Application Brief

Benefit of Low-Power Turns Count in AMR Sensing

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Introduction

Anisotropic Magneto-Resistive (AMR) sensors offer low noise angle measurements but are inherently constrained to a 180 degree measurement range due to their construction. Magneto-resistive segments are arranged in a Wheatstone bridge configuration, which when saturated by an input magnetic field responds with a resistivity that follows Equation 1.

$$\rho(\theta) = \rho_{\|} + \rho_{\perp} \times \left(1 - \cos^2 \theta\right) \tag{1}$$

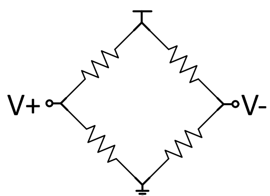

Figure 1. Wheatstone Configuration

This configuration can be implemented with structures to produce both sine and cosine outputs. These outputs make determining the angular position using the arc-tangent function possible, however, there are two full periods observed at the output to every one rotation of the magnetic field which leads to measurement uncertainty.

Overcoming 180 Degree Limitation

Since the output response of a typical AMR sensor repeats mechanically at 180° intervals, the calculated 1st quadrant angles become indistinguishable from 3rd quadrant angles. Standalone AMR sensors cannot be used well to measure absolute angle over a full 360° rotation with this measurement uncertainty.

TMAG6180-Q1 and TMAG6181-Q1 overcome this limitation by use of an integrated 2D Hall-effect latch at the center of the AMR sensor. The latches produce a quadrature result so that each 90 degree interval is easily differentiated as the magnet rotates. The TMAG6180-Q1 output plots in Figure 2 can be expected with a rotating magnetic field. TMAG6180-Q1 can easily detect the angular position in systems where the magnet rotation matches the measured angle change.

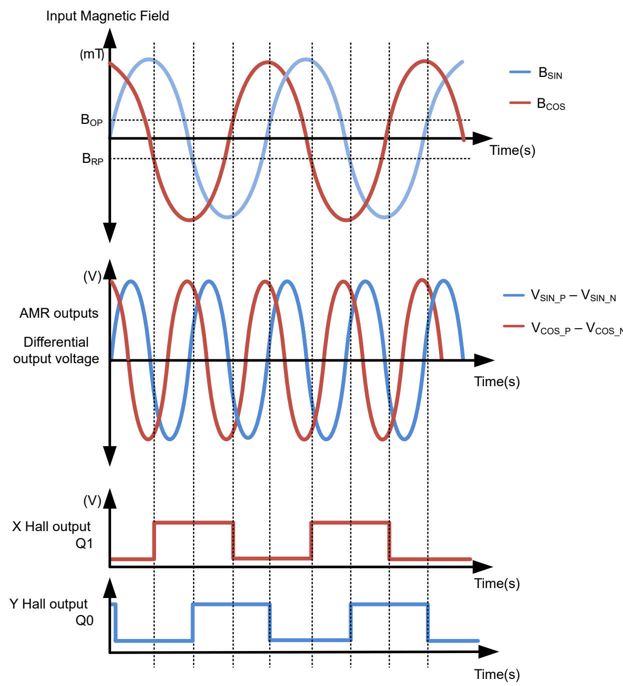

Figure 2. TMAG6180 Sensor Behavior

However, in TMAG6181-Q1 the quadrature data is not brought out to an external pin but is used instead to generate a turns counter PWM signal that is needed to track sequential quadrant changes, even in low power mode. Tracking turns is useful in systems where a full revolution of the magnet correlates to a partial mechanical rotation. In these cases, there are multiple instances of the same magnetic input as the magnet completes multiple revolutions.

Low Power Turns Counting

The low-power turns counter function in TMAG6181-Q1 is particularly useful in applications that run on battery power and can periodically deactivate subsystems to conserve power. Consider the case of the steering wheel in a modern car. Excellent tracking of the steering wheel position by the steer-by-wire system is important, even when the vehicle is off. This tracking is important so that when the vehicle is powered, the driven angle of the power-steering unit matches the actual wheel direction consistently. The standard steering wheel is capable of performing multiple full rotations in either direction from center while wheel angle is constrained to about 30-35 degrees in either direction. The sensor can be programmed to detect the rotation of magnets, which are geared to turn faster than the steering wheel for greater position resolution.

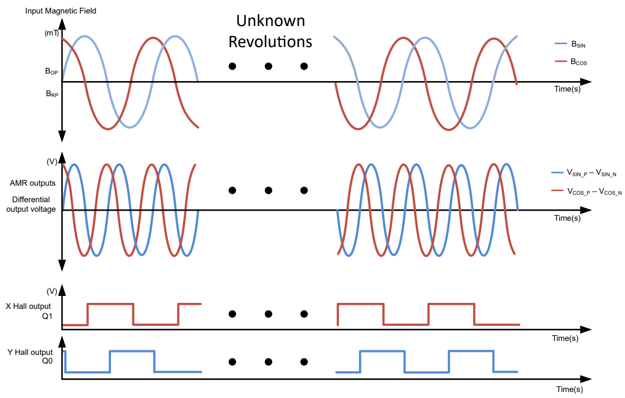

Figure 3. Unknown Revolutions after Inactive Sample Period

In systems without a turns count function, revolutions made while the MCU is inactive are not captured and the sync between the actual mechanical position and various control systems are lost. The turns counter in TMAG6181-Q1 is implemented as a PWM output that can be read while the device is active. The PWM output is inactive when TMAG6181-Q1 is in low power sleep mode but the Hall-effect latches continue to track and update the turns counter. Once the device leaves sleep mode, the PWM updates accordingly to provide the required turns information.

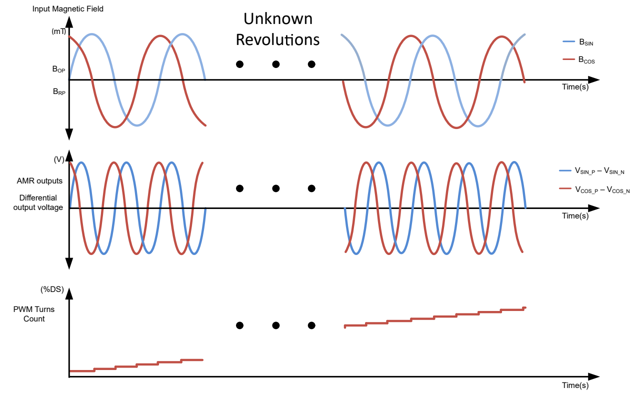

Figure 4. Turns Counting Through Inactive Sample Period

This function is also practical for other related safety requirements in collaborative robotics applications. For example, an operator can adjust the position of the various motor controlled joints when a robotic arm is powered down. If the robot has to search for the home position, this search can result in large motions that can cause unintended collisions with nearby objects. Low-power turns counting is a method for tracking adjustments made to any joint not actively in use. The PWM state is easily read to determine exactly what state the robot is in before moving when the system power is restored.

Conclusion

AMR sensing is excellent for low noise angle measurements and tracking rotation changes when coupled with a secondary sensing technology, such as Hall-effect latches, even when set to low power sleep mode. As a result, TMAG6181-Q1 is a benefit to both low power and user safety functions.

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