

# TI 2D Hall-Effect Latches: TMAG5110 & TMAG5111

March-2021

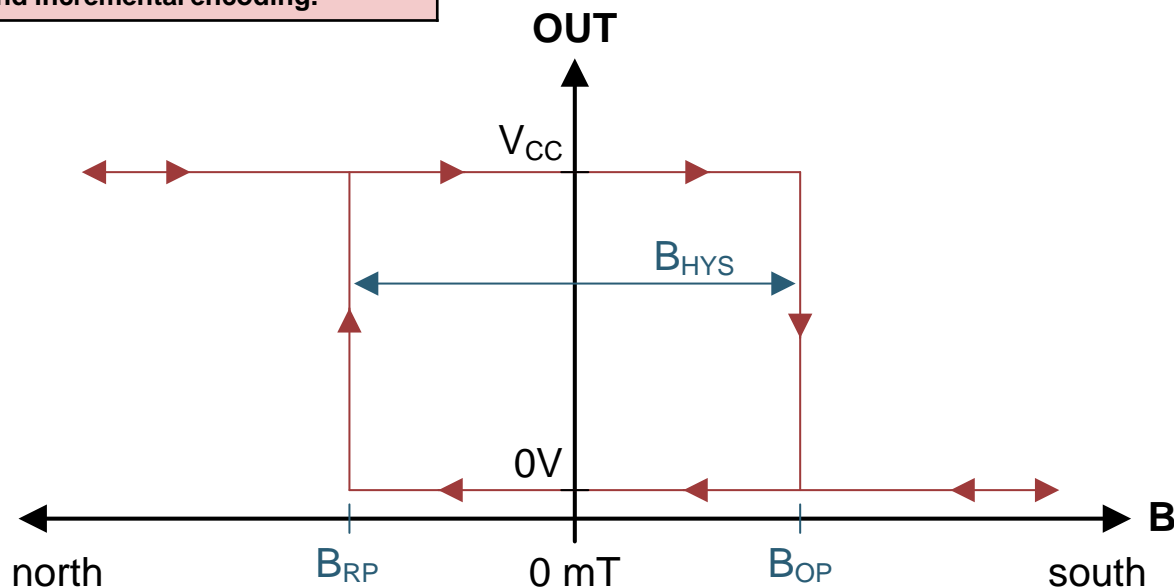
# Agenda

- Hall-effect latch functionality overview
- Comparing 1D, dual-planar, and 2D latches
- TI's new 2D Hall-effect ICs: TMAG5110 & TMAG5111
- Example applications
- Key online resources

# Hall-effect latch operation

## Hall-effect latch

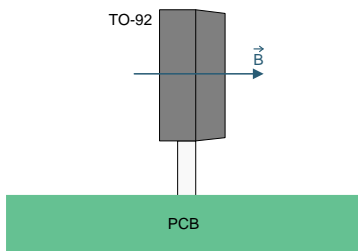
Indicates the most recently measured magnetic flux density. These are used in rotary applications such as BLDC motor sensors and incremental encoding.



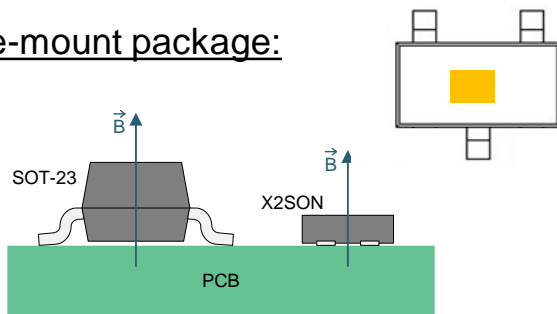
# Sensing directions

## 1D latch

- Through-hole package:

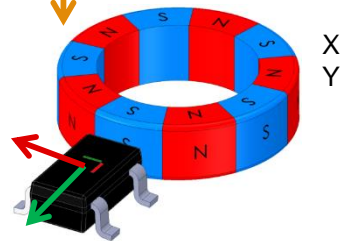
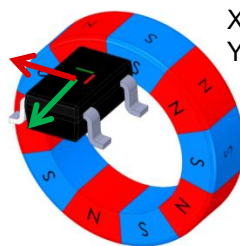
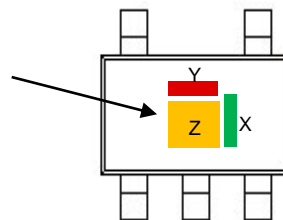


- Surface-mount package:

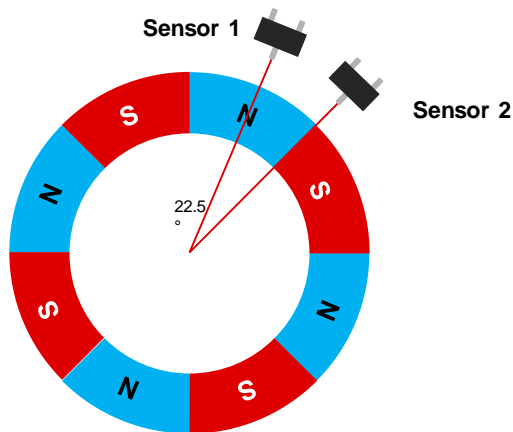


## 2D latch

Any 2 of the  
3 possible  
sensor  
orientations

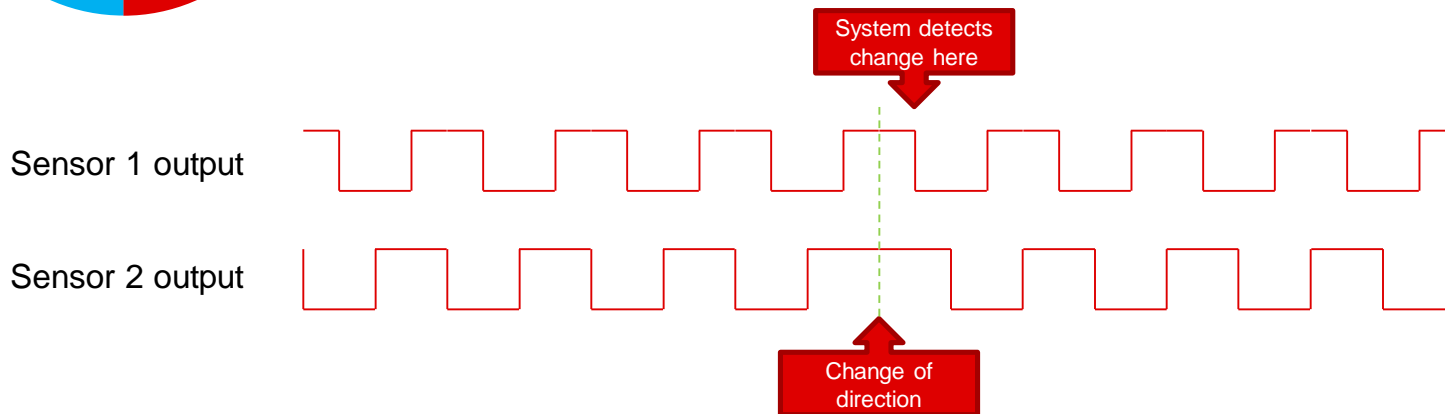


# Rotary encoding using 1D latches

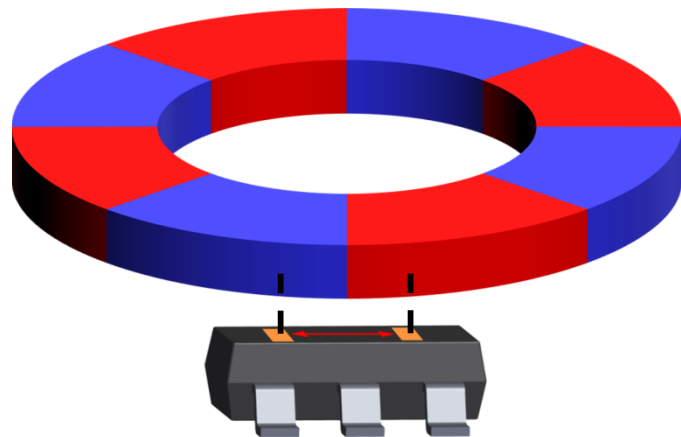
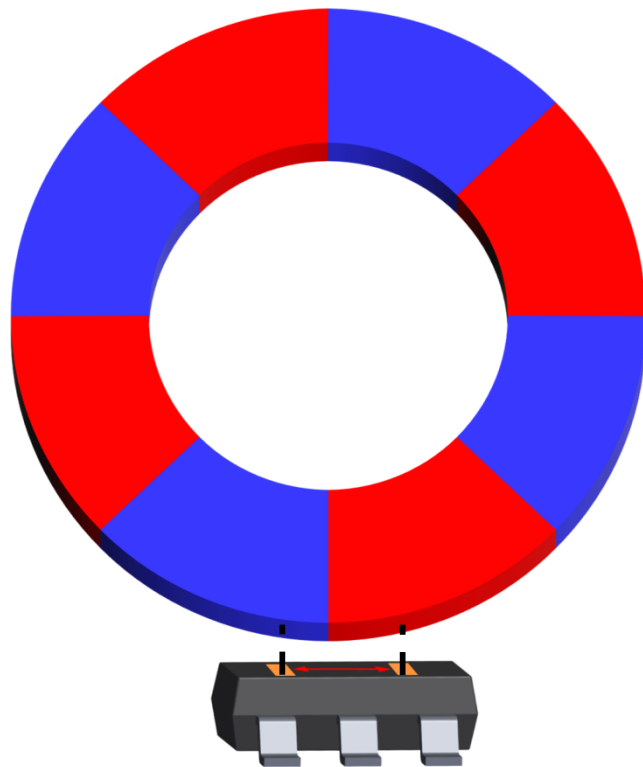


Latch spacing =  $\frac{1}{2}$  Pole Length + Integer # of Poles  
Output transitions =  $360^\circ / \# \text{ poles} / \# \text{ sensors}$

For example,  $\frac{1}{2}$  Pole - 1 Integer Poles produces  $90^\circ$  phase shift for the 8 pole magnet shown. In one full rotation we will have 16 transitions over a full  $360^\circ$  rotation. Each transition will represent  $22.5^\circ$  motion.

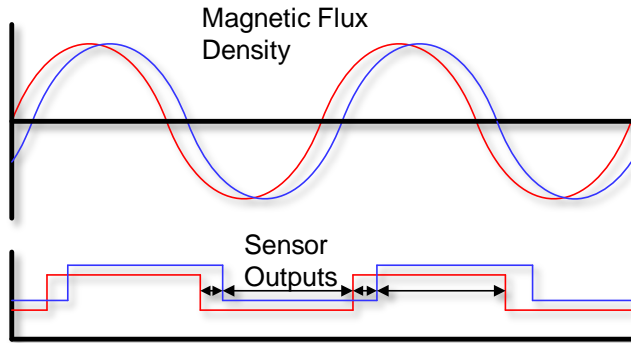
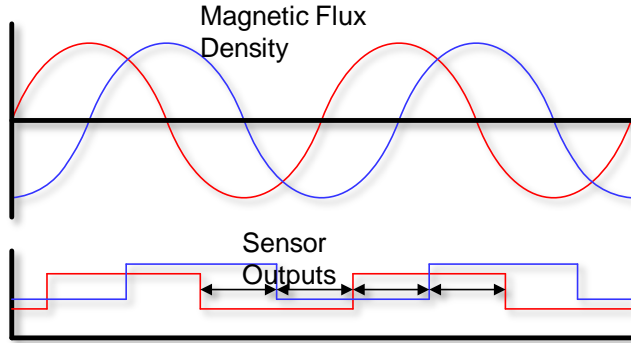


# Dual-planar latch

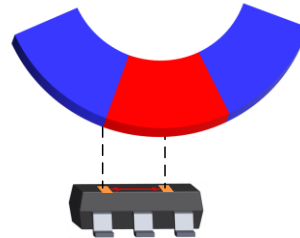


- IC/Magnet placement limited
- Magnet pole-pitch dependent on Hall sensor separation

# Dual-planar latch challenges: magnet pole pitch



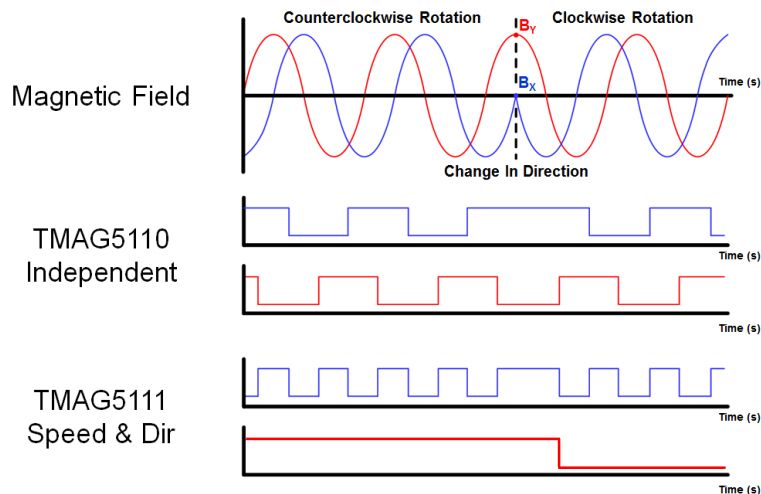
- Direction determination requires definitive quadrature
- Magnet pole placement & strength variation
  - Pole “size” variation up to  $\pm 3\%$
  - Pole field strength variation up to  $\pm 25\%$
- Precise design of pole pitch to optimize switching point needed



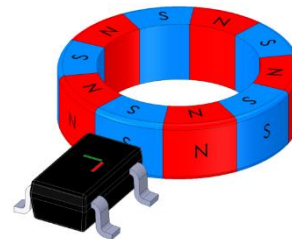
Pole pitch vs. Sensor Spacing

# Rotary encoding using a 2D latch

- Can be achieved utilizing a single TMAG5111 with speed and direction outputs
- Can also use the TMAG5110, but additional quadrature decoding is needed



XY



ZX



YZ





# TMAG5110 & TMAG5111

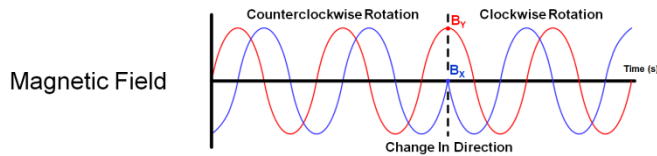
2-dimensional, dual-channel, high-sensitivity Hall-effect latches

## Features

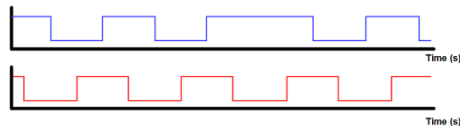
- TMAG5110: Dual Independent outputs
- TMAG5111: Speed and Direction outputs
- Magnetic threshold: 2.6 mT max
- Three 2-axis sensing options:
  - X axis & Y axis
  - X axis & Z axis
  - Y axis & Z axis
- Wide operating  $V_{CC}$ : 2.5 V to 38 V
- 40kHz sensing bandwidth (dual continuous channels)
- Open-Drain output
- 5-pin SOT-23 package
- Operating temperature range: -40°C to 125°C

## Benefits

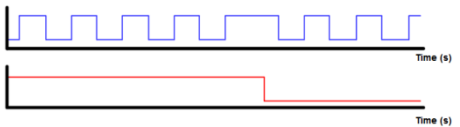
- Used in a wide range of applications with multipliable magnetic fields: bar and ring magnets
- High sensitivity reduces the required magnet size or increases the allowable air gap.
- Different sensing directions allows off axis sensing capabilities
- Fast sampling enables use in high-rpm BLDC motors.
- Consistent performance across wide temperature range
- Requires external pull-up, allowing for more flexible implementation.
- Voltage range compatible with many battery types and traditional MCUs.



TMAG5110  
Independent



TMAG5111  
Speed & Dir



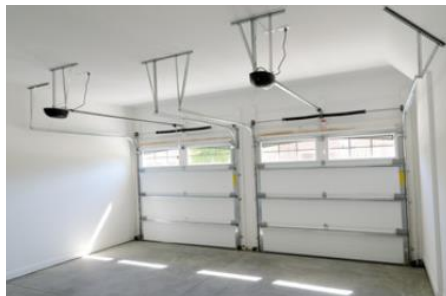
TEXAS INSTRUMENTS

# Example applications for 2D latches

**Automotive body motors & power closures**



**Garage door openers**



**Thermostat dials**



**Vacuum robot wheels**



**Motorized window blinds**



**Knobs**



# TMAG5110-5111EVM

## 2D, Dual-Channel, High Sensitivity Hall Effect Latch EVM

### Features

- Two different ICs on same board
  - TMAG5110: independent 2D outputs
  - TMAG5111: speed and direction outputs
- Mount capable of housing a multi-pole ceramic magnet in two orientations
  - Horizontally over device
  - Vertically alongside device
- 10-pole and 20-pole magnets packaged with PCB
- Magnetic viewing film and USB cable included in kit

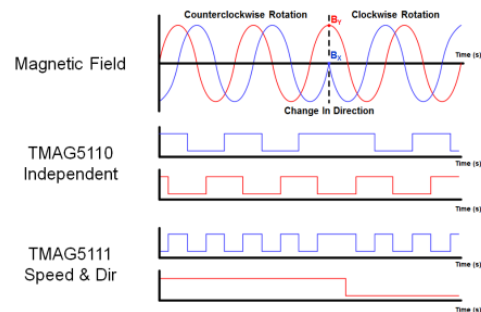
### Applications

- Incremental rotary encoding
- Brushed motor feedback
- Automotive power closures, window/sunroof/seat motors, seatbelt tensioners
- Wheel speed and direction (e.g. vacuum robots, factory logistic robots)
- Home-automated blinds
- E-locks
- Knobs
- Flow meters

### Benefits

- Ability to test and monitor quadrature decoding circuit and speed and direction circuit side by side
- Independence of magnet placement relative to sensor (allows for experimentation with further magnet placement options)
- Independence of magnet pole pitch
- Conveniently powered from a common micro-USB connector

### TMAG5110-5111EVM

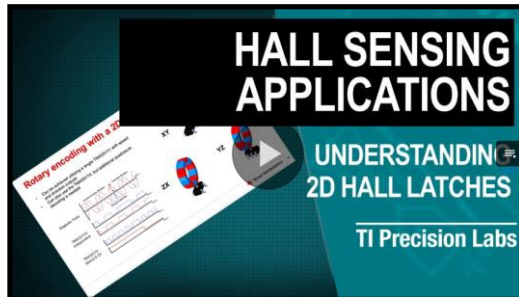


# Tools and resources

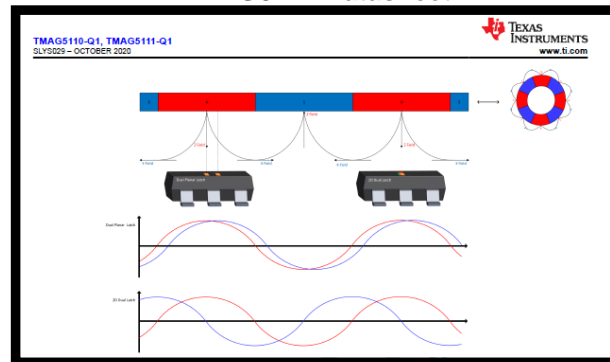
## TMAG5110-5111EVM



## TIPL Video




## TMAG511x Datasheet



## App Notes

**Application Report**  
**Reducing Quadrature Error for Incremental Rotary Encoding Using Two-Dimension Dual Hall-Effect Sensors**



Scott Bryson Analog Signal Chain - Sensing


**ABSTRACT**

Rotation tracking is an application commonly associated with latching Hall Sensors. Measurements of angular position, speed, and direction provide critical system feedback. Typically this application requires two sensors 90° out-of-phase from each other to achieve the desired quadrature output. Accuracy of the solution will depend on alignment and accuracy of the Hall Sensors. Devices such as TMAG5110 or TMAG5111 offer an additional in-plane sensor integrated into the package. This additional sensor is oriented in a second axis as well. This allows for intrinsic phase alignment in a single package, minimizes the layout effort by allowing a designer to use a single device, and provides excellent sensitivity threshold matching for superior performance. This application report discusses the nature of magnetic fields and design considerations related to two-dimensional Hall Sensors.

**TI TechNotes**

**Incremental Rotary Encoder Design Considerations**

Ross Eisenbeis, Magnetic Sensing Products




Incremental rotary encoders transduce rotational movement into electrical signals. Unlike absolute encoders that measure angle, incremental encoders generate high/low pulses as turning occurs.

Applications include computer mouse wheels, fluid flow meters, knobs, wheel speed sensors, stepper motor feedback for detecting missed steps, and brushed DC motor sensors for automotive windows.

**1. Contact:** This relies on mechanical contacts to make or break electrical connections. Typically, the stationary component has islands of metal throughout a ring. The piece above it is free to rotate and has metal brushes that momentarily make contact with the islands, connecting them to ground. Figure 3 shows the electrical schematic.

## Technical Article

 Gloria Kim Jan 7, 2021

Other Parts Discussed in Post: [TMAG5110](#), [TMAG5123-Q1](#)

Have you ever designed a circuit that didn't quite turn out the way you expected? I know I have! In this article I'll help you resolve three common challenges associated with Hall-effect sensors in industrial and automotive applications – rotary encoding, robust signaling and in-plane magnetic sensing.

Challenge No. 1 – you can't get a good quadrature signature for your rotary encoding application

**Thank you!**

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (<https://www.ti.com/legal/termsofsale.html>) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2021, Texas Instruments Incorporated