EXTENDING BATTERY LIFE & IMPROVING METERING DEVICE PERFORMANCE

WITH TMR (TUNNELING MAGNETORESISTANCE) MAGNETIC SENSORS

Metering applications demand careful monitoring and management of continuous streams of data. Consistency, precision, and accuracy of the information from the metering devices is essential. Since many metering devices rely solely on batteries to supply energy needed for up to 10 years of operating life, a reliable, ultra-low power consumption design is a key factor for all smart metering devices.

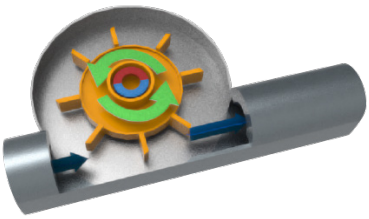

Figure 1: Flow meter with a ring magnet attached to the shaft

Magnetic flow meters provide high reliability due to the contactless sensing principle of their magnetic sensors. The conventional design uses reed switches to sense the magnetic flux from a rotating magnet attached to the shaft. However, while reed switches feature a desirable zero-current consumption, their glass envelope enclosures are extremely subject to vibration and shock. Alternatively, typical solid state magnetic sensors, (i.e. Hall Effect) are much more rugged, yet can consume an undesirable amount of current, which will drain batteries too rapidly, making them less than ideal for a battery-powered system. The "best of both worlds" is represented by Coto Technology's RedRock® TMR-based Magnetic Sensors and Switches – a solid state solution which offers high sensitivity and ultra-low power consumption in a small, rugged package. Due to its targeted set of features, using a RedRock® TMR magnetic sensor in a metering application design will result in a highly reliable and accurate device with an extended system lifetime.

Using RedRock® RR122 Digital Magnetic Sensors in a Metering Application

The RR122 is a push-pull output, solid-state magnetic sensor based on Tunneling Magnetoresistance (TMR) technology. Its preferred sensitivity orientation is parallel to the long side of the package (the x-axis). Conversely, the conventional Hall-Effect sensor has a sensitivity orientation perpendicular to the package (the z-axis).

Due to the difference in sensitivity direction, the RedRock® TMR sensor can sense higher magnetic flux density than a Hall-Effect sensor at the same position on a PCB in a smart meter device. Coto utilizes JMAG® software to simulate magnetic flux density of different orientations while assuming both sensors are placed at the same point beneath the ring magnet. As shown in Figure 2, maximum radial magnetic flux density is up to 80 Gauss flux component for RR122, while perpendicular magnetic flux density is roughly 25 Gauss flux component for Hall effect sensors. The higher magnetic flux density at RR122's preferred orientation helps to provide advantages like stable switching timing over operating temperature range, wider air gap flexibility, and feasibility of using a smaller magnet for cost reduction.

Magnet Shape	Ring
Inner Radius (mm)	2.5
Outer Radius (mm)	4.5
Thickness (mm)	1.5
Magnetic Poles Number	4
Magnet Material	Ferrite
Airgap (mm)	3
Magnetization Direction	Radial

Table 1: Ring magnet Parameters used for JMAG simulation

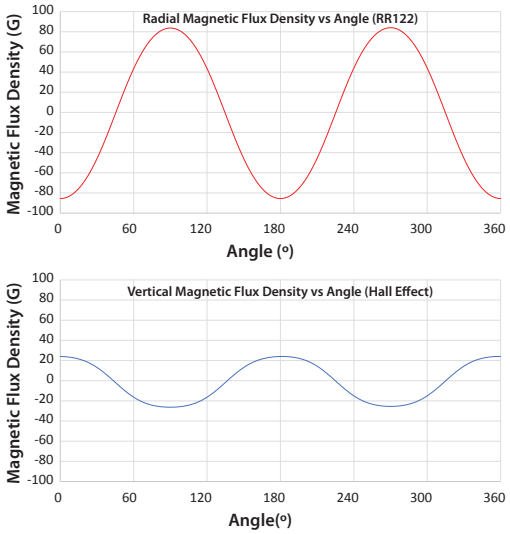

Figure 2: Comparison of Magnetic Flux Density vs. Angle

Output Pulse Duty Ratio

Reed switches were popular in early smart metering applications as they could provide features such as speed & direction information and anti-tamper proofing. Their polarity response behavior is similar to omnipolar solid state sensors – switching ON as long as enough magnetic field is present and switching OFF when the magnetic field is moved away. However, it has been shown that omnipolar type sensors are not ideal for ring magnet applications because they will react to both north and south polarity. The output duty ratio cannot be 50%, making it more difficult to obtain direction information by quadrature detection.

Fortunately, unlike reed switches, RedRock® TMR sensors are available with a bipolar response. A bipolar sensor requires a south polarity magnetic field to switch OFF output and will be switched ON when north polarity is present. It's an ideal solution for ring magnet applications since alternating magnetic fields will present while the magnet is rotating. As shown in Figure 3, CH1 (yellow) is the output waveform of an RR122 bipolar sensor responding to a rotating ring magnet, while CH2 (bottom, blue) is the output waveform of a reed switch. From the output comparison, it's clear that a RedRock® bipolar sensor provides a clean, consistent output signal.

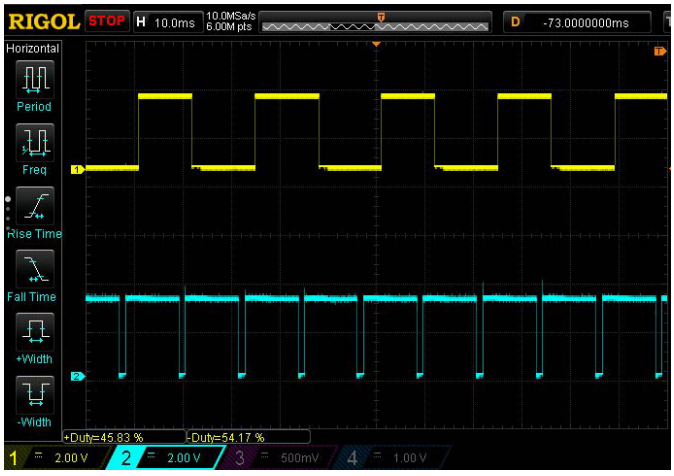

Figure 3: Output Duty Waveform Comparison
CH1: Bipolar TMR sensor (top) **CH2: Reed Switches (bottom)**

Current Consumption vs. Battery Drain

Most utility meters rely on battery power to support the device throughout its entire lifetime. While this method of operation eliminates the use of some magnetically-operated sensors such as Hall Effect or GMR (Giant Magnetoresistive); it does NOT rule out RedRock® TMR sensors. TMR is a monolithic magnetic sensor type, comprised of regulator, amplifier, comparator, transistors and a TMR sensing element in a compact surface-mounted package. Typical current consumption of RedRock® TMR sensors is lower than 200nA in accordance to operating frequency. And, for metering applications, the recommended RedRock® series part number will consume only about 1.7µA – nearly zero-power consumption – making it the only useful solid-state magnetic sensor for metering applications.

Conclusion

Metering applications require a sensor which can guarantee long battery life, accurate measurement, and high reliability against harsh environments. Over the years, different magnetic sensing solutions have been used in metering applications. While some have obvious advantages, they have all exhibited disadvantages such as high current consumption, low sensitivity, fragile packaging, or inconsistent duty ratio. Alternatively, the RedRock® TMR magnetic sensor is a monolithic solid state sensor using state-of-the-art TMR sensing technology which offers all of the advantages with none of the disadvantages of its predecessors. RedRock® TMR sensors have better sensitivity and orientation when compared to conventional Hall effect sensors in metering applications. Taking advantage of IC design, the RedRock® TMR sensor is flexible in polarity response behavior, current consumption, operating frequency, and package type. It provides consistent output signal duty ratio and superior reliability when compared to reed switches. Further tipping the scale in its favor is the nearly-zero current consumption – an all-important requirement for battery-powered metering applications

For more information, including how Coto Technology's applications support can help with your design efforts, please contact **redrock@cotorelay.com** or visit **www.cotorelay.com**.

MAGNETIC SENSOR TECHNOLOGY

RedRock® TMR Sensors combine very low power (<200nA) with a tiny package (LGA-4) and extremely high sensitivity (9G) for the most cost effective solution.

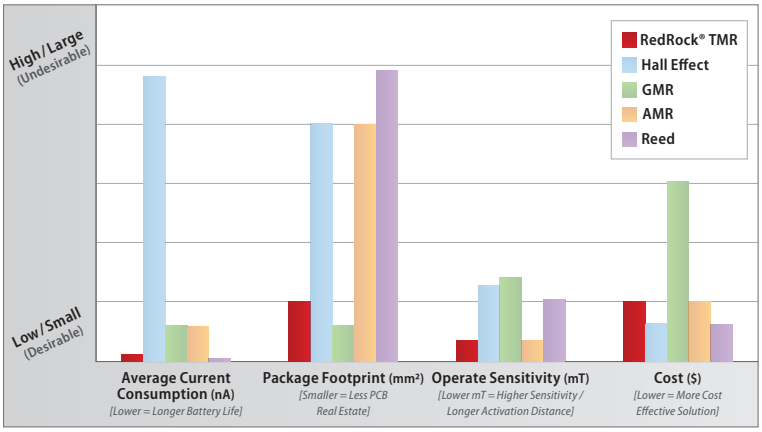

Figure 4: Magnetic Sensor Technology Comparison

RedRock®
Advanced Magnetic Sensing Technology