*Application Brief*

# *Using Hall-Effect Latches in Motorized Window Blinds*

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*Position Sensing*

## Introduction

Over the last few years, automation has left the industrial setting and has become integrated into many facets of our homes and workplaces through the Internet of Things (IoT). Smart homes have enabled us to securely connect many modern innovations such as robotic vacuum cleaners, motorized window blinds and electronic smart locks making our lives easier. By connecting appliances such as these to the IoT, we are now able to control these aspects of our homes from anywhere that promotes reliability and cost savings.

With smart devices becoming more autonomous, the need to know their state of operation and position at all times is essential. This functionality is especially important in low power, automated applications such as motorized window blinds where the user needs to be confident that the system is operating as intended. This application brief discusses key design challenges when implementing position sensing into motorized blinds, that are used to make opening and closing blinds fast and easy, and to also reduce air conditioning and heating costs.

## Operation of a Motorized Window Blind

Traditional window blinds are used to shade buildings by blocking the light coming through the windows. By placing a barrier between the window and the remainder of the building, it can help maintain the temperature indoors and save on heating and cooling costs. These blinds are typically lowered by manually pulling on a string or directly on the blind. Motorized window blinds offer an ease of use by having a motor attached to a roller that is controlled by a remote or cell phone app that sends a signal to the blind to move up, down, or to a preset position. Figure 1 shows a diagram of the functionality of a Hall-effect sensor system in a motorized window blind.

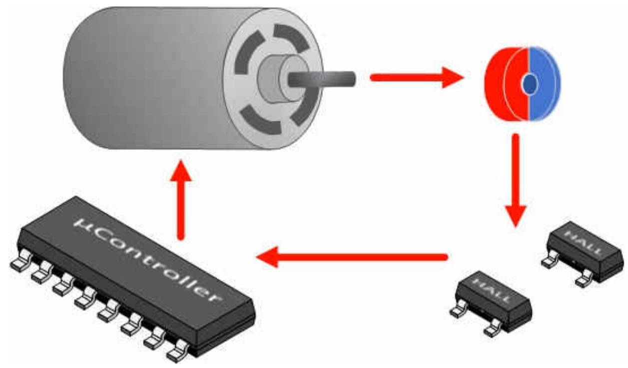


**Figure 1. Sensor System in Motorized Window Blind**

## Design Challenges in Motorized Blinds

Motorized blinds need to constantly know their position so the motor will not be strained when reaching the end of travel in either direction. The blinds also need to recognize when they have been manually adjusted by the user so the system can maintain real-time information about the state of the blinds. If the system cannot detect when the blinds have been moved manually, it can impact system performance and risk damaging the blind.

## Using Hall-effect Latches for Rotary Encoding

Hall-effect latches can provide exact position data by performing a function called rotary encoding. Incremental rotary encoders translate rotational movement into electrical signals for more precise control of automated systems. As rotation occurs, incremental encoders produce alternating high and low pulses that can indicate speed and direction of the rotating object. In motorized window blinds, Hall-effect latches can keep track of the changing polarity of a ring magnet that is attached to the shaft of the motor. This tracking indicates the number of motor rotations and this information allows the system to know the speed and position of the blind. For this type of application where the shade will be moving in two different directions, either two single-axis latches or one two-dimensional (2D) latch can be used to indicate the position of the blind.

## Single-Axis Latch Solution

When using two single-axis latches, such as the DRV5012, to determine direction, it is important to place the sensors precisely to achieve the optimal 90-degree quadrature offset. The 90-degree offset is attained when the sensors are separated by half the length of each magnet pole plus any integer number of pole lengths. Having the ideal 90-degree offset maximizes the timing margin between each state, that prevents errors due to mechanical tolerance, sensor mismatch, and signal jitter. The output signals in Figure 2 are an example of a 2-bit quadrature output that clearly show the four different states.

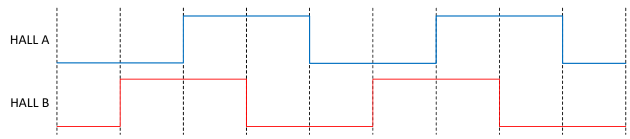


**Figure 2. 2-Bit Quadrature Output**

If there are errors in detecting the change in direction, this can cause the motorized blind to lose its position and incorrectly detect the end of travel. The magnetic incremental encoder Figure 3 shows the sensor configuration in relation to the ring magnet to achieve a 90-degree offset.

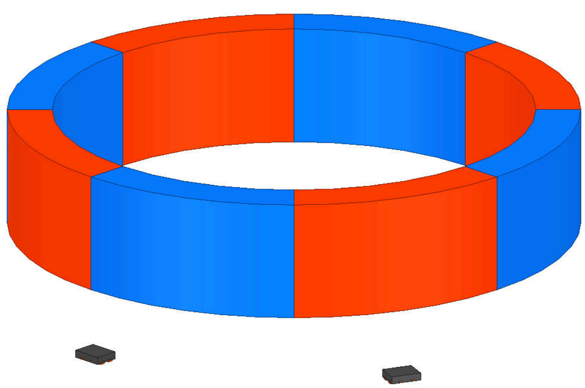

**Figure 3. Magnetic Incremental Encoder**

The DRV5012 device is an ultra-low-power digital-latch Hall effect sensor with a pin-selectable sampling rate and is recommended for power constrained applications such as battery powered window blinds.

## 2D Latch Solution

Another solution is to use a 2D Hall-effect latch, such as TMAG5110 or TMAG5111, that simplifies the design further and provides more flexibility in sensor placement. By integrating a second Hall element that is sensitive to an orthogonal component of the magnetic field vector, a single device can be used to measure the speed and direction of the rotating magnet. This process is possibly due to the natural effect of the magnet to product field components that are 90-degrees out of phase. This eliminates any errors that can occur due to placement of two single-axis sensors. Figure 4 highlights the flexibility in sensor and magnet placement when using a 2D latch.


**Figure 4. Rotary Encoding Using Ring Magnets, and Various Sensor Placements**

Using one 2D latch reduces board space compared to using two single-axis latches that is beneficial for size constrained applications such as motorized window blinds. TMAG5110 has two output signals that represent the response of each independent hall element. To simplify your design further, the TMAG5111 also has two output responses that represent the speed and direction of the magnet.

## Conclusion

Motorized window blinds are becoming more popular in smart homes because of their added convenience and energy conservation abilities. Hall-effect latches provide a precise and reliable position sensing solution in motorized window blinds and solves the major design challenge of knowing the window blinds position at all times. Two single-axis latches can be used for robust measurements or a 2D latch can be used for added flexibility in sensor and magnet placement as well as in power and space constrained applications.

**Table 1. Alternate Device Recommendations**

| Device | Characteristics | Design Considerations |
|---|---|---|
| DRV5011 | This device is offered in SOT-23, X2SON, DSBGA, and TO-92 packages with a maximum operating threshold of 3.8 mT | A high sensing bandwidth of 30 kHz allows this device to be versatile in most rotary applications. Package variations accommodate most applications. The device operates from a 2.5-V to 5.5-V supply. |
| DRV5012 | Low power consumption with pin-selectable bandwidth in a low-profile X2SON package. The maximum operating threshold is 3.3 mT. | Higher sample frequency results with a higher average current. The device operates at 1.65-V to 5.5-V supply. Selectable sample rates are 20 Hz and 2500 Hz. This rate should be at least twice the expected input frequency. |
| DRV5013 | Wide supply range of 2.5 V to 38 mV simplifies inclusion of this device in most designs | This device has a typical supply current of 3 mA and a sensing bandwidth of 20 kHz. Automotive and commercial grades are available. |
| DRV5015 | This device has a low 2-mT maximum threshold that helps improve overall quadrature accuracy | Operating voltage is limited to 2.5 V–5.5 V with a typical ICC current of 2.3 mA. Typical sensing bandwidth is 30 kHz. Automotive and commercial grades are available. |
| TMAG5110 | 2D Hall-effect latch with dual outputs for direct monitoring of latch behavior with a low maximum threshold of 1.4 mT | 2D latches offer design flexibility with a minimal component count. With direct outputs, the microcontroller needs to calculate speed and direction. |
| TMAG5111 | 2D Hall effect latch with dual outputs converted to speed and direction with a low maximum threshold of 1.4 mT | Similar to TMAG5110, but dual outputs are formatted for speed and direction. This is particularly useful for rotary encoding, but does not provide latch behavior that can be useful in correcting alignment for optimal quadrature alignment. |

**Table 2. Related Technical Resources**

| Name | Description |
|---|---|
| Incremental Rotary Encoders | An introduction to rotary encoding highlighting the various technologies that can be implemented. |
| Reducing Quadrature Error for Incremental Rotary Encoding Using 2D Hall-Effect Sensors | A design guide for 2D Hall latches that discusses incremental encoding and how to design for optimal quadrature alignment. |
| 3 Common Design Pitfalls when Designing with Hall-Effect Sensors - and How to Avoid Them | A discussion about common magnetic encoder problems and how possible solutions to improve performance. |
| TMAG511x Evaluation Module for High-Sensitivity, 2D, Dual-Channel, Hall-Effect Latches | A hands-on demonstration of rotary encoding using both TMAG5110 and TMAG5111 using both 10 and 20 pole magnets. |
| Absolute Angle Measurements for Rotational Motion Using Hall-Effect Sensors | An application brief that discusses angle sensing further and provides links and details to other related content. |
| TI Precision Labs - Understanding 2D Hall Sensor Latches | A helpful video covering 2D Hall-effect Latches. |
| TI Precision Labs - Using Hall-Effect Position Sensor for Rotary Encoding | A helpful video covering rotary encoding with Hall-effect sensors. |