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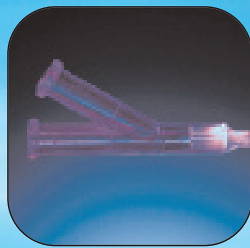

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Essential tips for designing with digital servo drives

You too, can make a flexible "one drive fits all" design for most motion control applications.

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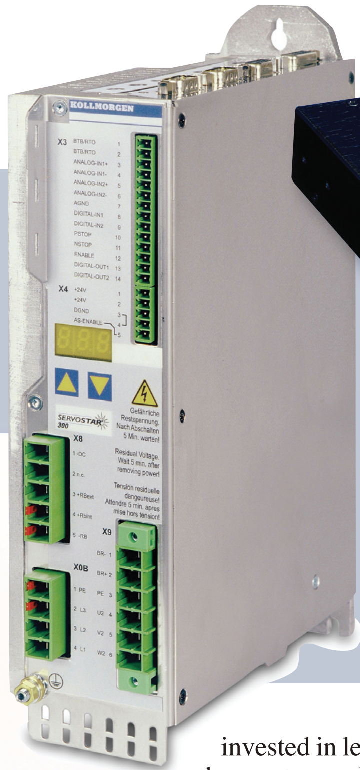
Whether you are an engineer who designs a wide variety of different types of motion control systems, or one type in various sizes, you may find an advantage to selecting a brand of flexible drive where "one type fits all." By doing so, you benefit from lower costs and less design time invested in learning, specifying, and implementing even the most complex system.



Kollmorgen's flexible drives work with its "eXMP" controller to handle a special motion bus called "SynqNet." Unlike an analog system, it updates each axis in 250 µs, which ensures that its operating parameters continually meet specifications. In addition, motor feedback information can be sent through the bus, which replaces a separate feedback cable.

Basic system architecture

To find out if this approach will work for you, analyze each basic motion system component that you usually deal with, including controllers, motors, and servo drives. Because the controller is the heart of the system, it is usually the component selected first. Some of the basic factors to consider include the controller's ability to integrate a human machine interface (HMI) and input/output (I/O) channels, connect to higher level controllers, close servo loops, and write application programs with ease. Also, consider whether you need central or distributed control, the type of programming language the controller uses, how that language is executed, and finally — the users' preferences.

Next, select the motor based on these several major factors:

Accuracy, repeatability, torque density, and torque ripple
Mounting configurations and physical constraints of the application
Feedback types: digital or sine encoders, resolvers, and hall-effect devices

The motor must meet the mechanical and dynamic motion requirements of the specific application. For example, select a linear motor when the system requires higher dynamic indexing than can be had with a rotary motor connected to a ball screw or belt and pulley. On the other hand, when a motor must be mated to a gearbox for its mechanical advantage, then choose a rotary servo motor.

Finally, consider the servo drive. It links the motors to I/O signal channels and the machine's central controller, which may be a PC, PLC, or other type of dedicated controller based on a microprocessor, FPGA, MCU, or DSP. Traditionally, servo drives contain the velocity loops and provide servo current and power conversion. Modern servo drives also control position, contain more digital and analog I/O, communicate over a number of different bus networks, and handle a wide selection of feedback devices.

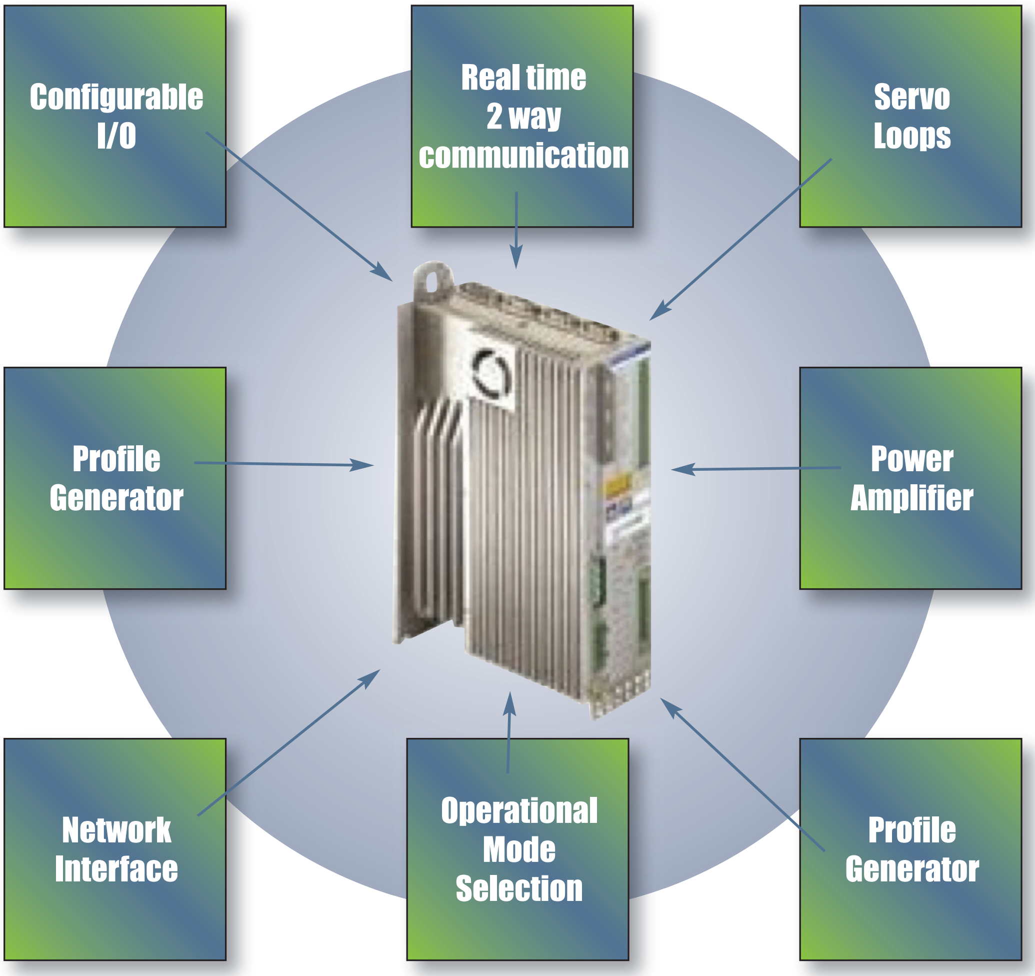
Honing the system

Unlike drives of just a few years ago, modern digital servo drives are capable of far more than simply being configured to fit the control scheme of the machine and perform basic functions. They substantially reduce the time needed to get the machine on line and significantly lower total machine expenses. The pathways laid out to achieve these benefits are wide and varied. They include selecting operating modes, master/slave configurations, and motion indexing and I/O functions. They also consider brake controls, tuning, system errors, network interfaces, information transfer, setup time, and feedback devices.

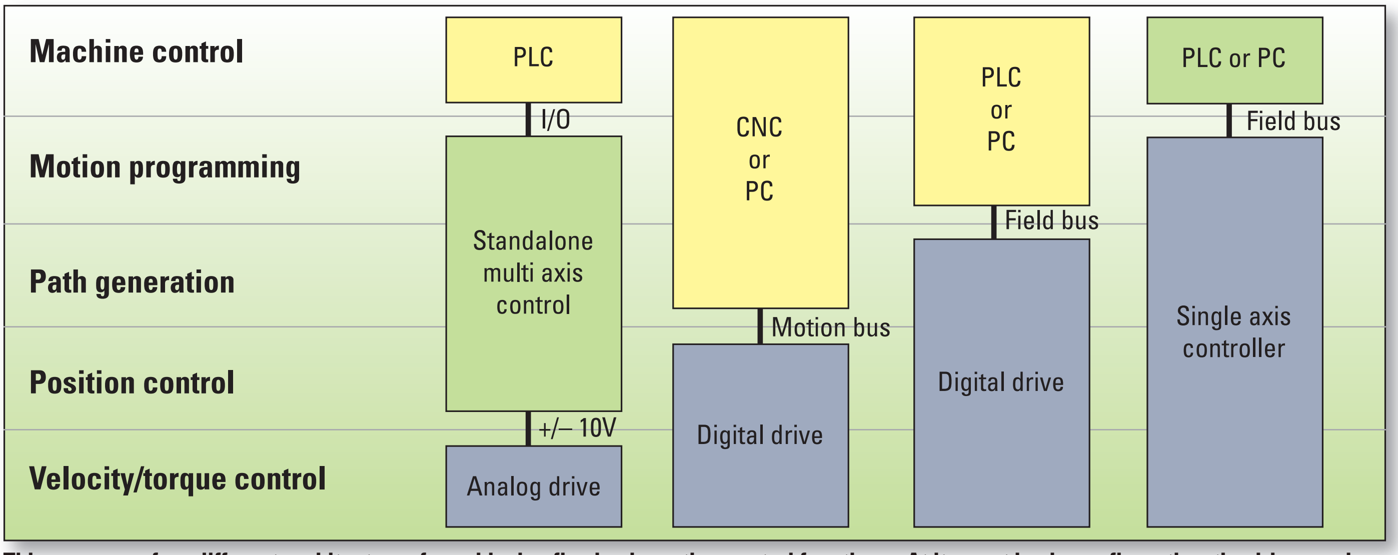
Operating Modes: A flexible digital drive has various possible architectures, from a simple current loop with a power amplifier, to a single unit that closes all servo loops, controls I/O, and handles some or all of the machine's controls. In some applications that use a central controller, the position and velocity loops are closed outside of the drive to tighten the synchronization between two or more motors. Machine tools, robots, and electronic assembly machines are examples that need this degree of coordination between axes to obtain micron-level positioning for smooth surface finishes on machined parts.

Some machine builders develop their own control algorithms while others use a commercial machine controller for advanced kinematics or multiple motion axes, such as Kollmorgen's eXMP controller. For example, this controller is an exceptional fit for a semiconductor pick-and-place machine. It uses an advanced motion profile generator and position and velocity controls to reduce time delays between controller and drive, which are required for high production rates.

Master/slave systems: In a master/slave configuration, the drive simply follows a master pulse train from a controller to position the motor. Traditionally, most applications had used stepper motors, but they have largely given way to servo motors for higher machine throughput. For example, the web converting and packaging industries usually use an encoder master signal from another drive or an encoder wheel where the



Modern, configurable, digital servo drives can handle many of the functions that were traditionally relegated to the machine controller. The drive is configured through the GUI, which can be done with a setup wizard in half the time normally needed.



This compares four different architectures for achieving five basic motion control functions. At its most basic configuration, the drive can be used as a simple current loop, while at the most complex, it can close all the servo loops, control all I/O, and handle some or all of the machine controls.

drive is electronically geared to another section of the machine.

Motion indexing drives: In some machines the drive stores and executes motion indexes using an internal profile generator. Multiple motion profiles or tasks can be created using the drive's setup software. Each task is made with the help of a fill-in-the-blanks screen, so you don't have to learn a new programming language. To get a better understanding of the motion task, the graphical user interface (GUI) can display it in a graphical form. Motion profiles stored in the drive frees the central machine controller from this task, which redirects processing power for other mission-critical processes. This approach eliminates extra cabinet space, spare parts, and a new programming language, as well as the cost of the PLC itself and associated wiring.

Switch operation mode: Some applications call for switching operating modes (Opmodes) on the fly. The machine does not have to stop to switch Opmodes with this kind of drive, and you can reduce cycle time while maintaining normal machine processing. Two common examples are position control in electronic gearing applications, and position-to-torque control in a clamping operation.

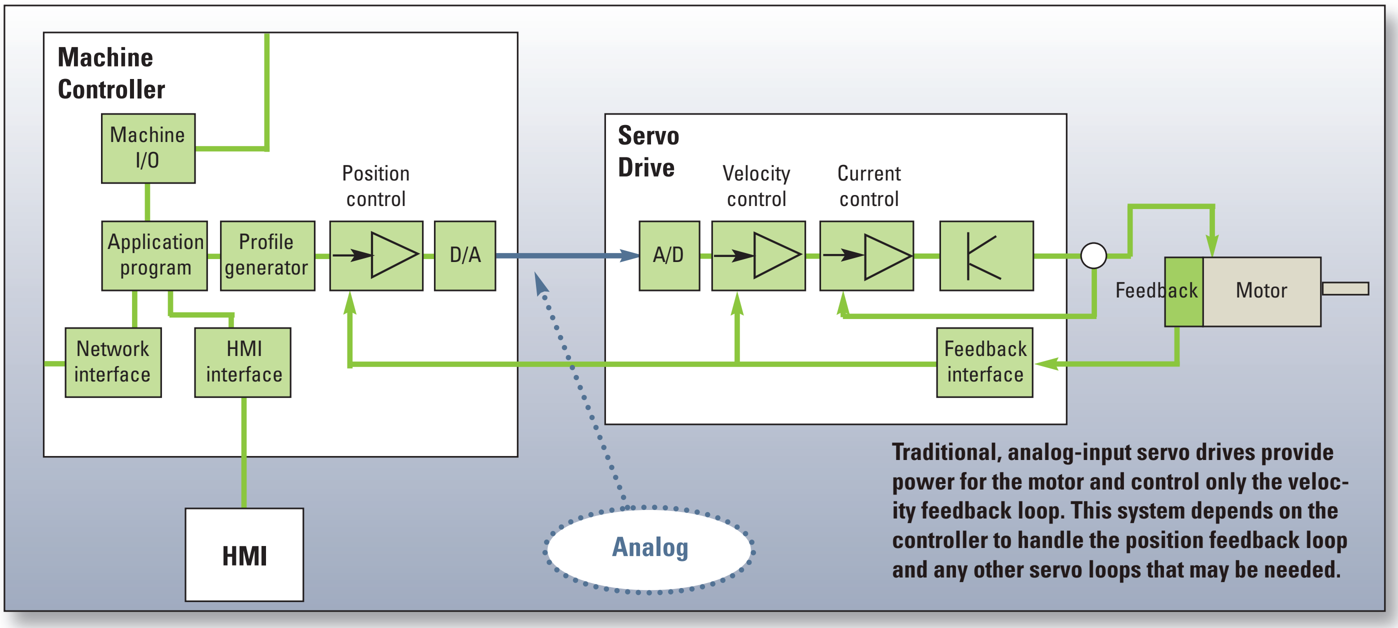
Input/output channels: I/O can be configured for a variety of machines. For instance, digital inputs can be used to start a motion profile, limit motion, represent a travel limit and switch Opmode, among other functions. But rarely are all these functions needed for one application. So, instead of supplying 20 or more dedicated inputs (one for each function) or application code written for a particular function, a flexible drive has only three to six inputs that can be configured for a specific need. This approach is also true for the digital outputs. Machines that use a digital bus such as Profibus or DeviceNet benefit from the flexible I/O because the controller can use it in the drive as a remote I/O point, which might eliminate the cost of another dedicated, remote I/O node. By comparison, older machines that did not use networks could not change parameters.

Inputs can also be configured to execute a string of commands that change multiple functions in the drive at once, such as tuning parameters, Opmodes, and I/O settings. A major benefit is being able to alter one or more tuning parameters simultaneously to compensate for changing machine load dynamics.

Brake control: Many digital drives contain a means to control a parking brake in the motor, often required when the mechanism operates in a vertical axis. The brake automatically disengages when the drive is enabled (motor torque applied), and engages when the drive is disabled (motor torque removed). Also, the time between turning the brake on when the drive is disabled and off when the drive is enabled can be retarded or advanced over an adjustable range of milliseconds. This calibrates the servo system to the machine load to prevent the motor from accidently moving and damaging the machine.

System error control: Often, when a fault appears or the machine operator pushes the Emergency Stop button to avoid an unsafe event, the machine should stop as quickly as possible. Now, flexible digital servo drives can be programmed to automatically decelerate the load faster than it normally would to handle this condition. This also means that extra code is not necessary in the controller to do the same thing.

Network interfaces: Often, customers specify which controller should be used. And because some controllers come with a particular fieldbus, that bus becomes the default network interface. But a flexible digital drive can interface to multiple field buses and is more attractive to OEM machine builders that must meet the needs of numerous users and vertical markets.

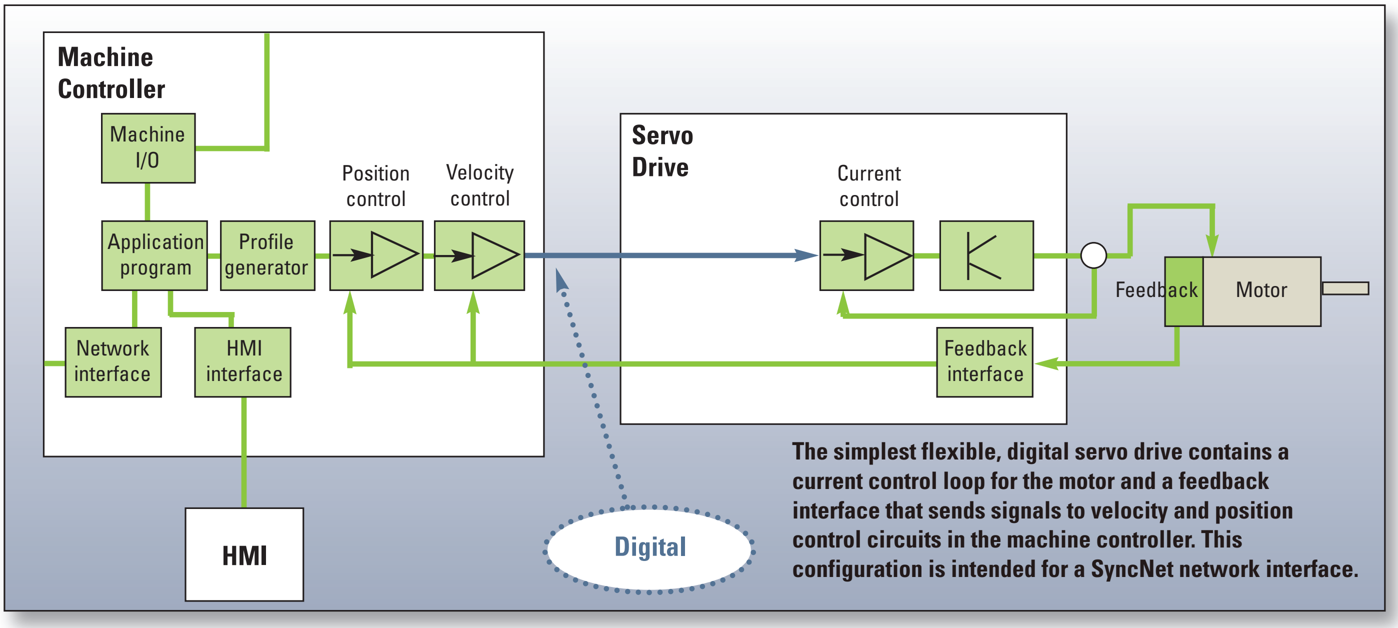


Traditional, analog-input servo drives provide power for the motor and control only the velocity feedback loop. This system depends on the controller to handle the position feedback loop and any other servo loops that may be needed.

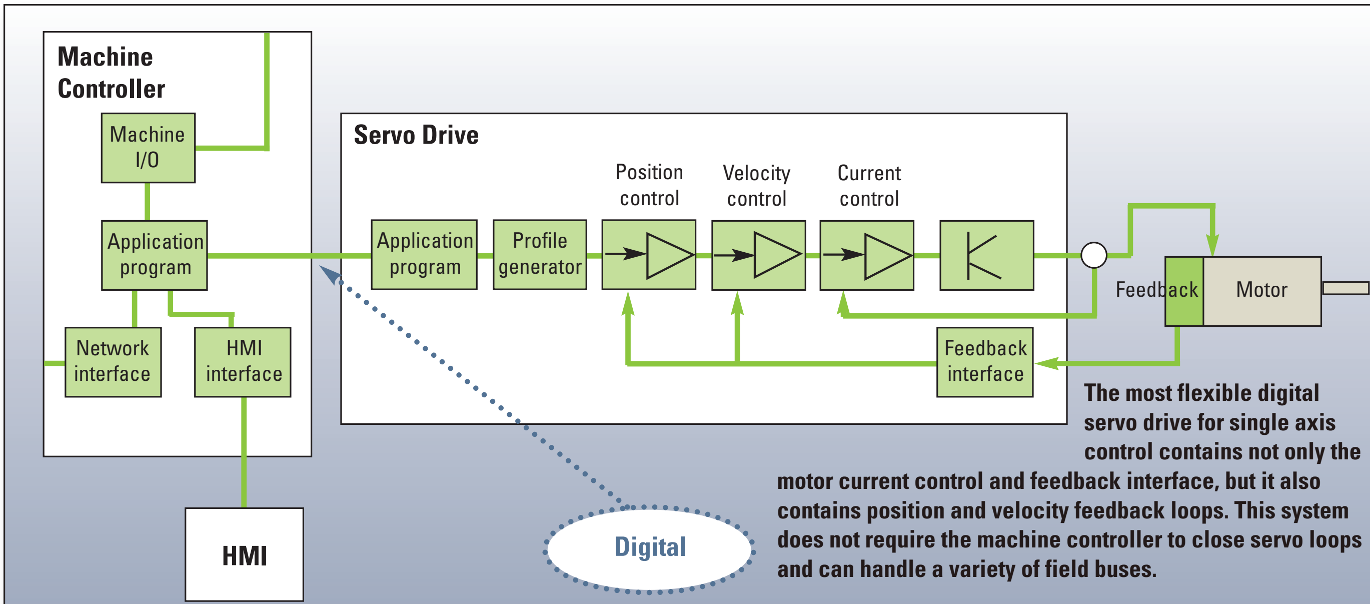
Real-time information transfer: Operating conditions that change from day to day, such as component friction that increases from normal wear, can affect the machine's product quality. For this reason, the flexible drive's operating parameters can be changed easily through a high-speed digital link to maintain consistent machine output.

Quick setup: The first time a new motion control system is powered on, it is not fully programmed, debugged, and operating according to specifications. GUIs for flexible drives contain an interface that helps you set the drive for the proper power supply voltage, motor, feedback loop, and initial tuning gains. It also adjusts machine limits, which include position constraints, maximum speed and current, and so forth. This interface reduces setup time significantly, so you can use scheduled project time and resources more productively in developing and finalizing other aspects of the machine.

Feedback flexibility: Flexible digital servo drives accommodate a wide variety of motor-feedback devices. The device selected depends primarily on the requirements of the specific application and the customer's preferences for the type of feedback device and the vendor that supplies it. For example, resolvers are rugged and can tolerate severe vibrations and high temperatures such as encountered in stamping machines. By comparison, sine encoders have the highest precision and are



The simplest flexible, digital servo drive contains a current control loop for the motor and a feedback interface that sends signals to velocity and position control circuits in the machine controller. This configuration is intended for a SyncNet network interface.



The most flexible digital servo drive for single axis control contains not only the motor current control and feedback interface, but it also contains position and velocity feedback loops. This system does not require the machine controller to close servo loops and can handle a variety of field buses.

well suited for pick-and-place, component insertion machines.

A drive that can interface with both types and still accommodate less expensive digital encoders lets the owner optimize the machine's "cost versus performance ratio" in each machine type. It can also handle high accuracy applications where a second linear position feedback device is connected directly to the load.

Tuning for maximum throughput

Modern machine manufacturers continually face increasing competition, so they must minimize production costs and maximize production rates. To reduce cost, machine builders sometimes make load structures lighter and compliant, but this often makes the structures susceptible to harmful resonances, especially when speeds change quickly. The GUI in flexible digital drives, however, contain advanced control schemes, observers, filters, and tuning tools to characterize machine resonance and other mechanical problems with bode plots. The drive can go so far as to calculate tuning parameter values to minimize these resonance effects. This is extremely helpful for tuning machines with belts and pulleys where the load's resonant frequencies affect the machine's operation. In this case, a built-in bode plot function helps users select different machine components or add control filters to the drive.

All these tuning strategies can increase machine throughput and make it much more valuable. For example, a machine was built that had a load-to-motor mismatch of 150:1, even after a 20:1 gear reduction using a belt and pulley. The resonant frequency of the belt was 25 Hz, which limited acceleration and deceleration to 10 s each. After the advanced tuning tools were applied, the motor could accelerate and decelerate in just 3s, which reduced the overall machine cycle time by 20%. DW

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