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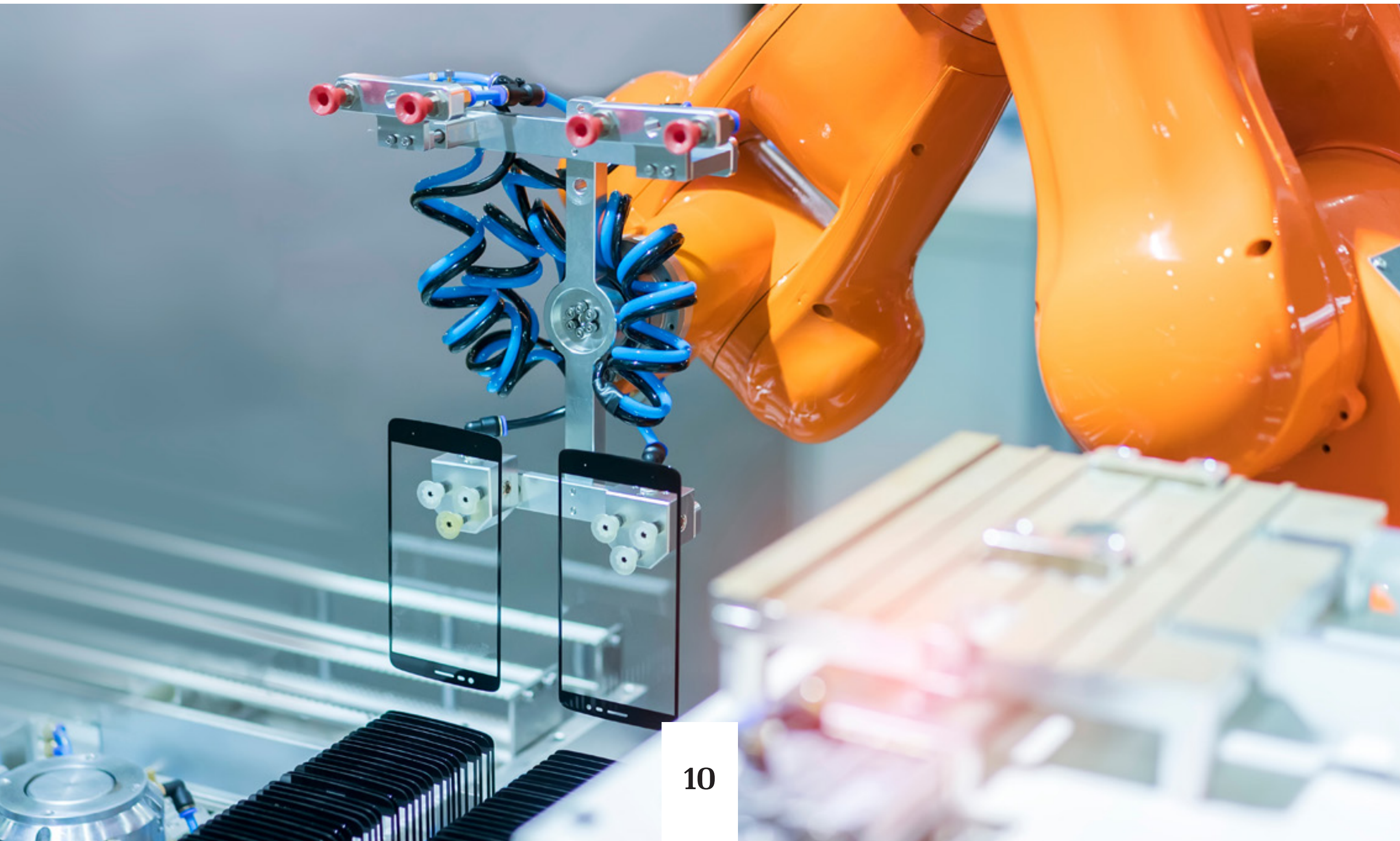
Christian Fell
Director of Technology Development, POSITAL-FRABA Inc.

Integrated Motor Feedback: A Challenge to Stand-Alone Encoders?

Both integrated and stand-alone digital encoders are smaller and tougher than their predecessors, making them viable both for industrial automation and for emerging industries such as renewable energy, robots, surgical tools and more.



AN interesting trend in industrial motion control has been the replacement of self-contained encoders — rotation sensors with their own housing, bearings, and shaft — with modular or 'kit' encoders. These new devices are designed to be installed on or inside the motor housing, measuring rotation directly from the host's shaft.

Integrating position feedback devices into motors or drives can save costs and simplify machine layouts. But does this mean the end of the road for traditional stand-alone encoders?

ABOUT ENCODERS

Rotary encoders have been key components in motion control systems since the earliest days of digital controls (see **Figure 1**), translating rotary motion into digital feedback signals for control systems.

Stand-alone encoders, which have their own shaft, bearings, housing and seals, have been a popular choice with machine builders and system integrators. These devices, which are available in a variety of sizes, shapes and performance characteristics, can be installed anywhere in a machine where rotary motions need monitored.

Figure 1. Stand-alone rotary encoders, which translate rotary motion into digital feedback signals for control systems, come in various shapes and sizes.

However, because many industrial motion control systems are powered by electric motors, interest is growing in integrating motion and position feedback into motors, creating servomotors or feedback-controlled stepper motors. The incentives have been cost reductions and a desire to simplify designs with a reduced number of separate components.

For integrated motor feedback, the measurement components of an encoder are built

Although integrated motor feedback is taking a growing share of the market for motion control systems, the future for stand-alone encoders continues to look bright.

into a motor's housing, with rotary motions measured directly from the drive shaft. The technologies used in these integrated devices often are closely related to those used in stand-alone encoders. These devices — referred to as kit, or modular encoders — often can be unbundled versions of their stand-alone counterparts.

INTEGRATED MOTOR FEEDBACK

Servomotors frequently are used for precise position control in robots or high-accuracy machine tools. Optical encoder technology has been a favorite in this area because of its accuracy and excellent dynamic response.

However, a new generation of precision magnetic encoder components (see **Figure 2**) offers an attractive alternative. These feature compact form factors (as small as 22 mm diameter) and are less susceptible to dust, moisture or shock and vibration. Magnetic encoders also are easier to install under normal factory conditions, because they can tolerate moderate misalignments between the shaft and the measurement module.

Further, magnetic encoders are available with multiturn measurement capabilities, with rotation counters powered by Wiegand energy harvesting technology. This means there's no need for backup batteries or the complex system of code disks arranged in a gear train used in many multiturn optical encoders.

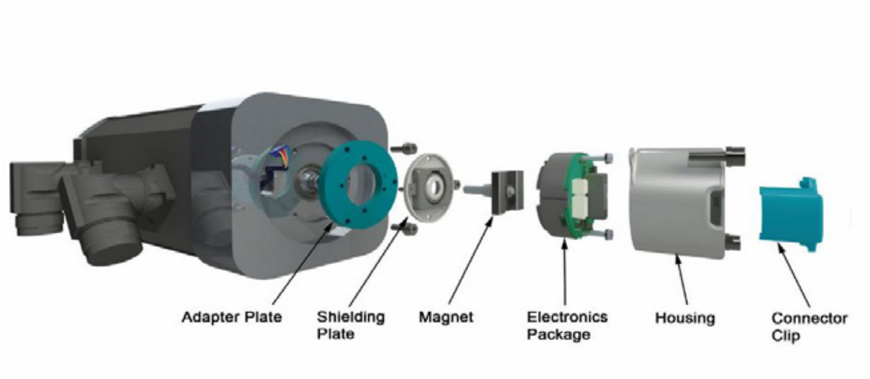


Figure 2. This is an example of integrated motor feedback with a magnetic kit encoder, which features compact form factors and is less susceptibility to dust, moisture or shock and vibration.

Figure 3. Kit encoders can also be installed on stepper motors to provide integrated feedback to the control system. This improves accuracy by mitigating positioning errors due to skipped steps.

Kit encoders can also be installed on **stepper motors** (see **Figure 3**) to provide integrated feedback to the control system. This improves accuracy by mitigating positioning errors due to skipped steps, which can become a significant problem at higher speeds when the torque output from stepper motors drops off and the likelihood of missed steps increases.

A big attraction of stepper motors is their relatively low cost, especially when compared to high-end servomotors. It follows, then, that cost is an important consideration when choosing an integrated encoder solution.

Magnetic encoder components feature compact form factors and are less susceptible to dust, moisture or shock and vibration.

Simple, inexpensive optical incremental encoders can verify that a step motion has been completed as requested, improving reliability.

For more demanding position control applications, absolute encoders can be a better choice, because these provide the controller with a complete picture of the rotary position of the motor's shaft, including the number of rotations that have been completed. Cost-effective multiturn magnetic absolute encoders are well suited for this task.

HOLLOW-SHAFT KIT ENCODERS

The kit encoders described previously often are mounted on the non-drive end of the motor. In some cases, though, it's useful to be able to position the rotation measuring elements at the drive end of a motor. Ring-shaped hollow-shaft encoders (see **Figure 4**) can be installed around the drive shaft or in other positions in the drive train. This can be beneficial when, for example, the drive system includes torque-amplifying reduction gears.

Hollow-shaft encoder elements can be mounted at the output end of the drive to avoid positioning errors caused by backlash in the gear train. For robot arm or wrist joints, angular deflections can be measured directly at the joint with hollow shaft elements built into the arm sections. The large central openings are available to route cables and media hoses inside the structure.

BEARING-LESS ENCODERS

Bearing-less encoders are a relatively new concept. These retain the robust housing of stand-alone encoders, but with the rotating part of the

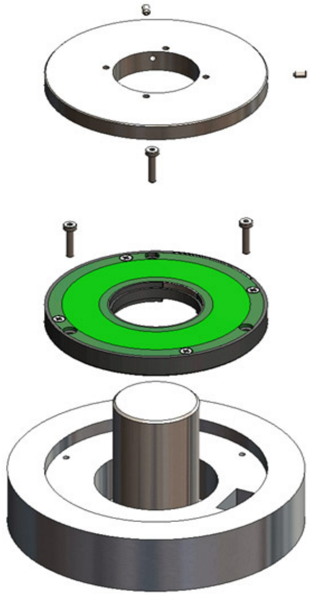


Figure 4. Kit encoders often are mounted on the motor's non-drive end. In some cases, it's useful to position the rotation measuring elements at the drive end of a motor. Ring-shaped hollow-shaft encoders can be installed around the drive shaft or in other positions in the drive train.

measurement system (such as a permanent magnet for magnetic encoders) attached directly to the shaft of the host machine.

This arrangement means there's no need for the bearings and shaft seals of conventional stand-alone encoders, saving space and reducing costs. The outer shell protects measurement elements from physical damage.

A CONTINUING ROLE FOR STAND-ALONE ENCODERS?

Although integrated motor feedback is taking a growing share of the market for motion control systems, the future for stand-alone encoders continues to look bright. It's driven by the explosive growth of digital motion and position control systems of all types. With dramatic advances in encoder technology, including the use of powerful microprocessors and sophisticated signal processing algorithms, many exciting new applications areas are becoming technically and economically feasible.

Modern digital encoders, both integrated and stand-alone, are significantly smaller, tougher and cheaper than their predecessors, making them viable in areas beyond their original base of manufacturing and industrial automation. Small, inexpensive encoders, paired with digital controls, have emerged as high-performance replacements for older analog systems based on potentiometers or resolvers in areas such as mobile machinery, medical equipment or even consumer electronics.

In the area of industrial motion control, stand-alone encoders still dominate important niches. Stand-alone encoders remain an excellent solution for machines that use non-electric prime movers such as pneumatics or hydraulics.

Also, because stand-alone devices can be installed close to the operational end of the machinery, they avoid any loss of positional accuracy that might occur when a motor's power is transmitted through long gear trains, belts or other mechanisms.

Economic factors also exist beyond the cost of devices. Stand-alone absolute digital encoders often support fieldbus or Ethernet communications that use shared-cable wiring systems. This allows simpler wiring layouts than would be possible with point-to-point analog or serial communications. Modern encoders with advanced communications might also feature self-diagnostic capabilities that simplify maintenance and troubleshooting.

Motion control plays a critical role in many emerging industries, including wind and solar power, autonomous guided vehicles (AGVs), robots/cobots and surgical tools. The special requirements in each of these areas will mean new requirements for encoders of all sorts, integrated and stand-alone. ●

POSITAL FRABA INC. Based in Hamilton, New Jersey, POSITAL FRABA Inc. is a Rockwell Automation Technology Partner. The company designs and markets sensors for high-precision industrial angle and displacement detection applications.