# 

**Product Focus: Motion Control** 

# **Motion Control**

Motion control is generally understood to mean the use of servo and/or stepper systems as the "muscle" to move a given load. These motion control systems are capable of extremely precise speed, position, and torque control. Applications that require positioning of product, synchronization of separate elements, or rapid start/stop motion are all perfect candidates for the use of motion control. PLCs are very capable of providing the signals required to command these servo and stepper systems in a cost-effective and digital (noise-free) manner.

In a typical motion control system, there are three basic components: the controller, the drive (sometimes referred to as an amplifier), and the motor. The path planning or trajectory calculations are performed in the controller, which sends command signals to the drive, which in turn applies the necessary voltage and current to the motor, resulting in the desired motion. Sometimes feedback devices on the motor or the load are used to notify the drive or the controller with specific details about the actual movement of the motor shaft or the load (thus "closing the loop"). This feedback data is used to increase the accuracy of the motion and can be used to compensate for dynamic changes that may occur at the load, such as changes in mass, friction or other disturbances. Servo systems operate in a closed-loop fashion and vary output torque to move into/stay at the commanded position, while most stepper systems typically provide open-loop position control.

The choice of open-loop versus closed-loop control depends on many factors and both are useful methods for controlling motion. PLC-based controllers can be used for either type of system. Applications that can be accomplished with a low-cost PLC and servo/stepper components include cut-to-length, indexing tables or conveyors, and x/y tables (plotter/cutter/router/placer).

# Motion Controller Discrete pulse and direction signals Controller Discrete pulse and direction signals Drive Network interface (EtherCAT or ModTCP) Multi-Axis Servo System

The classic 'pulse and direction' signals that are widely used with PLCs provide an inexpensive, noise-free (digital) method for precision motion control. While typically limited to a few axes of control and where coordination between axes is limited, PLC controllers with pulse and direction capability are an excellent fit for many motion applications. More capable PLC controllers use networks such as EtherCAT<sup>®</sup> or ModbusTCP to control multiple axes of motion with complex interactions such as interpolation, registration, and other advanced motion profiles.

Often, PLCs are already being used for logic control on the machinery and can also handle the motion tasks with the addition of a pulse output or network module and some additional programming. This can eliminate the need to integrate the logic controller with a separate motion controller. Machine builders can also save considerable time when implementing PLC-based systems, especially if they are already familiar with the PLC and its programming software.

# **Control Options**

**Internal Indexing:** Many servo and stepper drives have a built-in indexer that can enable simple point-to-point moves or run at predefined speeds or torques. These drives accept standard PLC discrete output signals to initiate the predefined moves OR use serial communications or network commands to set dynamic speeds and distances AND to initiate those moves. You can even use the internal indexer to provide manual machine control with just a few buttons and switches. For example, you could use a selector switch to select a predefined move from a table, and then use a pushbutton to START that move. Simple registration operations may even be possible with a built-in indexer and the appropriate sensor(s).



**Pulse Train:** Also called "Pulse and Direction" control, this is the most popular option for PLC-based control; the servo or stepper system accepts a high-speed pulse input signal (of up to 1MHz or more). If your PLC has a slower pulse train output (max speed), many drives can scale or 'smooth' the values. This works with PLC families that support high-speed outputs. Some stepper and servo systems also accept Clockwise/Counterclockwise (CW/CCW) pulses and quadrature pulse signals for encoder following applications.

**Analog Velocity or Torque Control:** Some systems accept a +10/-10V signal from a motion controller, PLC, or potentiometer. Just scale the voltage signal to your desired speed or torque (in the servo drive), it's that simple. These drives may even allow an "analog deadband" setting to eliminate jitter or drift when using a manual (potentiometer) signal for control.

**Network Command and Control:** Certain servo systems support advanced control of multi-axis servo configurations over EtherCAT<sup>®</sup> or ModbusTCP networks. With EtherCAT<sup>®</sup> cyclic modes, all drives are updated every EtherCAT cycle (~1 millisecond) with position, velocity, or torque setpoints. In profile modes, drives receive target setpoints for each move (over EtherCAT or ModbusTCP).

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# **Simple Motion with Steppers**

Stepper motors are named as such because they are commanded to move in small discrete steps, and they can do so rapidly. They typically work best below 1,000 rotations per minute (rpm) because torque falls off rapidly as speed increases. Stepper motors lack overload capability, therefore one industry rule of thumb is to size stepper motors and drives so that the expected load uses only 50% of the available torque to avoid potential stalling conditions.

The controller determines the step mode for pulse generation. There are several modes for the pulse-train that commands the stepping motion. In full-step mode there are usually 200 steps (or 1.8 degrees) for each 360-degree revolution, and each pulse moves the motor one step, but this mode is not typical because it lacks precision. Instead, users typically select half-step, quarter-step, or other microstepping modes which operate at 400, 800, or up to 50,000 steps per revolution. The key is to balance the tradeoff between accuracy and the required control signal bandwidth.

Although stepper motors are considered a low-cost motion control alternative to servo motors, steppers do have some distinct advantages. Stepper motors have no jitter/dither at zero speed. For applications without a constant load from gravity or some other force, most stepper drives have an idle current reduction option, which saves energy and reduces motor heating when the shaft is at standstill.

For machinery or equipment with motor-driven moving parts, perhaps using gearboxes or rack-and-pinion mechanisms, stepper motors are a good way to positively position a load. Although most stepper motors do not incorporate motor feedback, it is possible to add an encoder to the motor. For most applications, it is at least necessary to add sensors to the equipment to provide position feedback at one or more known locations.



#### **Taking the First Step**

A stepper controller is necessary to generate the specific pulse train to accomplish motion. In turn, the stepper controller is connected to a drive to send a pulse of the appropriate power level to the motor itself. The controller, drive, and motor are usually separate components, but in some cases two or three of these functions can be combined in a single housing.

The controller can be a standalone device, or certain programmable logic controllers (PLCs) can create the pulses, making it easier to tightly integrate motion control with other automation functions. Basic stepper drives are not intelligent as they simply receive the controller pulses and amplify them into voltage pulses to operate the motor.

White Paper: Steppers surpass servos in many motion control applications: <u>https://go2adc.com/stepper-wp</u>



# Choose controllers and drives with compatible pulse characteristics

The electrical signals may be open collector, line driver, or push-pull. High-speed pulses encode both the frequency and motor direction, using one of three methods:

- Pulse and direction signals are the most common method
- Separate clockwise (CW) / counterclockwise (CCW) pulses
- "Quadrature" signals are sometimes used for encoder following because this signal is often used by encoders

## **Motion Types**

A stepper system can create motion by commanding the motor with respect to how far and how fast it should rotate. Some common motion profile examples are:

- Moving at a fixed velocity
- Move a number of steps and then stop
- Accelerate from one velocity to another
- Move a number of steps from one stopped position to another, first accelerating to a target velocity then decelerating back to zero speed at the target position, known as a trapezoidal move
- Performing any move with variable accel/decel; known as S-curve motion

# **Homing and Position Verification**

Stepper systems can only perform accurate, relative movements after the controller has learned the home position through a homing procedure. Because there is usually no motor feedback, a periodic position verification may also be used to confirm accurate movements for ongoing operation.

Homing is often accomplished by installing a proximity sensor at a known equipment location. The controller/drive then moves the motor slowly and establishes the home once the position sensor is triggered. Position verification is similar, but it is generally a quick check performed during normal operation. If the motor is found to be out of position, the homing procedure can be repeated.



# **Exploring the Option\$**

Stepper motors can be an advantageous choice for many applications, and when they are suitable, they will be a lower cost option than servos. For applications where simple, accurate motion control is needed, stepper systems used in conjunction with position switches and/or an encoder will reliably operate machinery at about 25% the cost of servo motor systems.



Automation Direct offers an online stepper system selection tool here: <u>https://go2adc.com/selectors</u>

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# **Focus On EtherCAT®-based Servo Motion Control**

Modern multi-axis servo systems require a network for coordination of all the various movements. EtherCAT provides a high-speed cyclic mode that can update all the servo systems on the network within a few milliseconds. EtherCAT multi-axis servo systems can be created using the LS Electric XGB PLC in conjunction with LS Electric iX7 servo systems for high-performance multi-axis control in demanding applications. With an EtherCAT system, you can define up to 400 position setpoints per axis in the PLC, then trigger those moves over the network. All the motion parameters are stored, loaded and triggered in the PLC, which can simplify your control scheme.

#### Advanced motion features in the iX7 system include:

#### **Flying Shear**

Traversing axis tracks the motion of material feed to make cuts "on the fly", without having to stop or pause production (material flow).

# Electronic Gearing

Create multiple gear ratios between axes. Switch ratios "on the fly".

#### **Advanced Torque Control**

This mode is perfect for precise tensioning and winding applications.

### Registration

Set up precise registration corrections with a sensor input, and automatically correct for inconsistencies or variations in products or processes.

### **Electronic Camming**

Eight cam profiles (per axis) can be configured from a mix of 20 predefined curve shapes.

The LS iX7 servo systems can also be networked on a ModbusTCP network, with similar multi-axis motion control capabilities.

EtherCAT<sup>®</sup> is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

Checkout our Motion Control Videos! https://go2adc.com/videos-mc





#### LS Electric XGB Motion-Centric PLC

- Built-in ModbusTCP and Ethernet connectivity
- EtherCAT option modules
- EtherNet/IP option modules
- Supports several IEC programming languages including structured text and ladder logic programming
- High-speed inputs for encoders, and other motion related I/O
- High-speed outputs to control stepping systems

# Ether**CAT**®

#### LS Electric iX7 EtherCAT Servo Drives

- Cyclic mode: all drives are updated every EtherCAT cycle (~1 millisecond) with position, velocity, or torque setpoints
- Profile mode: drives receive target setpoints for each move (over EtherCAT or ModbusTCP)
- All drive/motion info is stored in the PLC and available over the network to simply your control scheme
- Download firmware over the network
- 110VAC 1φ operation up to 400W
- 230VAC 1φ operation up to 2.2kW
- All sizes accept 230VAC 3φ input power

#### Servo Compatible Servo Motors

- Motors 9 sizes from 100W to 3.5kW
  - Low and medium inertia models
  - Professionally manufactured cable sets in four lengths with continuous flexing option



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#### **Stepper System Selector**

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LS Servo System Selector

# Dozens of selectors available including motion products

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**Configuration Tool** 

#### Selector Use Example: SureServo2 Servo System Selector Tool

Use this tool to assure that you get all the required and optional accessories you need on your first order! This tool walks you through the selection process, starting with motor requirements.

Filter all the available motors by output torque, holding brake option, or the input power that you have

available. View the torque/speed curve of each motor to verify application suitability, then move to page two of the selector to pick the matching servo drive and cable set. The tool will offer you all the available accessories that work with your system, including properly-sized circuit breakers or fusing for a protected and safe installation.

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# Programmable Controllers

- LS Electric PLCs
- Productivity1000 micro-modular PLCs
- Productivity2000 micro-modular PLCs
- Productivity3000 modular PLCs
- Productivity®Open Arduino-compatible industrial controller
- Do-more<sup>®</sup> BRX, H2 and T1H series PLCs
- CLICK<sup>®</sup> and CLICK PLUS micro brick PLCs
- I/O expansion modules available include discrete, analog, temperature and high-speed (depending on model)
- DirectLOGIC<sup>®</sup> components still available for maintaining legacy systems



HMI/Operator

Interface

 C-more<sup>®</sup> operator interface HMI touch panels in various sizes up to 22 inches with wide screen options available
 C-more headless HMI - same functionality as C-more touch panels without display size restrictions

- Low-cost C-more Micro text and touch panels 3, 4, and 6-inch models
- C-more and C-more Micro HMI design software free to download
- ViewMarq<sup>®</sup> LED message displays
- ATLAS<sup>®</sup> industrial monitors

You Tube









- IO-Link master modules, hubs, and a variety of IO-Link enabled devices
- Distributed I/O with Modbus TCP, EtherNet/IP, Modbus RTU, DeviceNET communication options
- Various combinations of discrete (AC, DC, relay, high-speed) and analog inputs and outputs available

# Communications

- Industrial managed and unmanaged Ethernet switches
- StrideLinx VPN routers and cloud services for secure remote access
- Pocket Portal IIoT remote I/O
- MQTT gateways
- Modbus gateways
- Network adapters/ converters
- Ethernet cables





- DURAPULSE® variable frequency AC drives up to 300hp, featuring GS10, GS20, GS20X, and GS4 series
- WEG CFW100, CFW300 and CFW500 AC drives up to 150hp, depending on series
- WEG CFW500 drives up to 20hp, IronHorse® AC drives up to 30hp and DURAPulse GS20X drives up to 10hp available in a NEMA 4X enclosure
- IronHorse DC drives up to 3hp
- Drive accessories
- Soft starters up to 480A

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- Stainless steel AC motors
- IronHorse Farm Duty up to 10hp
- IronHorse three-phase ODP motors up to 50hp
- Marathon inverter duty AC motors up to 100hp
- Marathon permanent magnet AC motors up to 10hp
- Marathon single-phase AC motors up to 5hp
- DC motors up to 2hp
- Motor controls and contactors up to 300hp
- WEG single-phase AC motors up to 2hp
- WEG three-phase AC motors up to 3hp
- WEG brake motors up to 2hp
- U.S. Motors inverter duty AC motors up to 10hp
- Toshiba Severe Duty AC Motors up to 100hp



Temperature and process controllers

Motors and

Motor Controls

- Digital and process panel meters
- Temperature sensors and transmitters
- Infrared pyrometers
- Pressure sensors and gauges
- Level sensors and controllers
- Flow sensors and transmitters
- Signal conditioners
- Pipeline valves
- Solenoid /media separated process pipeline valves
- Current to pneumatic (I/P) transducers
- Vibration switches and transmitters
- Trumeter graphical panel meters
- Cloud data logger with I/O
- Hour meters and counters

Software

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  - Configuration software packages for a variety of process instruments
  - Free motion control systems' configuration software (download)

- Free HMI programming
- Free AC drive configuration and programming (built-in PLC) software (download)
- software (download)



# Safety



# **Power Transmission**

- ReeR MOSAIC safety controllers
- IDEM<sup>®</sup> and Dold<sup>®</sup> safety relays
- Speed/Standstill safety relay modules
- WEG safety contactors
- Safety laser scanners
- Magnetic safety switches
- Magnetic coded safety switches
- RFID coded safety switches
- Light curtains from Contrinex, ReeR and Datalogic
- Two-Hand controls
- Trapped key interlocks
- Safety enabling switches
- Safety mats and edges
- Safety bumpers
- Intrinsically safe isolators
- Hazardous location devices
- Safety enabling switches
- IDEM Z-Range safety devices
  - Worm gearboxes
  - Stainless steel worm gearboxes
  - Helical gearboxes
  - Precision gearboxes
  - Timing belts and pulleys
  - Couplings and bushings
  - Shafting and shaft supports
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  - GAM rack and pinions
  - Linear bearings and rail



# **Structural Frames/Rails**

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- No cut fees
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# **Relays & Timers**



- Electro-mechanical relays
- Intrinsically safe relays
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- Alternating relays
- Optocoupler relays
- Pump seal failure relays
- Voltage monitoring relays
- Slim interface relays
- Power relays
- Solid state relays
- Hazardous location relays
- Timer relays
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- Force-guided relays
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- Southwire, Wiha, and Wera nutdrivers
- Sensor tester
- Wera, Wiha, and MEGAPRO screwdrivering tools
- Wera wrenches, ratchets
  and sockets
- Southwire, Wiha, and AutomationDirect pliers and stripping tools
- SapiSelco cable ties
- RUKO hole cutting tools
- RUKO grinders and burrs
- Crimping tools from AutomationDirect, Southwire, Wiha, and Z+F,
- Tool cases and bags



# **Circuit Protection**



Identification

Eaton and Gladiator UL 489 miniature circuit breakers

- AutomationDirect, Gladiator, and Fuji UL 489 molded case circuit breakers
- Eaton and Gladiator UL1077 supplementary protectors
- Edison fuses, fuse holders and fuse blocks
- Socomec, Gladiator<sup>®</sup> and Bryant<sup>®</sup> disconnect switches
- Bryant UL 508 manual motor controllers
- Socomec manual transfer switches
- E-T-A, Gladiator, and WAGO electronic circuit protectors
- Merz rotary cam switches
- Code brand scanners, including 1D, 2D and DPM images; scanners can read all common barcodes.
- Contrinex RFID devices use radio frequencies to read and transmit data without the need for line of sight.
- AutomationDirect Standalone RFID R/W units provide fast and long range communication with RFID tags
- Datalogic smart vision sensors make a decision based on a captured image, very useful for applications requiring presence and/or orientation object detection.
- Swivellink mounting systems
- Wenglor vision lighting



# **Motion Control**



#### ProductivityMotion controller

- LS Electric<sup>®</sup> XGB Motion-Centric PLC with EtherCAT<sup>®</sup>
- SureServo<sup>®</sup>2 drives and motors, up to 15kW
- LS Electric<sup>®</sup> servo drives and motors up to 7.5kW (including EtherCAT<sup>®</sup> models)<sup>4</sup>
- Stepper and servo gearboxes
- SureStep<sup>®</sup> stepper drives and NEMA motors
- Stepper motor linear actuators
- Leadshine<sup>®</sup> stepper drives
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- Flow sensors
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- Fork sensors
- Linear position sensors
- Vibration sensors



# Pushbuttons, Switches and Lights

- KILLARK<sup>®</sup> hazardous location control stations
- IDEM emergency stops
- Fuji 16mm plastic pilot devices
- Fuji<sup>®</sup>, Schmersal, and Eaton metal/ plastic 22 and 30mm pilot devices
- IP69K-rated pilot devices from Schmersal
- Captron IP69K capacitive pilot devices
- WERMA and Patlite audible and visual signal beacons
- WERMA and Patlite stacklights
- Molex pendant switches
- Foot switches
- Alarms, horns and buzzers



# **Hydraulics**



# **Pneumatics**



# **Power Products**

- Acme Electric<sup>®</sup> and Hammond transformers
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- Roxburgh and Eaton line filters and surge protectors
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- Hammond drive isolation transformers
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- Surge protection devices

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NFPA style

cylinders with

many mounting

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options

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- Regulators
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- Hand valves
- Check valves
- Push-to-connect water fittings
- Tubing
- Hose
- Hose clamps

Water (Potable) Components



# Wiring Solutions

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- Sensor cables
- General- and special-purpose cable
- Epson portable label printers



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All of our cable is available cut to your specified lengths so you can eliminate waste and purchase only what you need - plus it's cut for free and shipped FAST!!

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- AWM appliance wire
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