



OMAC Motion for Packaging Working Group

Education Subcommittee

Glossary of Motion Control Terms

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Acceleration

The rate at which something increases its velocity. Acceleration is usually measured in units of velocity change for each unit of time (inches/ second(velocity)/ second (time)) and in this example would be written as in./sec/sec or in./sec².

Accuracy

The relative status of something compared to its absolute or perfect value. In motion control this will most often be a position description. A command may be sent to move 4.0". The accuracy of the system will be defined by how close to the absolute value of 4.0" the system can effect the move. Accuracy may be defined as a one time incident or the average over a number of cycles or motions. Positioning accuracy will normally be defined in terms of deviation (+/- from theoretical) or limits (acceptable variation from theoretical: ie. 3.8"-4.2" define acceptable limits of variation around a theoretical point of 4.0")

Active front end

A front end processor which interacts with both upstream and downstream equipment and makes required changes based on the incoming and outgoing parameters and data, without external control.

Actual position

The position of an axis relative to the commanded position. This may be the position at the end of the commanded move or the lag between command position at any point during the move and the actual position of the axis at that point. The later is commonly referred to as following error.

AC servo

A general term referring to a motor drive that generates sinusoidal shaped motor currents.

Alarm

An indication that a monitored parameter is not within the prescribed acceptable range. Usually this is in the form of an output that can be used to initiate an operator warning or advisory, to generate a corrective action, or to cause a cessation of the operation underway.

Analog servo

A servo system that utilizes analog control and feedback systems such as voltage variation, pressure changes etc. Analog servos are most commonly found in hydraulic and similar systems.

Analog signal

A communication within the system that is accomplished by means of a signal that varies in direct relation to the intensity or magnitude of the external quality being measured. Typical examples are a 0-10 volt motor control signal, a hydraulic pilot pressure, a pneumatic control pressure.

Axes of motion

The specific major directions along which controlled movement occurs. Usually the number of these major directions employed in a specific machine. Usually defined as follows:

- X: Linear motion in positioning direction
- Y: Linear motion perpendicular to positioning direction
- Z: Vertical linear motion
- A: Angular motion around X (roll)
- B: Angular motion around Y (pitch)
- C: Angular motion around Z (yaw)

Axis

A principal direction along which movement of a tool, component or workpiece occurs.

Brushless servo

A servo drive in which commutation of the current is accomplished electronically rather than through the use of mechanical brushes and a commutator. In a brushless motor, the windings are on the stator and the magnetic field is provided by permanent magnets in the armature. This results in lower inertial loadings and increased heat dissipation capability over a standard brush type motor.

Bus

One or more conductors used as a path over which information is sent from one of many sources to one of many destinations.

Centralized control

A control system in which all of the primary processing is done at a single location rather than at multiple points throughout the system.

Circular interpolation

The generation of an apparently circular motion through the coordinated movements of two axes. The actual path is a series of straight line approximations generated by software algorithms.

Collision detection

The use of sensors to detect the imminent impact of two or more parts in a system. The signals from the detection sensors can be used to stop motion or to provide a ramped slow down for a “soft” mating of the approaching components.

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

Converter

The process of changing AC to DC and back to AC again. This is accomplished through the use of a diode rectifier or thyristor rectifier circuit. The term "converter" may also refer to the process in an adjustable frequency drive, consisting of a rectifier, a DC intermediate circuit, an inverter and a control unit.

Coordination

The integration of the movements of two or more axes of motion so that the resultant motion is a path which none of the axes are capable of independently. Coordination may also involve the use of sensors and other internal or external commands in the integration effort which assist in effecting the movement or work desired.

Current controller

A system that utilizes an electronic method of limiting the maximum current available to a motor. This current is adjustable so that the motor's maximum current can be controlled and normally includes functions that serve as a protective measure to prevent extended overload conditions from damaging the motor or the controller.

Cut to length

A sub routine within a motion control processor or stand alone processor that is designed to feed material being processed a pre-set distance prior to performance of a secondary function such as a cut off. Feed back systems are employed to insure repeatability of the set feed length.

DC bus

A type of circuit or protocol that serves as a common communications pathway shared by several components and which uses a direct current voltage level as a reference. It may also be used to describe a power distribution system shared by multiple components within a machine or power distribution system.

Deceleration

The rate at which something decreases its velocity. Deceleration is usually measured in units of velocity change for each unit of time (Inches/ second(velocity)/ second (time)) and in this example would be written as in./sec/sec or in./sec².

Decentralized control

A control system in which the logic functions and input/output functions are located at individual pieces of equipment or sub systems and function essentially independent of each other. Normally the independent systems will have some means of communicating vital information with each other.

Deterministic scan time

The frequency with which a Programmable Logic Controller (PLC) executes a program, including scanning all the inputs and outputs on the system. This time is usually measured in milliseconds. PLCs will normally read or “scan” the instructions in the logic program in set, sequential manner. The time required to read a specific instruction and all of the following instructions, returning to the initial instruction is generally referred to as scan time.

Device level network

A means of putting sensors, actuators and other components on a common network cable that is connected to a PLC. It eliminates point -to-point wiring between the PLC and each device.

Diagnostic code

A code (usually alpha numeric or numeric) that is displayed on some type of operator interface or within a program that indicates the status of a monitored component. Usually diagnostic codes are used to indicate the location and nature of a fault or error condition that requires rectification.

Digital motion control

A motion control system that utilizes binary coding for all logic and control functions. Analog inputs can normally be used on a digital system, but they must be converted through an analog to digital converter before being processed.

Digital servo

A servo motor (see AC servo and Analog servo) which utilizes binary coding for all parameter generation and feed back.

Digital signal

A signal that communicates information in electrical pulses that represent binary 1s and 0s. It is widely believed that digital signals can transmit more information more reliably in a given unit of time than analog signals.

Drive

An electronic device that translates a given command from a motion controller into the electrical current that turns a motor.

Efficiency

The efficiency of a motor is the ratio of mechanical output to electrical input. It represents the effectiveness with which the motor converts electrical energy into mechanical energy.

Electronic cam profiles

A technique used to perform non-linear motion electronically similar to that achieved with mechanical cams.

Electronic clutch

The process of generating a slave profile based on master position or time periods by enabling and disabling electronic cam or gearing functions.

Electronic gearing

A method that simulates mechanical gears by electrically synchronizing one closed-loop axis to a second axis (open- or closed-loop) through a variable ratio.

Electronic line shaft

A virtual axis that is used as the master axis on a machine to which other axes are synchronized by electronic gearing or camming profiles.

Encoder

A feedback device that translates mechanical motion into electrical signals indicative of actuator position. Incremental and absolute encoders are common varieties; as the names imply, their output indicates incremental or absolute changes of position.

Encoder resolution

The number of electrically identified positions occurring in 360 degrees of input shaft rotation.

EnDat

An interface that has become a standard for serial data transfer covering position and parameters.

EMC/CE

Testing of electrical devices to check their ability of adhering to conducted/ radiated emissions. Set by the European Directive. Applications may need line filters, cabinet bonding, and shielded cabling to assist this effort.

E-Stop

A stop function which has all of the following requirements:

- It shall override all other functions and operations in all modes.
- Power to machine actuators that can cause a hazardous condition (s) shall be removed as quickly as possible without creating other hazards (e.g., by the provision of mechanical means of stopping requiring no external power, by reverse current braking for a Category 1 stop).
- Reset shall not initiate a restart.
- The emergency stop shall function as either a Category 0 or Category 1 stop. The choice of category of emergency stop shall be determined in accordance with the requirements of the application.
- Where a Category 0 stop is used for the emergency stop function, it shall have only hardwired electromechanical components. In addition, its operation shall not depend on electronic logic (hardware or software) or the transmission of commands over a communication network or link.
- Where a Category 1 stop is used for the emergency stop function, final removal of power to the machine actuators shall be ensured and shall be by means of electromechanical components.

Ethernet

An open networking standard, Ethernet is widely used in office automation and is increasingly being used for packaging machine networks. Originally developed for communications speed of 1.5 megabits/sec, newer versions permit speeds up to 100 megabits/sec.

Event

A change-of-state of an input parameter, such as the triggering of a limit switch or proximity sensor.

Fault

The error received when a drive or control has attempted an illegal process and becomes disabled.

Feedback

The signal or signals received from a controlled machine or process to denote its response to the command signal.

Feedforward

A method that "precompensates" a control loop for known errors due to motor, drive, or load characteristics to improve response. It depends only on the command, not the measured error.

Fiber optic

A lightwave system that utilizes a glass or plastic fiber guide to transmit light to a control source where the optic intensity is linearly translated into current or is used to determine the open/close state of a current path.

FieldBus

A process control local area network used for interconnecting sensors, actuators, and control devices to one another, as defined by ISA standard S50.02.

Flying restart

The ability of a drive to restart a spinning motor. This is normally done by sampling the motor speed, encoder input, or back EMF to restart the motor from the speed at which it is coasting.

Flying virtual master

The ability of a motion controller to swap virtual encoders instantaneously making advanced synchronizing features possible.

Following error

The difference between the commanded position of an axis and its actual position. The amount of Following Error present varies with the speed of the axis. The amount of following error allowed can be adjusted through the K_V parameter.

Frameless motor

A motor format which consists of only the stator and rotor provided such that a manufacturer can directly incorporate it into the framework of his machine and eliminate the need for couplings, shafts, or mechanical transmissions.

Gantry

An overhead framework that is designed to travel linearly in the X, Y, and/or Z axes. Tooling or other devices are generally designed into the framework to perform various functions as it moves from one location to another.

G code

A software used for programming machining processes. Typical applications include 3-axis milling and 2-axis wire cutting.

Hard, real-time control

Refers to the ability of a controller to respond to an event immediately, without delay. While PLCs are inherently designed for this, PCs can be trickier. To be a hard, real-time controller, a PC-based controller's software must be considered the highest priority task, and made independent of the rest of the PCs task.

Hardware limit switch

A switch that is operated by some part or motion of a power-driven machine or equipment to alter the electric circuit associated with the machine or equipment.

Holding brake

A positive-action mechanical friction device. Normal configuration is such that when the power is removed, the brake is set.

Home position

A reference position for all absolute positioning movements. Usually defined by a home limit switch and/or encoder marker. Normally set at power-up and retained as long as control system is operational.

Homing

Locating a unique reference position at power-up for axis calibration.

Human-machine interface (HMI)

The console at which an operator or mechanic interacts with the controller of a packaging machine or line. An HMI, or MMI (man-machine interface) or OI (operator interface), often is a computer display with a PC or industrial computer built into or connected to run specialized HMI software.

IGBT- Insulated Gate BiPolar Transistor

Used in power section of servo drives to invert the PWM signal to the servo motor.

Inching

A means of accomplishing momentary motor movement by repetitive closure of a circuit using a single pushbutton or contact element.

Indexer

An electronic unit that converts high-level commands from a host computer, PLC, or operator panel into step and direction pulses needed by a stepping motor driver.

Indexing

An axis or axes in the process of moving to a pre-programmed position, at a defined velocity and acceleration/deceleration rate.

Inertia

Property of a mass that causes it to resist any change in its direction of motion or speed. In a servo system, the inertia of the mass being moved is reflected back to the servo motor shaft. This is called “reflected inertia.” The servo system must be able to control this reflected inertia throughout the entire motion profile. Servo drives contain parameters to accomplish this. These parameters are Velocity Loop Proportional Gain (K_P), Position Loop Gain (K_V), and Velocity Loop Integral Action Time (T_N). The definitions of K_P , K_V , and T_N , can be found in this Glossary. See also: Tuning

In Position Window

The range of position increments in which the axis is considered by the controller to be at the commanded position point. Can be thought of in terms of +/- N position increments from the commanded position.

Interpolation

A coordinated move of two or more axes in a linear and/or circular motion.

Inverter

A drive that converts an AC, 60 Hz, power source to DC, then back to a variable frequency AC power source for a 3 phase induction motor.

Jerk limitation

Limits the rate of acceleration change during the movement of an axis. Its purpose is to eliminate mechanical jerking when speed changes are made.

Jitter free synchronization

In a master/slave configuration, it refers to the slave drive matching the speed of the master at an acceleration/deceleration rate that provides to a smooth transition.

Jog

An axis running at a fixed velocity and acceleration/deceleration rate, in a selected direction, with no specific destination.

 K_P

Velocity Loop Proportional Gain. Determines how much velocity error will be allowed by the servo system during a move. See also: Tuning

 K_V

Position Loop Gain. Determines how much positioning error, or following error, will be allowed by the servo system during a move. See also: Tuning

Length Units

The linear units for programming and configuring an axis, typically used in indexing, setting offsets, defining overtravel limits, etc. Length units are often defined in inches, feet, meters, or millimeters.

Linear

A relationship between an input and output in which the output varies in direct proportion to the input.

Loop Update Times

The time interval between updates to calculate the process variable from the following error.

Modulo Value

In a rotary axis, the position increment at which the axis position returns to 0, i.e. 360 degrees.

Noise

An unwanted electrical signal. Typically from RFI or EMI induced onto the drive's components, speed reference or feedback wiring, and can cause the axis to react unexpectedly. Sources of noise are AC power lines, motors, generators, transformers, fluorescent lights, CRT displays, and radio transmitters.

Offset

A preset distance between the actual zero reference point and a programmed zero reference point.

Open architecture

Hardware and/or software designed in a way to provide interchangeability of components and connectivity from multiple vendors.

Open loop/close loop

Open loop control refers to a motion control system with no external sensors to provide position or velocity correction signals. A closed loop control is a motion control system that has position and velocity feedback to generate a correction signal by comparing its position and velocity to desired parameters. Feedback devices are typically encoders, resolvers, LVTDs and/or tachometers.

Overcurrent

Any current in excess of the rated current of the drive to maintain or move to a new position at a given velocity and acceleration or deceleration rate.

Override

To force an axis to move during a faulted condition. Often required to get an axis to move off of an overtravel limit switch.

Overshoot

A system response where the output or result exceeds the desired value.

Over temperature

A warning or alarm generated by a motor or drive that indicates the device is too hot. This is generally caused by the demand for too much current through the device. There may be binding at the motor, calling for more torque, or the motor or drive may be undersized.

PC

Personal computer typically running under the Intel standard. PC architecture can be adapted for packaging machine control through software.

Phasing

Adjusting the position of one axis with respect to others during synchronization or electronic line shafting. This is usually done while the axis are moving, and done to correct for small registration problems.

PLC

Programmable Logic Controller is a type of computer that provides hard, real-time control of packaging and other equipment thanks to fast, repeatable deterministic scan times.

PLS

A Programmable Limit Switch is a dedicated, high-speed control that converts the rotary motion of a shaft into digital signals. PLS's are typically used to increase the accuracy of material or product positioning or registration.

Point-to-point wiring

A method of wiring each component on a packaging machine directly to the PLC. Hard-wiring eliminates the potential for communication delays found on a network.

Position error

Error caused when the difference between the actual position, and the command position is greater than a set amount.

Positioning

Specifying a move by giving a target position, a velocity and an acceleration. The target position can be an absolute position, or a relative position from the current position.

Position loop

Portion of the command signals that generates the position information based on position feedback.

Printmark synchronization

Feature that captures the position of a passing mark on the product and then compares this position with the expected position based on current speed, and then compensates for this difference.

Profile

Graphical representation of movement. This can be position vs. time, velocity vs. time or torque vs. time.

Programmable Limit Switch

See PLS

Programming language

Interface that allows the user to control the motion system according to the demands of the user.

Protocol

A particular method of encoding either analog or digital information for transmission over a cable. Often used interchangeably with Standard.

Pulse width frequency

The rate at which the IGBTs can switch.

Pulse-width modulation

A switch-mode control method used in amplifiers and drivers to control motor voltage and current to obtain higher efficiency than linear control. PWM refers to variable on/off times (or width) of the voltage pulses applied to the transistors.

Quadrature

A technique that separates signal channels by 90° (electrical) in feedback devices. It is used with encoders and resolvers to detect direction of motion.

Ramp function generator

Mathematical model that provides a square wave, triangular wave or sinusoidal wave output.

Rated speed

The maximum speed at which the servo motor can rotate.

Real master

Physical feedback which provides position information for a synchronized axis to follow.

Rectifier

Device that transforms AC power into DC for use by converter drives.

Referencing

Procedure to set the feedback device relative to the real world.

Regen

Power generated by a motor/drive system during the deceleration phase of movement. In some systems, this regen power can be used by other axis or put back on the network.

Resolver

A position transducer that uses magnetic coupling to measure absolute shaft position during one revolution.

Rollfeed

Function that calculates speed of a rotary axis to keep the linear speed of the feed material constant as the diameter of the rotary axis changes.

Rotary

Moving in a circular way, using degrees to indicate position instead of mm, or inches in a linear axis

Safe off

Procedure that ensures that power will not travel from the drive to the motor.

SCADA-Supervisory Control & Data Acquisition.

Refers to software and hardware that (1) permits the control or management of an entire packaging line and (2) automatically collects data on that line's efficiency.

S curve

S curve refers to a control pattern that accelerates and decelerates a motor slowly to reduce mechanical shock. This function is more sophisticated than linear acceleration, but does not have the performance of camming.

Sequence of operation

A series of steps to be executed that then causes an action in a machine.

SERCOS

Serial Real-time Communications Standard. An open communications protocol (adopted as IEC 1491) designed especially for motion-control networks. Defines a method for transmitting digital information over a fiber-optic cable at speeds of 2, and more recently, 4 megabits/sec.

Serial communications

Transmitting digital 1s and 0s in a series over a single cable, the primary method of communication used in and between packaging equipment. Parallel communications use several wires to simultaneously transmit groups of 1s and 0s.

Servo mechanism

An automatic, closed-loop motion control system that uses feedback to control a desired output such as position, velocity, or acceleration.

Servo motor

A motor that together with its resolver or encoder is capable of being precisely controlled. A resolver or encoder provides constant and highly accurate feedback on the motor's exact position, speed and torque to the drive that powers it.

Shielded cable

A cable that has a metallic sleeve wrapped around all of the conductors that comprise its center. The metal sleeve is then grounded to eliminate the effects of electrical noise on the signals being carried by the cable.

SinCos

An encoder that outputs both digital and high resolution analog signals used in servo control in packaging machines.

Software limit switch

A software function that turns physical outputs on and off, depending on the level of a specified input. Servomotors, resolvers or encoders usually offer the input for software limit switches.

SSI

Acronym for Serial Synchronous Interface. This is a type of multi-turn absolute encoder. The position information is sent from the encoder to the device reading the encoder as a serial string in Gray code format.

Synchronization

The condition that occurs when several functions of a machine (mechanical, servo or software) follow a common control signal and are in a specific position according to this signal.

Tachometer

An electromagnetic feedback transducer providing an analog voltage signal proportional to rotational speed.

Task

A software system control that determines the execution rates and priority levels for software modules running in a motion control or PLC.

TCP/IP

Transmission Control Protocol/Internet Protocol. A method of encoding data into a series of "packets" for transmission over a network. Designed initially for use on the Internet, TCP/IP is rapidly penetrating non-Internet uses, including the factory floor.

Teach position

The position of an axis that is "taught" into the motion control program. The axis is moved, typically by jogging, to the desired position. This "teach position" is then entered into the motion program automatically by the control (using whatever steps are required by the motion control manufacturer) and becomes the new programmed position. The motion control used must have the ability to do this type of program manipulation.

Telegram

Communication data packet between controller and device.

TeleService

The ability to remotely access a motion control or PLC for service purposes.

 T_N

Velocity Loop Integral Action Time. Associated with K_P . When velocity error occurs outside of the tolerance value set in K_P , T_N determines how quickly the servo drive will bring the velocity back within the specified tolerance. See also: Tuning

Torque limitation

A servo function that allows the monitoring and limiting of the current supplied to a servo motor.

Tuning

Adjusting the servo drive's internal characteristics to give it the ability to control the reflected inertia and gives the axis a smooth position/velocity profile. The process of Tuning involves setting the Velocity Loop Proportional Gain (K_P), Position Loop Gain (K_V), and the Velocity Loop Integral Action Time (T_N) values so that the axis has a position/velocity profile allowing only as much position/velocity error as the process will permit.

Twisted pair

Two wires twisted together for the purpose of eliminating the effect of electrical noise.

VxWorks

VxWorks™ is a real-time operating systems that guarantees an absolutely deterministic response. It is increasingly used in motion control because of its real-time behavior, stability, operating time, and memory efficiency. (Dev. by Wind River Systems)

Velocity

The speed at which a motor or mechanical system runs.

Velocity loop

A servo control function that sums a velocity command signal with a speed feedback signal from a servo motor, and outputs the difference as a torque command signal.

Virtual master

An encoder signal created in the software of a motion control to allow synchronizing multiple servo systems. A typical machine may have several virtual master encoders.

Warning

The error condition received from a drive or a controller that a problem if not remedied within a specified period will result in a fault. The controller or drive is generally not disabled until a fault condition occurs.

Wintel

The defacto industry standard for PCs, referring to Microsoft's Windows™ operating system running on Intel's microprocessors.

Zero point of feedback

The point at which a servomotor's encoder position and the machines physical position line up. If these two points don't agree, the servo axis must be "homed."

Resource List

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Design News, June 1999 Semiconductor Manufacturing

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Control Engineering, Terminology in Motion, January 8, 1998