies the wire thickness of the windings.
**Back EMF** - The voltage produced across a winding due to its interaction with the rotating magnetic field generated by the rotor’s motion.

**Back curve** - The second quadrant portion of the hysteresis loop generated when intrinsic induction is plotted against an applied field, which is mathematically related to the normal curve; most often used to determine the effects of demagnetizing or magnetizing fields.

**Backlash** - The amount of space between the gear teeth that exceeds the width of the engaging gear tooth. This value is measured at the operating pitch circle of the gears.

**Bearing** - Assembled inside the motor and supports the motor shaft for smooth rotation with little friction or wearing.

**Bipolar Chopper Driver** - A step motor driver that uses a switch mode (chopper) technique to control motor current and polarity. Bipolar indicates the capability of providing motor phase current of either polarity. (+ or -). Bipolar drives can be used with 4, 6, or 8 lead motors.

**Bipolar driver** - A driver that is designed for use with a bipolar motor. It can change the direction of the current going into the motor without changing the wiring.

**Bipolar motor** (4 lead wires) – A motor with a bipolar winding. Can be wound in series or parallel depending on torque and speed requirements of the motor.

**Bipolar winding** - One winding per phase. To switch direction of a bipolar wound motor, the current must be reversed by the driver.

**Breakaway Torque** - The torque required to start a machine in motion. Breakaway torque is almost always greater than running torque.
Step Motor Glossary

**Center tap** - Used with unipolar windings. The center tap provides a common power source to the two wires in a bifilar winding, and is where power enters the coils in a unipolar winding. The center taps are shown as A COM and B COM.

**Chopper Drive** – A step motor drive that uses switching amplifiers to control motor current. Chopper drives are more efficient than L/R drives or voltage drives. A chopper drive applies voltage to a winding until a predetermined current is achieved. The voltage is shut off once the current is reached and not turned on until the current decays to a predetermined value. Chopper drives are also known as Constant current drives or PWM drives.

**Class B Insulation** – A NEMA insulation specification. Class B insulation is rated for an operating temperature of 130 degrees C.

**Class F Insulation** – A NEMA insulation specification. Class F insulation is rated for an operating temperature of 155 degrees C.

**Class H Insulation** – A NEMA insulation specification. Class H insulation is rated for an operating temperature of 180 degrees C.

**Closed loop system** – A broadly used term, relating to any system in which the output is measured and compared to the input. The output is then adjusted to reach the desired condition. In motion control, the term typically describes a system utilizing a velocity and or position.

**Cogging** – A term used to describe non-uniform angular velocity. Cogging appears as a jerkiness especially at low speeds.

**Commutation** – A term that refers to switching voltage or current to the proper motor phases to produce rotation and torque.

**Constant current drive** – Also known as chopper drive. It generates a constant current in each winding instead of supplying a constant voltage. Initially, a high voltage is applied to a winding so the current will rise quickly, then when the current exceeds a preset value the voltage is shut off. (Continued next page)
(Continued from previous page)

current limit, the voltage is switched off. When the current gets below a preset limit, the voltage is switched on again. This allows step motors to be run at higher speeds with higher torque.

**Constant Voltage Drive** – A driver that maintains a constant voltage applied to the windings. The flow of current is limited only by the resistance/impedance of each winding.

**Controller** - A device or circuit that generates a DC pulse train that is sent to the step motor drive. The number and rate of pulses is determined by the number and rate of steps the motor will ultimately execute. A typical controller consists of a DC power supply plus.

**Controller/driver** - A combined controller and driver that can be wired to a motor to provide commands and drive the motor from the same device.

**Copper Loss** – One of the major causes of motor heating. Current flowing through the motor winding produces losses which are approximately proportional to $I^2 \times R$. where $I$ is the motor phase current, $R$ is the motor phase resistance.

**Current** - The flow of charge through the step motor windings.

**Current rise time** - The amount of time it takes for the current to go from 10% to 90% of its final value.
**Damper** - A device used on a stepper motor to suppress step oscillations and prevent resonances.

**Demagnetization Current** - The current level at which the motor magnets will start to be demagnetized. This is an irreversible effect, which will alter the motor characteristics and degrade performance.

**Detent Torque** - While all phases are de-energized, a periodic torque ripple occurs due to the tendency of the rotor and stator poles aligning themselves into positions of minimal reluctance.

**Detent Position** - The static angular position in which the rotor of an unloaded and un-energized stepper motor comes to rest.

**Discrete motion** - Motion in discrete angular movements.

**Displacement** - For stepper motors, this is the angular displacement in degrees of the rotor being rotated around the rotor axis.

**Drive/Driver** - An electrical device that powers a stepper motor based on pulses from a controller, computer, or pulse generator. It converts the digital signal received to electric current pulses and drives them to the appropriate motor windings.

**Duty Cycle** - Ratio of on time to total cycle. Normally expressed as percentage. The following formula will calculate the duty cycle as a percentage. Duty cycle (%) = [on time] / (on time + off time) x 100%.

*Example 1*: a motor that runs continuously has a 100% duty cycle.

**Dynamic Torque** - The maximum torque that can be applied to a motor before it stalls or loses synchronization. The maximum dynamic torque of a stepper motor is about 30% less than the holding torque. The dynamic torque also depends on the speed of the motor, and decreases as the motor speed increases. This is the torque represented on a Torque-Speed Curve.
**Eddy Current** - Current that is generated in a transformer due to induced voltage in each lamination. It is proportional to the square of the lamination thickness and to the square of the frequency.

**Efficiency** - The ratio of power output to power input, typically given as a percentage.

**Electromotive Force (EMF)** - Voltage generated by a time varying magnetic field that induces an electric current.

**Electronic Time Constant** - The time needed for a motor's windings to charge to 63% of their rated current value.

**Encoder** - An electromechanical feedback device that monitors position and/or velocity by translating mechanical motion into electronic signals and feeding those values back to the controller.

**End Cap** - A component designed to cover the windings and in most cases position a bearing in relationship to the stator in a step motor. Also known as bearing bracket or end bell.

**End Play** - See axial play

**End taps** - The lead ends that terminate a winding. They are used to connect a motor to an application, and with 8 leads, can be wired together to create a parallel or series winding.

**Energize/excite** - To send current through a phase or phases of a step motor.

**Engraving and printing** - An industry that depends on the use of stepper motors on multiple axes to print or engrave using many different mediums and techniques.
Feedback – The process of sending the measured output of a system (i.e., speed or position of a motor) back to the controller for comparison with the input during closed loop operations.

Flux path - Direction of magnetic field lines. In a step motor, the energized flux path is three-dimensional, and is what causes the motor torque.

Force - The mass of an object multiplied by its acceleration. It is the push or pull on an object with respect to its size and movement, and is the capacity to do work or cause a physical change.

Friction (coulomb) - A resistance to motion between non-lubricated surfaces. This force remains constant with velocity.

Friction (viscous) - A resistance to motion between lubricated surfaces. This force is proportional to the relative velocity between the surfaces.

Full Step Angle - The size of an incremental move made by a step motor determined solely by the motor’s construction. Also known as step angle.

Full Stepping - A method of driving a step motor in which each incremental movement is equal to the motor’s full step angle.

For more information, Please click here.

RESOURCES

How To Use Microstepping To Get More Torque
A Fair Comparison Reveals some Surprises

For more information, Please click here.
**Gearbox** – Allows amplified output torque from a motor depending on the gear ratio, but requires an increased motor speed. The ratio of gearbox torque output to motor torque output is the inverse ratio of the gearbox speed to the motor speed. Therefore, if the gearbox increases the motor torque by 5 times, the gearbox output speed will be 5 times less than the motor speed.

**Gearbox ratio** - The ratio of the pitch diameters of two meshing gears, or the ratio of the numbers of teeth. This is the multiplier for gearbox torque output, and the divider for gearbox speed output with respect to the motor torque and motor speed.

**Gravitational operation** - A vertical driven load using a stepper motor and pulley system.

**Spur and Planetary Available**
- Available in multiple ratios
- Available for NEMA 17 and NEMA 23

**NEW!**
**Slim Planetary Gearbox**
- High efficiency
- Shortest Planetary Gear box
- 5:1 gear ratio
- Cost effective
- Standard NEMA 17 Mount
- Powder Metal Gears
**Half Stepping** - Driving a stepper motor in increments equal to half the motor's full step angle. It is done by alternating the amount of current sent to the motor's phases.

**Hall sensor (BLDC)** - Sensors inside BLDC motors that directly measure the rotor position based on the production of a voltage difference across an electrical conductor.

**Heatsink** - A component designed to lower the temperature of an electronic device by dissipating heat into the surrounding air.

**Henry** - The SI unit of inductance. It is equal to the electromotive force of one volt in a closed circuit with a rate of change of one ampere per second.

**Hold current** - The minimum current which must pass through the device in order for it to remain in the ‘ON’ state after a coil is energized.

**Holding Torque** - The maximum torque that can be externally applied to a stopped, energized motor without causing the rotor to rotate continuously.

**Hysteresis (positional)** - The difference between step positions when moving CW and the step position when stepping CCW. A step motor may stop slightly short of the true position, thus creating a slight difference in position CW to CCW.

**Hybrid Motor** - A stepper motor that uses a permanent magnet rotor and variable reluctance stator.
**Inaccurate Stepping** - When the motor step error does not meet mechanical or electrical tolerances and causes inaccuracies in stepping. This can be due to phase imbalance in inductance, pole or rotor misalignment, inconsistent air gap between the rotor and stator, stator and tooth relationship, and torque stiffness.

**Indexer** - Electronic device which converts motion commands into pulse and direction signals for use by a step motor.

**Inductance (mutual)** - When two coils are kept close to each other and a varying current flows through one, the intensity of the magnetic field due to the current will vary. Hence flux through the other coil will keep on changing with time producing an EMF. This process is called mutual-induction and is measured in units of Henrys [H].

**Inductance (self)** - The property of an electric conductor or circuit that causes an electromotive force (emf) to be generated by a change in current flowing. The emf causes an opposing current to be generated in the wire, which slows the incoming current flow. The inductance is proportional to the number of turns per coil squared. Low inductance motors will run better at fast speeds whereas high inductance motors will work better at low speeds.

**Inertia** - The property of an object to resist change in velocity unless acted upon by an outside force. Higher inertia loads require larger torques to accelerate and decelerate. Inertia is dependent on the mass and shape of the object.

**Inertial Match** - For most efficient operation, the system coupling ratio should be selected so that the reflected inertia of the load is equal to the rotor inertia of the motor.

**IP rating** - Stands for Ingress Protection rating, and is a system of environmental protection rating where the first number represents protection against dust/exposure to solids (0 to 6), and the last number represents protection against liquids (0 to 8). For example, our IP65 motor is 100% dust resistant and protected against low pressure jets of water, and our IP X7 motor is not protected against dust, but is submersible in water for up to 30 minutes.

**Iron Loss** - The power loss in a motor due to hysteresis and eddy current losses. It is one of the major causes of motor heating, and is confined mainly to the laminated core of the stator and rotor.

**ITAR** - International Traffic in Arms Regulations. This is a set of government regulations that control importing and exporting defense related articles and services on the United States Munitions List.
Lead - A wire of the stepper motor that is internally connected to the motor phase windings and externally connected to the driver output terminals.

Leadscrew - A screw used as a linkage in a machine, to translate turning motion provided by stepper motor in to linear motion.

Linear Actuator –
An actuator that creates motion in a straight line.

Linear motion (Force)-
Motion along a straight line. The force is one dimensional.

Lin Engineering - A Reputation of Excellence in Step Motor Manufacturing and Service. Lin Engineering has earned the reputation as the technical leader in step motor design with the ability to “Maximize Torque at Desired Speed”.

President Ted T. Lin is one of the foremost step motor designers in the industry. In 1984, Warner Electric named him “Father of New Step Motor Technology” at their Motion Control System Division, where he directed the design of the step motors for early disk drive applications.

L/R drive - A drive that uses external resistance to allow a higher voltage than that of a voltage drive. L/R drives have better performance than constant voltage drives, but less performance and efficiency than a chopper drive. L is for inductance and R is for resistance.
Magnetic Flux - A measure of the quantity of magnetism, being the total number of magnetic lines of force passing through a specified area in a magnetic field.

Mass - The quantity of matter in an object. The SI unit of mass is kilograms.

Mechanical Damper - A vibration reducing device that is physically attached to a stepper motor.

Medical Industry - The medical device industry is considered a hub of innovation for good reason; with constantly improving designs and processes, the possibilities seem endless. Over the past 20 years, stepper motors from Lin Engineering have played a role in this innovation. In fact, you may find our stepper motors in applications such as plate readers, liquid and specimen handling systems, chromatography, and In Vitro diagnostic machines.

Microstepping - An electronic control technique that proportions the current in the motor’s windings to provide additional intermediate positions (steps) between poles. Produces smooth rotation and high positional resolution.

Momentum - The amount of motion of a moving body. Momentum is the product of mass and velocity of an object.

Motor Mounting Face - A flat surface on the front end cap of a motor that provides features for assembly of a motor onto a mating piece in a system.

Motor Mounting Pilot - A cylindrical protrusion extending from the motor mounting face that allows for relative axial positioning of a motor output shaft in relationship to the system.

Misstep - When a step motor skips a step or loses synchronization with the input pulses because of a large inertia mismatch and lack of motor torque.

How To Use Microstepping To Get More Torque
A Fair Comparison Reveals some Surprises

For more information, please click here.
**NEMA** - Stands for National Electrical Manufacturer’s Association. They establish the standard for motor dimensions, which are used by Lin Engineering.

**Neodymium Iron Boron** - A type of rare-earth permanent magnet material. At the present Neodymium magnets are the strongest commercially available magnets, however they are also very brittle.

**Noise** - Stepper motors can run very quietly. They need not make any more noise when attached to the scope as when held in your hand. It’s common star party etiquette to run a quiet operation, and you will make a good impression of your system.

**Non-Condensing Humidity** - An environmental condition that allows for humidity, but does not allow any condensation inside the motor. Condensation is normally caused by extreme fluctuation in temperature.

**Non-cumulative error** - Error that does not add or accumulate over multiple steps or incremental moves.
Online Stepper Motor Selection Tool - Tool designed to help user select the best stepper motor based on their specification requirements.

Oscillator - Something that causes an object to move back and forth, or oscillate.

Overshoot - The amount (in degrees) that the rotor moves beyond the desired position.

Open loop system - A system of control in which the motor operates without feedback.

Operating temperature - The temperature range at which the stepper motor can operate effectively.

Operating Speed - The speed range at which the stepper motor can operate effectively. The speed of operation determines how much torque the motor will be able to provide, and this correlation is represented on the Torque-Speed curve for each motor.

Optimal Winding - The best motor winding for a specific application to maximize torque at the desired speed. Lin Engineering will create a new motor winding to optimize performance for an application if an existing motor winding is not sufficient.
**Parallel winding** - A way of winding a bipolar motor so that there are two coils per pole that are wired together in parallel. Twice as much current needs to be supplied to give the same Ampereturns as a series winding, and the parallel winding has half the resistance and the same inductance as a half coil winding.

**Permanent Magnet Step Motor** - A step motor having a permanent magnet rotor and wound stator. The rotor has a permanent magnet sandwiched between the top and bottom halves of the rotor, and is magnetized axially with north and south poles. Both the rotor and the stator have mechanically formed or stamped teeth.

**PM Motor** - A stepper motor whose rotor is a permanent magnet.

**Poles** - A coil of the stator, where an electromagnetic force is generated by passing current through the coil windings.

**Positional Accuracy** - The maximum error in one revolution of a full step in 360 degrees. Expressed as a percentage of a full step.

**Power** - A supply of mechanical or electrical energy. Power must be supplied to a step motor to make it run. The power supplied to a step motor is equal to the input current multiplied by the input voltage. The units of power are Watts, or a Joule/second.

**Power loss** - Loss of power within a motor due to resistance and heat loss. The power losses in a step motor are due to Copper losses, which depend on resistance of the windings and the current going through them, and the Iron losses, which have to do with hysteresis caused by the magnetic field.

**Pre-load** - A condition where an axial force is applied to either the inner race or outer race of a ball bearing to remove excess play in the bearing.

**Pre-load force** - The amount of force applied to a bearing to remove manufacturing excess play in the bearing. Pre-load force is measured at a minimum axial shaft movement. Normally 0.001”.

**Pull-in Torque** - The maximum torque the motor develops without losing synchronization when instantaneously started. The pull-in torque will change with any change in inertia.

**Peak Current** - The maximum current that can be input into a motor without exceeding the motor's RMS current rating. The peak current is equal to $1.414$ multiplied by the motor's rated current. If the peak current is exceeded, the coils can burn and cause permanent damage to the motor.

**Phase current** - See Amps/phase

**Phase/Winding** - A group of electrically connected coils.
Pull-Out Torque - The pull-out torque is the maximum torque which can be applied to the stepper motor at a desired speed without losing synchronization. When the pull-out torque has been exceeded, the motor stalls (stops). Pull-out torque values are used to produce dynamic torque-speed curves for individual stepper motors.

Pulse (step) - A single current impulse sent into the motor windings to move the rotor from one energized position to the next.

Pulse frequency - The number of times a pulse occurs every second. In a step motor, the input pulses are what make the motor change phase and cause rotation, so a higher pulse frequency would correlate to a faster motor speed.

Pulses Per Second (PPS)/Step Rate - The rate, in steps per second, at which a stepper motor is commanded to operate.

PWM - Pulse Width Modulation. A method of controlling the average current in a motors phase windings by varying the on-time of transistor switches.

Packaging - An industry that specializes in packaging products for distribution, storing, and selling.
Radial Play - Side to side movement of the shaft due to clearances between the shaft and bearing, bearing to housing and bearing internal clearances for ball bearings and roller bearings. 
(Also called Side Play)

Ramping - Accelerating or decelerating the motor gradually to a desired speed to prevent de-synchronization.

Rapid Prototyping - a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three dimensional computer aided design.

Rated Current - The maximum allowable current that a motor can handle without exceeding its temperature rating. It is also the current at which the holding torque is derived. Measured in units of Amperes [A].

Rated Voltage - The voltage at which the rated torque of the motor is generated. Its value is the product of rated current and winding resistance. Measured in units of volts [V].

Repeatability - The degree to which a parameter such as position or velocity can be duplicated

Resolution - Division of movement into small increments. The resolution tells how many intervals of movement for a certain distance.

Resolver - A feedback device with a construction similar to a motor’s construction (stator and rotor). A resolver provides velocity and position information into a drive’s microprocessor or DSP to electronically commutate the motor.

Resistance - An electrical conductor’s (i.e. a motor’s windings) opposition to the passage of current through it. Measured in units of ohms [Ω].

Resonance - A phenomena where excessive vibration occurs due to the motor operating at a frequency at or near the natural frequency of the entire system. This can lead to a decrease in torque or loss of synchronism.

Resonant Range - The range where a motor’s step rate is near the natural frequency of the motor.

Ringing - Oscillation of a system following a sudden change in state.

RMS Current - Root Mean Square Current. In an intermittent duty cycle application, the RMS current is equal to the value of steady state torque which would produce the equivalent motor heating over a period of time.

Rotational speed - The velocity of a rotating object in terms of radians per second.
**Rotor** - The rotating part of the motor that takes part in generating torque.

**Rotor teeth** - The teeth on the rotor that are attracted to and repelled from the stator teeth. The number of rotor teeth determines the step angle and the step error.

**R-Winding** - A motor winding created to reduce noise and vibration for lower torque applications. This winding operates with two phases always “on” at a time.

**Step Motor Terminology got you stumped?**
Lin Engineering explains the differences between Amps/Phase and Amps Peak Current.

⇒ For more information, please click here.
Security and surveillance systems - An industry that specializes in motion sensing cameras and technology.

Semiconductor - A substance that is halfway between a conductor and an insulator, and is used in electric circuitry. The manufacturing of semiconductors requires very precise and accurate movement and machining.

Series winding - A way of winding a bipolar motor so that there are two coils per pole that are wired together in series. This doubles the Ampereturns per coil, which increases motor torque without having to increase the input current. The series winding has double the resistance and four times the inductance of a half-coil winding.

Settling Time - The time needed for a motor to reach its desired position after oscillation has diminished.

Shaft - The rotating part of the motor that gives the usable output speed and torque. The shaft is connected to the rotor and can be modified for coupling with many different applications.

Slew Range - The region between the pull-in and pull-out torque curves. It represents the movement of the rotor in the range of continuous and smooth rotation-synchronous motion with the stator’s magnetic circuit flow.

Speed Stability - A test that measures accuracy of a step motor’s position in relation to various speeds. The graph generated by a speed stability test is used to identify speeds where resonance is greater than normal.

Spike Accuracy - Sudden but regular torque spikes caused by geometric and electrical imperfections.

Spur Gears - Spur gears are the simplest and most common type of gear. They are generally a cylinder or disk with teeth projecting out radially, parallel to the axis of rotation. These gears will commonly mesh together correctly if they are fitted to parallel axles.

Static holding - See Holding torque

Stator - The stationary part of the motor that encompasses the rotor and helps create the magnetic pole.

Stator teeth - The teeth on the stator that attract and repel the rotor teeth when the stator coils are magnetized.
**Step** - The movement of the rotor from one energized position to the next position

**Step Accuracy** - A measure of a step motor’s maximum deviation from its desired or indicated position. Step accuracy is non-cumulative or the deviation found in any number of steps is no greater than the maximum deviation for a single step.

**Step angle** - The nominal angle through which a step motor shaft rotates between two adjacent step positions. The step angle is dependent on if a motor is being full, half or microstepped.

**Step Error** - See step accuracy

**Step oscillations** - The oscillation that occurs each time the motor takes a step. This value is greater for full stepping motors, and is reduced with microstepping.

**Step rate** - The rate at which a stepper motor moves from one step position to the next step position. A higher step rate corresponds to a higher angular velocity.

**Step resolution** - Gives how many motor steps for one rotation of the motor shaft. The step resolution increases with microstepping.

**Step sequence** - The order in which current pulses are sent to the different phases of a motor. The step sequence determines the direction of the motor.

**Step to Step Accuracy** - The maximum error that occurs between any adjacent steps. It is normally expressed as a percentage of one full step.

**Stepper Motor** - An actuator that translates discrete input pulses into pulses of motion composed of discrete incremental commands.

**Stiffness** - The ability to resist movement induced by an applied torque. It is often specified as a torque displacement curve, indicating how much the shaft will rotate upon application of a known external force when stopped.

**Switching Sequence** - The sequence and polarity of voltages applied to the coils of a step motor that result in a specified direction of rotation.

**Synchronism** - The condition in which a rotor’s rotation matches the rotation of the magnetic field created by the stator’s windings. In synchronism, the motor’s step rate equals the controller’s input pulse rate. When synchronism is lost, the motor will stall or miss-step.
**T-Connection** - A bipolar connection that is good for reducing noise and vibration at low speeds. It uses the same current and twice the inductance of a bipolar half-coil winding, and has less holding torque than series or parallel windings.

**Teeth** - Projections on the rotor and stator of a hybrid step motor.

**Thermal resistance** - The amount that material resists heat flow. It is the difference in temperature between two surfaces that induces heat flow rate per area.

**Torque** - The tendency of a force to rotate an object about an axis. Usually measured in units [oz-in] or [N-m].

**Torque gradient** - The change in holding torque with respect to changes in shaft position in an energized motor.

**Torque margin** - A torque safety factor used in case the intended application differs slightly from the actual application of a step motor.

**Torque Ripple** - The cyclical variation of generated torque at a frequency given by the product of motor angular velocity and number of commutated segments or magnetic poles.
**Torque-Speed Curve** - A curve plotting the dynamic/pull-out torque at different operating speeds.

**Torque stiffness (K)** - The change in torque over the change in angle. It affects the resonance frequency of a motor, and when increased, will increase the resonance frequency of a system. Torque stiffness also determines step accuracy.

**Torque to Inertia Ratio** - A motor's holding torque divided by the inertia of its rotor. The higher the ratio, the higher a motor’s maximum acceleration capability.

**RESOURCES**

Comparing the Step Accuracy of Two-Phase vs. Five-Phase Step Motors

Count stator and rotor teeth, not phases

→ For more information, please click here.
**Undershoot** - The amount (in degrees) that the rotor is short of the desired position.

**Unipolar Driver** - The motor phase winding current is switched in one direction only. The polarity of the applied voltage to each winding is always the same. Uni-polar drives require 6 or 8 lead wires.

**Unipolar winding** - A motor wound with two coils on each pole with a center tap, where only one of the coils is being used at a time. The two coils allow the motor to rotate in both directions, and using one coil will rotate the motor forward, while switching power to the other coil will rotate the motor backward. To switch directions using a unipolar winding, the wiring changes but the current direction does not. This is different than a bipolar winding because a bipolar winding can change direction using only one coil by changing the current direction.
**Vacuum rating** - Measurement of how capable a motor is of running in a very low pressure environment. The units of vacuum rating are in Torr.

**Variable Reluctance Motor** - A step motor having wound stator or stators with salient poles working with a soft iron rotor having salient poles on the periphery. A VR motor does not use a permanent magnet.

**Velocity** - A vector that gives a speed magnitude and a direction.

**Vibration** - Also known as motor resonance caused by step oscillation and when operating speed matches the natural frequency of the motor. Too much vibration can cause the motor to misstep or lose synchronization.

**Viscous Damping** - A damper which provides drag or friction torque proportional to speed. At zero speed the drag torque is reduced to zero.

**Viscous Inertia Damper** - A damper with an inertia coupled to the motor shaft, through a thin film of viscous fluid, usually silicone oil to minimize viscosity variations due to temperature changes. This damper only responds when the velocity between the damper inertia and the motor shaft changes. At steady state speed there is no effect from the damper.

**Voltage** - A measure of electric potential difference across a circuit or winding. The units are in volts.

**Voltage Constant** - A constant of the BEMF generated by a DC motor at a defined speed. Usually quoted in volts per 1000rpm.

**How To Take Vibration Out of Step Motors**

The best way to handle resonance in stepmotors usually involves moving troublesome areas out of harm’s way.

→ For more information, please click here.
**Wave drive** - A driver that energizes one motor phase or winding at a time.

**Winding-Bifilar** - Two windings wound (in parallel) on the same pole. Bifilar winding allows reversal of the poles magnetic polarity using a simple switching device. Bifilar windings are required for a unipolar drive.

**Winding-Unfilar** - A single winding is wound a pole. Unifilar windings are used with a bipolar drive.

**Wire gauge** - A measure of wire thickness, usually measured in AWG (American Wire Gauge).
**X-Ray Machine** - Common medical application

**Xtreme torque motor** - Lin Engineering’s NEMA 17 motor that gives up to 35% more torque than standard size NEMA 17 motors.

**RESOURCES**

How to Select the Right Step motor for a Medical Device
Appears in Print As: Getting the Right Stepmotor for Your Medical Device

→ For more information, please click here.
WHY LIN?

Over the past decade, Lin Engineering has gained a tremendous amount of market share and earned a reputation as the “Leader in Step Motor Technology.”

Why are more and more engineers choosing Lin Engineering?

Versatile Product Lines

- **powerStep**
  - High Torque and Extreme Torque stepper motors that will help you avoid stalling and skipping steps.

- **smoothStep**
  - Get high accuracy, low resonance, and quiet performance from these stepper motors.

- **enviroStep**
  - Stepper motors specifically designed to weather extreme environments like high/low temperatures, clean rooms, dust and water.

- **miniStep**
  - Small stepper motors perfect for applications with compact space and size constraints.

Proven Application Support, Performance and Quality

- **Unrivaled Application Support**
  - 98% application success rate
  - 95% of prototypes shipped in less than 1 week

- **High Performance**
  - Highest torque output
  - High accuracy = no skipping steps
  - Reduced vibration and resonance
  - Versatile Product Lines to accommodate many applications

- **Reliable Quality**
  - Consistent Performance
  - 4.5 Sigma System
  - ISO 9001 Certified
  - Continuous Improvement

Growing Market Share

Customers in 2004

Customers in 2014

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