How Today's Flexible Digital Servo Drives Help OEM's Build a Better Machine, Faster.

Flexible and scalable digital servo drives, such as the AKD™ make it possible for a single drive to be configured for a diverse range of machine control architectures.

KOLLMORGEN®

Because Motion Matters™

White Paper

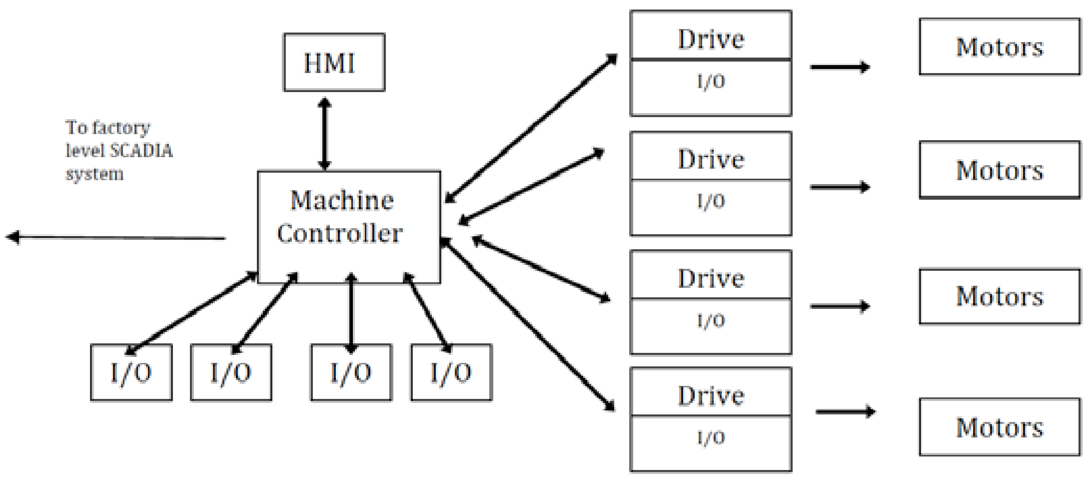
Carroll Wontrop, Senior System Engineer

Advances in digital hardware technology and software innovations now allow for a single digital servo drive to be configured to work in a variety of machine control architectures.

The advantage to machine builders is that they only needs to work with one drive from a single vendor to fulfill a variety of applications. Only one drive to specify, learn, and implement. Not only that, but setting up the drive for a particular machine control type requires simple configuration in the drive's setup software. There is no traditional programming language to learn, write or debug.

In the machine control structure, the servo drive is the link between the motors and I/O, and the machine's central controller, which is typically a PLC (Programmable Logic Controller) or PAC (Programmable Automation Controller). Traditionally (see sidebar) the servo drive provided the power conversion and contained the servo current and velocity loops.

With the incorporation of digital technology, including microprocessor and FPGA (Field Programmable Gate Array); servo drives can now control the servo position loop, have more digital and analog I/O, can communicate on a bus network, and can accept multiple feedback types. That said, in any given application, the servo drive capabilities that are ultimately utilized depend primarily on the machine's control architecture and the other components that are specified prior to the drive.



Main Machine Components

Because it serves as the "heart of the control," a machine designer will often select the PLC or PAC control platform and software prior to drive selection. Key factors for selecting the machine controller are:

- Ability to integrate an HMI
- Ability to integrate I/O
- Programming language/capability
- Execution capability
- Connectivity to higher-level controllers
- Ability to close servo loops
- Application need for centralized or decentralized control
- End customer preference

The motor type may also be selected prior to the drive, as the motor must be capable of meeting the mechanical and dynamic motion capabilities of the application. For example, a linear motor would be used if the application requires high dynamic indexing greater than can be achieved with a rotary motor with a ball screw or bell and pulley, in order to convert the rotary to linear motion.

Alternatively, if a motor is needed that will mate well with a gearbox in order to obtain good mechanical advantage a traditional rotary style servomotor would be selected.

Other key factors in motor selection include:

- Accuracy, repeatability, torque density, torque ripple, etc.
- Mounting configurations and physical constraints of the application
- Feedback types: dig enc, sine encoder, resolver, encoder with halls

The servo drive must be compatible with the motor and/or controller, which have often already been selected. Based on the capabilities of the PAC or PLC controller, the servo drive will be tasked with providing many of the following functions, in addition to basic power conversion and current loop servo control:

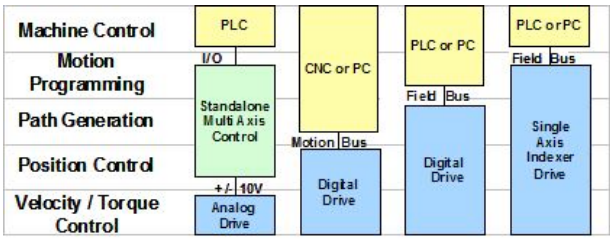
- Compatibility to the feedback device
- Velocity loop servo control
- Position loop servo control
- Machine I/O control (motion related) –travel limit switches, home switch, etc.
- Controller interface part (digital, analog, bus) with commands and status information flowing
- Motor brake control
- Profile generation (and motion task)

Flexibility Increases Machine Performance

Today's high performance servo drives are capable of far more than simply being configured to fit into the control scheme of the machine and performing basic functions. They can actually increase machine performance, shorten the time it takes to get the machine up and running, and lower total machine cost. The remainder of this article explains several of these key benefits.

Opmode (Operating Mode) Selection

The graphic to the right illustrates the various architectural types that a flexible digital drive can be utilized in. The servo drive can be used as a simple current loop with power amp, all the way to a unit that closes all the servo loops, controls I/O and performs some or even all of the machine control.



A few examples are:

Current Loop Only (SynqNet®)

In some applications it is desirable to close the servo velocity and position loops outside the drive in a central controller. This allows extremely tight motion coordination between two or more motors. Applications such as machine tool, robots, and electronic assembly require very tight coordination between axes to achieve the desired machine performance such as smooth surface finish and micron level positioning.

Some machine developers want to develop their own control algorithm, while others will use a commercial machine controller such as the Kollmorgen eXMP that provides advanced motion kinematics for controlling multiple axes of motion. The drive will accept either an analog or digital current command. For a digital command, a motion bus such as SynqNet® can be used. With an update rate of 250 microseconds for each axis, there is no degradation of performance when compared with an analog interface. Additional motor feedback information can be sent through the bus, completely eliminating the feedback cable.

One example would be a semiconductor pick-and-place machine where advanced motion profiles are required to satisfy the demand for ever-increasing production rates. Having a profile generator, position and velocity control in a single device reduces the time delays between a motion controller and traditional servo drive, to deliver higher production rates.

Position Mode (EtherCAT®)

In this configuration all servo loops are closed in the drive relieving the machine controller from the task of closing servo loops. When used with a high performance machine controller such as the Kollmorgen Automation Suite™, high performance control is maintained through EtherCAT bus deterministic transfer of data between the drive and controller with update rates down to 0.25 milliseconds.

Master / Slave

In a master/slave configuration, the purpose of the drive is simply to position the motor, and thus the machine, by following a master pulse train from a controller. Traditionally, such applications have tended to use stepper motors, but over time have transitioned to servo systems to achieve higher machine production rates.

Another example is an encoder master signal from either another drive, or an encoder wheel where the drive is electronically geared to another section of the machine. These applications are often found in the web converting and packaging industries.

Motion Indexing in the Drive

In some applications, the drive stores and executes motion indexes using an internal profile generator. Multiple motion profiles, or tasks, can be created using the drive's software setup environment.

This image shows a table of multiple motion tasks that have been created and stored in the drive. Each task is created with the help of a fill-in-the-blanks screen, eliminating the need to learn a programming language. To get a better understanding of the motion task created, the GUI can display the task in a graphical form. Storing motion tasks in the drive frees up the central machine controller from having to do this task, thereby saving processing power for other mission-critical processes. Additionally, in some applications the need for a separate PLC is eliminated. And it's not just saving the cost of the PLC itself; it is also the cost of wiring, extra cabinet space, spare parts and the need to learn a programming language. The bottom line - motion indexing simplifies machine control, resulting in faster time to market.

Switch Operation Mode on the Fly

Some applications call for switching opmodes on the fly. Drives with this functionality enable users to reduce cycle time while maintaining machine process performance by eliminating the need to stop the machine to switch opmodes.

Two common examples include position control to gearing in an electronic gearing application, or position to torque control in a clamp application.

I/O Functionality

I/O can to be configured for a variety of application needs. For example digital inputs can be used to start a motion profile, limit motion, represent a travel limit and switch opmode, among multiple other functions. But rarely are all these functions needed in every application.

So instead of having 20 or more dedicated inputs (one for each function), or having to write application code to implement a particular function; a configurable drive has a smaller set of three to eight inputs, which are configurable for the particular application's need.

The same holds true for digital outputs. Applications using a digital bus such as Profibus or DeviceNet benefit from the flexible I/O because the controller can use the I/O in the drive as a remote I/O point, possibly eliminating the need and cost to add another dedicated remote I/O node. In the past, in a traditional machine control structure without a network, it was not possible to change parameters.

Another option with a configurable input is to configure it to execute a string of commands to change multiple functions in the drive at once, such as tuning parameters, opmode and I/O settings. One good use of this option is changing one or multiple tuning parameters at the same time to compensate for changing machine load dynamics.

Brake Control

Control of the motor's brake, often required in vertical motion applications, is integrated into the drive. With digital servo drives, the brake automatically disengages when the drive is enabled (motor torque applied), and engages when the drive is disabled (no motor torque applied). Additionally, synchronization timing of brake engagement and disengagement with the drive enabled or disabled can be delayed or advanced through a user setting in resolutions of milliseconds. These adjustments calibrate the servo system to the machine load to prevent unwanted motor movement that could result in lower production rates, or even machine damage.

Tuning for Higher Machine Performance

Today's machines face ever-increasing competition, and as a result must be manufactured to minimize production cost while maximizing production rates. To reduce cost, manufacturers will sometimes modify load structures to make them lighter, but also more compliant and susceptible to resonance when required to change speeds quickly. Flexible digital drives help overcome such challenges by providing advanced control schemes with tuning filters and observers to maintain, and even increase, overall machine performance.

Advanced tuning tools in the drive's GUI allow for machine resonance and other mechanical issues to be characterized via a Bode plot. The GUI will even calculate tuning parameter values to minimize the effects of the resonance.

This is extremely helpful for machines with belt-and-pulleys, where resonant frequencies of the load limit machine performance. The bode plot helps the user characterize the machine resonance, which then leads to changing machine components, or adding additional control filters in the drive.

For the machine builder, all this can result in higher machine throughput, making the machine more valuable to the customers. One example of this is a motor connected to a load with a load to motor inertia mismatch of 150 to 1, even after a 20 to 1 gear reduction. The resonance frequency of the belt (25 Hz) limited the acceleration and deceleration time to 10 seconds each. When advanced tuning tools were incorporated, the motor could accelerate and decelerate the load in 3 seconds each, resulting in a 20 percent reduction in cycle time.

System Error Control

Often, when a fault occurs or the machine operator pushes the machine emergency-stop button, for safety reasons it is desirable to bring the machine to a complete stop as rapidly as possible. Flexible digital servo drives can be configured to automatically decelerate at a higher rate than normal. This functionality at the drive level eliminates the need for extra code to be developed for the controller.

Network Interface

Often an OEM machine builder is told by the customer which machine controller must be incorporated into the machine, which leads to default fieldbus selection. A flexible digital drive that can interface to various field buses (for example: CANopen®) and motion buses (for example: EtherCAT®) is therefore attractive to OEM machine builders tasked with meeting the needs of various end users and vertical markets.

Real-Time Transfer of Information

Day-to-day operating challenges such as increased machine friction can reduce performance. Having the ability to change drive parameters through a high-speed digital link to the machine controller can keep production rates high.

When developing a servo system for a given machine, there is often a sigh of satisfaction and relief when the machine's axes actually move for the first time. Although maybe not yet fully programmed, debugged, and operating in its final state, to get the load moving requires assembly of mechanical parts, machine wiring, and installation of the motor, cables and drive.

GUI's in a flexible digital drive provide a user interface that walk the user through setting the drive up for the power voltage, motor and feedback, machine limits (position limits, top speed, mix current, etc.), and initial tuning gains. This can save significant time, allowing the machine builder to spend that time on other areas of machine development.

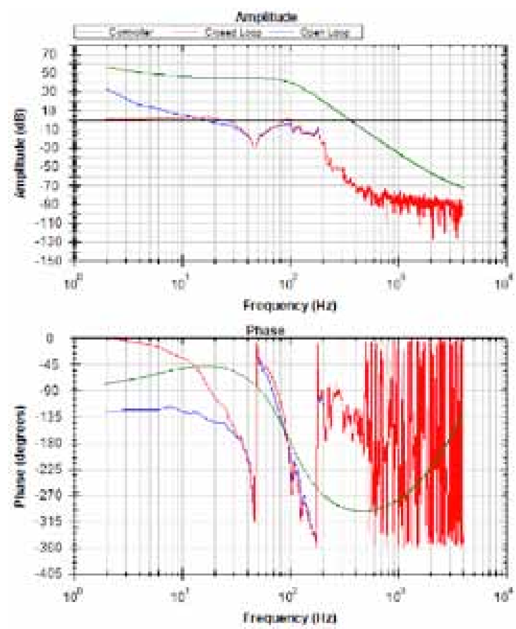
Feedback Flexibility

A variety of motor feedback choices are available to today's machine builder. The one selected for the application depends primarily on customer preference, application needs, and vendor preference. For example, resolvers are rugged and well suited for high vibration, high temperature applications such as material stamping machines. Sine encoders offer the highest precision and are well suited for use with pick and place circuit board, component insertion machines.

A drive that can interface with both, as well as to potentially more cost effective digital encoders, offers the user the ability to optimize cost versus performance for each application. In high accuracy applications that use rotary-to-linear motion conversions, the drive can interface to a second linear position feedback device connected directly to the load.

One Drive to Learn

Anyone who has set up and worked with servo drives for any amount of time knows there is a learning curve for each new drive, in one flexible drive that can be used in a variety of applications saves the user from spending valuable time learning additional drives for other applications, and the engineering support staff can spend more time focused on improving other aspects of the machine design.



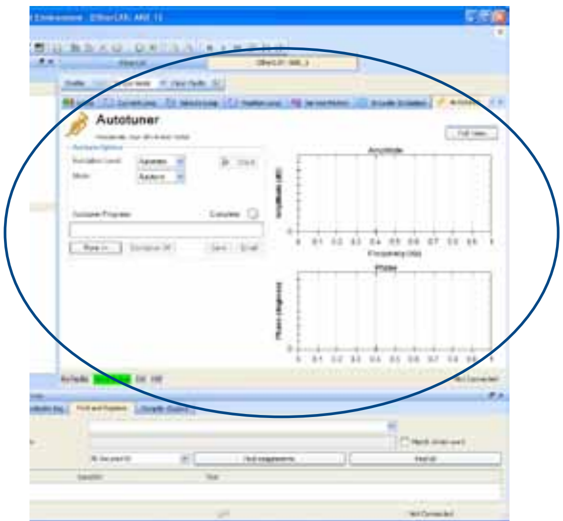
Bode Plot Showing Machine Performance
With it the machine developer can determine motion performance capabilities and limitations.

Configurable, Not Programmable

Configuring the drive for all of this functionality can be accomplished through GUI and/or drop-down selection fields, eliminating the need to learn another software language. Time to completely configure the drive for the application is reduced by as much as 50 percent when using a set-up wizard.

Integrated Drive Setup in the Machine Control Software

For ease of setup the drive can be configured inside the machine controller IDE (integrated development environment). The user has just one software to not only write the machine program but configure the servo drives as well.



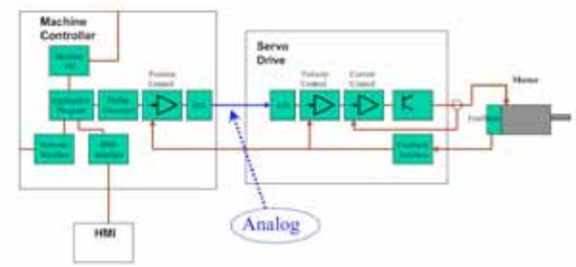
Machine Analysis

The drive and configuration tool contain Bode plot capabilities. This allows the user to analyze the performance of the mechanical load indicating where mechanical compliance or resonance limits performance. Given this information the user can make mechanical machine changes or add the servo loop filters or other advanced tuning algorithms.

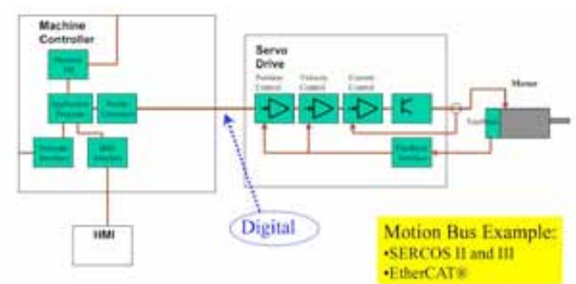
Closing Summary

The short of it is that a configurable high-performance servo can increase machine throughput and reduce commissioning time. It can take on some of the tasks usually assigned to the machine controller.

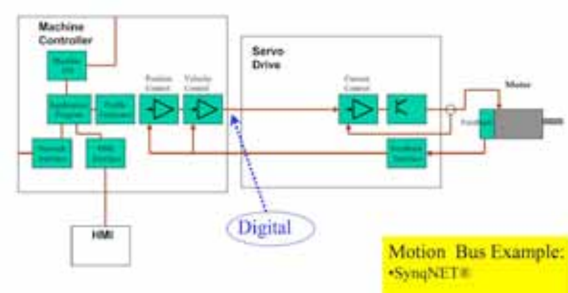
Sidebar



Sidebar Figure 1 - Traditional Machine Control System



Sidebar Figure 2 - Digital Interface Motion Bus Interface

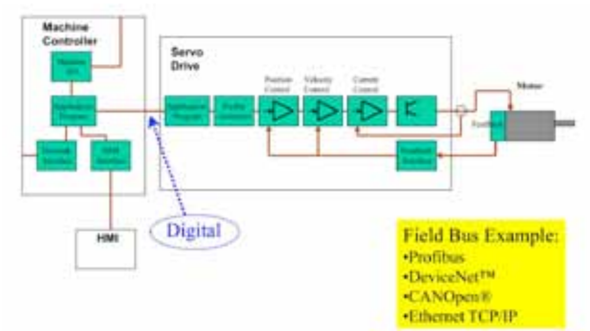


Sidebar Figure 3 - Digital Interface Motion Bus Interface

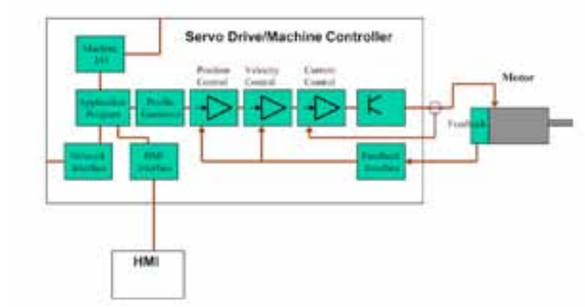
KOLLMORGEN®

Because Motion Matters™

Sidebar (continued)



Sidebar Figure 4 – Single-axis Controller / Drive Fieldbus Interface



Sidebar Figure 5 – Single-axis Controller / Drive; Level 2

ABOUT KOLLMORGEN

Kollmorgen is a leading provider of motion systems and components for machine builders around the globe, with over 70 years of motion control design and application expertise.

Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthough solutions unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

For more information visit www.kollmorgen.com, email support@kollmorgen.com or call 1-540-633-3545.