

Glossary

Abbe error – The positioning error resulting from angular motion and an offset between the measuring device and the point of interest.

Abbe offset – The value of the offset between the measuring device and the point of interest.

Absolute move – A move referenced to a known point or datum.

Absolute programming – A positioning coordinate reference where all positions are specified relative to a reference or “home” position.

AC brushless servo – A servomotor with stationary windings in the stator assembly and permanent magnet rotor. AC brushless generally refers to a sinusoidally wound motor (such as BM series) to be commutated via sinusoidal current waveform. (see DC Brushless Servo)

Acceleration – The change in velocity as a function of time.

Accuracy – An absolute measurement defining the difference between actual and commanded position.

Accuracy grade – In reference to an encoder grating, accuracy grade is the tolerance of the placement of the graduations on the encoder scale.

ASCII – American Standard Code for Information Interchange. This code assigns a number to each numeral and letter of the alphabet. Information can then be transmitted between machines as a series of binary numbers.

Axial runout – Positioning error of the rotary stage in the vertical direction when the tabletop is oriented in the horizontal plane. Axial runout is defined as the total indicator reading on a spherical ball positioned 50 mm above the tabletop and centered on the axis of rotation.

Axis of rotation – A center line about which rotation occurs.

Back emf, K_{emf} – The voltage generated when a permanent magnet motor is rotated. This voltage is proportional to motor speed and is present whether the motor windings are energized or not.

Backlash – A component of bidirectional repeatability, it is the non-responsiveness of the system load to reversal of input command.

Ball screw – A precision device for translating rotary motion into linear motion. A lead screw is a lower cost, lower

performance device performing the same function. Unit consists of an externally threaded screw and an internally threaded ball nut.

Ball screw lead – The linear distance a carriage will travel for one revolution of the ball screw (lead screw).

Bandwidth – A measurement, expressed in frequency (hertz), of the range which an amplifier or motor can respond to an input command from DC to -3dB on a frequency sweep.

Baud rate – The number of bits transmitted per second on a serial communication channel such as RS-232 or modem.

BCD – Binary Coded Decimal - A number system using four bits to represent 0-F (15).

Bearing – A support mechanism allowing relative motion between two surfaces loaded against each other. This can be a rotary ball bearing, linear slide bearing, or air bearing (zero friction).

Bidirectional repeatability – See Repeatability.

CAM profile – A technique used to perform nonlinear motion that is electronically similar to the motion achieved with mechanical cams.

Cantilevered load – A load not symmetrically mounted on a stage.

Closed loop – A broad term relating to any system where the output is measured and compared to the input. Output is adjusted to reach the desired condition.

CNC – Computer Numerical Control. A computer-based motion control device programmable in numerical word address format.

Coefficient of friction – Defined as the ratio of the force required to move a given load to the magnitude of that load.

Cogging – Nonuniform angular/linear velocity. Cogging appears as a jerkiness, especially at low speeds, and is due to the magnetic poles’ attraction to steel laminations.

Commutation – The action of steering currents to the proper motor phases to produce optimum motor torque/force. In brush-type motors, commutation is done electromechanically via the brushes and commutator. A brushless motor is electronically commutated using a position feedback device such as an encoder or Hall effect devices. Stepping motors are electronically commutated without feedback in an open-loop fashion.

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Commutation, 6-step – Also referred to as trapezoidal commutation. The process of switching motor phase current based on three Hall effect signals spaced 120 electrical degrees beginning 30 degrees into the electrical cycle. This method is the easiest for commutation of brushless motors.

Commutation, modified 6-step – Also referred to as modified sine commutation. The process of switching motor phase current based on three Hall effect signals spaced 120 electrical degrees beginning at 0 electrical degrees. This method is slightly more difficult to implement than standard 6-step, but more closely approximates the motor's back emf. The result is smoother control and less ripple. Aerotech's BA series self-commutate using this method.

Commutation, sinusoidal – The process of switching motor phase current based on motor position information, usually from an encoder. In this method, the three phase currents are switched in very small increments that closely resemble the motor's back emf. Sinusoidal commutation requires digital signal processing to convert position information into three-phase current values and, consequently, is most expensive to implement. The result, however, is the best possible control. All Aerotech controllers, as well as the BAS series amplifiers, self-commutate using this method.

Coordinated motion – Multi-axis motion where the position of each axis is dependent on the other axis, such that the path and velocity of a move can be accurately controlled. Drawing a circle requires coordinated motion.

Critical speed – A term used in the specification of a lead screw or ball screw indicating the maximum rotation speed before resonance occurs. This speed limit is a function of the screw diameter, distance between support bearings, and bearing rigidity.

Current command – Motor driver or amplifier configuration where the input signal is commanding motor current directly, which translates to motor torque/force at the motor output. Brushless motors can be commutated directly from a controller that can output current phase A and B commands.

Current, peak – An allowable current to run a motor above its rated load, usually during starting conditions. Peak current listed on a data sheet is usually the highest current safely allowed to the motor.

Current, rms – Root Mean Square. Average of effective currents over an amount of time. This current is calculated based on the load and duty cycle of the application.

Cycle – When motion is repeated (move and dwell) such as repetitive back-and-forth motion.

DC brushless servo – A servomotor with stationary windings in the stator assembly and permanent magnet rotor. (See AC Brushless Servo)

Deceleration – The change in velocity as a function of time.

Duty cycle – For a repetitive cycle, the ratio of "on" time to total cycle time used to determine a motor's rms current and torque/force.

Dwell time – Time in a cycle at which no motion occurs. Used in the calculation of rms power.

Efficiency – Ratio of input power vs. output power.

Electronic gearing – Technique used to electrically simulate mechanical gearing. Causes one closed loop axis to be slaved to another open or closed loop axis with a variable ratio.

Encoder marker – Once-per-revolution signal provided by some incremental encoders to accurately specify a reference point within that revolution. Also known as Zero Reference Signal or Index Pulse.

Encoder resolution – Measure of the smallest positional change which can be detected by the encoder. A 1000-line encoder with a quadrature output will produce 4000 counts per revolution.

Encoder, incremental – Position encoding device in which the output is a series of pulses relative to the amount of movement.

Feedback – Signal that provides process or loop information such as speed, torque, and position back to the controller to produce a closed-loop system.

Flatness (of travel) – Measure of the vertical deviation of a stage as it travels in a horizontal plane.

Force, continuous – The value of force that a particular motor can produce in a continuous stall or running (as calculated by the rms values) condition.

Force, peak – The maximum value of force that a particular motor can produce. When sizing for a specific application, the peak force is usually that required during acceleration and deceleration of the move profile. The peak force is used in conjunction with the continuous force and duty cycle to calculate the rms force required by the application.

Friction – The resistance to motion between two surfaces in contact with each other.

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G.P.I.B. – A standard protocol, analogous to RS-232, for transmitting digital information. The G.P.I.B. interface (IEEE-488) transmits data in parallel instead of serial format. (See IEEE-488)

Gain – Comparison or ratio of the output signal and the input signal. In general, the higher the system gain, the higher the response.

Grating period – Actual distance between graduations on an encoder.

Hall effect sensors – Feedback device (HED) used in a brushless servo system to provide information for the amplifier to electronically commutate the motor.

HED – Hall Effect Device. (See Hall effect sensors)

HMI – Human Machine Interface. Used as a means of getting operator data into the system. (See MMI)

Home – Reference position for all absolute positioning movements. Usually defined by a home limit switch and/or encoder marker.

Home switch – A sensor used to determine an accurate starting position for the home cycle.

Hysteresis – A component of bidirectional repeatability. Hysteresis is the deviation between actual and commanded position and is created by the elastic forces in the drive systems.

I/O – Input/Output. The reception and transmission of information between control devices using discrete connection points.

IEEE-488 – A set of codes and formats to be used by devices connected via a parallel bus system. This standard also defines communication protocols that are necessary for message exchanges, and further defines common commands and characteristics. (See G.P.I.B.)

Incremental move – A move referenced from its starting point (relative move).

Inertia – The physical property of an object to resist changes in velocity when acted upon by an outside force. Inertia is dependent upon the mass and shape of an object.

Lead error – The deviation of a lead screw or ball screw from its nominal pitch.

Lead screw – A device for translating rotary motion into linear motion. Unit consists of an externally threaded screw and an internally threaded carriage (nut). (See Ball screw)

Life – The minimum rated lifetime of a stage at maximum payload while maintaining positioning specifications.

Limit switch – A sensor used to determine the end of travel on a linear motion assembly.

Limits – Sensors called limits that alert the control electronics that the physical end of travel is being approached and motion should stop.

Linear motor – A motor consisting of two parts, typically a moving coil and stationary magnet track. When driven with a standard servo amplifier, it creates a thrust force along the longitudinal axis of the magnet track.

Load carrying capability – The maximum recommended payload that does not degrade the listed specifications for a mechanical stage.

Master-slave – Type of coordinated motion control where the master axis position is used to generate one or more slave axis position commands.

MMI – Man Machine Interface used as a means of getting operator data into the system. (See HMI)

Motion profile – A method of describing a process in terms of velocity, time, and position.

Motor brush – The conductive element in a DC brush-type motor used to transfer current to the internal windings.

Motor, brushless – Type of direct current motor that utilizes electronic commutation rather than brushes to transfer current.

Motor, stepping – Specialized motor that allows discrete positioning without feedback. Used for noncritical, low power applications, since positional information is easily lost if acceleration or velocity limits are exceeded.

NC – Numerical Control. Automated equipment or process used for contouring or positioning. (See CNC)

NEMA – National Electrical Manufacturer's Association. Sets standards for motors and other industrial electrical equipment.

Non-volatile memory – Memory in a system that maintains information when power is removed.

Open collector – A signal output that is performed with a transistor. Open collector output acts like a switch closure with one end of the switch at circuit common potential and the other end of the switch accessible.

Open loop – Control circuit that has an input signal only, and thus cannot make any corrections based on external influences.

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Operator interface – Device that allows the operator to communicate with a machine. A keyboard or thumbwheel is used to enter instructions into a machine. (See HMI or MMI)

Optical encoder – A linear or angular position feedback device using light fringes to develop position information.

Opto-isolated – System or circuit that transmits signal with no direct electrical connections, using photoelectric coupling between elements.

Orthogonality – The condition of a surface or axis which is perpendicular (offset 90 degrees) to a second surface or axis. Orthogonality specification refers to the error from 90 degrees from which two surfaces of axes are aligned.

Overshoot – In a servo system, referred to the amount of velocity and/or position overrun from the input command. Overshoot is a result of many factors including mechanical structure, tuning gains, servo controller capability, and inertial mismatch.

PID – A group of gain terms in classical control theory (Proportional Integral Derivative) used in compensation of a closed-loop system. The terms are optimally adjusted to have the output response equal the input command. Aerotech controllers utilize the more sophisticated PID FVFA loop which incorporates additional terms for greater system performance.

Pitch (of travel) – Angular motion of a carriage around an axis perpendicular to the motion direction and perpendicular to the yaw axis.

Pitch error – Positioning error resulting from a pitching motion.

PLC – Programmable Logic Controller. A programmable device that utilizes “ladder logic” to control a number of input and output discrete devices.

PWM – Pulse Width Modulation. Switch-mode technique used in amplifiers and drivers to control motor current. The output voltage is constant and switched at the bus value (160 VDC with a 115 VAC input line).

Quadrature – Refers to the property of position transducers that allows them to detect direction of motion using the phase relationship of two signal channels. A 1000-line encoder will yield 4000 counts via quadrature.

Radial runout – Positioning error of the rotary stage in the horizontal direction when the tabletop is oriented in the horizontal plane. Radial runout is defined as the total indicator reading on a spherical ball positioned 50 mm above the tabletop and centered on the axis of rotation.

Ramp time – Time it takes to accelerate from one velocity to another.

Range – The maximum allowable travel of a positioning stage.

RDC – Resolver to Digital Converter. Electronic component that converts the analog signals from a resolver (transmitter type) into a digital word representing angular position.

Repeatability – The maximum deviation from the mean (each side) when repeatedly approaching a position. Unidirectional repeatability refers to the value established by moving toward a position in the same direction. Bidirectional repeatability refers to the value established by moving toward a position in the same or opposite direction.

Resolution – The smallest change in distance that a device can measure.

Retroreflector – An optical element with the property that an input light beam is reflected and returns along the same angle as the input beam. Used with laser interferometers.

Roll (of travel) – Angular motion of a carriage around an axis parallel to the motion direction and perpendicular to the yaw axis.

Roll error – Positioning error resulting from a roll motion.

Rotor – The rotating part of a magnetic structure. In a motor, the rotor is connected to the motor shaft.

RS-232C – Industry standard for sending signals utilizing a single-ended driver/receiver circuit. As such, the maximum distance is limited based on the baud rate setting but is typically 50-100 feet. This standard defines pin assignments, handshaking, and signal levels for receiving and sending devices.

RS-274 – Industry standard programming language. Also referred to as G-code machine programming. A command set specific for the machine tool industry that defines geometric moves.

RS-422 – Industry communication standard for sending signals over distances up to 4000 feet. Standard line driver encoder interfaces utilize RS-422 because of the noise immunity.

Runout – The deviation from the desired form of a surface during full rotation (360 degrees) about an axis. Runout is measured as Total Indicated Reading (TIR). For a rotary stage, axis runout refers to the deviation of the axis of rotation from the theoretical axis of rotation.

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Servo system – Refers to a closed loop control system where a command is issued for a change in position and the change is then verified via a feedback system.

Settling time – Time required for a motion system to cease motion once the command for motion has ended.

Shaft radial load – Maximum radial load that can be applied to the end of the motor shaft at maximum motor speed.

Shaft runout – Deviation from straight line travel.

Slotless – Describes the type of laminations used in a motor that eliminates cogging torque due to magnetic attraction of the rotor to the stator slots.

Stator – Non-rotating part of a magnetic structure. In a motor, the stator usually contains the mounting surface, bearings, and non-rotating windings.

Stiction – Friction encountered when accelerating an object from a stationary position. Static friction is always greater than moving friction, and limits the smallest possible increment of movement.

Straightness of travel – Measure of the side-to-side deviation of a stage as it travels in a horizontal plane.

Torque – Rotary equivalent to force. Equal to the product of the force perpendicular to the radius of motion and distance from the center of rotation to the point where the force is applied.

Torque, continuous – Torque needed to drive a load over a continuous time.

Torque, peak – Maximum amount of torque a motor can deliver when the highest allowable peak currents are applied.

Torque, rms – Root Mean Square (rms) is a mathematical method to determine a steadfast or average torque for a motor.

Torque, stall – The maximum torque without burning out the motor.

Total Indicated Reading (TIR) – The full indicator reading observed when a dial indicator is in contact with the part surface during one full revolution of the part about its axis of rotation.

Tuning – In a servo system, the process of optimizing loop gains (usually PID terms) to achieve the desired response from a stage or mechanism from an input command.

Unidirectional repeatability – See Repeatability

Velocity command – Motor driver or amplifier configuration where the input signal is commanding motor velocity. Motors with analog tachometers are normally driven by this driver configuration.

Wobble – An irregular, non-repeatable rocking or staggering motion of the table top of a rotary stage. Wobble is defined as an angular error between the actual axis of rotation and the theoretical axis of rotation.

Yaw (of travel) – Rotation about the vertical axis, perpendicular to the axis of travel. Angular movement (error) that affects straightness and positioning accuracy.

Yaw error – Positioning error resulting from a yaw motion.