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ESSENTIALS OF **DISTRIBUTED SERVO SYSTEMS**

A Control Design Essentials Guide, by the editors of Control Design

About the *Control Design Essentials* Series

The mission of the *Control Design Essentials* series is to provide industrial machinery designers with an up-to-date, top-level understanding of a range of key machine automation topics. Our intent is to present essential engineering concepts in a practical, non-commercial fashion, together with a review of the latest technology and marketplace drivers—all in a form factor well suited for onscreen consumption. Check in at ControlDesign.com/Essentials for other installments in the series.

—The Control Design Editorial Team

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THE CASE FOR DISTRIBUTED SERVOS

From a functional standpoint, the primary distinguishing factor of a servo system compared with other types of motion control systems is the inclusion of direct feedback between the motor being driven and the servo drive controller. With a servo system, the power supplied to the motor is continuously adjusted based on direct feedback such that precise speed and/or position control is achieved despite variations in load (Figure 1).

Until a few years ago, the servo drives and associated power supplies for the typical machine were all installed in air-conditioned, centralized drive cabinets, often requiring long power runs and feedback cables out to the motors themselves. On large machines especially, this approach required that a good bit of installation and commissioning work be reserved for the end user's facility, adding onsite troubleshooting effort and start-up time. Further, centralized drive cabinets and all those long wire runs made it difficult to add or change machine functionality once the system was up and running.

Meanwhile, end users were demanding more modular, more flexible machines that could accommodate rapidly shifting demand for different products and product variations. Machine builders responded with new and innovative machine designs based on networked modular machine sections intended to operate as functional clusters or as coordinated subsystems. And while machine builders wanted to go more modular—to build more flexible production lines by adding sections one at a time—long cable runs back to centralized drive cabinets complicated the task at hand.

Servo providers rose to the challenge. Enabled in part by concomitant advances in semiconductor electronics that had allowed drives to be made more compact and more efficient (and require less cooling), they created new drive designs that could be mounted on the machine frame, in a local enclosure, or on the servo motor itself. These distributed approaches were further enabled by robust, high-speed digital networks that allowed the operational validation of multiple modular machine sections at the machine builder's facility. Then, once the disassembled sections were shipped to the end user, only power and Ethernet connections were needed to get the machine up and running.

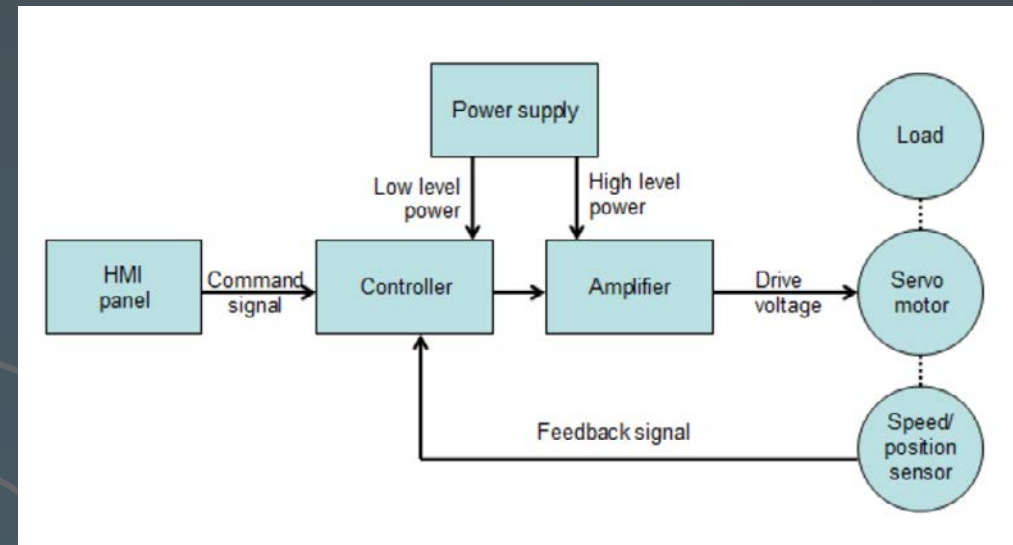


Figure 1. While the essential functions of centralized and distributed servo systems are the same, distributed architectures push more functionality into the field, enabling more modular machine designs.

SERVO ARCHITECTURE OPTIONS

In general, all three of the major servo architecture options—centralized, distributed and unitized motor-drives assemblies—offer much of the same functional, safety and networking capabilities. The choice among them is dictated by a number of factors, including power requirements, available cabinet space, application complexity and the modularity requirements of the production line itself.

In a centralized servo system, the servo motors are connected by one or more cables to the servo drives, power supplies and supervisory controller located in a centralized cabinet (Figure 2, leftmost image). Decentralized or distributed systems, on the other hand, move the servo drives closer to the machine and the motors themselves, typically on a smaller rack in a local cabinet or directly mounted on the machine frame (Figure 2, center images).

Another decentralized configuration is the integrated, or unitized, servo drive-motor combination, in which the drive is mounted directly on the servo motor. This eliminates the need for the machine builder to install cables between the two (Figure 2, rightmost image). This also eliminates the need to install a separate

feedback encoder. Unitized systems are ideal for simple motor control applications, and can be connected to a central system for data collection or coordination.

It's also important to note that the decision to distribute is seldom an all-or-nothing proposition. Indeed, machine builders and end users can mix and match these approaches even within the design of a single machine.

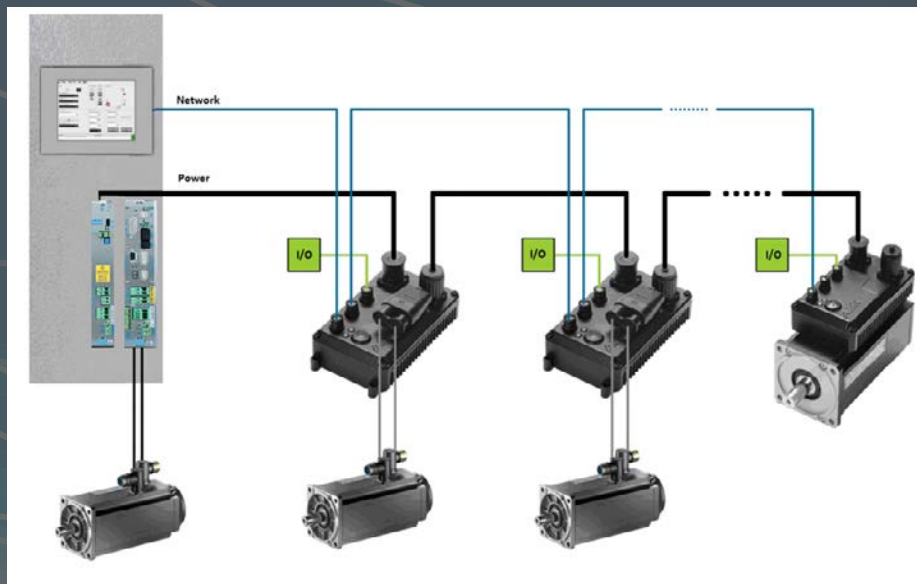


Figure 2. Shown are the three primary configurational approaches implemented together as a hybrid system. Illustrated are a cabinet-mounted servo and power supply (left); distributed inverters located near the motors they control (center); and a unitized servo motor-drive combination (right).



Figure 3. Three degrees of distribution: From left to right, a unitized servo motor-drive assembly, an IP65-sealed servo drive suitable for machine-mounting, and a traditional rack-mount servo drive. HMI panel is shown in background.

THE POWER OF CENTRALIZATION

Despite the flexible appeal of distributed servo solutions, high power requirements and complex, coordinated motion control often dictate more centralized solutions.

In particular, power requirements are a key limiting factor for machine- or motor-mounted servos, which often are sealed in IP65 enclosures and must rely on passive cooling to dissipate generated heat. Further, for unitized drive-motor combinations, the close proximity of the drive and motor will derate output compared with a standard servo implementation.

Indeed, despite advances in drive efficiency, thermal management remains an issue for drives more powerful than 10-15 hp, and active cooling typically is required. Active cooling adds to system costs, and the economic benefit of centralized cooling for multiple servo drives places a limit on the practical extent of servo distribution. On the other hand, the power capabilities of centralized servo drive systems are essentially limitless, making them well suited for large machines in many industries from metal forming to plastic injection molding.

On complex, multi-axis drive systems, certain axes might require tightly integrated onboard processing of input data. With traditional rack-mounted drives these needs are addressed by complementary plug-in processing boards. This functionality cannot be added easily to sealed, decentralized drives and such application requirements also speak to a more centralized approach.



Figure 4: Centralized servo systems have their place in high power applications or those with complex coordinated motion control requirements.



Figure 5: One recent advance designed to simplify and streamline the deployment of drive solutions is the combination of voltage supply and digital encoder signal in a single cable between the motor and drive. Half the wiring also means less mass, which can improve the efficiency of movable axis applications.

DISTRIBUTION LENDS FLEXIBILITY

Distributed servo drive configurations feature both compelling advantages and noteworthy limitations. On the one hand, distributed approaches enable more modular, flexible machine designs. Without the need to land individual power and feedback wires in a centralized drive cabinet (which often happens after the machine reaches its final destination), machine sections can be fully assembled and thoroughly tested before they leave the machine builder's facility. This reduces troubleshooting and start-up time, even while improving future flexibility.

Reducing or eliminating the need for conventional drive cabinets saves on capital costs, ongoing energy costs for cooling as well as valuable plant real estate. Savings due to shorter power and feedback cables between distributed drives and motors also can add up, especially in the case of movable axes that require high-strand, high-flex cables.

In some applications, additional space savings can be achieved by combining three drive amplifiers into a single housing, a three-in-one servo drive solution (see image) that can be placed anywhere convenient on the machine frame. This represents a unique opportunity for certain three-axis machine sections: a single power line can feed three drives, each individually controlled through a single network connection (such as EtherCat or Sercos III) or the device's built-in I/O structure.

Because of thermal management issues, however, the sweet spot for decentralized servos tends to be at lower power ratings, from ½- to 10-hp motors. As such, machine-mounted servos are well suited to smaller, relatively low power machines or to machines where the combined power can be divided up into smaller modular sections. This is an advantage in the packaging, converting and printing industry and also in some robotic handling applications.

The ultimate distributed servo configuration is variously called the integrated, all-in-one, or unitized drive-motor combination, in which the servo is mounted directly on the motor itself. This approach completely eliminates the need for the machine builder to install power or encoder feedback cabling between the two. There are two key limitations to this otherwise elegant approach. First, the close proximity of the motor and drive derates its power output compared with a standard servo configuration. Second, on some machines with a particularly high motor density, space constraints may dictate a less distributed approach.



Figure 6: Three-in-one
Distributed servo drives come in a variety of form factors. This machine-mountable unit includes power supply and controllers for three separate servo motors as well as local I/O and network connections.



Figure 7: Unitized motor-drive
This unitized servomotor-drive system obviates the need for machine builders to install power or encoder feedback cabling between the two components.

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ABOUT THE SPONSOR

This *Control Design Essentials* guide on Distributed Servo Systems was made possible by the AMK Group, which provides servo motors, intelligent servo converters, PLC controls and powertrain solutions. The highly innovative drive and control technology products manufactured by AMK are designed to meet today's stringent requirements in terms of energy usage and environmental friendliness. The company continues to devote particular attention to sustaining and improving its products' energy efficiency and environmental performance.

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