INDUSTRIAL ROTARY ENCODERS

Selecting the Right Device for Your Application

Rotary encoders play important roles in motion control and industrial automation systems, providing control systems with information about the motion of motor shafts, pulleys, robot arms, etc. There are many variants available — some familiar and some highly innovative.

Optical Encoders

Optical encoders offer a high level of precision for critical positioning tasks. Optical encoders are built around a code disk — a glass or plastic disk attached to the encoder' s shaft with a concentric pattern of transparent and opaque areas (Figure 1). There is a light source on one side of the disk and an array of photocells on the other. As the disk rotates, a coded pattern of light will fall on the photocells, generating either pulses (incremental encoder) or a digital "word" representing absolute angular position. Multi-turn absolute optical encoders typically use a set of secondary code disks geared to the main shaft. These rotate more slowly than the main disk, and measure the total number of turns that the encoder shaft undergoes.

Optical encoders have excellent dynamic response and resolution; however, to achieve high accuracy, the code disk needs to have a relatively large diameter. Multi-turn versions need room for the secondary code disks, further adding to the size of these units. Optical encoders can be sensitive to humidity and mechanical shock and vibration, which can limit their suitability for harsh environments

Magnetic Encoders

Magnetic encoders are an attractive alternative to optical encoders for most applications. They are more compact, less susceptible to dust and moisture, and more tolerant of shock and vibration loads (Figure 2). Magnetic encoders have a small permanent magnet mounted on the rotating shaft, with Hall-effect sensors on the body of the encoder to measure the position of the magnet. With sophisticated signal processing algorithms, 17-bit resolution can be achieved, with accuracies and jitter good enough for closed loop control of high-speed dynamic control systems. For multi-turn variants, Wiegand-effect energy har vesting technology can be used to power a multi-turn rotation counter, eliminating the need for gear systems or backup batteries. Magnetic encoders are available in incremental or absolute forms with a wide range of communications options and mechanical configurations.

Figure 1. Optical rotary encoder

Magnetic kit encoders (Figure 3) are essentially the internal components of magnetic encoders, packaged as modules that can be easily incorporated into drive motors and other rotating machines to provide information on shaft position for control systems and/or motor commutation. They are an ideal choice for cost- and space-sensitive OEM applications.

Capacitive Encoders

Capacitive encoders make use of small changes in the capacitance between two circular printed circuit boards, one rotating and one static. This technology can be used to make a

wide variety of through-shaft (ring-shaped) configurations that are well adapted to position measurement tasks in small robots and other equipment where the encoder element is required to fit into a limited space around a shaft or axle. Rotation counters powered by Wiegand-effect energy harvesting technologies will provide maintenance-free, multi-turn capabilities.

Selecting the Right Encoders

A useful starting point in selecting encoders is to decide between incremental and absolute encoders. In - cremental encoders send a stream of signal pulses to the controller as the device's shaft rotates. The relationship between rotation speed and pulse rate is defined by the device's resolution, expressed as the number of pulses per rotation (PPR). Most incremental encoders also report the direction of rotation.

Incremental encoders are ideal for speed control of motors or other equipment since they provide a real-time reading of the rotation rate. Incremental encoders can be used for positioning tasks, with the control system keeping track of absolute position by counting the number of pulses sent by the encoder. However, when positioning systems are built around incremental encoders, this position count could be lost during a power failure or system shutdown. In this case, it may be necessary to return the machinery to a known reference position and restart the position count before operations can resume.

Absolute encoders provide a snapshot reading of the shaft's angle of rotation, usually as a multi-byte digital word, in response to a request from the system's controller. For multi-turn absolute encoders, the output combines the angle of rotation with a count of the number of complete rotations that the encoder shaft has experienced. Absolute encoders are ideal for positioning tasks, since most can report their complete absolute rotational position (including the number of complete turns) immediately on startup. This eliminates the position reset problem encountered with incremental encoders.

Figure 2. Magnetic encoder

Figure 3. Magnetic kit encoder electronics package

Communications Interfaces

Incremental encoders transmit pulses typically using line drivers (RS-422) or push-pull outputs. Inverted signals and index pulses are also commonly used. A separate cable is required for each sensor.

Absolute encoders are available with a wide variety of interfaces, from analog, through SSI, to Fieldbus, and on to industrial Ethernet. Point-to-point wired setups (analog or SSI) can be useful in simple motion control systems; however, for complex, multi-axis machines, Fieldbus or industrial Ethernet connections that use a shared wiring backbone can result in much cleaner, less complex designs.

Fieldbus communications (e.g. CANopen, DeviceNet, ProfiBus) are well suited to standalone machines or small work cells. Industrial Ethernet (e.g. EtherNet/IP, EtherCAT, PROFI - NET, Powerlink) is becoming popular for larger systems with many devices working together. In some critical motion control systems, real-time signals and alarms are important. Some variants of industrial Ethernet (e.g. EtherCAT, PROFI NET/RT) provide special communications protocols that guarantee priority delivery of critical alarm messages.

Mechanical Features

Some encoder manufacturers offer a wide range of mechanical configurations, allowing buyers to choose the device size, flange configuration, shaft configuration, housing materials, and connection type they need, without having to resort to special adaptors or couplers.

Machiner y used in mill, factory, or outdoor settings may be exposed to dust and moisture. Food-handling or pharmaceutical equipment may require frequent washdowns with high-pressure water jets and aggressive cleaning solutions. The IP (ingress protection) rating system indicates the suitability of devices for environmental risks, as shown in the table below.

IP65	Fully sealed against dust; protected from moderate water jet
IP67	Fully sealed against dust, and immersion in water for 30 minutes to a depth of 1 m
IP69K	Fully sealed against dust; protected from hot, high-pressure water jet (14-16 liters/minute, pressure 8-10 MPa, distance 0.1 – 0.15 m, 80 °C)

Summary

Modern rotary encoders are available with per formance levels, communications interfaces, and mechanical features that can meet almost any requirement. Your challenge, as a buyer and user, is to understand your requirements clearly, while remaining open to the possibilities of using new technologies and features that can result in better-performing, more cost-effective solutions.

This article was written by Christian Fell of POSITAL-FRABA Inc., Hamilton, NJ. For more information, visithttp://info.hotims.com/69505-324