Inductive Switch Improves Reliability of Proximity Sensing

Electronic Design
Lou Frenzel
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A common application seen throughout the industrial and commercial sectors is proximity sensing—detecting when some object is physically close to a sensor. A variety of processes can be implemented with proximity sensors, which come in a range of flavors, each with varying degrees of detection range, sensitivity and reliability. However, a new inductive sensor has arrived that could change the face of proximity sensing.

Proximity-Sensing Applications

In terms of common applications, one of the most prevalent is the pushbutton. When the button is depressed, it initiates some action. In its simplest form, the pushbutton closes mechanical contacts. However, over time and heavy usage, these contacts can become worn or dirty, making the electrical connection problematic. Inductive non-contact switching can eliminate this situation.

Another typical application is door or window open/close detection. This requires a highly reliable indication of door or window state. A common use is in industrial equipment or home-security systems.

Proximity sensing also is often employed for event counting. This may involve counting objects on a moving conveyer or detecting fan-blade or gear-rotation speed. Rotary encoders and flow meters are other use-case examples.

In event-counting applications, proximity sensors are typically photodetectors and Hall-effect devices. The combination of a light source and photodetector sensor is fast and simple, but it can become dirty in a harsh ustrial environment and give false or no indication. Hall-effect detectors are expensive and require a magnet for ection.

However, it’s been shown that implementing inductive sensing in these and the other applications can improve reliability and accuracy.

How Does Inductive Sensing Work?

The inductive-sensing method uses two matched inductors connected into oscillator circuits with a resonating capacitor. One coil is a reference and the other is the sensor; the oscillators generate an ac magnetic field in the coils. An object is detected when it comes close to the coils. To be detected, the object must be conductive.

When the object comes within range of the coils, the ac magnetic field induces a current into the conductive object called an eddy current. The eddy current also produces an ac magnetic field that induces an opposing current back into the sense coil, thus lowering the coil’s inductance. Decreasing the inductance increases the frequency of oscillation, which is detected and converted into an off/on switching signal.

Inductor-Sensing Details

The inductors are usually flat, spiral coils of wire. Their size depends on the size of the object to be detected and the sensing range. The coils are usually mounted side by side on a flat surface. Alternately, the coils can be etched on a printed-circuit board. When using a PCB, the coils can be stacked one on top of the other by making the coils on both the top and bottom of the board.

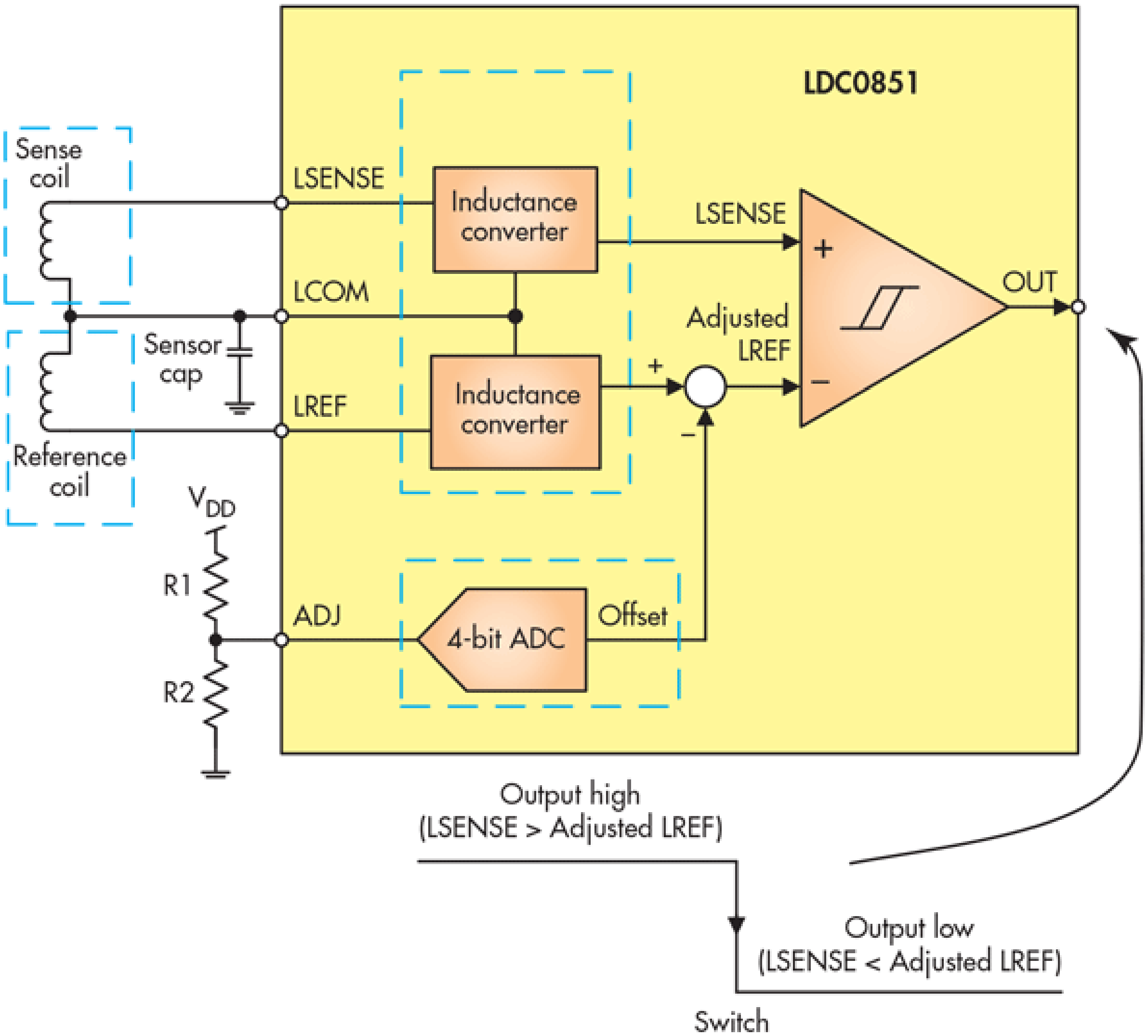
Coil size can range from about 10 to 50 mm in diameter. The inductance is in the microhenry (µH) range, and along with a capacitor, produces an oscillation frequency somewhere in the 300-kHz to 19-MHz range.

In general, a larger coil means a longer sensing range. Sensing range is usually short, mostly less than 20 mm. Target size with respect to coil size also affects range. The sensing range decreases when the target is smaller than the coil size. As a rule of thumb, the coil diameter needs to be at least 2.5 times greater than the sensing range to be fully reliable.

If the sensed target is non-conductive, the solution is to attach a small patch of copper foil tape. Make the target as large as possible with respect to the coil size for best results.

The Secret to Reliable Proximity Sensing

The key to a reliable and repeatable proximity switch is the use of two inductance coils in a differential circuit arrangement. This arrangement compares the inductance of a sense coil to an identical reference coil. Switching occurs when the inductances are equal. One arrangement for implementing this method is shown in the *figure*. The identical coils are resonant with a common capacitor. The oscillation frequency of each coil is then converted into a dc level by the inductance converters. These dc levels are compared in a comparator circuit that generates the switching output.



In general, the output switches low when the sense inductance drops below the reference and returns high when the reference inductance is higher than the sense inductance. Switching occurs during the crossover point when the two inductances are equal.

The comparator actually has built-in hysteresis that helps prevent false switching due to noise or mechanical vibration. This hysteresis is set so that the output switches on when the sense-coil inductance drops 0.4% below the reference-coil inductance and returns to the off state when the sense-coil inductance exceeds the reference-coil inductance by 0.4% or more.

The switching threshold can be altered by applying an external dc input *(see voltage divider R1-R2 in the figure)* that changes the reference level of the reference-coil input to the comparator. This allows for fine-tuning of the switching condition to match the application.

The advantages of the dual-coil inductance-sensing method are repeatable and reliable switching despite any physical impediments inherent to the environment. It also eliminates magnets, and there's no need for calibration procedures on the final product.

All of these above mentioned features are implemented in a single IC developed by Texas Instruments, [the LDC0851](#).

Implementing a Design

e inductive-sensing circuit is commonly used with a microcontroller to convert the switching pulses into a more ful output. The output pulses from the comparator are connected to an interrupt input on the microcontroller that in turn accumulates a count value. The value may be useful as is, or it may be combined with a time factor to calculate a rotational speed in RPM or other desired measurement.

One possible application is a flow meter. The flow meter incorporates a rotary impeller with blades that are moved by the flowing liquid. The impeller's rotational speed can then be determined with the inductive sensing and converted into a flow rate, such as liters per minute, by the microcontroller.

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