Incremental or absolute? Encoder selection discussed

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Across motion control applications, encoders are a common choice to provide feedback over position, direction, and speed. A key aspect of their specification is the selection of an incremental or an absolute encoder type. This decision directly affects system performance, determining whether the controller can rely on relative motion tracking, or if immediate knowledge of absolute position is required.

Gerard Bush, engineer at motion specialist INMOCO, explains.

Any closed-loop motion control system, ranging from a robotic joint through to a precision 3D printing machine, requires feedback. Closing the loop involves continuously measuring the motion, using that feedback to correct errors and ensure the system's position, speed, or torque matches the commanded values.

In the first of a trio of articles with leading motion vendor Kollmorgen, we looked at the various feedback technologies available, before moving on to explain the sensor options within encoders. This final article in the series will explain encoder selection according to application requirements.

In the first instance, the need for feedback is often necessary for commutation. Unlike brushed DC motors, which use mechanical means, brushless DC (BLDC) motors and AC servo motors involve electronic commutation, the process of switching current to align the magnetic field with the magnetic poles to produce rotation. Electronic commutation falls to an encoder when higher resolution and more precise rotor position feedback is required than a Hall-effect sensor can provide (read more here).

Incremental encoders

To achieve precision commutation, an incremental encoder is installed on the rotor to provide sinusoidal commutation for smooth and precise torque delivery. An incremental encoder can give fine relative position data across one revolution of the rotor. While resolution of up to 5,000 lines per revolution (LPR) is standard, line counts up to 100,000 are also available ***(1)***. Using A/B quadrature to measure motion, the encoder outputs two pulse signals with a 90° phase difference. This allows the controller to determine the rotation direction, while the pulses provide relative position. By counting pulses over time, the controller can also calculate rotor speed.

Incremental encoders are compact and cost effective. However, a potential limitation is that they provide relative, rather than absolute, position. This means that movement is measured from a known starting point, rather than providing true angular position. For commutation, this might not present a challenge for many machines. At startup, the motor can use an alignment routine or stored offset to establish the initial electrical angle. An incremental encoder sensor can also be sufficient if speed control is the application's requirement, such as the motion of a conveyor belt. In this case, velocity can be derived from the position of a roller through time, but the number of roller turns is irrelevant.

Incremental encoders can track multiple revolutions of the rotor if the master controller maintains a count of the A/B pulses. However, after power loss, this data is also lost, unless there's battery-backed memory or external storage. Even with a homing capability, this approach might be too slow for a start-up procedure in an application that requires multiple rotations of the motor shaft to return to its intended point. More seriously, if precise control of the output is critical, such as the control of a surgical robot, maintaining position data at all times is essential.

Absolute encoders

In these situations, an absolute encoder is required, usually installed on the shaft of the motor, rather than the rotor, to provide true position feedback on the output. Although larger and more complex than an incremental encoder because of its coding mechanism and signal processing requirements, an absolute encoder can always provide position information,

including after a power shut down. Whereas an incremental encoder outputs relative pulses, logging changes in position relative to the previous movement, an absolute encoder assigns a unique digital code to every shaft position. This enables an absolute encoder to report the exact angle immediately when power is restored.

An absolute encoder, such as the Kollmorgen SFD-M, can provide resolution at 24 bits per revolution (2^{32} counts per revolution), which translates as 16,777,216 counts at 0.0772 arc-sec per count. Moreover, absolute encoders can also have a multi-turn capability, with a feedback sensor that counts the number of complete revolutions. This multi-turn capability is typically provided at 12-bit or up to 16-bit resolution, translating to 65,536 turns of the shaft. Concerning positional accuracy, whether for single or multi-turn operation, a range of +/- 1-3 arc-min is expected.

Multi-turn feedback can be implemented through a system of gears with individual readouts or by using an electronic counter. The latter is a more compact solution and generally returns higher-turn counts. Meanwhile, to power the memory of an absolute multi-turn encoder when power is off, the system can use a battery backup system. To increase reliability, energy-harvesting technology can also be used.

Engineering support

When selecting the right encoder system, engineering assistance can be the faster and more reliable approach when it comes to design. However, making the process easier, systems with the motor, feedback device, as well as drive and cables combined, are also available, saving time in design as well as installation. Manufacturers like Kollmorgen also offer smart feedback devices within their motors that achieve plug-and-play operation by providing the drive with an electronic motor nameplate that specifies motor parameters.

For the most specialised requirements, the integration of distinct technology types might also be required. In situations like this, motion engineering expertise is advised to optimise application design. At INMOCO, our engineers are regularly involved in encoder specification as part of providing wider motion system development advice.

Source(1): *https://www.kollmorgen.com/en-us/developer-network/incremental-encoder*

Image Captions:

Image 1: A correctly specified Servo motor-powered motion control systems are fast and accurate.

About INMOCO

Established in 1987, INMOCO now offers an extensive range of motion control equipment including: compact servo amplifiers, position controllers, stepper motors, PLC controllers, linear motors, sensors, electric actuators and gearheads. INMOCO's product portfolio is supported by extensive applications and technical expertise, in addition to customer-specified electro-mechanical development and sub- assembly services; including calibrating and testing in a class 10,000 clean room facility.

About Kollmorgen

Kollmorgen has more than 100 years of motion experience, proven in the industry's highest-performing, most reliable motors, drives, linear actuators, gearheads, AGV control solutions and automation platforms. Kollmorgen delivers breakthrough solutions that are unmatched in performance, reliability, and ease of use, giving machine builders an irrefutable marketplace advantage.

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