Magnetic Angle Sensors Offer Superior Overall Benefits to Optical Sensors

Introduction

Advances in sensor technology are opening a world of new possibilities, from smart homes to autonomous vehicles. As the demand for more automated applications increases, designers are finding innovative ways to provide precision motion control in an efficient and cost-effective manner.

Sensor technology is a key part of both the manufacturing and the automotive industry. Sensors are widely used to monitor the environment: they can detect part positions, check fill levels, inspect labels, and perform quality control. For automobiles, they are a vital link between motion control assemblies and other subsystems.

While sensors are used for many different applications, the fundamental technology is the same: a sensor converts changes in the physical environment — such as heat, light, sound, and motion — into an electrical signal. These signals are then converted into a binary code, which is passed on to a computer as data.

In a motion control system, for example, the motor feedback sensor performs an essential task. This sensor is typically attached to the motor shaft or the load, and it supplies the control system with an input that can be converted into speed or position. The control system uses the data from the sensor to reduce the error between the actual and commanded position/speed.

Options for Position Sensors

One of the most important applications for both optical and magnetic sensor technology is measuring the movement of electric motors. As electric motors rotate, it is critical to measure their angular position. This allows the controller to send the correct electrical signals to the motor driver, which optimizes motor efficiency.

Measuring proximity and displacement of an object is very important for both automotive and manufacturing, particularly for applications that may require any of the following: positioning the valve, detecting fluid levels, safety, machine control, and process control.

Modern machinery —from power tools to dishwashers to garage door openers — relies on precise position sensors. Generally, if you push a button to operate a machine, it has both an electric motor and a position sensor that collect the necessary data for the device to function normally.

There are different ways that a sensor can collect its data. The first type of sensors are optical sensors, which compute changes from light beams. These sensors consist of a light source, a photodetector, and an opaque disc, with features that interrupt the light path. As the machine moves, the disc moves in sync, and the light passes through or reflects off these features, providing information about the relative position of the object.

The number of discs used to potentially interrupt the light is directly related to precision, such that additional discs increase precision. This ability to improve precision is a particularly attractive feature of optical sensors, though additional discs lead to additional costs.

Another type of sensor is magnetic sensors, which utilize a technology directly related to the magnets. A magnetic sensor converts changes in the magnetic properties of sensitive materials (e.g. gallium arsenide, indium antimonide, and silicon) as well as physical changes — such as magnetic field, current, or temperature — into an electrical signal. Like an optical sensor, magnetic sensors can detect the presence, absence, or motion of an object.

When to Use Magnetic Sensors

While many designers may be more familiar with optical angle sensors, magnetic angle sensors have been an increasingly competitive and ideal choice for sensor applications.

While optical sensors can offer highly precise measurements, they can be as much as 7 to 10 times more expensive compared to magnetic sensors. A single heavy-duty optical sensor can cost as much as $1000, depending on the resolution. Optical sensors are also physically larger than magnetic sensors.

In automotive systems, magnetic sensors are widely used to sense position and speed. For example, sensors are used to measure the angular position of the crank shaft to ensure the correct firing angle of the spark plugs. Magnetic sensors can measure and communicate the data on everything from the wheel speed for anti-lock braking systems to the position of car seats for air bag control.

Magnetic sensors offer several key advantages when compared to optical sensors. For example, they are completely contactless, while optical sensors require mounting a rotating disc to the motor shaft. Magnetic sensors do not. Given that fewer components interact, the magnetic sensors have a longer lifespan due to reduced wear and tear.

Figure 1 shows that an optical encoder requires an emitter PCB and a receiver, while magnetic encoders are far more compact: they operate only using only a magnet and a PCB. This benefit, known as contactless measurements, means that magnetic encoders are less expensive to manufacture than optical sensors, because they do not require bearings or mechanical coupling. They are fabricated using standard silicon integrated circuit processes, with manufacturing technology that has been streamlined to be cost-effective.

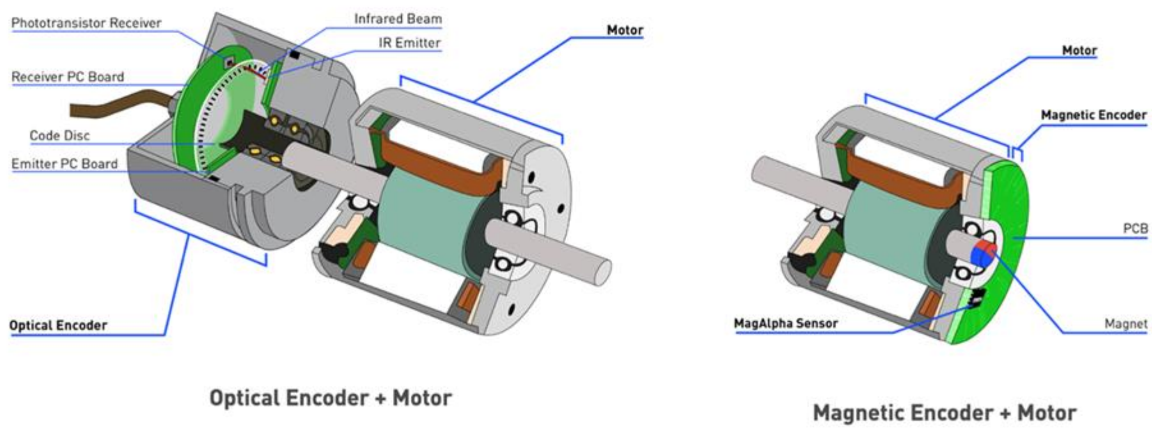

Figure 1: Optical Encoders Have a Bigger Footprint than Magnetic Encoders

A magnetic encoder has a smaller footprint than an optical encoder, but it does need to be custom fit with a given motor. Optical encoders are designed for specific form factors, which means they can be used many different motors, as long as the motor meets the form factor standard. Despite this disadvantage, magnetic encoders are still more cost-effective and have a simplified design.

MPS Supports Innovative Magnetic Sensor Technology

Traditional magnetic angle position sensors sometimes fell short on precision and bandwidth.

However, MPS has pioneered the technological developments for magnetic sensors so that they can surpass the abilities of optical sensors, with a smaller footprint and at a lower cost. MPS's MagAlpha family of magnetic angle position sensors use an innovative approach for measuring angles. These sensors use a patented *SpinAxis*™ Hall measurement technique that provides an instantaneous angle position in a digital format. They also leverage a phase detection approach that provides immediate data, making an analog-to-digital conversion or complex angle calculation unnecessary.

The MA600 is a state-of-the-art example of MagAlpha technology that includes motors and rotary encoders. The MA600 can support a wide range of magnetic field strengths and spatial configurations. The extensive list includes precision robotics, factory automation, building automation and control, power-assisted steering, automotive electronic braking systems, thermal and fluid management, and autonomous driving.

The MA600 can support a wide range of magnetic field strengths and spatial configurations. It offers 15 bits of resolution at a 75Hz bandwidth, or 12.5 bits at a 12kHz bandwidth, which is a level of performance that competes with optical sensors. The MA600 uses a tunnel magnetoresistance bridge to detect the magnetic field for improved sensitivity and lower noise. This device is extremely precise, integrating a high-bandwidth magnetic position sensor that rivals optical encoders. The MA600 comes in a tiny QFN-16 (3mmx3mm) package.

Some sensor applications (e.g. the dial on the radio) do not require this level of precision. For low-power angle detection, MPS has developed the MA800, which is cost-effective and recommended for human machine interface (HMI) solutions (e.g. turning the radio volume up). This sensor has 8 bits of resolution. Possible applications for the MA800 include a broad range of electronic equipment with buttons or knobs to control performance: white goods, smart thermostats, dials on keypads, smart speakers, kitchen ranges, and appliance controls.

The MA800 is more reliable than a comparable optical sensor because there are no mechanical moving parts. It is also the smallest solution with a QFN-16 (3mmx3mm) package, as well as a single sensor for dial and push-button operation. It is easy to design in, with configurable detection thresholds and a configurable field strength between 20mT and 120mT.

The MA302 is a 12-bit resolution position sensor solution that is suitable for any brushless DC (BLDC) motor application. Because it does not rely on Hall effect technology, its design is efficient and reduces PCB footprint (see Figure 2 below). Potential applications include portable hand tools, kitchen appliances, water pumps, motor speed and direction control, and robotic cleaners.

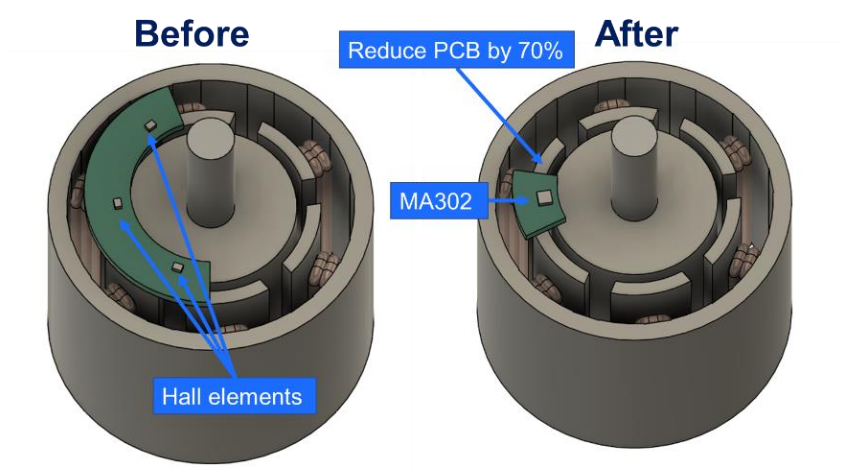

Figure 2: The MA302's Improved Magnetic Sensor Technology Reduces Its Footprint

Functional safety is becoming critical in the automotive sector, and MPS is including these safety parameters in the development of new sensor power products. One upcoming offering, the MAQ79010FS, is a 14-bit absolute angle position sensor that uses MagDiff™ technology. It includes comprehensive on-chip diagnostics as a back-up system for functional safety to make it ASIL compliant. It is designed to be immune to stray magnetic fields, providing a protection for vehicles against an identified danger on a busy highway.

Conclusion

Sensor technology is progressing quickly, and magnetic sensors options are a competitive and compelling choice for sensors. MPS is the leader in the field of magnetic sensor power solutions, providing state-of-the-art options for everything from ATM machines to oil pumps to automotive interiors.

Options like the MA600 are smaller and more cost-effective than their optical counterparts, which in turn increases the desirability of the end product. MPS is focusing on expanding its range of functional safety sensor options, especially for the automotive industry. For learn more about MPS's work in the magnetic sensor sector, please visit our website.