Schneider Electric

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Simplify Motion Control with Integrated Motors

machine design

medical design

Simplify Motion Control with Integrated Motors

Integrated motion systems save time, cost, and streamline the motion control design process.

—By Victoria Burt

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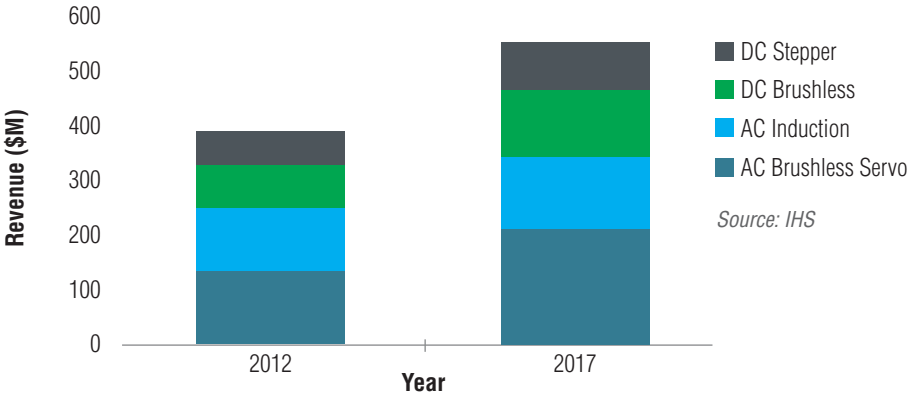
Engineers today are faced with the challenge of creating machines that are more robust, smaller, less expensive, and more reliable. Designers who are not experts in motion control are expected to take on challenges in the design process for which they did not necessarily study or train.

One way to address motion control design challenges without being a mechatronics expert is to use an integrated motion control system. Such a solution combines the motor and drive along with other system components—such as a motion controller/intelligence onboard and I/O—all in one unit, reducing the number of necessary parts.

By using an integrated solution, designers can spend more time developing machines and less time solving compatibility issues between various system components. With an integrated motion system, the components have already been designed and sized for use as a complete unit.

The world market for integrated motors



Designers can lower power consumption in conveying applications thanks to the Schneider Electric Lexium MDrive©, an integrated stepper motor that has the benefits of a servo motor.

The Market for Integrated Motors

Integrated motors have been around for more than 20 years, with the first integrated AC induction motors introduced in the mid 1990s. But, they are still unknown to many designers who have applications that could benefit from them.

The integrated motor market includes four product types: AC brushless servo, DC stepper, DC brushless, and AC induction motors. Analyst Michelle Figgs of IMS Research, now part of IHS Electronics & Media, Englewood, CO, says the AC induction motors market, which traditionally had the biggest share of the integrated motors market, is now at 30%, with the AC brushless servo motors segment now being the largest, at 35%. “The shares of the other two types are a bit smaller, with DC brushless motors coming in at 21% and DC stepper motors at 16%.”

IHS estimates that in 2012, the worldwide market for integrated motors was $392 million. In 2002, the worldwide market was closer to $110 million.

Integrating Electronics into Motors as a Solution

Simply put, an integrated motor is a motor and drive along with other system components all within a single housing. Drives and motors that are in separate enclosures but mounted onto each other are also considered integrated motors, even though they are not in the same enclosure.

The decision to use an integrated motor is based on finding the right fit for the application. The following considerations help determine if an application is suited to integrated motors.

2012 market leaders for worldwide integrated motors

Rank	AC Brushless Servo Motors	DC Stepper Motors	DC Brushless Motors	AC Induction Motors
1	Bosch Rexroth	Schneider Electric (IMS acquisition)	Dunkermotoren	SEW-Eurodrive
2	Schneider Electric	Muscle Corp.	Moog/Animatics	Norwood
3	Baumuller	Applied Motion/Shanghai Moon	EBM-Papst	Leroy-Somer

Source: IHS

Europe is the biggest market for integrated motors, being responsible for 65.5% of the market in 2012, according to IHS. "Part of the reason for that is most of the leading suppliers are European," says Michelle Figgs, analyst. "The exception is the stepper motors market. The U.S. accounts for 40% of the stepper motors market, which makes sense because the leading stepper motors supplier, IMS, acquired by Schneider Electric in 2008, is a U.S.-based company," she says. Figgs also notes that Asia is not a big market for integrated motors, as "domestic suppliers of traditional components can manufacture them at such low prices, so adoption of integrated motors is very low."

"When a machine builder is buying servo motors for a million dollar machine, paying an additional 10% to 20% for an integrated product can improve the machine design without significantly increasing the total machine cost."

—Analyst Michelle Figgs, IHS

Machine size. Integrated motors can reduce the amount of space needed for a machine by consolidating components and eliminating cabling. In cases where the integrated motor replaces a drive and motor housed in separate enclosures, one enclosure can be eliminated. Bringing the separate components into one solution reduces the required panel space significantly. And in the case of a multi-axis system, this can lead to a substantial reduction in the required real estate.

On the other hand, when looking to put an integrated motor on an existing machine design, there must be adequate space. Because the drive and other system components are mounted onto the motor, more space is needed where the motor is used. If that space is not available, it may not be cost-effective to redesign an existing machine to accept an integrated motor.

Cost. There are definitely cost savings associated with integrated motors compared to traditional components. The cost of cabling is an expense that goes away with an integrated motor. If the drive is in a centralized cabinet and the motor is a distance away on a long packaging machine or long conveying machine, a decent amount of money is spent on the cabling. This is especially true for servo motors, where there is a power cable and cable for the feedback device back to the drive. Mounting the drive directly on the motor eliminates the cabling, contributing to some cost reduction. Distributed control via networking,

such as Ethernet and CAN, also can represent a significant cost saving.

One of the reasons integrated motors cost more is the economies of scale. According to Figgs, integrated motors ship less than 1 million units worldwide, compared to the traditional motors and drives markets, which ship over a billion units. It's a growing but still relatively small market. Mass production will reduce costs.

Depending on the application, the higher cost of the integrated motor may be offset by the reduced cost of cabling and the centralized cabinet. Even when this is not the case, there are applications where the higher cost of an integrated motor is offset by the value of the technology. "Designers looking at an integrated servo motor solution realize that servo motors are a high-performance, premium-type product," says Figgs. The servo motors themselves cost more, and they typically go into machines that are also expensive. "When a machine builder is buying servo motors for a million dollar machine, paying an additional 10% to 20% for an integrated product can improve the machine design without significantly increasing the total machine cost," says Figgs.

Reliability. According to Figgs, reliability has been a concern in the past with integrated motors, especially with regard to heat dissipation. However, as the technology has become more advanced and accepted, users find that the motors are reliable and don't fail at a higher rate than a regular motor and drive system. Also, by reducing the number of components in a system, and thus the number of wire connections, the overall reliability of the machine is increased.

Modular systems. A growing trend in industrial automation is modular machine building. This essentially means developing a large machine responsible for multiple functions by combining small subsystems that are each responsible for a single task. For example, a packaging machine that's used in the food and beverage industry may feed the packaging material in the machine, fill and form the pouch, seal and cut the pouch, and send the product out to other machinery in the system. A modular design allows taking each one of those tasks and making an individual subsection machine that's responsible for just that task, which operates independently from the rest of the system.

This is beneficial for a couple of reasons. It allows designers to easily change just one modular section, so it's an inexpensive way to provide customized machines. In the packaging machine example, say the designer wants to accommodate different packaging materials: the machine can now offer that without much added cost.

This modular building concept also makes shipping and delivering the product easier. Independent modules can be shipped to the factory floor for easy assembly. In addition, setting up these modular machines is made easier when the drive and motor are placed directly in the machine rather than located in some centralized cabinet. Integrated motors are one way to do that.

Distributed control. In more industrial applications, there is a real benefit to what is called distributed control. Motor operation and synchronization are carried out through digital data signals transmitted between the motors and a master control system such as a programmable logic controller (PLC) or process automation controller (PAC). The PLC or PAC sends a command to execute a particular function, and it's up to the controller on the motor to carry out that command.

This distributed control system provides faster response and greater accuracies than that obtained by a single

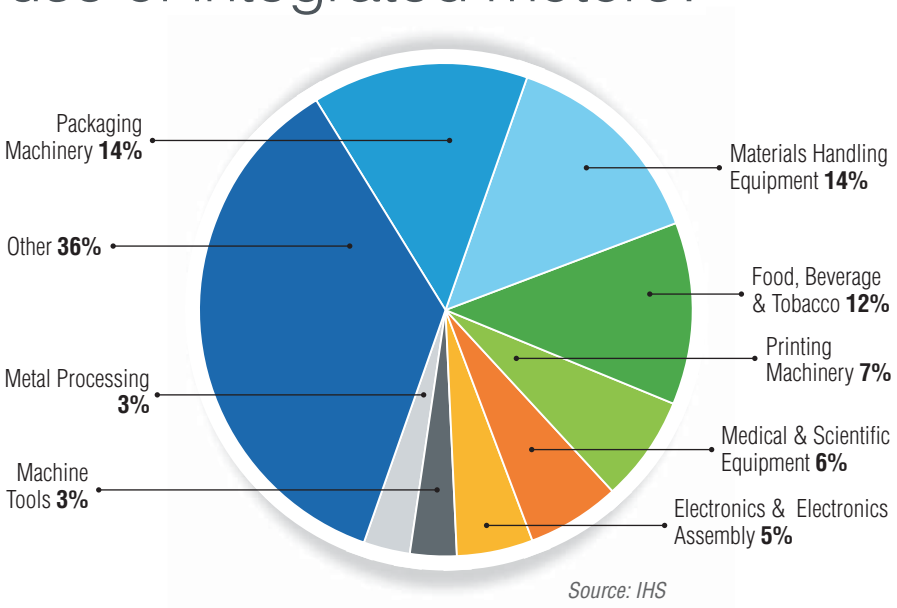
Integrated Motors Market on a Growth Path

IMS Research, now part of IHS Electronics & Media, Englewood, CO, has studied the market for integrated motors for over a decade. Its *Integrated Motors—World—2013* study provides forecasts and analysis for four integrated product types: AC brushless servo, DC stepper, DC brushless, and AC induction motors. The report reviews how the market was affected by the uncertain global economic climate in 2012, with insight into which regions and industry sectors are projected to propel market growth over the next five years.

The 2013 report provides detailed revenue, unit shipment, and average selling price analyses based on sales data and interviews with supplier personnel working throughout the world. With more than 175 pages examining the trends, market sectors, and competitive environment, the report offers an unbiased view of the market for integrated motors.

For further information, visit *www.imsresearch.com.*

What industries make up overall use of integrated motors?



Source: IHS

central control point running all operations. Clark Hummel, applications engineering manager, Schneider Electric Motion USA, explains: "In a centralized control system, if you want to home an axis, it has to move so it can see the sensor, roll off the sensor, and then set its position reference from there. Instead of having to do all those steps, with distributed control, you can just tell the axis to go home; because of the intelligence on board, it will go to the right position."

Available features. One of the considerations when using an integrated motor is that there are only so many options available, as far as specs go. The motor supplier will take a few motors and a few drives and pair them together. There's a chance the products won't meet the requirements of the machine design. With a separate motor and drive, there are more options.

"Over the years, integrated motor suppliers have gotten better at balancing the need for key features demanded by target applications with maintaining a reasonable price point for product replacement," says Figgs. "If you over-engineer with too many features, you'll price yourself out of the market. But if you don't have the features designers really want,

they won't buy it, either." As more traditional suppliers offer integrated motors along with traditional solutions, the challenge of getting the best specifications for a design is diminishing.

Electromagnetic compatibility. An integrated motor solution has already been designed with electromagnetic interference issues settled. And, reduced cabling minimizes electrical noise.

Leading-Edge Applications

As motors and drives have decreased in weight and size, areas that can benefit from integrated motors are new applications that weren't necessarily around years ago. "For example, a growth market we see for DC brushless integrated motors are AGVs, or automated guided vehicles," says Figgs. These have long been used to transport materials in the pharmaceutical, automotive, and chemical industries and are now used in hospitals and distribution centers. "Where you have small machines that are moving around, integrated motors are a good solution for that due to their compactness and lack of cabling," she says.

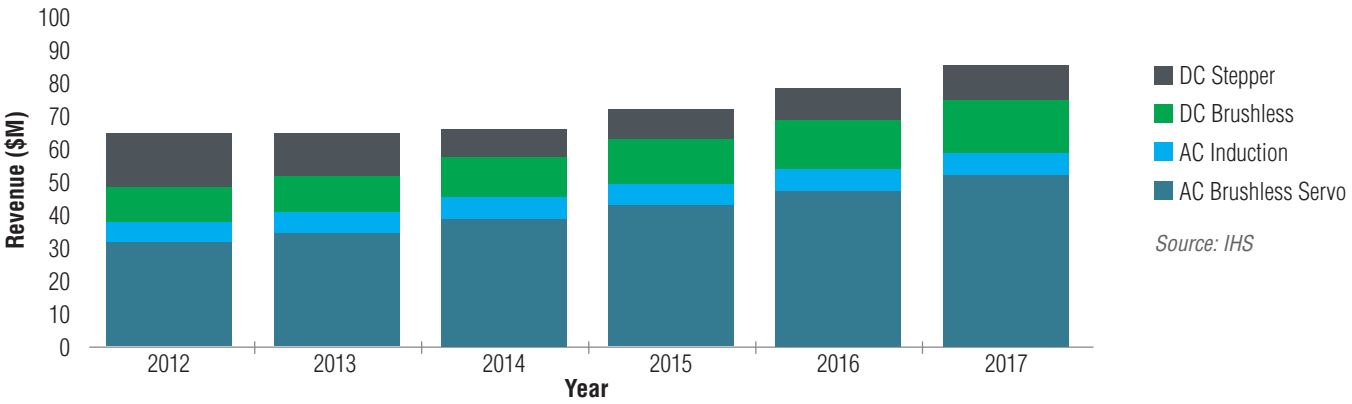
The medical market is growing for DC brushless as well as DC stepper integrated motors, in applications such as DNA analyzers. "There's demand for these products in criminal investigations, paternity tests, people who want to test their genetics for diseases, etc. Motorized prosthetics and artificial hearts are technologies that have advanced significantly in the past decade. They need small, compact motors that are easy to use, and that's what an integrated motor can provide," Figgs adds.

A Closer Look: Stepper and Servo Motors

Together, integrated stepper and servo motors make up 51% of the integrated market worldwide, according to IHS.

There is a demand for use of integrated motors in leading-edge applications such as criminal investigations, paternity tests, and genetics.

Integrated motors in the packaging industry by product type



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Stepper motors are advantageous for certain applications. They’re inexpensive compared to servo motors, and they’re a less complicated product to set up and run. It’s possible to get a high torque at the starting or low speed, but the available torque declines steeply as the speed of the motor increases. This is one of the limitations of stepper motors; if the application needs high speed, a servo might be the best option.

Other challenges with stepper motors are that they have higher vibration, they’re not as energy-efficient, and they can have slippage. If the torque exceeds the motor speed-torque rating, it loses accuracy and is no longer in the position it should have been in.

To address those three challenges, suppliers can run a stepper in a closed loop system. They put a feedback device on a stepper and actually monitor the position of the shaft and take away some of the disadvantages of that product.

But because there’s an added feedback device, the cost differential between a stepper and servo motor is smaller. “It is one way to have a stepper with somewhat higher performance,” says Figgs. “This is a growing trend we’re seeing, and it increases the overlap in the competition between these two products.”

Motor Technologies—Defined and Differentiated

There are a number of motor technologies available to machine designers, and choosing the best motor for a design is a matter of finding the best fit for the application.

Linear motors take a rotor and stator and lay them flat so that there is a forcer (rotor) on a magnetic track. When the motor is excited electrically, it produces a linear force along its length.

Linear motors allow direct coupling to the load and deliver high speeds, high precision, fast response, stiffness, zero backlash, and low maintenance, as there are no contacting parts to wear. However, the biggest drawbacks to using linear motors are their comparatively high cost, higher bandwidth drives and controls, and force-per-package size.

Linear motors are good for applications that don't need mechanical parts and require high acceleration and high accuracy. These reasons might justify the extra cost for a linear motor.

Rotary motors have a rotor and stator that are circular and produce rotational motion when they are excited electrically. It's possible to use a rotary motor and translate the motion to linear using mechanical parts, such as ballscrews, leadscrews, belt drives, and rack and pinions. The drawbacks with these added components are that they introduce inertia, friction, compliance, and backlash to the system.

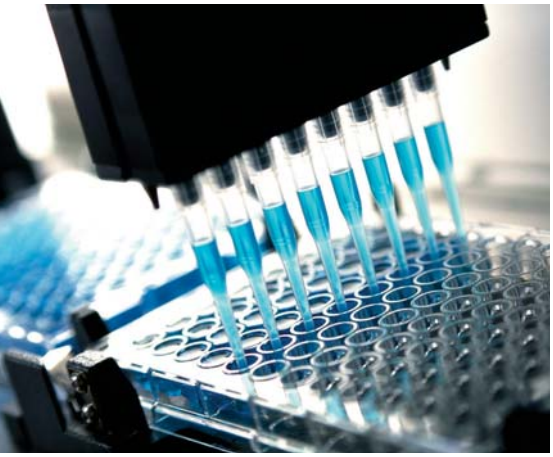
There's a difference between applications that need linear motion using a rotary motor versus ones that need a true linear motor.

For applications that need linear motion using a rotary motor, machine designers frequently choose stepper motors and/or servo motors.

A **stepper motor** is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor as long as the motor is carefully sized to the application.

A **servo motor** is a rotary actuator that allows for precise control of angular position, velocity, and acceleration. It consists of a motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servo motors

No matter which type of motor is chosen, a complete motion system needs to include additional components, including a compatible stand-alone controller, drive, encoder, and cabling. Taking the time to source each individual component, making sure they work with each other, and then assembling and testing the entire system can take a lot of time and guesswork. There are several ways to simplify the design process, one of which is a motor with a drive and other components built in.



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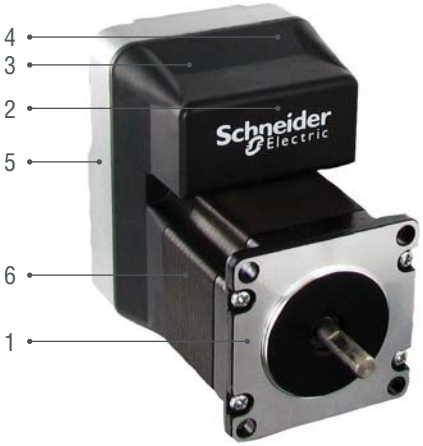


1. Rotary stepper motor
2. Microstepping drive
3. Programmable motion controller
4. 8 I/O lines
5. Internal encoder option
6. Closed loop performance

Next-Generation Integrated Motors

One motor supplier has recognized this overlapping trend and created a new iteration of integrated stepper motors that provides benefits of both servo and stepper motors. Schneider Electric's Lexium MDrive© products consist of a driver and controller, stepper motor, and internal encoder—all in one package. This boils down to an integrated stepper motor that has the benefits of a servo.

One of the benefits stepper motors provide is their smooth motion at low speed. Stepper motors do not require tuning, allow for a greater inertia mismatch, and have very high-torque density. This torque is 100% available immediately upon start-up, which can be very advantageous when doing short quick moves, or when coupled to high-inertia loads. Because stepper motors are synchronous motors with a high pole count, they are able to run smoothly at extremely slow speeds with no cogging.

Stepper motors have some disadvantages, however. The most critical drawback is the loss of synchronization and torque if a large load exceeds the motor's capacity to resynchronize once the load is reduced to a level within the motor's capacity. These motors also tend to run hot because they draw constant current.

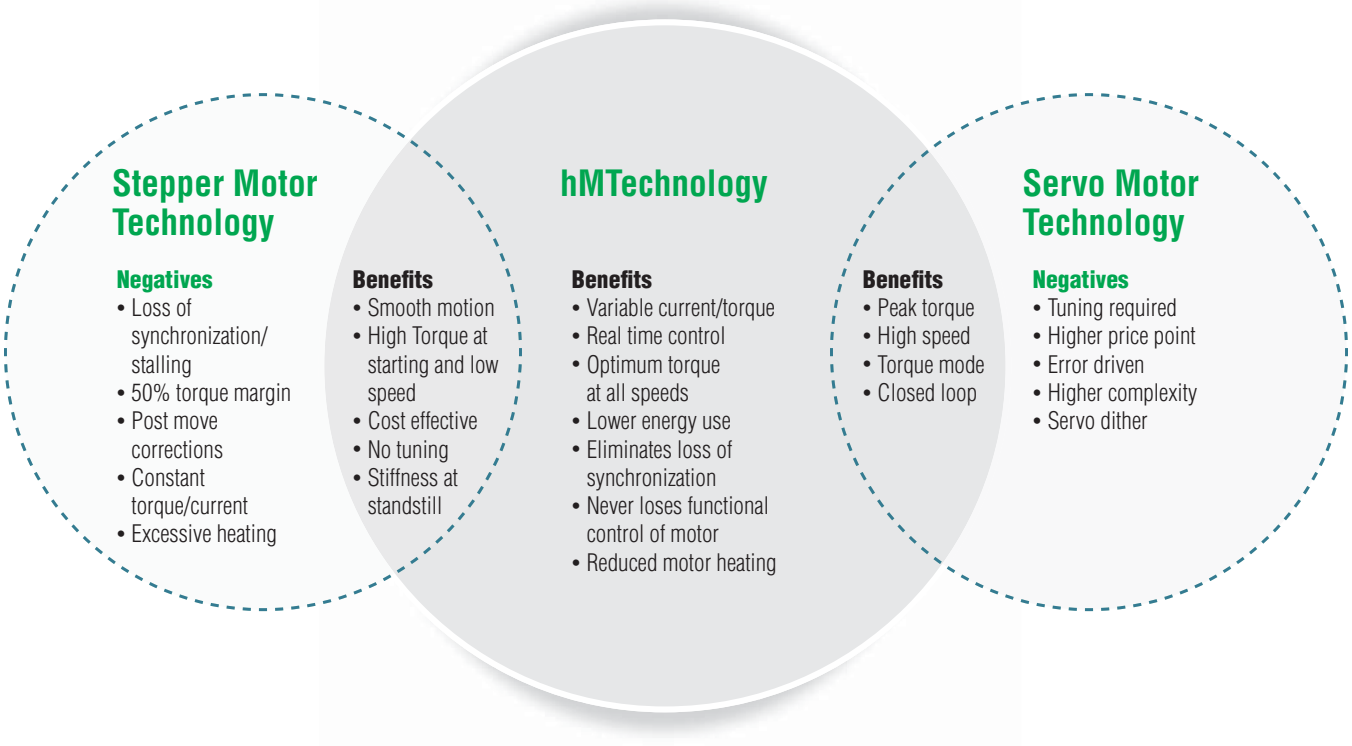
"Stalling has always been the albatross around the neck of stepper motors," says Hummel. Many designers initially use stepper motors because they're so much more cost-effective than using servo motors. "However," he explains, "during use, if the motor didn't end up in a position where you thought you were, and you had no idea you weren't there, that causes all kinds of problems."

Hummel notes that the Lexium MDrive has an encoder built in to not only check the position "but if you get to the point where there's too much torque and it's not going to be synchronous anymore, the encoder stops the field from rotating. It will sit and hold torque, meanwhile keeping track of where it should have been. So, if it does loosen up at some point, it can catch its way back up to where it is supposed to be.

"Problems with stalling and not knowing position," Hummel adds, "are eliminated."

Schneider Electric's closed loop technology, known as hMTechnology, or hybrid motion technology, delivers servo-like performance from a stepper, eliminating many negatives traditionally associated with the motor technology.

hMTechnology:
Blending stepper & servo motor benefits



This includes eliminating loss of synchronization, allowing safe operation of a motor at its maximum torque curve. Therefore, sizing a motor with up to 50% torque margin is no longer required. This may also allow a smaller frame size or shorter stack length motor in some applications. It also enables a system to ride through known transient overloads, further eliminating the requirement for a larger motor and enabling stepper motors to be used in applications outside their traditional range.

The closed loop functionality of the Lexium MDrive also enables a stepper motor to perform under variable torque control. Designers can use it in thrust, pressing, and tension control applications—capabilities that are not usually possible with stepper technology.

Saving Time, Effort, and Money

There are many examples where the Lexium MDrive shows measurable savings and success. Applications with equipment that is sensitive to heat changes, for example, lab and imaging equipment, are good fits for the solution. A typical stepper motor might draw 2.5 A continuously, whether it's being used or not. With a Lexium MDrive, variable current control saves energy and lowers heat by drawing only as much power as is needed to execute a move. The heat dissipation will be less if the motor only needs to draw 2.5 A for the 10% of the time it is being used, and 0.5 A for the other 90%.

Conveying applications represent another example where a Lexium MDrive shows significant power consumption cost savings. Conveyors may run 24 hours a day, seven days a week, with varying loads. The Lexium MDrive allows the motor to run at the minimum current needed to complete the motion, and then increases current only when the load demands it.

T.A. Systems Inc., a manufacturer and integrator of automation equipment, assembly systems, and test equipment, relies on integrated motors for many of its applications. In particular, T.A. Systems' Controls and R&D Manager Matthew Ballough uses the hybrid motion technology on a slide package for measuring how much load it takes to close a glove box door on a car.

"Using this motor gives me the ability to easily integrate an Allen-Bradley processor using EtherNet/IP to control the motor and look at the load cell feedback," Ballough explains. The application requires smooth actuation. Although he considered using an air cylinder, Ballough reasoned that "an air cylinder wouldn't run smooth, or have adjustable rate and positioning capabilities."

Ballough has been running this line for over a year and currently has plans to install at least 12 more hybrid motors on a different line that assembles sunroofs. The motors will allow the glass to be positioned correctly before being clamped onto the rails, enabling it to move back and forth. He says it is very easy to put the system together, and "after you figure out the integration of the software into the motor itself, in my case with EtherNet/IP, it's a breeze." He adds, "You get complete control over the motor, making it do exactly what you want."

Many other applications with various network communication protocols are finding success using the Lexium MDrive products. A material packaging application benefits from the servo performance to insert cotton packing into plastic bottles. The machine's shock load/resistance caused stalling in typical stepper motors but was overcome with the hybrid technology.

One company that needed to cut medical tubing now uses two Lexium MDrive products in its machine. A rotary motor drives a friction wheel to move the plastic tubing to a specified length for cutting. A linear motor raises and lowers the material platform to the friction wheel. The integrated frame size, speed/torque of the motor, and cost of the system were the main factors in choosing the integrated motor solution.

Summary

Using an integrated motor is an efficient, easy, and effective way to let designers spend more time developing machines and less time studying motion control design. With an integrated motion solution, the integrated components have already been designed and sized for use as a complete unit.

When looking at the types of integrated motors, AC servo motors are the fastest growing segment, but also the most expensive. An alternative to the premium servo motor is a hybrid product called Lexium MDrive, which is an integrated stepper motor with closed loop feedback that acts like a servo.

Lexium MDrive products address the stalling issues associated with stepper motors while keeping the benefits of smooth motion and high starting torque at low speeds. These integrated motors can be used in thrust, pressing, and tension control applications.

Victoria Burt is a Contributing Editor to Machine Design *magazine.*

Want to learn more about integrated motor solutions? Contact Schneider Electric Motion USA at *www.motion.schneider-electric.com.*