Current sensors expand precision motion control capabilities

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Small in size, large in capabilities, Hall-effect devices sense currents to improve system performance in both precision motion control and general-purpose applications. Here's what they are and how they do it.

In many industrial applications it is desirable to precisely detect the presence of a magnetic field. A typical example is detecting a field to establish the instantaneous rotor position in a brushless dc (BLDC) motor. In other related installations, sensing current magnitude enables control systems to improve productivity. For both of these requirements, a Hall-effect device is often specified, Figure 1, especially where the space is limited and ambient temperatures fluctuate over wide ranges.

How it works

A Hall-effect element consists of a silicon chip or integrated circuit, only 0.070 × 0.090 in, that contains about 125 resistors and transistors to amplify and condition the output signal. When connected to a small input voltage (typically 6 to 24 Vdc), the chip produces a voltage output signal that is proportional to the strength of a magnetic field passing through the device. A Hall-effect device can sense dc and other non-sine-wave currents, as well as sine-wave currents.

To sense current flowing through a wire, the device is placed in a gap of a toroidal core, Figure 2. The current in a conductor passing through the core produces a magnetic field that is proportional to the current. The toroidal core receives some of the lines of magnetic flux and concentrates them at the Hall-effect device. It, in turn, produces a voltage proportional to the current flowing in the wire.

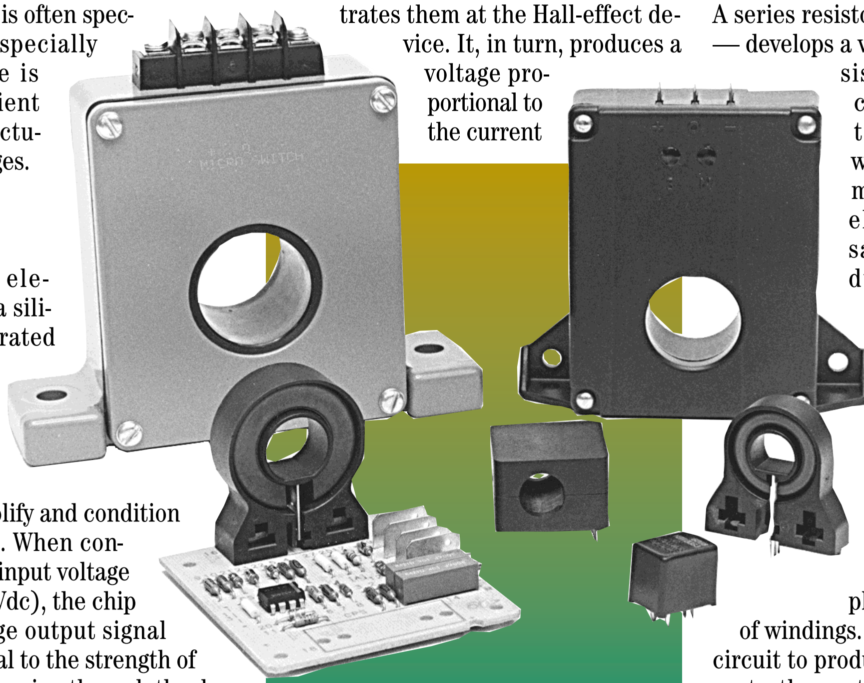

Figure 1 — Various types of Hall-effect devices sense different levels of current.

Other methods such as current transformers and series resistors also sense current. Although a current transformer isolates the output from the current-carrying wire, it is larger and more costly than a Hall-effect device. A current transformer works best for sine-wave currents, not as good for dc and other wave forms. A series resistor — often called a shunt — develops a voltage drop across the resistor proportional to the current, but this voltage is tied directly to the wire, which can be at 480 V or more. This usually requires electrical isolation for safety reasons and to reduce the needed equipment insulation.

Precision motion control

A BLDC motor uses electrical circuitry — rather than a commutator and brushes — to apply voltage to the proper set of windings. For the electrical control circuit to produce the proper phase currents, the controller must know the precise rotor speed. This is established by connecting an encoder or resolver to the motor shaft, or by imbedding Hall-effect devices in the motor to sense the instant each rotor magnet passes a given point.

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The control receives this information, compares it to the desired speed, and makes any necessary changes in the voltage to the stator windings.

Hall-effect devices are also frequently installed in many different types of precision motion controls, including BLDC, servo, and step motor controls. In these controls, the current sensor is used in the current feedback loop that limits or regulates the motor output torque. Again the space saving and electrical isolation are valuable characteristics.

General-purpose applications

Hall-effect sensors also detect the amount of current being used by an electric motor. Monitoring this current can tell you many things such as whether the motor is on or off, the drive is intact, the bearings and shaft are in good condition, and the load is too heavy or too light.

In one type of application, current sensors are used in motor circuits to control conveyor loads.

Conveyor load control. In a warehouse serving ocean liners, a shipping company installed a conveyor belt to decrease forklift mileage and accidents associated with moving crates. The new conveyor transports packages from one end of the warehouse to the shipping dock, so the forklift only needs to load packages onto, or unload them from, the conveyor belt.

In designing the conveyor, engineers used the inertia of pulleys, belt, and load to calculate the torque required from the conveyor belt drive. The load inertia was based on an assumption that there are 10 crates on the conveyor, all loaded to their maximum weight (1,000 lb), which requires a conveyor drive capable of moving a 10,000-lb payload. The belt, rollers, and conveyor structure were also designed to handle this maximum weight.

A photoelectric sensor and process computer arrangement detects when a crate is approaching the end of the conveyor and stops the belt before the crate falls off. The forklift then moves the crates from conveyor to shipping dock and the conveyor starts again.

Though the conveyor reduced forklift usage as planned, it increased the time required to load and unload ocean liners. What was the reason for this decreased efficiency? The belt was able to handle only 10 crates at a time, even though many crates were not filled to capacity and their combined weight was usually much less than the 10,000-lb design limit. To overcome this limitation, the engineers added a current sensor to monitor the total weight on the conveyor.

The recently installed current sensor measures the amount of current drawn by the motor, which is proportional to torque and to the total weight of crates on the conveyor, Figure 3. The sensor sends this information to the process computer, which then directs a small auxiliary conveyor to load additional crates onto the main conveyor until the weight reaches the 10,000 lb maximum. Thus, if all crates weigh only 50% of maximum load, then the system loads 20 crates on the belt, increasing the loading and unloading efficiencies. The current sensor also detects overcurrent conditions (jammed belt, broken rollers, or bent shafts) and turns the motor off before it can be damaged. ■

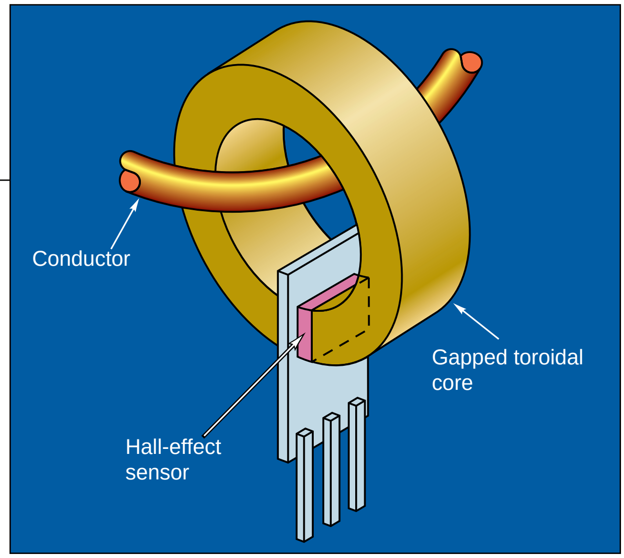

Figure 2 — Hall-effect device detects a magnetic field generated by the current in a conductor and produces a voltage proportional to the current.

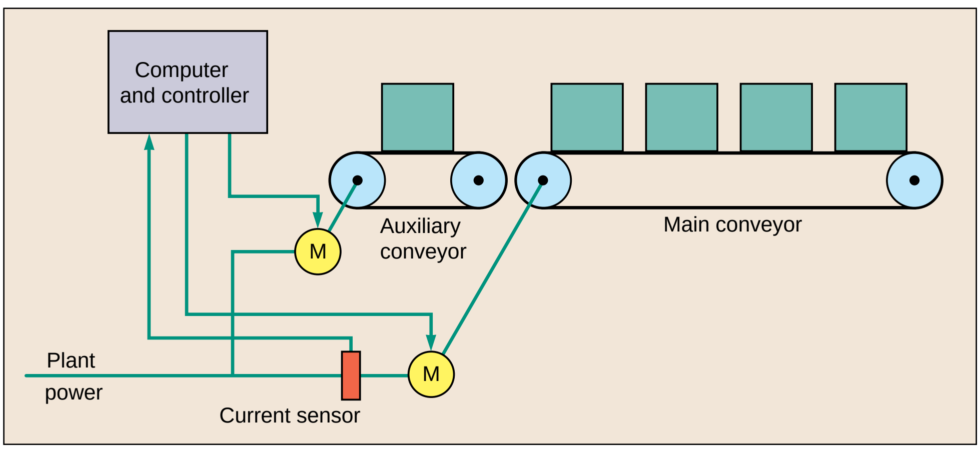

Figure 3 — Hall-effect sensor measures the current drawn by a conveyor drive motor, which is proportional to weight on the conveyor. Then, it sends this data to a computer, which controls the loading of crates on the conveyor so they don't exceed the load limit.