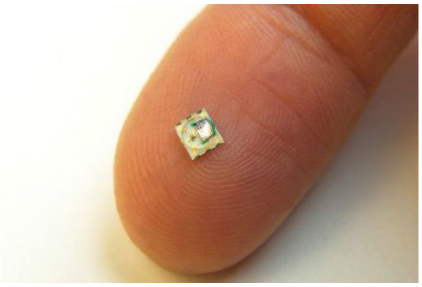
White Paper

Portable and Affordable Sensors for the Medical Device Market

Reflective Surface Optical Motion Sensor Encoders



Description

In the complex medical device market today, device manufacturers strive to develop products that have competitive advantages and compelling end-user value. For instance, demand is rapidly increasing for home-managed therapy as consumer awareness grows of the benefits and cost savings of self-administered medical care.

Rising fuel and energy costs have limited the funds available for consumer health care. Outpatient treatment with its lower cost structure is a popular and growing alternative to inpatient care. This trend among health care providers and consumers opens new and large markets for medical healthcare device companies that can develop new portable, cost effective and user-friendly devices.

Today, there are many diagnostic and therapeutic devices readily available for inpatient and outpatient treatment, such as dialysis equipment, portable insulin pumps, insulin inhalers, respiratory ventilator, needle free drug injector devices, diabetes management systems, and many more. Growing medical device demand is expected to push component suppliers to introduce innovative, low cost products for medical device use.

To meet an aggressive time-to-market strategy, product designers must begin their design by carefully searching for components that support their product vision, cost, reliability, and form factor needs. Time-to-market is an overriding consideration because it influences market share and financial results. Designers must expand their search to include new technologies that offer the same or better performance and quality levels as old solutions have. Newer technology is usually more compact and weighs less.

One new technology example surrounds miniature reflective encoders for motion sensing. Reflective encoders have become a popular choice among portable medical device manufacturers that must offer products with greater precision, lower power consumption, lower weight, and smaller size at a cost to be successful in the health care device market. Major encoder and motor manufacturers have begun to incorporate the reflective encoder sensors in their new products and in their future product road maps. These enhanced motion control feedback devices exceed present magnetic technology-based encoder devices without increasing cost or power dissipation.

This article discusses reflective encoder technology and motion sensing. It compares reflective encoders to incumbent magnetic encoder solutions. Examples where reflective encoder solutions have revealed improved results are also discussed. Ultimately, this white paper provides a better understanding on why reflective encoders positively answer device designer questions about electro-magnetic interference, form factors, and precision—and at the same time, ensuring the encoder remains small, cost effective, and easy to design with in medical applications and environments.

Searching for the Right Motion Feedback Solution

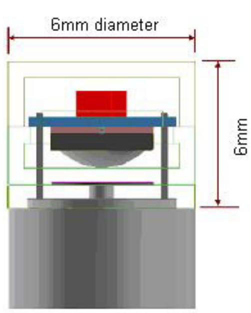
The portable medical device market is becoming more competitive. Device suppliers now focus on product segments where they have a distinct advantage or a product differentiator that sets them apart from competitors in the eyes of the consumer. These advantages or differentiators are primarily derived from customer feedback and market research about existing applications and products, current product limitations, and unfilled market needs. From the feedback and studies reviewed, the design staff must make tradeoff decisions. Prioritizing design requirements is the key step in selecting affordable components that meet the most critical product priorities and at the same time satisfy financial objectives.

Portable medical device components selection is typically evaluated with the following criteria. The order and weight given to each item is specific to each product design, the served medical market, or both. The same generic product may have different product tradeoffs for segments within a given market class.

Weight and Size

The name "portable" implies that the device must be easily carried around. In comparison to its desktop or permanently-mounted siblings, size and weight are critical to product design because the designer has a limited space and weight allowance for components (see Figure 1).

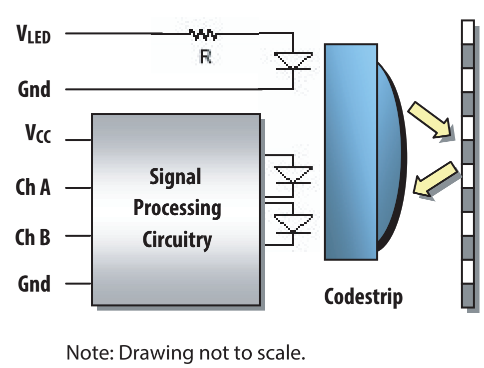
Figure 1: Reflective Encoder Assembly



For example, a portable medical device that requires precise mechanical positioning may need an encoder or an electromechanical motion feedback device to translate mechanical motion to an electrical output for precise position tracking. The most common solution for this is a rotary encoder attached on the back of a motor with the motor driving the mechanical system. Alternatively, a linear encoder may use a codestrip, a strip that has a series of black and white tracks on it, mounted on the moving part of the system for motion tracking (see Figure 2). These solutions are not possible with conventional encoder offerings that do not meet the size, weight, resolution, and cost system requirements.

With the high-volume availability of nearly weightless reflective encoder motion sensors that measure just over **3 mm in length and width**, this new encoder technology offers a very competitive alternative to older magnetic sensors in the market. In addition, the reflective encoder is priced relatively low, while providing greater resolution and higher accuracy than a magnetic-based encoder.

Figure 2: Typical Component Block Diagram



Resolution, Frequency/Speed and Accuracy

Another important criteria in selecting the right motion feedback encoder is device resolution, frequency/speed, and accuracy. The resolution determines the total number of steps that represent one revolution of motion from the rotary system. Resolution is often measured as counts per revolution (CPR) for rotary applications, or lines per inch (LPI) for linear applications. Higher CPR does not necessarily imply that a better accuracy in the design can be achieved. On the contrary, it only provides more counts per revolution for your application and does not reveal details about potential cycle error.

The final output resolution of a rotary encoder is determined by the count density of the encoder module and the size of the matching media or codewheel. The relationship between encoder output resolution (CPR), codewheel size, often expressed as optical radius (Rop), and encoder count density, LPI, is as follows:

$$LPI = CPR / (2 \times \pi \times Rop)$$

With Rop measured in inches, LPI is in lines-per-inch. If Rop is in millimeters, LPI is in lines-per-mm.

An optical encoder with a 6-mm diameter housed encoder can offer at least 50 CPR pre-quadrature resolution or higher. This could be further multiplied by four times with an external electronics to obtain post-quadrature output.

The frequency rating of an encoder determines how fast your motor can spin without the encoder losing count. A typical miniature DC motor is rated at around 20,000 RPM, or lower, at no-load. Typical applications run at 6000 to 10,000 RPM. At the stated motor speed, a typical 50 CPR encoder will need to meet at least a 16.7-kHz specification.

A typical magnetic-based encoder with an interpolator has a three to four times higher cycle error than comparable optical-based encoders. Therefore, it is crucial to choose the encoder technology that matches your product design requirements. If a high accuracy output is desired, for instance, less than ±20 electrical degree cycle errors, optical encoder technology is the best option.

Cost

Medical device manufacturers seek to tap the self-help portable medical device market as cost-conscious consumers strive to control their health care costs while maintaining a high level of effective care. Miniaturized electronics has made this possible.

Often, engineers are challenged to find the right component at the right price. Motion control products take a large portion of the design budget because precision motion control components choices are limited and traditionally expensive.

In addition, mechanical mounting of the encoder device is another concern due to the lack of expertise and tools to assemble the encoder in the medical device. The most common practice is to rely on motor manufacturers for a complete motor and encoder solution. However, this has often been limited to magnetic based encoder solutions.

Reflective encoders are easy to assemble, and suppliers usually provide assembly jigs and tools. With reflective encoder technology, engineers now have a new proven option for their applications that ensures component costs remain low and manufacturing is easy.

Power Consumption

Engineers that design battery-powered portable medical devices must keep the power consumption of all components at the lowest possible level to maximize operating time. Adopting a component that consumes less power will extend device operating time or allow more flexibility in selecting other components.

Typically, reflective encoder power consumption is below 30 mW from a 3V power source—comparable to or less than older technology devices.

EMI

Another consideration in selecting the right motion feedback solution is its immunity against electromagnetic interference (EMI). EMI issues have become more significant in recent years as devices use more sensitive electronic components.

Over this period, there had been reports of EMI-related device malfunctions. One reason for this could be due to the extensive adoption of wireless communication devices, such as cell phones, WiFi networks, and other radio transmitters. Ironically, many motor manufacturers continue to design their encoders based on custom discrete magnetic solutions that are sensitive to EMI. To avoid device failures or issues related to EMI, engineers should adopt optical-based encoders as an alternative to magnetic-based encoders. Optical-based encoders have better immunity to EMI failure.

Reflective Motion Sensor Medical Applications

Many assembly methods are used with reflective encoders. The most common practice is to have the optical reflective encoder mounted at the back of the motor (see Figure 3). The sensor then provides feedback data based on the motion (rotation) of the motor shaft.

Figure 4 shows a typical geared motor with a rotary encoder (for example, HEDR-542x and AS22 series). The motor drives the lead screw through gears. The lead screw pushes against the plunger head at a programmed rate. The motion control encoder captures the motion of the motor shaft and sends a signal to the system controller to form a closed-loop system.

Alternatively, a reflective encoder module or a codestrip may be attached to the moving mechanism, see Figure 5, and have the encoder module track the motion.

Figure 3: House Encoder Integrated at the Rear of the Miniature Motor

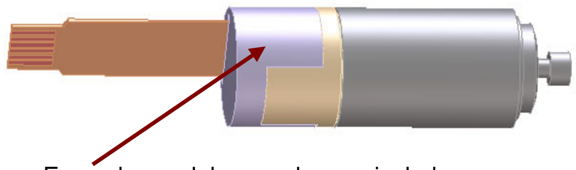


Figure 4: Volumetric Dispenser

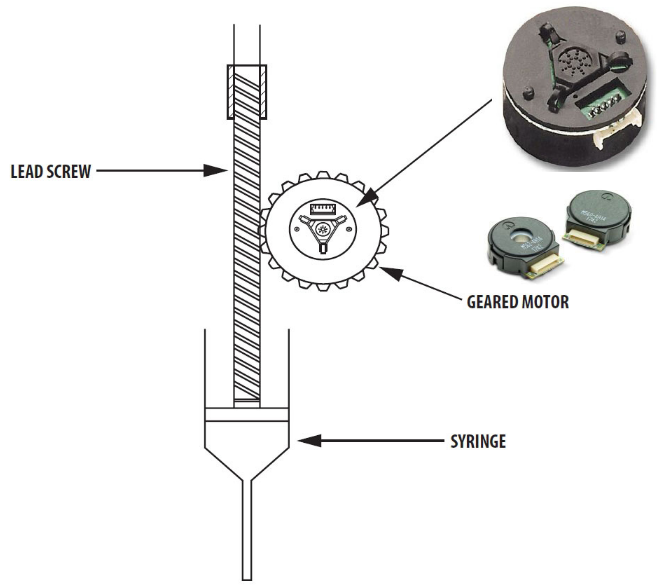
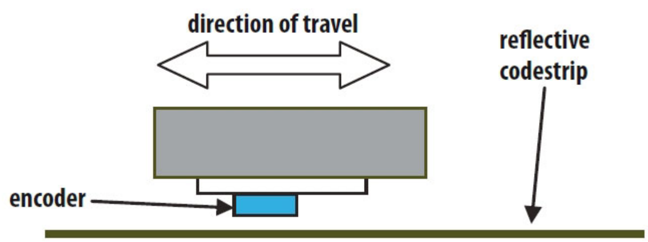


Figure 5: Linear Motion Tracking



Conclusion

Finding a suitable and inexpensive motion encoder solution for portable medical device design remains a challenge, but new reflective feedback motion sensor products make the task much easier. Designers now have access to a new generation of reflective encoder products that offer greater performance yet remain cost effective for consumer medical devices.

Properly setting your overall system priorities during the product definition stage will simplify your work and set the project on a path to success and quick market entry.

Reflective encoders are ideal for many medical device applications—respiratory ventilator, blood analyzer system, drug delivery devices, automated syringe products, and endoscope systems are a few examples.

Broadcom products include the following:

Reflective module encoder, including AEDR-8300/8400/8500/871x/872x and AEDR-9820/9830, AR18/AR35, and house encoder HEDR-542x, AS22 series.