GE
Intelligent Platforms

Integrating Next Generation Motion Control with GE Programmable Automation Controllers

Integrating Next Generation Motion Control with GE Programmable Automation Controllers

Introduction

The explosion of new products and increasing customer expectations requires OEMs to provide better flexibility, reliability, openness, and performance for their manufacturing and production customers. Maximizing productivity and performance is imperative to success and is driving OEMs to adopt and invest in the latest technologies that can meet their customers' challenges.

At the forefront of these performance-driven technologies is an integrated control system, called a programmable automation controller (PAC), and latest generation motion solutions. PACs provide easy integration for multi-domain functionality, such as motion control, process control, logic control and HMI—enabling the operational excellence that allows companies to become more productive and more efficient. PACs with integrated motion control can especially benefit applications in high-performance industries that require multi-axes motion control for mid- to high-end applications.

This white paper discusses the background and recent trends that have led to the need for PACs, presents some of the benefits of integrating the latest generation of motion control with PACs, and reviews the critical capabilities OEMs should assess when selecting such an integrated automation control system.

Industry trends

Consumer desire for an endless variety of manufactured goods is fueling an explosion of new product introductions, differentiation in packaging and multiple line extensions. Strolling through a typical supermarket reflects this reality with 10 different versions of the same brand toothpaste on the shelf: with tartar control, with whitening enhancer, with calcium, with gingivitis protection, and so on. Likewise, there may be five different sizes for the same flavor of crackers: school snack pack, 100-calorie pack, 20 oz, 32 oz and family size. Shelf life is much shorter as products come in and out of vogue, and stores are continually restocking their shelves to meet consumers' demands for new offerings. Global requirements such as new languages and metric-only labels can also double the number of SKUs.

OEMs and end users are driving a major shift in automation solutions to adapt to these trends. In the past, end users would choose to standardize on a given automation platform and specify to OEMs what control platform they should use, even if it did not allow the level of performance, openness and flexibility to maximize productivity. The primary reason was to reduce the learning curve for their engineers and to leverage their existing expertise and intellectual property on a particular system. However, to keep pace with the growing demand for increased productivity and product variability, more end users are allowing OEMs to select a control platform that maximizes productivity by leveraging the highest degree of innovation and the latest technology. To maximize asset utilization, end users must have the ability to run more products on the same line and at increasing production speeds. This flexibility to handle frequent line changes and increase machine or line throughput is raising the bar on performance for new machine designs.

As a result, OEMs are leading with performance-driven solutions that enable a higher level of flexibility, accuracy and speed. They are seeking to deliver automation systems that can handle faster product turnover, greater variability and shorter production runs while delivering increased product quality. Ultimately, the goal is to help end users maximize the productivity of their machines for a sustainable competitive advantage.

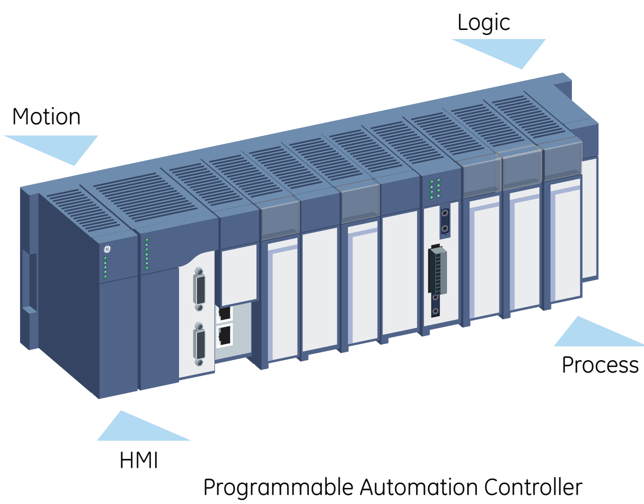
The marketplace shift toward PACs

As productivity and time-to-market have become more critical than ever, integrating disparate plant floor equipment and networking them to operations and enterprise-level systems as a way to improve productivity has led to greater demand for integrated control systems such as PACs that integrate high performance motion control.

While a PAC's form factor can be similar to that of a traditional PLC, a PAC's capabilities are far more comprehensive. PACs are multi-functional controller platforms that encompass various technologies and products that users can implement as needed. It can include motion control, process control, logic control and HMI—enabling true convergence. Since their introduction in 2003, PACs have become attractive to end users because they can greatly reduce the total cost of ownership.

Key PAC features include:

- A single integrated, multi-discipline development environment
- Common tag names and a single tag database for access by all functions
- An open architecture for interoperability with other suppliers' solutions based on interface standards such as TCP/IP, OPC and XML, and open communication standards such as Ethernet/IP, Profibus and CAN



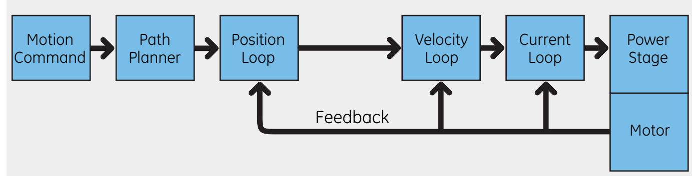
Easy integration of multi-domain functionality in one controller

The drawbacks of traditional automation and motion solutions

For many years, OEMs and end users implemented automation control solutions using PLC, PC or other host controllers to deliver the speed and reliability necessary for industrial applications in demanding plant environments. These systems typically integrate motion control using one of three traditional system architectures described on the following pages; the architectural difference is in how each product or automation supplier chooses to distribute, combine and connect the functional blocks within the various system hardware components and their associated microprocessors. For an overview of servo motion control, see the accompanying sidebar, which describes the basic control structure used by nearly all servo motion solutions.

Basic servo motion control structure

The block diagram below shows the basic functional blocks of a closed loop motion control system. The process starts with a motion command, usually part of a motion program, which defines the parameters for the required motion. For a basic point-to-point move, this includes the distance to be moved (position), velocity, acceleration, deceleration and jerk. The path planner is a software function used to periodically calculate the position commands for each axis based on the parametric data of the motion command and how the new motion must interface to any other motion occurring on the axis such as blending or superimposing the motion command with the previous motion. The path planner runs on a precise clock cycle and recalculates the position commands for each axis every cycle. As more axes are added, more processing power must be allocated to the path planner for calculating motion trajectories or else the clock cycle must be made longer.

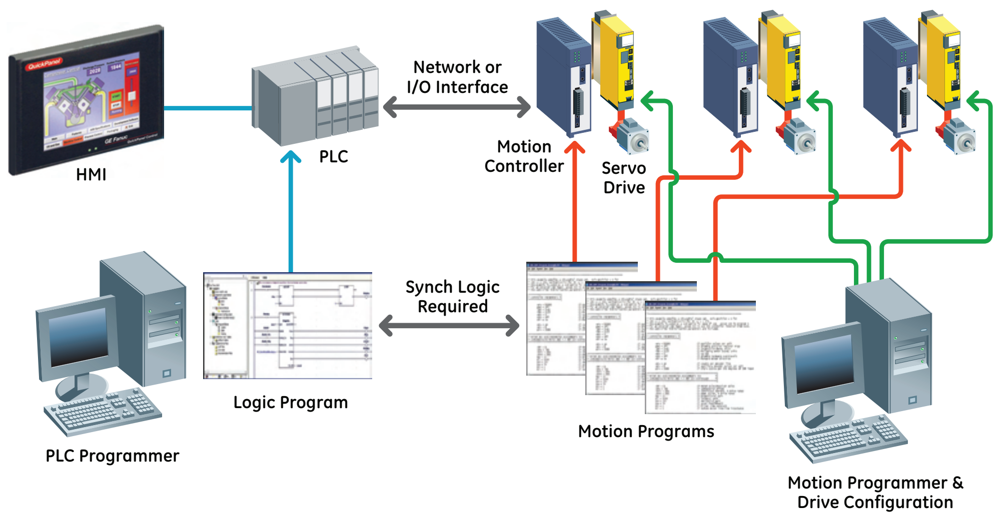


The position commands computed by the path planner are then passed to the servo control loops. Servos typically use three nested loops consisting of an inner current (torque) loop, a middle velocity loop and an outer position loop to implement the real-time servo motor control. Each loop compares an input command to feedback from the motor, and any difference represents a deviation from the desired motion path, which is then used to make corrections to try to reduce the error. Like the path planner, each servo loop runs at a precise periodic update rate with each inner loop typically running at a faster update rate than the next outer loop. Following the performance increases in microprocessors, the servo loop update rates have continued to increase in speed over the years. Today, many current loops run at update rates of up to 62.5 μs or faster.

Integrating Next Generation Motion Control with GE Programmable Automation Controllers

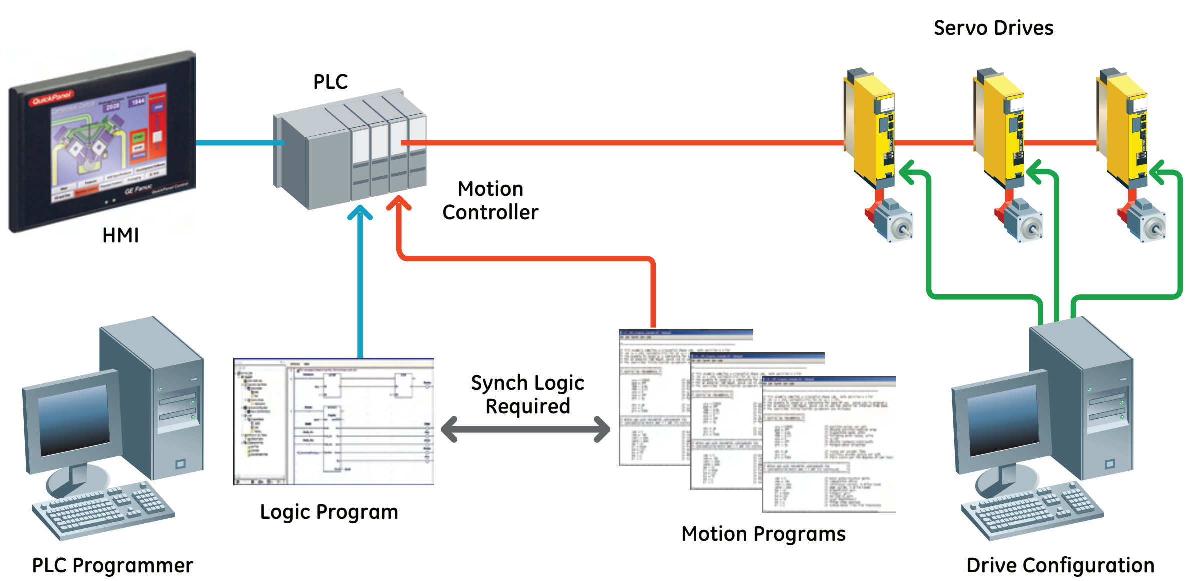
Traditional Architecture 1

Separate stand-alone motion controllers connect to the host controller via a network or field bus. In this case, the host controller (PLC, PC, etc.) is usually programmed separately from the motion controller. For multi-axis systems, there may be one multi-axis motion controller or multiple single-axis motion controllers, depending on the need/preference for centralized or distributed control. In the case of the multi-axis controller, the servo amplifiers are typically connected using a motion network. Single-axis motion controllers typically incorporate the servo amplifier. In this architecture, each motion controller requires a separate program.



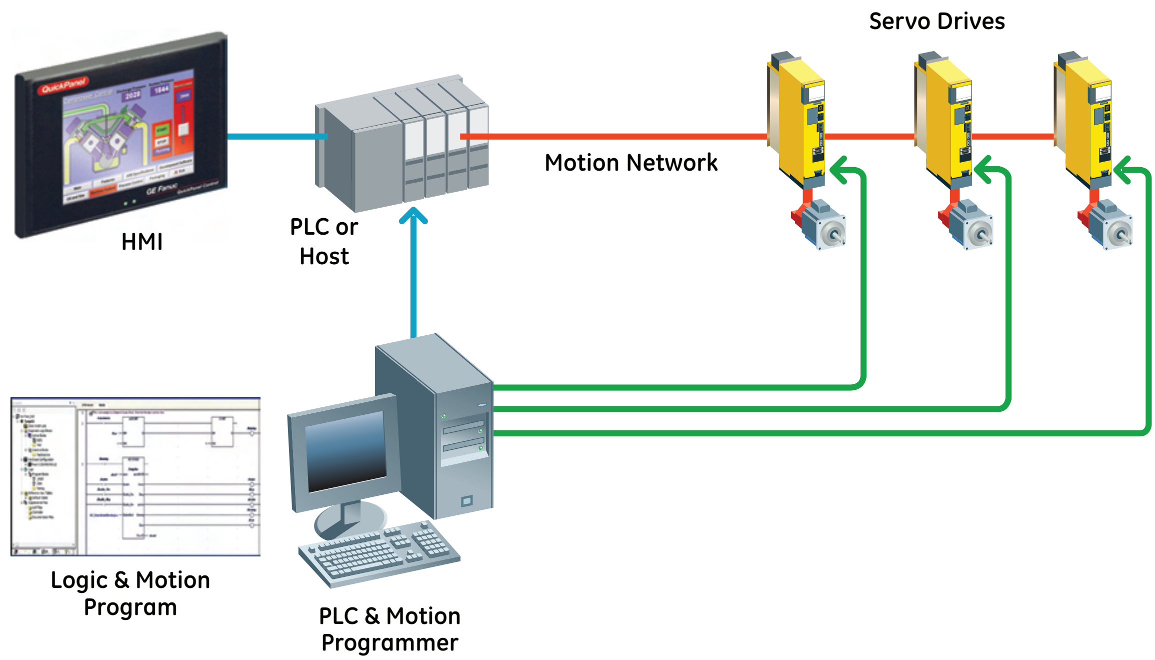
Traditional Architecture 2

Motion controller modules/cards that plug into the PLC backplane or PC host have separate motion programs. Like the first architecture, each motion controller may have a separate program, and the additional programming required to synchronize the main machine control (logic) program and the motion programs can be significant. Servo amplifiers are connected via a motion network (SERCOS, Profibus, etc.) or an analog command interface. If the amplifiers are intelligent (close loops), there may be additional software for configuring their mode settings and tuning parameters.



Traditional Architecture 3

This configuration uses a motion network interface (SERCOS, Profibus or Profinet) that either plugs into the PLC backplane or is included directly on the host controller. These systems typically use a distributed intelligence architecture that shares the host controller (PLC, PC) CPU processing power to do motion path planning for all axes in the system. The motion network passes new position commands to each axis every path planner update cycle, and then the servo control loops are closed in the individual axis amplifiers. Amplifiers in these systems must be configured and tuned using separate software or sometimes can be configured by the host controller over the motion network.

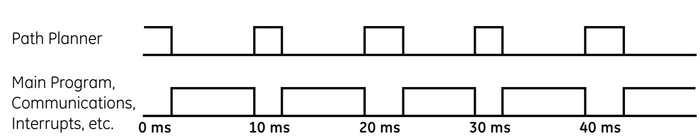


Additional effort required for synchronization

The drawbacks of traditional architectures 1 and 2 include having to use and learn different programming software environments for the host controller, motion controller, and servo configuration. Each piece of the system requires its own individual application program(s), and the additional programming required to synchronize the main machine control (logic) program and the motion program(s) can be significant. As a result, system performance can be limited because of the processor burden to run additional synchronization logic, the timing constraints for asynchronous handshaking between programs, and even the bandwidth of the motion interface. The coordination of passing information between the multiple programs forces tradeoffs between quantity of data and speed, and also introduces another layer of complexity where errors and bugs may occur.

Reduced system performance with additional axes

Architecture 3 has the benefit of combining the motion and machine control (logic) programs; however, it introduces a significant limitation as more axes of motion are added. Because the motion path planning is a processor-intensive function, as more axes are added, more system processing power must be allocated to calculating motion trajectories. The path planner must run at an exact update rate or "heartbeat;" therefore, it is typically one of the highest priority tasks and will interrupt any other tasks, including processing of application-related interrupts and executing the main control program as shown in the diagram below. In this example, the path planner runs every 10 ms.



As axes are added, there may be insufficient processing power to provide acceptable system performance, in which case, the path planner update rate or heartbeat must be slowed down. Particularly in high-speed applications, longer motion path planner update times mean that the axis can not react as quickly to changes in the motion required to properly control the system or machine.

For example, a system with a 10 ms path planner cycle can only react to a program request to change the end destination or velocity of an in-process move on the next update which, in this example, could be almost 10 ms. For high cycle rate machines, the in-process move could be completed before the system can react. This variability in the path planner update rate on systems with a different number of axes can result in inconsistent performance in different machines or applications using the same control solution. Additionally, in most systems, motion can only be started on the next path planner update, resulting in a delay that can cause position errors and application limitations in a variety of high-performance motion solutions. This will be explored in more detail later in this paper.

Greater potential for errors

In some products using a traditional architecture, the main host controller CPU is also used to close the servo position loop for each axis. Because of this additional processor load, the time between position loop updates must increase as more axes are added. This means that the motor's actual position and commanded position are compared less frequently—resulting in larger position errors. Because greater position error can have a direct impact on product quality, the machine cycle rate (throughput) may have to be reduced to compensate.

For example, imagine a thermostat in a home that is trying to maintain a set temperature (the command). If the thermostat checks the temperature once every hour (the feedback), there can be large swings in the actual temperature over that hour (the error). On the next update cycle, the temperature is checked against the set point, and the thermostat detects the temperature error and turns on the air conditioner to attempt to bring the temperature back to the desired level. However, the A/C system can quickly cool the house and over the next one-hour cycle of the thermostat, the temperature drops well below the desired temperature set point, again resulting in significant error in the desired temperature. The same thermostat, if checked once every five minutes would reduce the error in temperature and keep a much more constant temperature in the house.

Servo position loops work in much the same way; the more frequently they are checked, the more accurately they will control axis motion on the machine. A fast position loop update keeps position error small when torque disturbances are encountered. Torque disturbances can arise from machine binding, excessive friction, impact loads, etc. The faster the servo can recognize the disturbance, the more quickly corrective action can be initiated.

GE PACMotion — An Alternative to Traditional Architectures

The latest generation of motion control when tightly coupled with a PAC controller, such as GE's PACMotion and RX3i, can overcome the limitations of the traditional architectures and provide some significant customer benefits, including:

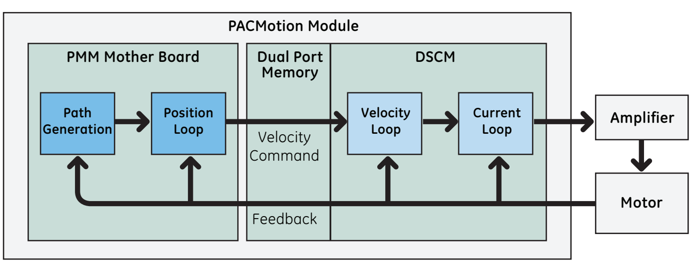
- Improved machine productivity
- Increased engineering efficiency
- Enhanced machine flexibility

Improved machine productivity

PACs integrated with motion controllers can use a very high speed backplane and real-time data exchange techniques to provide tighter synchronization of multi-axis motion and between motion and logic events. PACMotion's unique PACSync architecture employs a demand-driven data exchange and dual port shared memory with the PAC CPU, which reduces scan time impact and ensures the most recent motion data is readily available to the application program. Unlike a traditional PLC with motion, you do not have to pass motion data (for example, axis actual position) at specific times within each CPU scan. PACMotion passes instance data to the program motion function blocks asynchronously as soon as new data is available, allowing access to the motion data without waiting for the next CPU scan. A scan delay may cause phase errors to occur because the data may be stale by the next CPU scan. This level of data synchronization is critical for accurate control of high speed machines.

Similarly, PACMotion synchronizes the position loop update of all axes in the RX3i rack, ensuring that phase errors do not occur due to asynchronous position loop updates of different axes in the system. In many machines, phase errors resulting from asynchronous position update from axis to axis can directly impact product quality. For example, consider an axis driving a web of paper through a set of pinch rolls at a speed of 1 meter/second. A second shear axis is used to cut the moving web into fixed length sheets. A 1 ms phase error between these two axes will result in a variation in cut length up to 1 mm.

PACMotion uses a different architecture than the three traditional cases described earlier. In the PACMotion PACSync architecture, motion path planning and all servo loops are handled by a motion co-processor in each PACMotion module (PMM). Each PMM supports up to four axes of motion and one virtual master axis with full motion programming. This architecture provides consistent, high speed, path planner and position loop update rates for each axis. As more axes are added, there is no compromise to system performance by increasing motion update rates or by constantly interrupting the application program to do motion calculations. The PACMotion path planner runs at a constant 1 ms update rate, and all axes position loops are simultaneously updated every 500 µs. The block diagram below shows the details of this architecture.

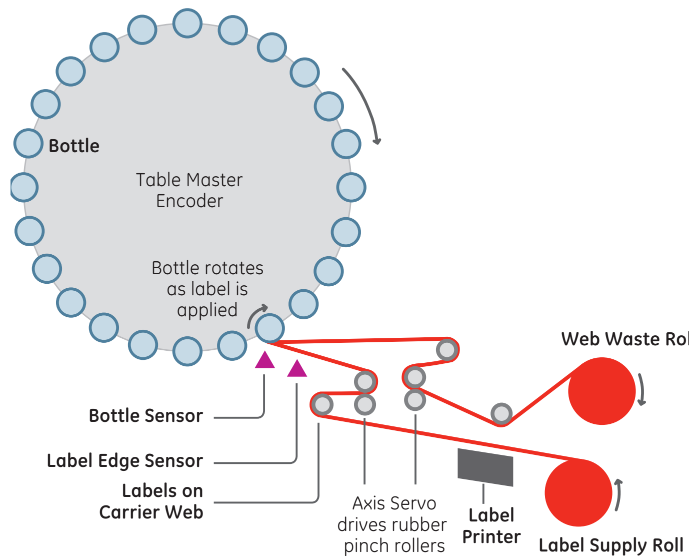


Because all servo loops are closed in the motion controller, the amplifiers are power blocks and do not require configuration or tuning parameters to be stored to the amplifier. Although the motors and amplifiers boast remarkable reliability records if one does fail, the Mean-Time-To-Repair (MTTR) is very low due to plug-and-play connections, and there's no need to retune or reconfigure the loops.

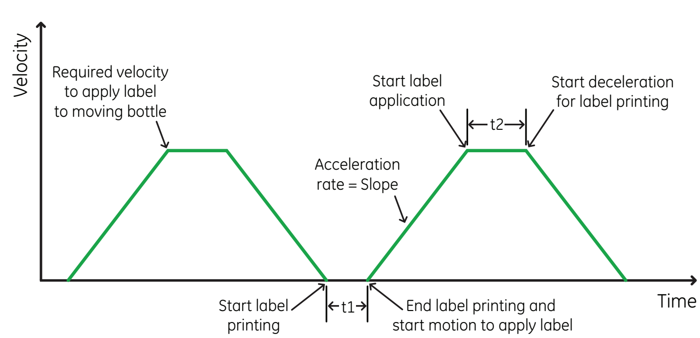
Delayed start and synchronized start functions

PACMotion also supports delayed start and synchronized start functions that can further improve system performance on high-speed applications. For example, an application requires an adhesive label to be applied to bottles moving past the labeling head at a rate of 400 bottles per minute (150 ms per bottle). The labels are affixed to a carrier web, which is advanced at a speed of 1.67 meters/second by a servo motor driving a set of pinch rolls in order to match the label feed speed to the bottle surface speed during application. The labels are indexed in a start/stop motion (one label) to allow the same machine to apply labels of different lengths and with different label spacing on the carrier web. Typical label placement accuracy on the bottle is ±0.5 mm. The mechanical configuration for this application is shown in the diagram below.

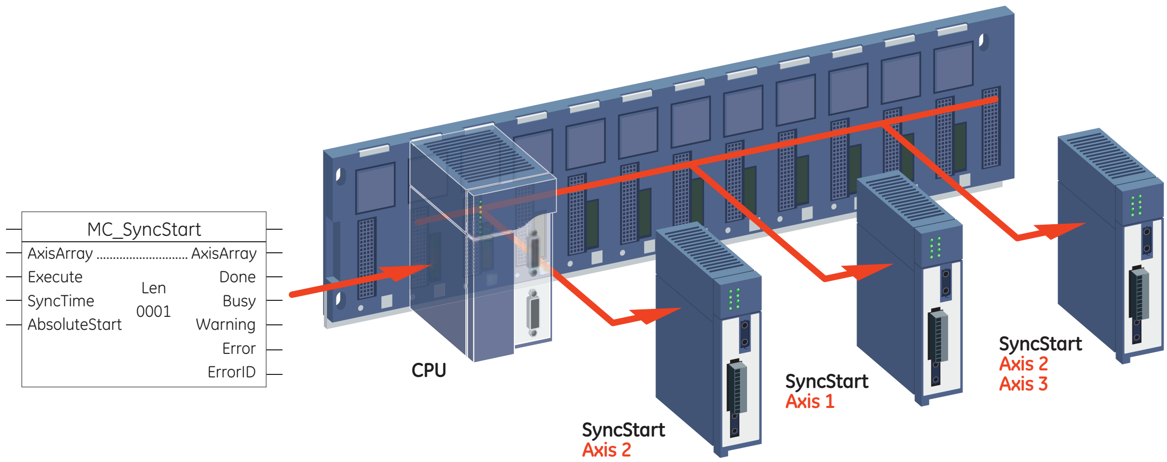
Between successive label applications, the labels are imprinted with unit or batch specific data such as date codes. There is a



fixed time required to print the labels based on the printer speed and number of characters, and the labels must be stationary during the printing process. Once accelerated to the application speed, the labels must remain at this speed for the entire length of the label to avoid tearing or bunching of the label while it is in contact with the bottle. These two constant speed times are shown in the diagram below as t1 (print time) and t2 (label application time).

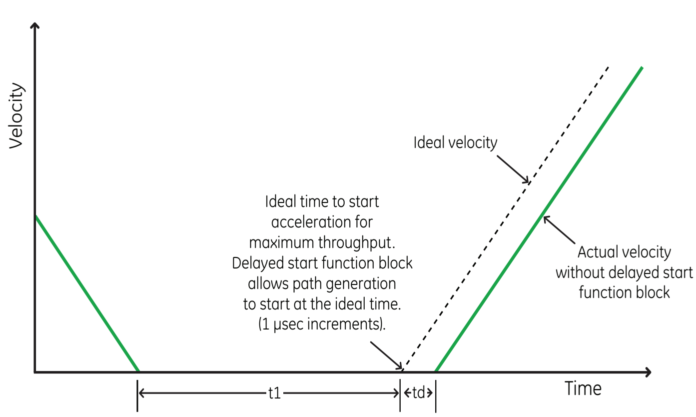


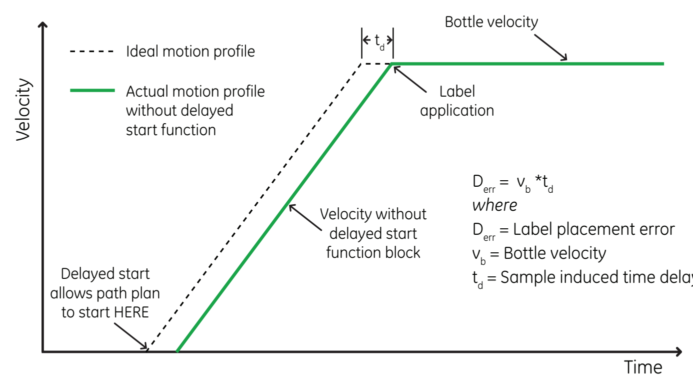
Integrating Next Generation Motion Control with GE Programmable Automation Controllers



The acceleration and deceleration of the labels are generally limited by the label carrier material properties to avoid stretching or tearing and/or the acceleration limits of the servo motor and connected load inertia. Most systems generally push these limits to maximize throughput. Therefore, if we assume that the acceleration rate is essentially fixed, then it can be shown that the start time of the label motion has a direct impact on the label placement accuracy. Ideally, for maximum throughput, the label motion should begin immediately at the end of the printer time t1. However, in most systems, motion must always begin exactly on the next path planner update. Depending on the various application variables, the delay in the start of motion from one label to the next could be as long as one path planner update cycle. This delay from the ideal motion start time is shown in the diagram below as time (td).

The effect of this delay can be shown in an actual numerical example shown in detail in the following diagram.





Earlier, we stated that the required label placement accuracy was ±0.5 mm (Derr), and the label application speed needed to be 1.67 m/sec to match the surface speed of the bottles (vb). Given these parameters, we can solve for the maximum sample induced time delay (td) that will still result in acceptable label placement, as illustrated in this simplified example below.

$$vb = 1.67 \text{ m/sec}$$

$$Derr = \pm 0.5 \text{ mm}$$

$$td = \frac{Derr}{vb}$$

$$td = \frac{0.5 \text{ mm}}{1.67 \text{ m/sec}}$$

$$td = 299.94\ \mu\text{sec}$$

For this application, any motion system with a path planner update rate longer than about 300 μs will result in placement of some labels that are outside of the allowable tolerance.

PACMotion's delayed start feature allows motion to begin at times in between path planner updates with a resolution of 1 μs. This capability ensures that each label will be placed accurately regardless of the path planner update rate. Although this is just one example, the concept has much broader application. Any cyclic application requiring target acquisition on a system whose application acceleration has been maximized to enhance machine throughput will benefit from the delayed start feature.

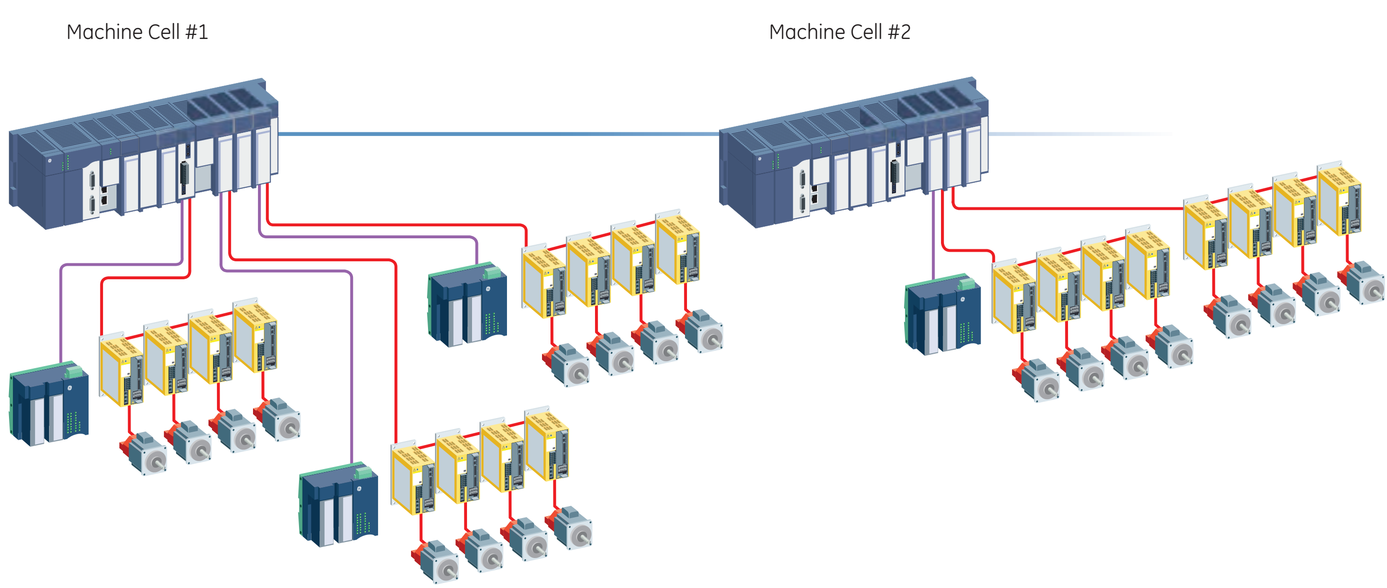
PACMotion also supports a synchronized start function that allows the start of motion to be precisely synchronized on up to eight axes. This synchronized start is orchestrated by the PACMotion PACSync architecture using peer-to-peer communication over the RX3i high speed PCI backplane. Each axis verifies that it is in a valid state before synchronously starting the motion it has received from a motion function block.

Increased engineering efficiency for quicker time to market

As time-to-market is critical for success in today's competitive marketplace, integrating motion into one common environment with HMI, logic and process control substantially increases engineering efficiency. With a common open standard programming language, tag database and function blocks, engineers can spend less time and effort learning new programming environments and synchronizing different programs for control of machine logic, motion, and view applications. The result is faster program development, quicker time to market and faster machine commissioning.

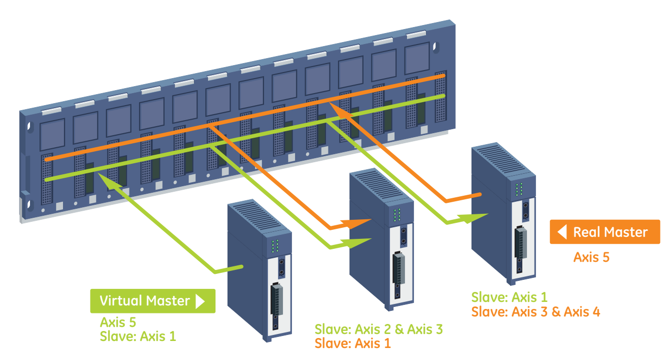
However, this integrated environment should not be confused with a "simple" programming environment, as most integrated control programming packages allow users to program in many of the standard IEC languages such as structured text, ladder logic, 'C', and others. For example, GE's PACSystems features a control engine that is portable to multiple platforms and allows users to choose the hardware and programming language that best suits each particular application. When integrating motion control, the system provides a universal engineering development environment for rapid development, implementation and migration.

A noteworthy trend affecting engineering efficiency is a motion programming paradigm shift—away from proprietary languages toward open standards. PLCopen has developed the only open standard motion programming language that integrates with the existing, widely accepted IEC languages. Open standard programming significantly increases programmer productivity and protects investment in intellectual property by providing portability to different hardware platforms. PACMotion supports over 50 motion functions in both structured text and ladder diagram function block, and its programming has been developed in compliance with the PLCopen standards.



Integrating Next Generation Motion Control with GE Programmable Automation Controllers

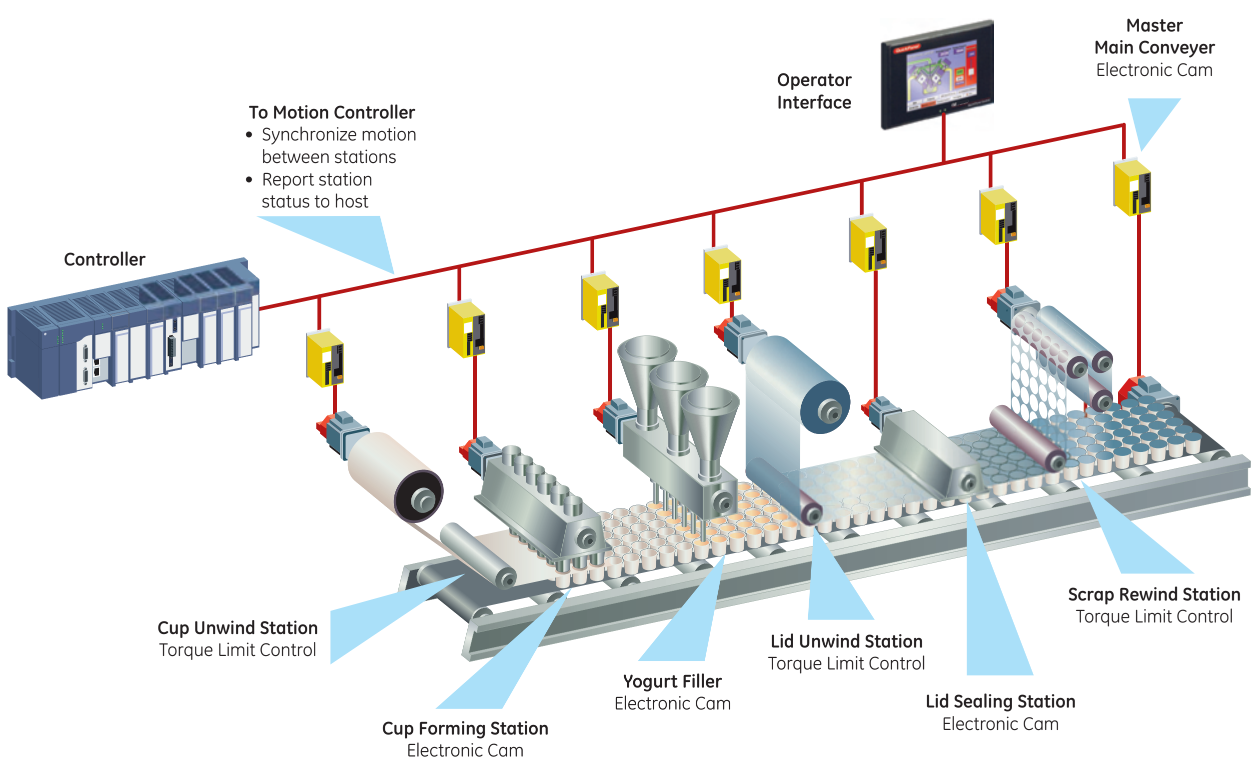
Furthermore, a fiber optic I/O terminal block (FTB) connected to the PACMotion controller reduces the number of wires for motion I/O by consolidating wiring from field devices such as home switches, over-travel limits, and registration sensors for all four axes into a single fiber cable. The FTB can be located up to 100 meters from the PACMotion controller. This allows islands of automation where all devices are brought into a single cabinet, then connected back to the line controller via noise immune fiber optic links; this star fiber optic network minimizes potential machine downtime if a link is damaged or disconnected.



Enhanced machine flexibility

Because of the explosion of new products, production lines must run a variety of products, and production runs are routinely turned over multiple times per day. As a result, today's production lines require an incredible level of automation flexibility. Automation and motion control solutions not only must provide the scalability to handle machines with varying levels of performance and different numbers of axes, but also facilitate instant line reconfiguration at the push of a button. A single line might fill 16 ounce, 20 ounce and 2-liter bottles in successive daily production runs. To realize this capability, current generation machines utilize electronic line shafts (ELS) to synchronize all axes of motion on a machine or a complete production line.

To realize this electronic axis synchronization, a single master axis acts as the pacer for all other slave axes. This master can be a real axis such as a motor or external encoder, an external encoder mounted on the machine, or a time-based virtual master. Each PMM includes a master axis that can be configured as a real master tied to an encoder or as a virtual master with full motion programming support. PACMotion provides the flexibility to tightly synchronize all axes in the system by passing master axes over the RX3i backplane. Any axis can be a master or a slave to any other axis in the system without any external wiring. More importantly, these master/slave relationships can be redefined on the fly by the application program.



This electronic synchronization not only simplifies system wiring and reduces I/O, but enables instant line conversion at any time. For example, in a line used to manufacture, fill and seal plastic yogurt cups, each operation must be synchronized to the main conveyor moving the cups through the line. The cup forming press, filling and sealing stations use electronic cam profiles that can be changed or scaled on the fly to adapt for different cup sizes or shapes. Torque control is used on the wind/unwind stations to control tension in the plastic film used to make the cups and the foil used to form the lid. These torque limits can quickly and easily be changed to conform to the requirements of different materials used across the range of yogurt cups made on this line.

Furthermore, PACMotion integration with the RX3i PAC controller leverages flexible system configuration, whereby both centralized and hybrid distributed architectures are supported. Hybrid solutions merge the benefits of centralized programming and control with reduced wiring by distributing the amplifiers and motors. Distributing the amplifiers and motors also facilitates modular machine designs such as multi-color printing presses where different color stations are racked in, depending on the requirements of the print run.

Key considerations for selecting an automation control system to maximize productivity

A control system is central to a machine's performance, and selecting one is an important business decision that involves many factors, including cost, change management, a learning curve and potential supplier risk. Therefore, it is imperative to know what you are buying. As you investigate alternative control systems, there are important considerations to factor into your potential investment.

System architecture—single CPU vs. distributed CPU

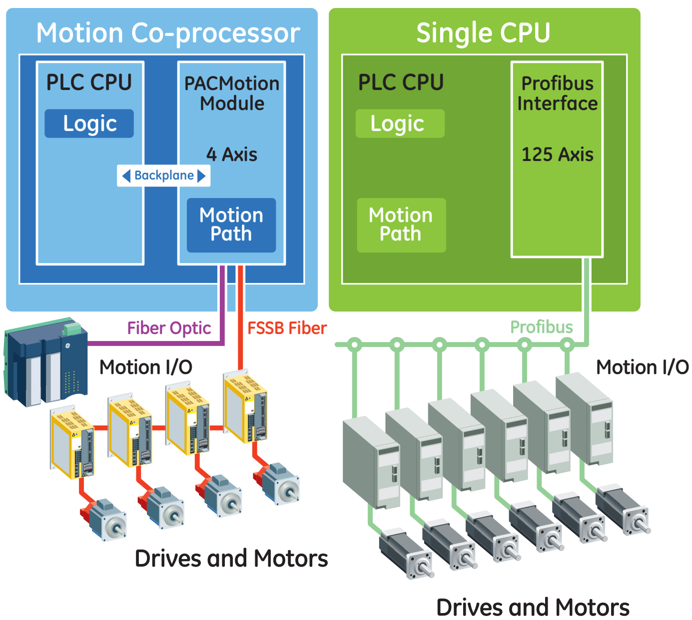
In addition to reduced system performance as you add more axes of motion, the limitations with a single CPU are further complicated because the motion path planning calculation must take precedence over everything else in the system. As you add more axes, the motion calculations must be slowed down to accommodate the increased calculation load on the shared CPU, which can result in significant performance limitations for high-speed applications. Similar to what happens in a personal computer when you have a lot of applications open, the computer slows down because the main processor is timesharing between all of the tasks and must slow down to handle the load.

Would an integrated control system benefit your business?

Switching your automation or motion control platform requires careful consideration. Ultimately, the decision may come down to risk management—whether the benefits of a PAC controller with integrated, high performance motion control outweigh any potential risks. Some questions to assess the potential benefits of an integrated control system include:

- Are you or your customers getting the machine throughput desired with your current motion controls? What is the bottleneck in your current machine?
- Do you have the flexibility to automate more axes without degrading machine performance?
- Is the throughput of your machine limited by slow servo update rates, the ability to respond to motion events quickly enough or long program scan time resulting from sharing a single processor for motion and logic control?
- Would eliminating position phase errors between axes by updating all position loops simultaneously improve machine accuracy that would improve production yield?
- Are you able to instantly reconfigure your machine or line to handle different products? Can you programmatically change master/slave axis assignments and scaling, electronic gear ratios or engineering units (e.g. English to metric) on the fly?
- Could your solution benefit from the reduced wiring and improved noise immunity and reliability provided by distributing servo amplifiers and motion centric machine I/O via a fiber optic cable?
- Would your engineering resources benefit from an integrated environment? Does your solution include multiple programming software packages and/or different programs for machine sequence, logic, motion, and operator interface control that must be synchronized? Would an integrated programming environment reduce development risk or improve engineering efficiency?

Integrating Next Generation Motion Control with GE Programmable Automation Controllers



Advantages of a distributed CPU

By contrast, with PACMotion's PACSync architecture, the motion calculations are done in dedicated motion CPUs. The PAC CPU runs the application program, and separate co-processors run the motion path planning and servo control loops. A predefined number of axes are calculated in each motion co-processor so regardless of axis count, the motion update rates and resulting system performance are consistent.

As machine speeds continue to increase to achieve greater throughput, cycle times become compressed, providing less time to respond to changes in the motion path based on unexpected disturbances or real-time events. Because of the faster response provided by a distributed CPU architecture, the path planner can quickly recalculate the planned motion in response to environmental or program changes while fast position loops quickly compensate for changes or disturbances to minimize position error.

Demand for higher production rates is often compounded by the need for tighter control of product tolerances. Responding to errors and program changes more quickly and accurately is critical to delivering increased machine throughput and consistent yield. This is a major advantage for any machine maker or end user and should be one of the primary considerations in selecting an integrated automation control system.

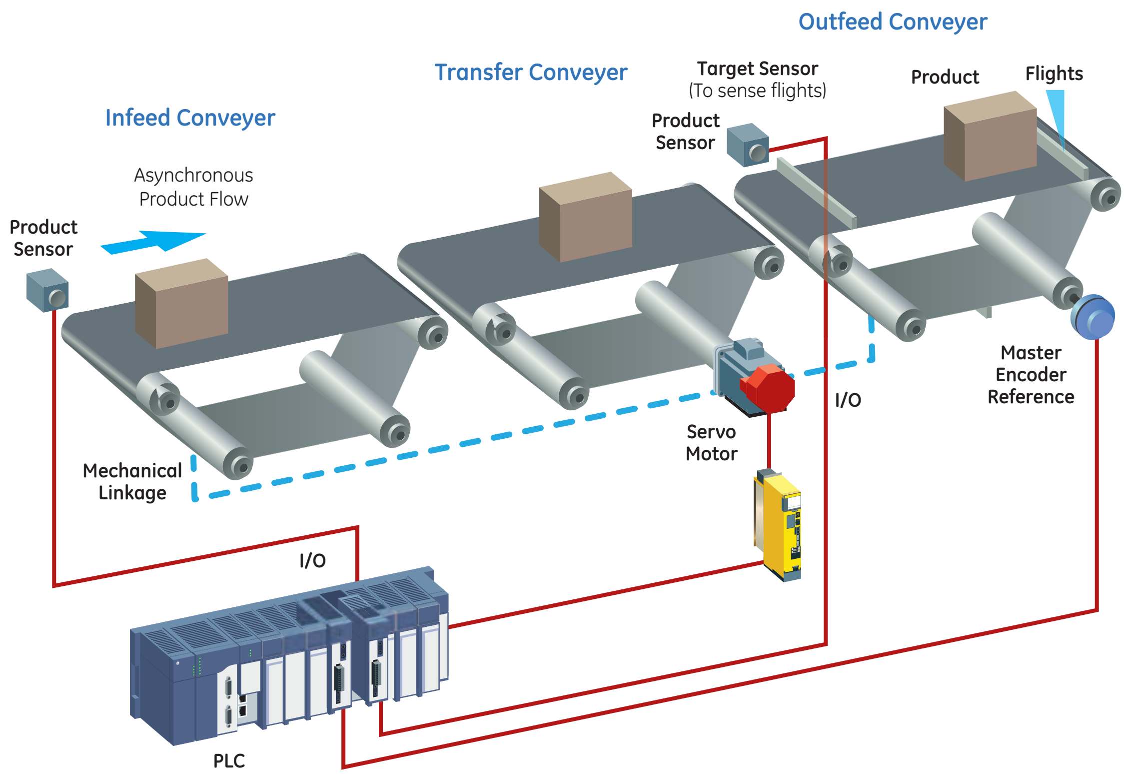
Key considerations when purchasing an integrated motion control system are the ability to deliver fast, consistent motion update rates that do not degrade application performance due to excessive CPU loading and the ability to precisely start motion anytime rather than on the next path planner update.

Common programming environment supported by open standards

As discussed, an integrated automation control system that is supported by a single programming environment based on open programming standards is key to improving engineering efficiency. The programming package should have comprehensive support for all of your application requirements. If the breadth of your applications includes machine logic, motion and process control, in addition to HMI products, it is critical that the programming environment consolidates all device programming and uses a common tag database to simplify programming and reduce commissioning time. Programming languages should comply with open standards to protect your IP investment and reduce the learning curve and training costs.

Advanced features in motion control with PACs

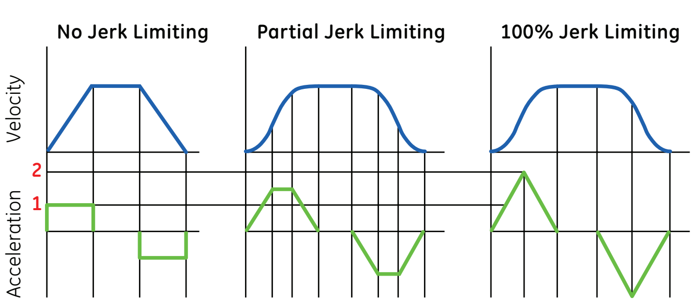
The sweet spot for motion integrated with PACs may be in the more complex applications that require higher cycle rates and tight coordination of multiple axes. Many of these complex applications can benefit from advanced motion features such as variable jerk control and blending of jerk limited profiles. Jerk control can be advantageous in certain applications such as transporting liquids without spilling or preventing boxes from toppling or slipping on a conveyor belt. As machine speeds continue to increase, the cycle time per product gets shorter and axis velocity and accelerations must increase to keep pace. As acceleration rates increase, the application problems stated above only get worse. Additionally, abrupt transition of these higher accelerations causes severe impact loading on all mechanical components on the machine. Proper application of variable jerk control can minimize machine wear while optimizing servo motor sizing. Minimizing motion jerk reduces the repetitive impact loads on mechanical components such as lead screws, gearboxes and couplings that can cause them to fail prematurely. The tradeoff of using jerk control is that it requires greater torque (acceleration) capability from the motor.

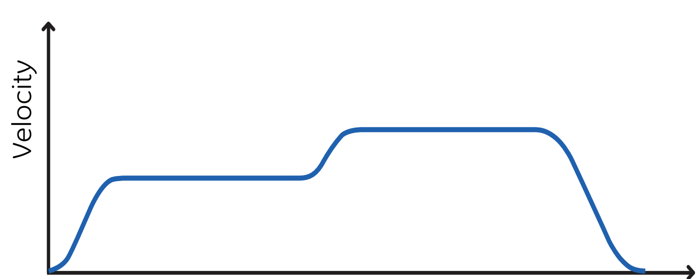


As shown in the diagram below, full (100%) jerk control requires exactly twice the acceleration torque from the motor compared to linear acceleration in the same amount of time. Variable jerk control can tap the motor reserve torque to minimize machine wear without increasing motor size and cost. However, some motion path planners only support an all (100%) or nothing approach to jerk control, so it is critical to consider a motion control solution that will meet all of your application requirements while reducing maintenance costs and maximizing machine life.

The blending of jerk limited profiles can provide much tighter control in applications where velocity changes are required during the move. For example, a packaging line transfer conveyor (also called a smart belt or random infeed) is used to equalize the random spacing of products coming off an infeed conveyor as they are transferred to an outfeed conveyor for wrapping or packaging as shown in the above diagram.

As the product is transferred from the infeed conveyor to the transfer conveyor, the speed of the two belts must be equal. Once the transfer is complete, the transfer conveyor will accelerate or decelerate based on input from the target sensor to equalize the spacing as it is transferred to the outfeed conveyor. During the transfer conveyor's speed changes, it is critical that the product does not slip on the belt or the product spacing will be incorrect. In this case, it is important to blend two jerk limited profiles as shown in the diagram below.





Integrating Next Generation Motion Control with GE Programmable Automation Controllers

Many motion controllers are not capable of this type of complex motion control—especially systems that utilize a single processor design since the path planner calculations required to plan blended profiles with jerk limited acceleration can place a large demand on the motion processor. PACMotion's patented technology supports replanning and blending of jerk limited moves during any part of the move profile, providing significant application advantages in addition to enhancing system reliability.

> Some systems do not have the flexibility to change the motion path during the deceleration segment even when linear deceleration is used, whereas GE's PACMotion can adjust to inputs such as registration marks to change the path during deceleration, resulting in the highest accuracy possible.

Machine reliability

Finally, when evaluating integrated motion control systems, reliability is critical. An integral part of machine reliability is motion control—made up of moving parts and power electronics, which have a higher probability of failing. The motion systems that run these parts undergo more physical stress than any other part of the system, and the application programs that run them tend to be some of the most complex programs running on the system. Therefore, you should be sure to evaluate the motion control system for reliability, as well as low MTTR for fast recovery and reduced down time. Manufacturers should publish mean time to failure based on historical information, which can help you gauge component reliability in real-world applications.

For example, GE's PACMotion controller uses the highly reliable servos, which have a mean time before failure (MTBF) measured in decades. The amplifiers have no stored configuration or tuning parameters that must be loaded when replaced so they are easily swapped in the rare case of failure. This type of design in any motion control system can directly impact the reliability of the entire machine or production line.

Summary

As OEMs increasingly adopt and invest in the latest technologies to meet their customers' challenges, selecting an integrated motion control solution with the performance, flexibility and reliability to keep pace with the ever increasing demand for productivity and more flexible asset utilization becomes a critical success factor. Companies in high-performance industries that require multi-axis motion control for mid- to high-end applications may especially benefit from integrated control systems such as GE 's PACSystems and PACMotion as they help maximize machine productivity for a sustainable competitive advantage.

GE Intelligent Platforms Contact Information

Americas: **1 800 433 2682** or **1 434 978 5100**.
Global regional phone numbers are listed by location on our web site at **www.ge-ip.com/contact**.

www.ge-ip.com

01.10 GFT-708A