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White Paper

A New Way of Motion Control

ABSTRACT

In this paper, the author discusses new paradigms in motion control, which allow machine designers and end users alike the ability to reduce motion design time and training costs, while increasing performance and transparency in the end product. A brief review of the motor, drives and controller technology is presented, with an emphasis on integrated safety, diagnostics and simulation, as the industry trends towards the digital factory.

Authors

Kevin Wu, Product Manager for Motion Controllers,
Siemens Industry, Factory Automation and
Craig Nelson, Product Manager for Sinamics S Drives,
Siemens Industry, Digital Factory

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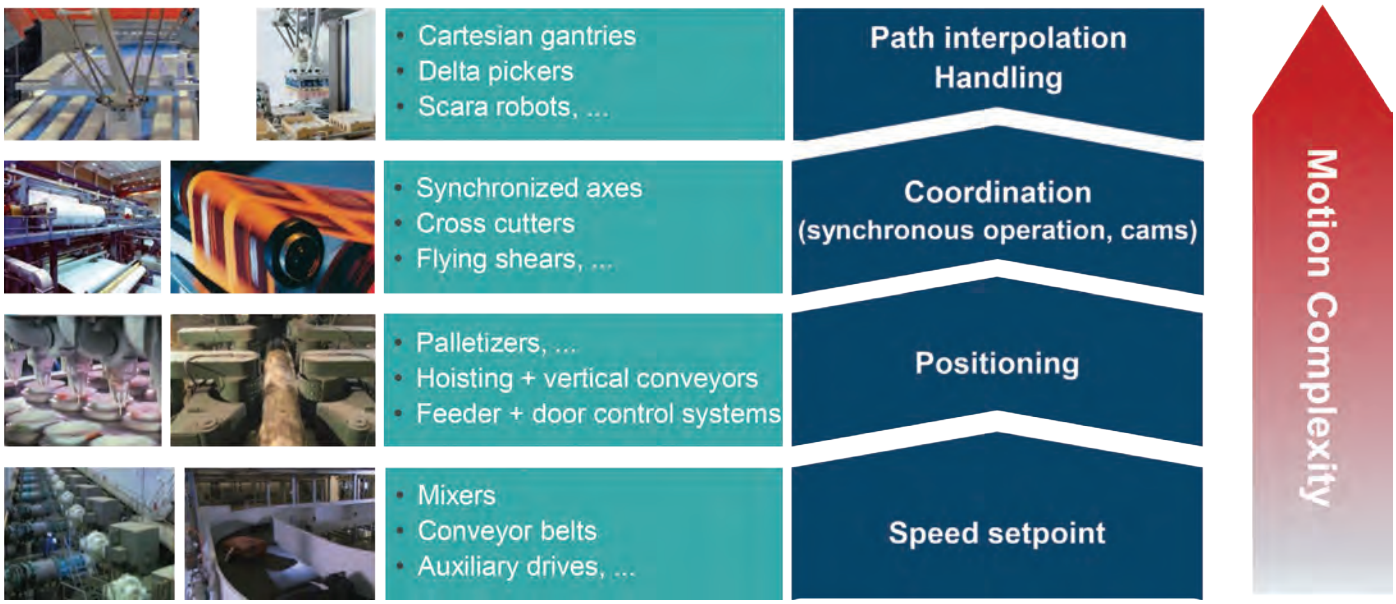

Figure 1. Motion control applications

To compete in the global market today, machine builders must deliver high-performance machines that are faster, more automated and more flexible, while always meeting customer expectations and keeping design costs under control. New technologies exist today to enable designers to fashion their motion control schemes with the full integration of the motor, drive and controller devices, while simultaneously integrating safety, diagnostic and operational simulation into the design, all in a virtual environment. The last development has myriad advantages, described in this paper.

As Fig. 1 demonstrates in the abstract, a typical machine today may have a wide variety of functions operating in multiple axes, ranging from the simple movements and speed setpoint control of a pallet indexer, mixer or component insertion device to the highly complex motions of Cartesian gantries, delta pickers, SCARA robots and other devices with path interpolation handling considerations. Also, the coordination of synchronized axes, cross cutters, flying shears, palletizers, hoisting or vertical conveyors, feeder and door control systems as well as large converting operations with constantly changing roll diameter and tension systems require sophisticated positioning, synchronized cam movements and other motion complexities. Add to this the growing need for machines to be more flexible, even to the point of continuous low-volume, even one-off, production and the motion control design and execution challenges grow.

Further, with the impact of digitalization in the modern factory, the need to extract more data, prioritize it and even simulate operations on a machine prior to construction continues to present designers with unprecedented requirements in a time-constrained working environment.

But there are new ways to confront these challenges today. Here is a brief review of the typical motion control needs on today's machines.

Fig. 2 illustrates a variety of cyclic and continuous production requirements. For our purposes in this paper, we define "cyclic" as those in which an object is created stage by stage over a series of workstations, while "continuous" is defined as flow production without interruption, whether additive or subtractive, often in a CNC environment. Thus,the range of motions being controlled range considerably, from the basic to the high-end.

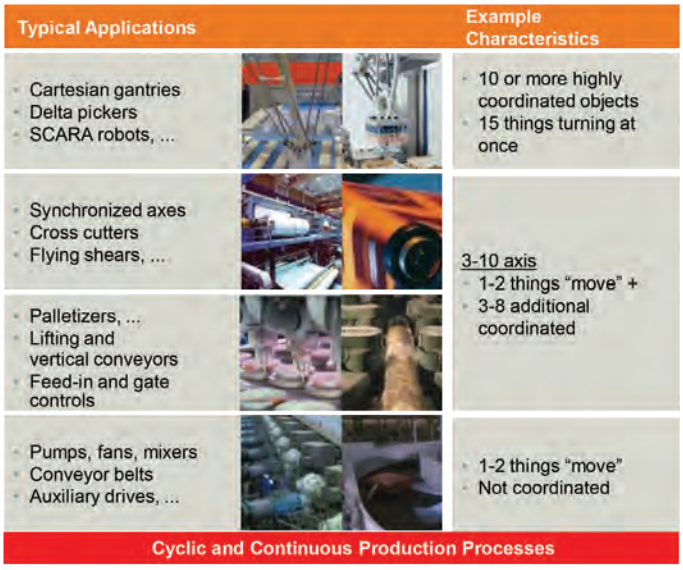

Figure 2. Motion control market (cyclic and continuous)

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Fig. 3 likewise illustrates the various motion control levels of complexity faced by designers today.

Four essential characteristics exist for the machine designer, as a result of these motion control challenges. Each must be satisfied by the components used and the method of integration applied.

1) Synchronization with specification of the synchronous position;
2) Synchronization without specification of the synchronous position

Figure 3. Overview of motor control functionalities

Easy to Program

When a motion is required, it must be:

1. Graphically configured in the drive.
2. Selectable in the motion functions, using technology objects.
3. Programming with pre-engineered PLC open Motion Control function blocks or similarly proven machine libraries of function blocks.

The technology objects handle motion control as well as the closed loop control and diagnoses of the axes involved.

A good downloadable library of ready-to-apply function blocks should include such operations as camming, cross-cutter, gearing, flying saw, jog path, load sharing, positioning, rotary knife, splice control, synchronism, speed control, measuring probes, cam disc, cam/cam track, gripper feed, print mark correction, double misfire and other industry-specific tasks. Some controls suppliers offer such libraries with their design software today.

Programming involves the configuration of the motion applications using graphic editors, the operation of the axis/drive from the control panel, detailed display of the diagnostic and status messages, function-related motion blocks for the motion commands and the determination of the comprehensive feedback signals from the motion blocks. The good news is that all these functions can occur in a drag-and-drop scenario.

System Simulation

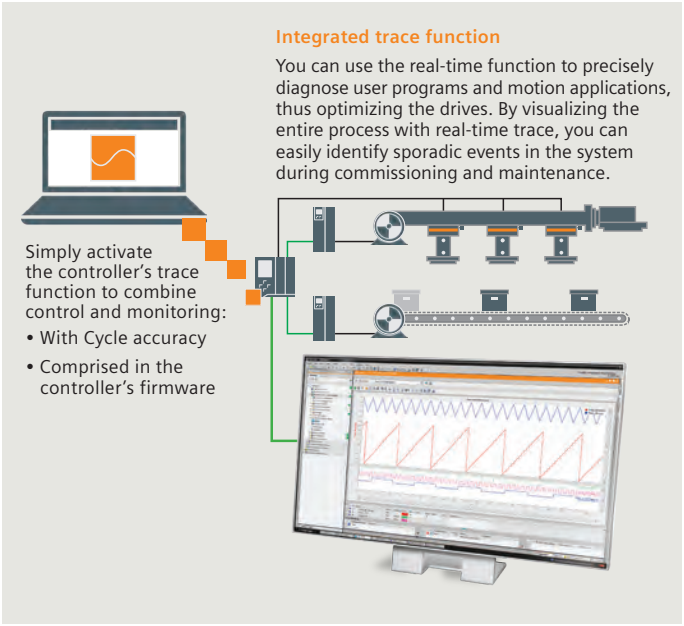
The early detection and elimination of programming errors allows the designer to accelerate commissioning time and increase program quality. In a proper software package, simulation should be integrated into a single engineering framework, so no other software should be required. Ideally, with the use of only a physical PLC, the designer should be able to simulate all machine motions and full kinematics under load to determine the stress points, potential bottlenecks and other possible problems in operation, prior to construction startup.

This function is not theoretical today. Full machine test, validation of production and optimization of the application codes should be possible, without the physical hardware of the machine.

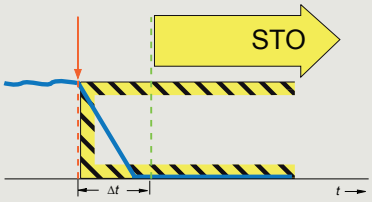
The controller itself can be simulated, along with all drive axes, HMI, motor condition and all the complex motion functions in a totally software environment, with integrated trace functionality for precise diagnoses.

Finally, when the satisfactory results have been achieved, the code can be seamlessly integrated by the designer into the actual hardware on the machine. Combining the control and monitoring is done by simple activation of the virtual controller's trace function, with complete cycle accuracy. The designer can use the real-time trace function to diagnose precisely all user programs and motion applications on the machine, which simultaneously optimizes the drives.

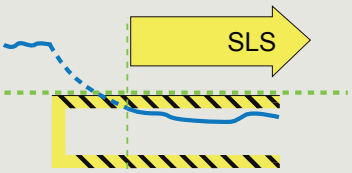
On the near horizon, it should be noted, the availability of PLC simulation function will create a totally virtual design option for the machine builder.



Integrated Safety



Safe torque off (STO)



Standard and fail-safe conditions can be integrated into the automation program to improve plant safety and increase productivity by quickly identifying faults and effecting remediation. On the design platform, safety and standard control should be done on a single network, through a safety PLC library with certified blocks utilized on a fail-safe PLC. Drives-based safety functions including motion and the safety acceptance test protocol should likewise be available to the designer in a single engineering tool.

Motion will always react correctly with safety control even for coordinated axes because safety and motion control are operated simultaneously in one CPU.

Built-in Diagnostics

Uniform system diagnostics can today be automatically generated during device configuration, meaning a faster troubleshooting protocol and streamlined maintenance for reduced downtime onstream. This reduction in engineering time can today be coupled with no additional programming requirements for diagnostic information. Easily understood fault and drive messaging can be automatically displayed on the design portal, HMI, web server and line/machine controller without any further engineering time.

On today's PLC with trace-based diagnostics, it is possible to get a recording of up to 16 different variables in separate CPU memory areas, with multiple independent trace jobs running in parallel and cycle-synchronous recording in real time of all values. A wide range of trigger conditions, with recording on the CPU and display on the engineering system HMI for optimization and simple search of sporadic errors, is possible. Likewise, exportable measurements for documentation and further processing as csv or ttrec files are offered in today's PLC software.

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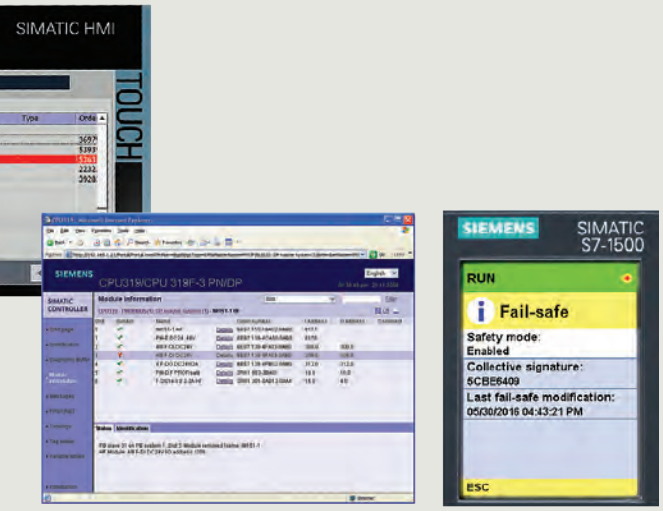

Automatic system diagnostics for faster troubleshooting protocol and streamlined maintenance.

In a typical example shown on the following page, the motion control in a machine system benefits greatly from the enhanced design, performance and communications features offered in today's components.

Controller

When a controller has all standard, safety and control functions onboard, a high degree of engineering efficiency results from the graphical and tabular configuration and optimization of, for example, cams, all integrated in a single engineering tool. This results in less time to market with less hardware to program. Plus, there are cost benefits to the builder in reduced engineering time, training and end user downtime, due to the easier operation of the controller.

Drives

AC/AC and AC/DC drives are available today to allow one drive line to perform high-performance induction and servo applications. The plug-and-play configuration of electronic nameplates is a desirable feature, as well, as it contributes to cost savings on both the commissioning and repair or retrofit operations for the user.

Today's memory cards provide simple and rapid drive replacement, regardless of firmware, which increases productivity in use, while the modular design of cabinet rack and decentralized "open" drive designs can more easily bring the devices to the location of use, saving cost while never compromising safety in operation.

Regenerative drives, though not new per se, are used in more creative ways today, running other plant equipment, creating stored power or simply returning to the grid to reduce overall plant energy costs.

Motors

Automatic configuration with self-identifying encoders are a convenient means of saving considerable time to market, due to less engineering time, plus they benefit the end user in repair and retrofit scenarios.

Many models have a single cable for power and feedback, reducing the wiring costs, cabinet space and installation expense.

As all industries move into a more global environment, the ability to design virtually has greater appeal than ever. Online support should be available from all vendors and should include technical operation assistance, application-specific engineering advice, 24/7 advice and assistance in all areas of device functionality, handling and fault clearance. Through many of today's system integrators and controls suppliers, full communication of data can be integrated to the cloud or a plant-wide communications system.

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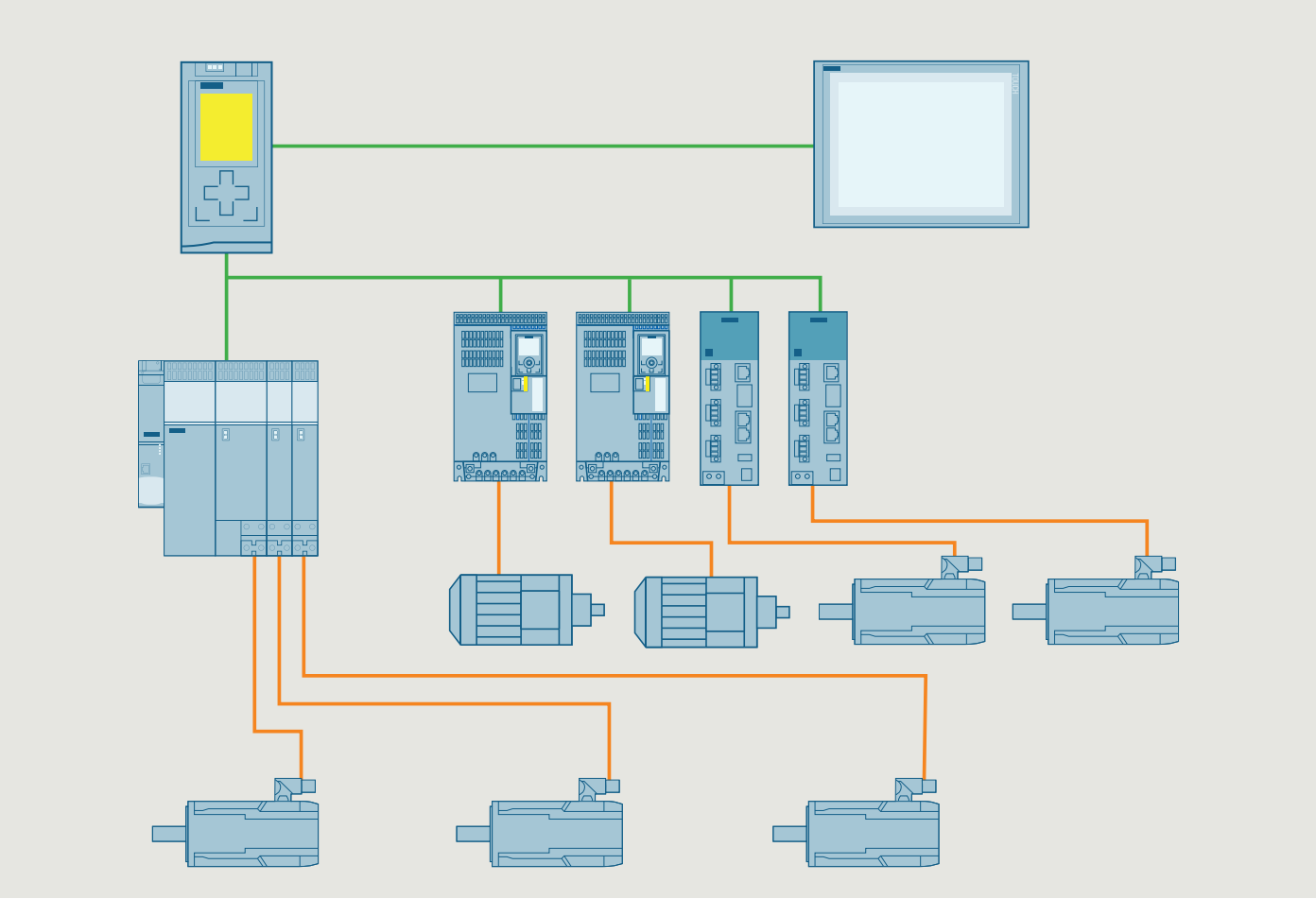

The motion control in a machine system benefits greatly from the enhanced design, performance and communications features offered in today's components.

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Author:

Kevin Wu may be reached for comments or questions at wu.kevin@siemens.com or 770-871-3982.

Craig Nelson may be reached for comments or questions at craig.nelson@siemens.com or 770-871-3868.

Editor note: Please direct all publication-generated inquiries to Karen Kasik, Manager of Marketing Communications at Siemens Industry, Factory Automation. Phone: 470-709-3641. Email: karen.kasik@siemens.com.

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Siemens Industry, Inc.
5300 Triangle Parkway
Norcross, GA 30092

For more information, please contact
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