MicroMo
FAULHABER GROUP

Look Closer at the World's Smallest Encoders

Consumers have grown to expect quality products in increasingly compact packages. As engineers design more compact systems, the need for smaller components becomes a necessity. Devices that require miniature motors are no exception.

As more applications become automated, the need for motor feedback becomes a design requirement. While motor technology still leads feedback in terms of miniaturization, MicroMo has found a solution to close some of this gap with the PA2-50.

PA2-50 Assembled to 0615...S

A Little History

MicroMo led the motor-feedback industry by reducing the rotary incremental encoders to Ø15mm and Ø10mm with product launches in 1987 and 1993, respectively. By using a multi-pole magnetic disk, Hall-Effect devices, and a wire-bonded application specific integrated circuit (ASIC), the technological breakthrough provided feedback for motors down to Ø10mm without an increase in the diameter of the assembly. Later reductions in the size of brushed motors to Ø8mm and Ø6mm outpaced the capability to further reduce the feedback device.

MicroMo pursued research and development along the two technologies: magnetic and optical feedback. MicroMo's success with magnetic encoders led to further size reduction with improvements in resolution. Optical technologies held more promise for further reduction in size, but overcoming unacceptable length and excessive power consumption required a fresh perspective.

Technological Collaboration

While MicroMo designed the first encoder to fit in a Ø10mm package, producing an encoder in a Ø6mm package required collaboration with another industry leader. Avago Technologies, the industry-leading supplier of motion control encoders, proved to be a great resource and partner in the design process of a new miniature encoder. Besides offering an unmatched understanding of optical encoders, Avago owns an impressive portfolio of designs. The heart of the solution existed before MicroMo sought it. Avago had commercialized the technology necessary to make the next breakthrough, but the partnership brought the necessary minds together to make the next breakthrough possible.

AEDR-8400

Next Generation

Working toward a compact device, MicroMo and Avago choose to use a reflective encoder technology with a small footprint. With both the optical transmitter and receiver on the same surface-mount-technology chip, the overall length could be held to a minimum. In contrast, a transmissive configuration requires more length due to a separate transmitter chip and a separate receiver chip facing each other with an optical code wheel in between.

Avago's AEDR-8400, known as the "world's smallest reflective encoder," proved to be a great technical foundation. Avago's wealth of knowledge and engineering resources paired with MicroMo's expertise in miniature motor technologies lead to a uniquely designed reflective codewheel that give birth to the PA2-50 or "the world's smallest rotary encoder" possible.

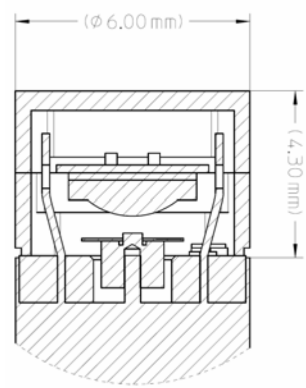
PA2-50 and Ø6mm Motor

Simple Construction

The elegance and simplicity of the design becomes apparent from studying the construction. A hub press fit to the rear shaft of the motor holds the reflective codewheel. The housing, shown in green for better contrast, protects the AEDR-8400 and supporting circuitry. The flexible printed circuit connects all the surface-mount-technology electrical components and the motor terminals to provide the interface for the encoder signals as well as the motor power. The end cap, shown in tan, protects the assembly.

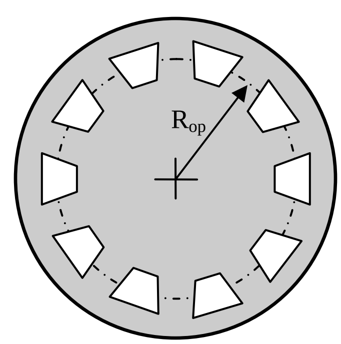
Dimensions Define Details

Keeping the encoder housing the same diameter as the motor limits the resolution of the feedback. To keep the additional length to a minimum, the codewheel must not only fit within the housing, but fit between the motor terminals. Several limitations define the resolution of the PA2-50 to 50 lines per revolution (lpr) pre-quadrature.



PA2-50 Cutaway View

The AEDR-8400 comes in two different models that would allow more resolution. One model resolves up to 10 lines per millimeter, and the second resolves up to 12 lines per millimeter. The codewheel of the PA2-50 measures 2.6 millimeters in diameter. The reflective patterns have an inner radius of 0.63 millimeters and outer radius of 1.25 millimeters. The center of these radii is the optical radius (R_{OP}), which measures 0.94 millimeters.



Optical Codewheel

Circumference = 2*π*r
Optical radius = R_{OP} = 0.94 mm

Solving for lines per revolution (lpr):

$2*\pi*R_{OP} = 2*\pi*0.94$ mm = 5.91mm/rev

5.91mm/rev * 12lines/mm ~ 70lpr

5.91mm/rev * 10lines/mm ~ 59lpr

The encoder resolution limitation comes from the process to make the codewheel. Each reflective area needs an adjacent non-reflective. The PA2-50 consists of 50 reflect areas and 50 non-reflective areas. The technology used to deposit the reflective material cannot be accurately reproduced at a resolution much higher. Considering miniature motors are commonly used with a gearbox, 50 lines per revolution should not present much of a limitation.

Benefits

Creating the first Ø6mm encoder is a technological achievement, but the PA2-50 advances the design of miniature encoders beyond that of previous magnetic designs. While the PA2-50 is an incremental encoder like that of its magnetic predecessor, the optical technology produces higher resolution with a more consistent signal. Where the optical codewheel uses reflective material, the magnetic codewheel needs multiple poles charged in a magnetizing fixture. Even at lower and equal resolutions, charging a magnetic codewheel with multiple pole pairs remains relatively less precise. Beyond variance in manufacturing, the magnetic encoder also remains susceptible to external magnetic interference.

Even if the magnetic code wheel could achieve similar resolution, the disk would be thicker and denser. The material used in the optical codewheel design reduces the moment of inertia. An equivalent resolution magnetic codewheel would have substantially increased the inertia, thus reducing acceleration and decreasing efficiency of the motor.

While magnetic encoders had long been used in favor of optical encoders for battery run applications, the PA2-50 is an even more natural fit. The AEDR-8400 operates at lower voltages and with a lower current draw than many larger encoders. Considering many applications that would use a Ø6mm motor rely on batteries, an operational range of 2.7VDC to 3.3VDC allows the use of two 1.5VDC cells or one 3VDC cell. The low-current draw increases the battery life allowing the application to run longer.

For applications using pulse width modulation (PWM) to control motor current, the PA2-50 incorporates a capacitor to filter noise before it reaches the encoder circuitry. Since noise injected into the encoder could trigger false encoder counts, this small addition increases the reliability of the encoder and the feedback loop.

Conclusion

Not only is the PA2-50 the first encoder to fit a Ø6mm motor, but the technological advances improve the performance and reliability over earlier magnetic encoders designs. By working with Avago, MicroMo has again led the miniature-motor industry with another motor feedback first.