Motion Glossary

Acceleration
A change in velocity as a function of time. Acceleration usually refers to increasing velocity, and deceleration to decreasing velocity.

Accuracy
A measure of the difference between expected position and actual position of a motor or mechanical system. Motor accuracy is usually specified as an angle representing the maximum deviation from expected position.

Ambient Temperature
The temperature of the cooling medium, usually air, immediately surrounding the motor or another device.

Angular Accuracy
The measure of shaft positioning accuracy on a servo or stepping motor.

Back EMF
The voltage generated when a permanent magnet motor is rotated. This voltage is proportional to motor speed and is present regardless of whether the motor winding(s) are energized or de-energized.

Breakaway Torque
The torque required to start a machine in motion. Almost always greater than the running torque.

Brushless Motor
Class of motors that operate using electronic commutation of phase currents, rather than electromechanical (brush-type) commutation. Brushless motors typically have a permanent magnet rotor and a wound stator.

Closed Loop
A broadly applied 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 transducer to generate correction signals in relation to desired parameters.

Cogging (Cogging Torque)
A term used to describe non-uniform angular velocity. Cogging appears as a jerkiness, especially at low speeds.

Commutation
A term which refers to the action of steering currents or voltages to the proper motor phases so as to produce optimum motor torque. Proper commutation means the relationship of the Rotor to the Stator must be known at all times.

1. In brush type motors, commutation is done electromechanically via the brushes and commutator.
2. In brushless motors, commutation is done by the switching electronics using rotor position information obtained by Hall sensors, single turn absolute encoder, or a resolver.

Controller
A term describing a functional block containing an amplifier, power supplies, and possibly position-control electronics for operating a servomotor or step motor.

Current at Peak Torque (IPK) (Amperes)
The amount of input current required to develop “peak torque”. This is often outside the linear torque/current relationship.

Current, Rated
The maximum allowable continuous current a motor can handle without exceeding motor temperature limits.

Detent Torque
The maximum torque that can be applied to an un-energized step motor without causing continuous rotating motion.

Duty Cycle
For a repetitive cycle, the ratio of on time to total cycle time. Duty cycle (%) = [On time / (On time + Off time)] x 100%

Dynamic Braking
A passive technique for stopping a permanent magnet brush or brushless motor. The motor windings are shorted together through a resistor which results in motor braking with an exponential decrease in speed.

Efficiency
The ratio of power output to power input.

Electrical Time Constant (te) (Seconds)
The time required for current to reach 63.2% of its final value for a fixed voltage level. Can be calculated from the relationship te=L/R where L is inductance (henries) and R is resistance (ohms).

Encoder
A feedback device which converts mechanical motion into electronic signals. The most commonly used, rotary encoders, output digital pulses corresponding to incremental angular motion. For example, a 1000-line encoder produces 1000 pulses every mechanical revolution. The encoder consists of a glass or metal wheel with alternating transparent and opaque stripes, detected by optical sensors to produce the digital outputs.

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Feedback
A signal which is transferred from the output back to the input for use in a closed loop system.

Form Factor
The ratio of RMS current to average current. This number is a measure of the current ripple in a SCR or other switch-mode type of drive. Since motor heating is a function of RMS current while motor torque is a function of average current, a form factor greater than 1.00 means some fraction of motor current is producing heat but not torque.

Four Quadrant
Refers to a motion system which can operate in all four quadrants; i.e., velocity in either direction and torque in either direction. This means that the motor can accelerate, run, and decelerate in either direction.

Friction
A resistance to motion caused by contact with a surface. Friction can be constant with varying speed (Coulomb friction) or proportional to speed (viscous friction).

Hall Sensor
A feedback device which is used in a brushless servo system to provide information for the amplifier to electronically commutate the motor. The device uses a magnetized wheel and hall effect sensors to generate the commutation signals.

Holding Torque
Sometimes called static torque, holding torque specifies the maximum external torque that can be applied to a stopped, energized motor without causing the rotor to rotate. Generally used as a figure of merit when comparing motors.

Horsepower
A Unit of measure of Power. One horsepower is equal to 746 watts. The measurement of Rotatry power must take speed and torque into account. Horsepower is a measure of a motor's torque and speed capability.

Formula: HP = Torque (lb-in.) x Speed (RPM)/63,025
HP = Torque (lb-ft.) x Speed (RPM)/5,252
HP = Volts x Amps x Efficiency/746

Inductance (L) (mH - millihenries line-to-line)
The electrical equivalent to mechanical inertia; that is, the property of a circuit, which has a tendency to resist current flow when no current is flowing, and when current is flowing has a tendency to maintain that current flow.

Inductance (mutual)
Mutual inductance is the property that exists between two current carrying conductors or coils when magnetic lines of force from one link with those of the other.

Inertia
The property of an object to resist change in velocity unless acted upon by an outside force. Higher inertia objects require larger torques to accelerate and decelerate. Inertia is dependent upon 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.

Open-loop
A system in which there is no feedback. Motor motion is expected to faithfully follow the input command. Stepping motor systems are an example of open-loop control.

Overload Capacity
The ability of a drive to withstand currents above its continuous rating. It is defined by NEMA as 150% of the rated full-load current for "standard industrial DC motors" for one minute.

Peak torque (Tpk) (lb-in.)
The maximum torque a brushless motor can deliver for short periods of time. Operating permanent magnet motors above the maximum torque value can cause demagnetization of the rare-earth magnets. This is an irreversible effect that will alter the motor characteristics and degrade performance. This is also known as peak current. Not to be confused with system peak torque, which is often determined by amplifier peak current limitations, where peak current is typically two times continuous current.

Poles
Refers to the number of magnetic poles arranged on the rotor of the brushless motor. Unlike an AC motor, the number of poles has no direct relationship to the base speed of the motor.

Power
The rate at which work is done. In motion control, power is equal to torque multiplied by speed.
Power (watts) = force x distance/time. Power= voltage x current

Power Factor
Ratio of true power (kW) to apparent power (kVA).

Pulse Rate
The frequency of the step pulses applied to a step motor driver. The pulse rate, multiplied by the resolution of the motor/driver combination (in steps per revolution), yields the rotational speed in revolutions per second.

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Pulse Width Modulation (PWM)
Pulse width modulation (PWM), describes a switch-mode (as opposed to linear) control technique used in amplifiers and drivers to control motor voltage and current.

Regeneration
The action during motor braking, in which the motor acts as a generator and takes kinetic energy from the load, converts it to electrical energy, and returns it to the amplifier.

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

Resolution
The smallest increment into which a parameter can be broken down. For example, a 1000 line encoder has a resolution of 1/1000 of a revolution.

Resonance
Oscillatory behavior caused by mechanical or electromechanical harmonics and limitations.

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 current which would produce the equivalent motor heating over a period of time.

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

Rotor
The moving part of the motor, consisting of the shaft and magnets. These magnets are analogous to the field winding of a brush-type DC motor.

Settling Time
The time required for a parameter to stop oscillating or ringing and reach its final value.

Speed
Describes the linear or rotational velocity of a motor or other object in motion.

Stall Torque
The amount of torque developed with voltage applied and shaft locked, or not rotating. Also known as locked-rotor torque.

Stator
The non-moving part of the motor. Specifically, it is the iron core with the wire winding in it that is pressed into the frame shell. The winding pattern determines the voltage constant of the motor.

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

Torque
A measure of angular force which produces rotational motion. This force is defined by a linear force multiplied by a radius; e.g. lb-in. Formula: Torque (lb-ft.) = 5,250 x HP/RPM

Torque Constant (KT = lb-ft./A)
An expression of the relationship between input current and output torque. For each ampere of current, a fixed amount of torque is produced.

NOTE: Torque constants ARE NOT linear over the operating range of a motor. They apply best at ~75% of no load maximum speed or where the peak and continuous torque curves meet.

Torque-to-Inertia Ratio
Defined as the motor's holding torque divided by the inertia of its rotor. The higher the ratio, the higher a motor's maximum acceleration capability will be.

Velocity
The change in position as a function of time. Velocity has both a magnitude and sign.

Voltage Constant (KE) (V/kRPM peak, line-to-line)
May also be termed Back-EMF constant. When a motor is operated, it generates a voltage proportional to speed, but opposing the applied voltage. The shape of the voltage waveform depends upon the specific motor design. For example, in a brushless motor, the wave shape may be trapezoidal or sinusoidal in nature.