Application Note

Benefits of Designing With Magnetic Versus Optical Solutions in Incremental Encoders

TEXAS INSTRUMENTS

Isaac Lara & Mekre Mesganaw

Position Sensing

ABSTRACT

Incremental rotary encoders are essential in many robotic vacuum cleaner systems today, contributing critical position information that can be fed back to the system for various uses. This brief explores two incremental rotary encoding solutions—magnetic rotary encoding and optical rotary encoding—and details how magnetic rotary encoding can help improve your design over its optical counterpart. This document delivers side-by-side comparisons of these two technologies where we will observe their power performance and test their susceptibility to external particles in a TI-RSLK kit.

Table of Contents

Trademarks

LaunchPad™ and SimpleLink™ are trademarks of Texas Instruments.
All trademarks are the property of their respective owners.

Copyright © 2022 Texas Instruments Incorporated

1 Introduction

Motors can be used to harness and convert electrical energy into mechanical energy, enabling us to control the motion of components connected to them. Typically, this is done by controlling the rotation of the motor's shaft and having external components connected so that they rotate along with it. For today's standards, causing an external component to move is simply not enough. Many systems require detection of the external components' relative movement to extract the speed in which the module is rotating. This allows us to pass the information back to the system so that it could be refined to meet the systems requirements. Information such as speed or displacement of an object can be derived by tracking the speed of a motor shaft.

To detect the speed of each motor shaft, either an incremental or absolute encoder may be implemented. An absolute encoder can provide information on the position of the shaft itself. An incremental encoder, on the other hand, simply provides information on the incremental change in position instead of the exact position of the shaft, which is sufficient for measuring the shaft speed. Magnetic incremental encoders and optical incremental encoders are two common implementations for incremental encoding.

This document expands on some of the topics covered in the Differences Between Optical and Magnetic Incremental Encoders application brief. The breif mainly focuses on the use of incremental encoders in robotic vacuum cleaners, but encoders can be found in a vast amount of devices and across various industries. Automatic blinds, textile machines, ventilators, automotive seat position modules, and liquid flow meters are all some examples of equipment that use rotary encoders.

The following sections provide an overview on how to design with Hall-effect latches and how to setup the TI RSLK platform used for testing the magnetic and optical incremental encoders developed. There are also a test/result-based comparison near the end of this document. The test will cover the ability to measure speed of pulses, show how the system performs in a dusty environment, and lists current consumption measurements between both implementations.

2 System Block Diagram

To showcase magnetic incremental wheel encoding, the TI-RSLK robotic kit was used and modified for this design. This kit includes the following:

- Robot chassis with two wheels and one ball caster
- Chassis board that includes DRV8838 motor drivers, connection headers to an external LaunchPad™ development kit, and power management circuits
- Two gear motors each with their own encoder assembly
- Bumper switch assembly (not used in design)
- Sensors for detecting changes in reflectance on the ground (not used in design)

The encoder board that comes with the kit uses two 1D latches to detect wheel speed and direction. For magnetic encoder testing, a new version of this board was created to use one TMAG511x 2D latch per encoder instead of two 1D latches. The board can support either the TMAG5110 or TMAG5111. If the TMAG5110 is used, two independent outputs are produced, which provides more resolution than one independent output. If the TMAG5111 is used, there are dedicated speed and direction outputs, which simplifies determining the direction at which the motor shaft is rotating (clockwise or counterclockwise).

The optical encoder testing was done using another board, which includes an IR emitter and phototransistor. A code disc was 3D printed to fit on the motor shaft so that it would alternate between allowing and blocking the light beam sent from the IR emitter to the phototransistor.

Two CC26x2R1 LaunchPad development kits can control the TI-RSLK robot wirelessly. One CC26x2R1 LaunchPad development kit is connected to the TI-RSLK kit while the other is connected to a PC. The PC LaunchPad development kit also has a TMAG5273EVM with a connected joystick attachment. When the joystick is pressed, the program moves the robot either forward or backward, where the speed of the robot is controlled based on how far the joystick is pressed in a direction. As the robot moves, the encoder outputs a number of pulses. The TI-RSLK LaunchPad development kits counts the number of pulses released and sends that information to the PC LaunchPad. The PC LaunchPad converts the number of pulses on each encoder output back into a frequency. The PC LaunchPad sends the encoder output frequencies across the LaunchPad's application serial port at a baud rate of 115.2 kbps using 8 bits and one stop bit (8N1).

Copyright © 2022 Texas Instruments Incorporated

Figure 2-1 shows the block diagram of the system used to test the magnetic encoder.

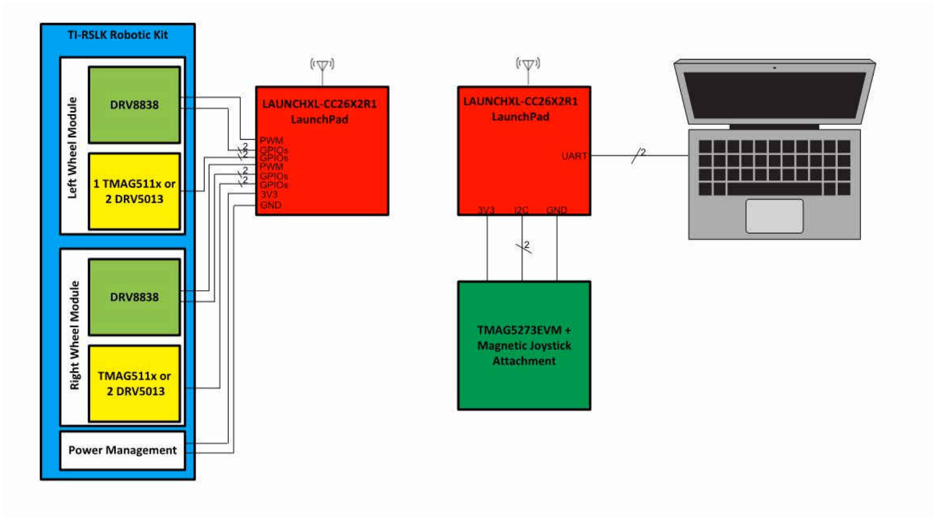

Figure 2-1. System Block Diagram

3 Key System Specifications

Table 3-1. System Features

Features	Description
Robotic Chassis Kit	• TI-RSLK
Microcontroller	• CC26x2 (from LAUNCHXL-CC26X2R1 LaunchPad)
Magnet Specs	• 2-mm thickness • Outer diameter = 9.7 mm • Inner diameter = 1.5 mm • 6 poles (3 north and 3 south)
Encoder Hall latch	TMAG5110 (2 independent outputs) or TMAG5111 (speed and direction) 2D latch
Motor	• Gear Ratio = 120:1 • 1.5-mm diameter motor shaft • No-load speed at 4.5 V: 150 rpm
Maximum transitions per Hall latch output	120 gear ratio × 6 poles = 720 transitions per wheel revolution

4 HW Connections

To prepare the TI-RSLK:

1. Solder an external wire from Pin 9 on header J1 to the ELA pad on the TI-RSLK.
2. Solder an external wire from Pin 10 on header J1 to the ERA pad on the TI-RSLK.
3. Connect an external wire from 3V3 on LaunchPad to the 3V3 header pin on the TI-RSLK.
4. Connect an external wire from GND on LaunchPad to the GND header pin on the TI-RSLK.
5. Make your following jumper changes to the default emulator jumper settings.
6. Remove the 5V jumper.
7. Remove the 3V3 jumper.
8. Move the jumper from the *XDS110 Power* position to the *External Pwr* position.
9. Place the CC26x2R1 LaunchPad kit onto TI-RSLK robot.

Copyright © 2022 Texas Instruments Incorporated

The following table shows the connections from the TI-RSLK to the LaunchPad after following these steps:

Table 4-1. LaunchPad to TI-RSLK Hardware Connections

CC26x2 LaunchPad Pin Number	IO Name	Function1
Pin 1 (Header J1)	3V3	Power. Must connect external wire from here to the 3V3 on the TI-RSLK
Pin 9 (Header J1)	DIO4	ELA: OUT2 pin (direction) of TMAG511x on left wheel encoder. Must solder external wire from here to the ELA on the TI-RSLK.
Pin 10 (Header J1)	DIO5	ERA: OUT2 pin (direction) of TMAG511x on right wheel encoder. Must solder external wire from here to the ERA on the TI-RSLK.
Pin 11 (Header J2)	DIO15	nSLPR: DRV8838 Motor driver nSLEEP pin on the right motor
Pin 12 (Header J2)	DIO14	ELB: OUT1 pin (speed) of TMAG511x on left wheel encoder
Pin 13 (Header J2)	DIO13	ERB: OUT1 pin (speed) of TMAG511x on right wheel encoder
Pin 20 (Header J2)	GND	Board GND
Pin 21 (Header J3)	5V	
Pin 22 (Header J3)	GND	Board GND. Must connect external wire from here to GND on the TI-RSLK.
Pin 29 (Header J3)	DIO0	DIR_L: DRV8838 Motor driver PH (direction) pin of the left motor
Pin 30 (Header J3)	DIO1	DIR_R: DRV8838 Motor driver PH (direction) pin of the right motor
Pin 31 (Header J4)	DIO17	nSLPL: DRV8838 Motor driver nSLEEP pin of the left motor
Pin 39 (Header J4)	DIO6	PWMR: DRV8838 Motor driver EN (PWM) pin of the right motor
Pin 40 (Header J4)	DIO7	PWML: DRV8838 Motor driver EN (PWM) pin of the left motor

To connect the joystick, TMAG5273EVM, and CC26x2R1 LaunchPad together:

1. Connect an external wire from GND on the LaunchPad to pin 4 (top row, second pin on left) of TMAG5273EVM. This connects the GND pins together.
2. Connect an external wire from 3V3 on the LaunchPad to pin 6 (top row, third pin on left) of TMAG5273EVM. This connects the power pins together.
3. Connect an external wire from DIO4 on the LaunchPad to pin 10 (top row, fifth pin on left) of TMAG5273EVM. This connects the SCL pins together.
4. Connect an external wire from DIO5 on the LaunchPad to pin 10 (top row, last pin on left) of TMAG5273EVM. This connects the SDA pins together.
5. Connect the joystick to TMAG5273EVM.

Copyright © 2022 Texas Instruments Incorporated

The following table shows the connections from the TMAG5273EVM to the LaunchPad after following these steps:

Table 4-2. LaunchPad to TMAG5273EVM Hardware Connections

CC26x2 LaunchPad Pin Number	IO Name	Function1
Pin 1 (Header J1)	3V3	Power. Must connect external wire from here to pin 6 (top row, third pin on left) of the TMAG5273EVM.
Pin 9 (Header J1)	DIO4	SCL I2C line. Must connect external wire from here to pin 10 (top row, fifth pin on left) of the TMAG5273EVM.
Pin 10 (Header J1)	DIO5	SDA I2C line. Must connect external wire from here to pin 10 (top row, last pin on left) of the TMAG5273EVM
Pin 22 (Header J3)	GND	Board GND. Must connect external wire from here to pin 4 (top row, second pin on left) of the TMAG5273EVM.

5 Software

The software on the TI-RSLK LaunchPad development kit is a modified version of the *rfEchoTx* project example that is in version 3.40.00.02 of the SimpleLink™ CC13x2 26x2 SDK. Similarly, the PC LaunchPad uses the *rfEchoRx* code example within the same SDK. Both of these code examples are within the *Software/SimpleLink CC13x2 C26x2 SDK v:3.40.00.02/Examples/ TI Drivers* folder of the SimpleLink CC13x2 26x2 SDK.

These two code examples set up bidirectional communication between the TI-RSLK LaunchPad and PC LaunchPad. The code examples were modified to use a packet interval of 0.3 seconds instead of the 1 second default. Besides this, the other radio settings have been reused from the code example. Figure 5-1 shows the timing of the packet transmission and reception at the TI-RSLK LaunchPad and the PC LaunchPad.

Copyright © 2022 Texas Instruments Incorporated

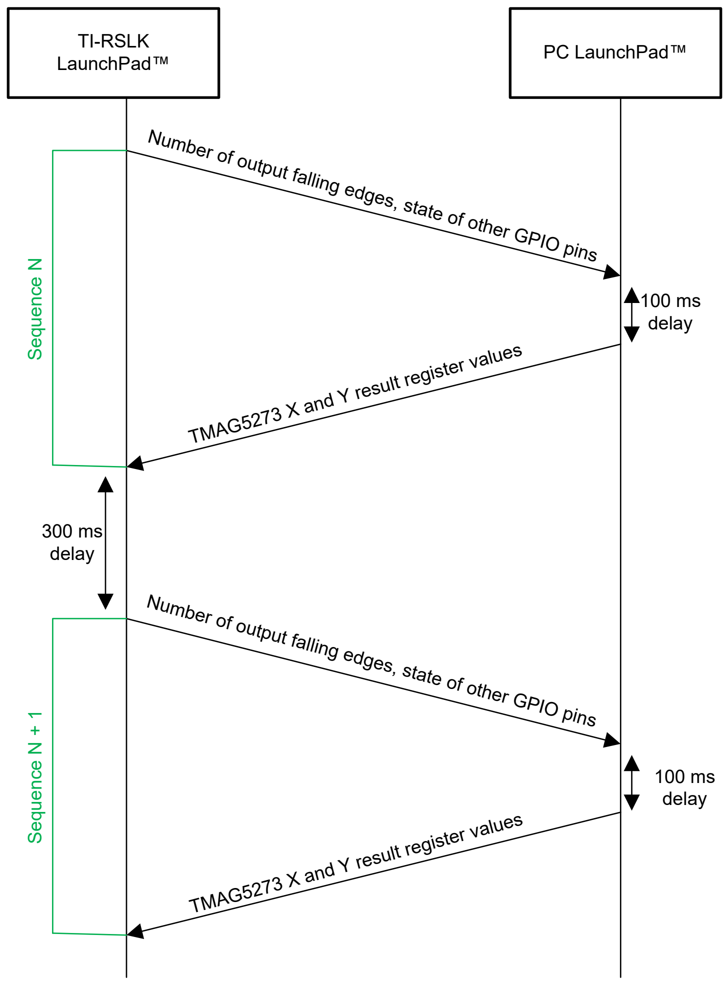

Figure 5-1. Packet Transmission and Reception Scheme

5.1 TI-RSLK LaunchPad Software

When the TI-RSLK is first powered on, the various peripherals on the CC26x2 microcontroller are first initialized. The GPIOs are first initialized to the following configuration:

- **GPIO pins connected to the TMAG511x OUT1/OUT2 pins**: These GPIOs are configured as input with interrupts. Each time there is a falling edge on one of these TMAG511x pins, an interrupt is generated to increment the falling-edge counter variable for that specific OUT pin. There are a total of variables that keep track of the number of falling edges since the last packet transmission to the PC LaunchPad:
  - **ELA**: This is the falling-edge counter variable for the *OUT2* pin of the TMAG511x device that measures the speed of the *left* wheel module. This is cleared once per packet transmission.
  - **ERA**: This is the falling-edge counter variable for the *OUT2* pin of the TMAG511x device that measures the speed of the *right* wheel module. This is cleared once per packet transmission.
  - **ELB**: This is the falling-edge counter variable for the *OUT1* pin of the TMAG511x device that measures the speed of the *left* wheel module. This is cleared once per packet transmission.
  - **ERB**: This is the falling-edge counter variable for the *OUT1* pin of the TMAG511x device that measures the speed of the *right* wheel module. This is cleared once per packet transmission.
- **GPIO pins connected to the PH pin of DRV8838 devices**: These GPIO pins are configured as outputs. There are separate GPIO pins for the DRV8838 devices on the left and right wheel modules, which allows the different wheels to spin in opposite directions if ever desired in the future. Driving a logic low at one of these GPIO pins causes the corresponding wheel to spin forward while driving a logic high causes the wheel to spin backwards.

Copyright © 2022 Texas Instruments Incorporated

- **GPIO pins connected to the nSLEEP pin of DRV8838 devices**: These GPIO pins are configured as outputs. There are also separate GPIO pins for the DRV8838 devices on the left and right wheel modules. These devices are never put in sleep mode, however, which means these GPIOs are always set to logic high.
- **GPIO pins connected to the EN pin of DRV8838 devices**: These GPIO pins are configured as pulse-width modulated (PWM) outputs with a PWM period of 69.5 μs. There are separate GPIO pins for the DRV8838 devices on the left and right wheel modules, which means each DRV8838 can drive with a different duty cycle. These PWMs are also connected to LEDs on the LaunchPad. As a result, increasing the PWM duty cycle results in these LEDs becoming brighter.

After the GPIOs and other microcontroller peripherals are initialized, the TI-RSLK LaunchPad sends a message to the PC LaunchPad. This message includes the values of the ELA, ERA, ELB, and ERB variables, as well as the state of some GPIO pins on another device.

After sending the packet, the TI-RSLK packet waits for the PC LaunchPad to respond with the TMAG5273 X and Y axis readings from the joystick. When the TI-RSLK LaunchPad receives the TMAG5273 readings, the TI-RSLK LaunchPad converts these readings from register units into units of mT. The further up the joystick is, the more positive the Y axis reading. The TI-RSLK LaunchPad checks to see if the sensed Y reading is greater than the UP_THRESHOLD or less than the DOWN_THRESHOLD values. These thresholds are added so that the TI-RSLK only moves forward or backwards when the joystick has been at least pressed past a certain amount from the center position. This ensures that the TI-RSLK does not move when the joystick is near its center position. If the Y reading is greater than the UP_THRESHOLD, the TI-RSLK moves forward by setting each PH pin to logic low. If the Y reading is less than the DOWN_THRESHOLD, the TI-RSLK moves forward by setting each PH pin to logic high. The duty cycle is scaled so that the robot moves faster the closer the joystick is to its upmost or downmost position. Assuming that the sensed Y reading is greater than the UP_THRESHOLD, use the following formula to calculate the time spent at logic high within the 69.5-μs pulse period:

$$time\_high = (DUTY\_MIN \times pwmPeriod + ((y\_mT - UP\_THRESHOLD)/(UP\_MAX - UP\_THRESHOLD)) \times DUTY\_MAX\_INCREMENT \times pwmPeriod \quad (1)$$

where:

- *DUTY_MIN* is a fraction from 0 to 1 that represents which duty cycle to use when the Y reading equals UP_THRESHOLD. A value of 0 corresponds to logic 0 and a value of 1 corresponds to logic 1 during the entire pulse period.
- *pwmPeriod* is the total time in a pulse period (69.5 μs in this case).
- *y_mT* is the Y reading from the TMAG5273 in units of mT
- *UP_THRESHOLD* is the desired minimum reading to trigger TI-RSLK movement. The user can experimentally determine this value by moving the joystick up from the center position until it reaches the minimum distance desired to trigger TI-RSLK movement. The user can then log the resulting Y reading as the *UP_THRESHOLD* value.
- *UP_MAX* is the maximum Y reading observed when the joystick is pushed to its upmost position. The user can experimentally determine this value by pushing the joystick to its upmost position and then logging the resulting Y reading as the value for UP_MAX.
- *DUTY_MAX_INCREMENT* is the change in the duty cycle fraction when the Y reading goes from UP_THRESHOLD to UP_MAX. DUTY_MAX_INCREMENT. This change is also expressed as a fraction from 0 to 1. Consequently, DUTY_MIN + DUTY_MAX_INCREMENT is the duty cycle fraction when the Y reading equals UP_MAX.

A similar formula also calculates the time spent at logic high when the sensed Y reading is less than the DOWN_THRESHOLD, but different thresholds and maximum values will be used instead (more specifically, UP_THRESHOLD is replaced by DOWN_THRESHOLD variable and UP_MAX is replaced with DOWN_MIN variable).

Copyright © 2022 Texas Instruments Incorporated

5.2 LaunchPad Software

After the PC LaunchPad is powered, the following peripherals are initialized on the CC26x2 microcontroller:

- **I2C**: The I2C first configures the TMAG5273 to enable conversions on the X and Y channels.
- **Serial Terminal**: The backchannel UART on the XDS110 debugger is enabled so that a serial port is created when the LaunchPad USB connection is connected to a USB port on the laptop. The baudrate for this backchannel UART is 115200 baud per second with the 8N1 configuration.

While the PC LaunchPad waits for a packet, it triggers a new reading of the TMAG52730 X and Y channels. When the PC LaunchPad receives a packet from the TI-RSLK LaunchPad, it converts the number of falling edge transitions indicated by ELA, ERA, ELB, and ERB into frequency readings by dividing the number of transitions by the time interval between packets. The frequency readings output to a terminal. After outputting the parameters onto the terminal, the PC LaunchPad sends the TMAG5273 X and Y readings to the TI-RSLK kit.

6 How to Design With Hall-Effect Latches

Hall-effect devices may seem challenging to design for due to the complexity of magnetic equations and their non-linear behavior. Thankfully, with the help of design tools such as Ansys, Femm, or Magpy, we can simplify and streamline the design process by simulating the magnetic field (also referred to as B-field) behavior.

To select a Hall-effect sensor with adequate sensitivity for the magnet used in rotary encoding applications, we must consider a couple of items. The positioning and size of the magnet can have significant influence on magnetic flux density sensed by the Hall-effect sensor. Hall-effect devices are often available with multiple sensitivity options to suit the specific sensitivity requirements of an application. It is necessary to select a Hall-effect sensor with enough magnetic headroom to reliably trigger on changes in magnetic field.

Magnetic incremental encoding is implemented by placing a magnetic disc on the motor shaft so that the disc rotates along with the motor shaft. The disc typically has multiple sets of north/south poles. A Hall-effect latch is placed underneath the magnet. As the ring magnet rotates over the sensor, the sensor detects the polarity changes in the magnetic field. The output of the device will change to either high or low as the magnetic field meets the B_{OP} or B_{RP} sensitivity specification of the Hall-effect latch. Figure 6-1 shows an example implementation for magnetic incremental encoding that uses one 2D Hall latch.

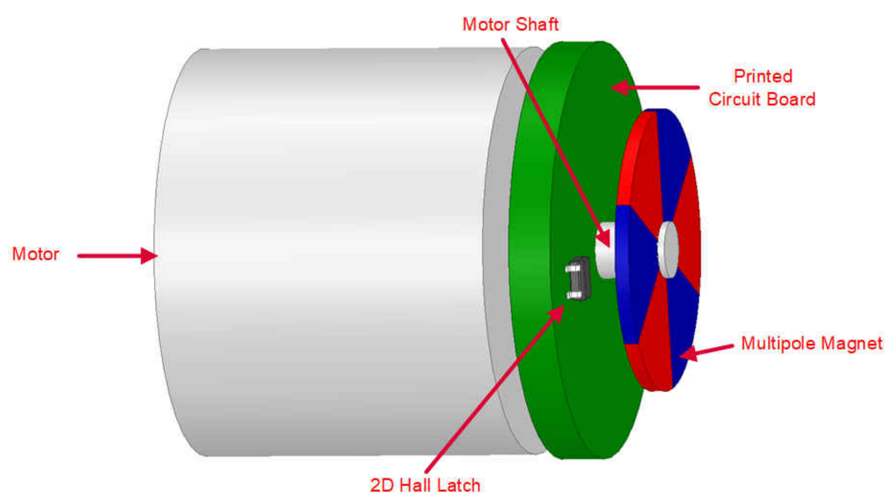

Figure 6-1. Incremental Wheel Encoding With 2D Hall Latch

Copyright © 2022 Texas Instruments Incorporated

7 Simulation Results

To develop a board that can replace the two 1D latches used in the TI RSLK kit with a 2D latch solution, it was necessary to perform simulations. This ensures that the right sensitivity variant of the device is selected, confirms that the ideal axis of sensitivity is selected, and can help identify practical placement for the magnet and sensor.

The purpose of this board was to create a replacement for the existing TI-RSLK encoder board, therefore the simulation was carried out to use similar ring magnet specifications as the current encoder and similar placement. Figure 7-1 shows the ring magnet placement, and Figure 7-2 shows the results of the simulation.

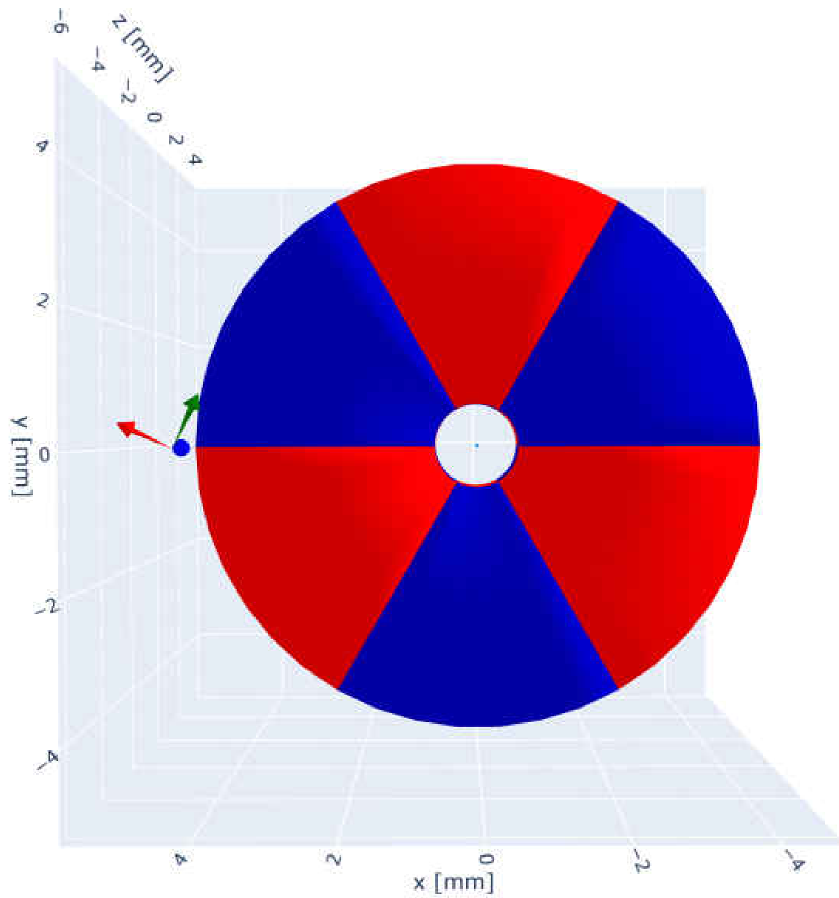

Figure 7-1. Ring Magnet Simulation Placement

Copyright © 2022 Texas Instruments Incorporated

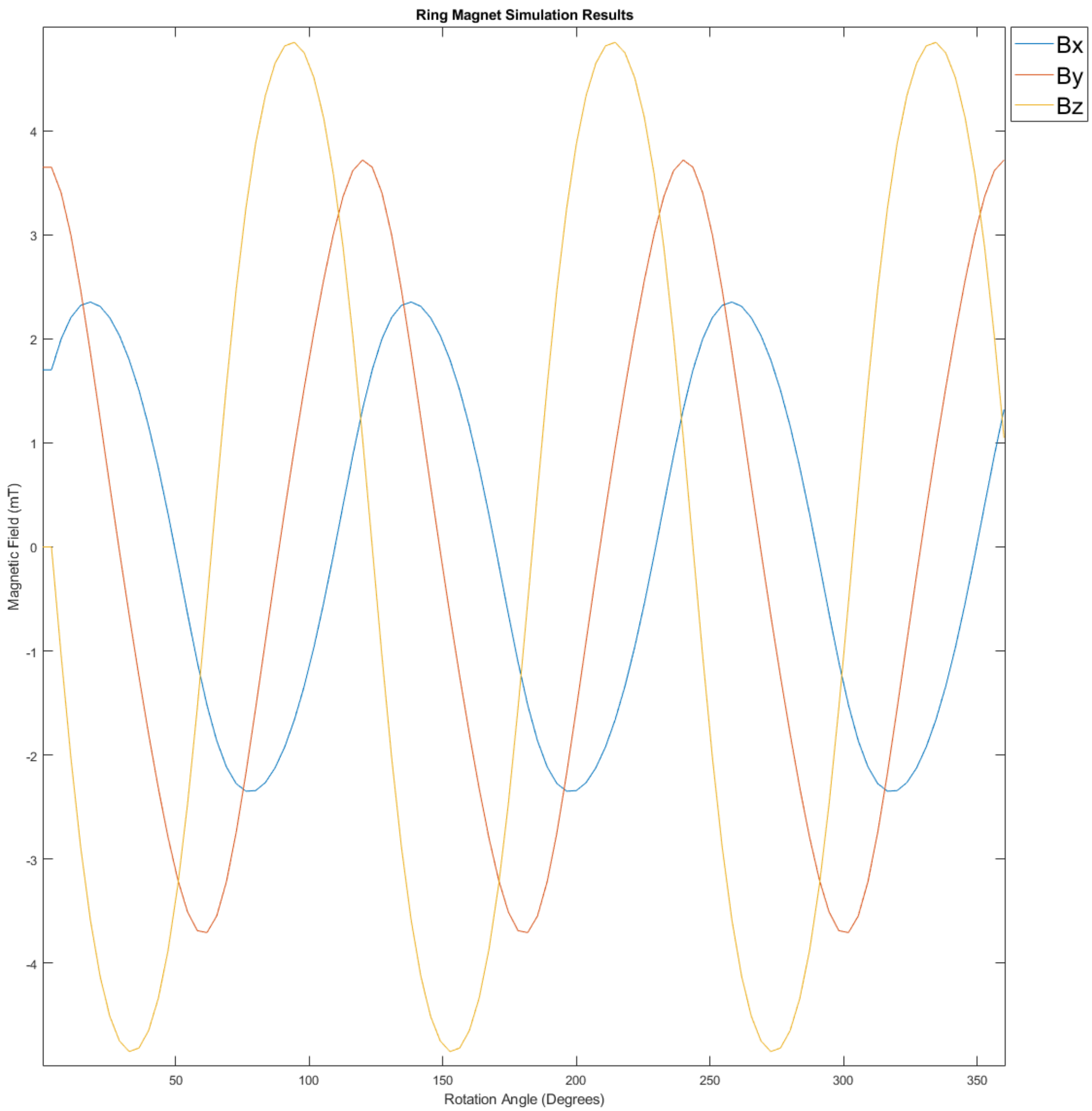

Figure 7-2. Ring Magnet Simulation Results

7.1 Select Device Sensitivity

The simulation results all yielded a peak B field beyond 1.4 mT. This indicates that all axes would detect enough magnetic flux to operate properly with the most sensitive version of the TMAG511x devices. The next largest sensitivity option is 3 mT, which indicates that the X axis would never experience enough magnetic flux to change states.

7.2 Select Axis of Sensitivity

In rotary encoding systems that require both speed and direction, the sensors should be placed ideally 90° out of phase from each other. Using a 2D sensor enables the user to achieve this 90° offset more simply because the sensors are naturally orthogonal to each other, meaning there is a natural 90° phase difference from each

Copyright © 2022 Texas Instruments Incorporated

sensor. This means that, when picking a 2D sensor, it is necessary to pick the two directions that have the closest phase angle difference of 90° from each other. To calculate this, we can use the following formula:

$$\theta° = \frac{x_2 - x_1}{period} \times 360° \quad (2)$$

Where X_2- X_1 is the difference between the leading and lagging sinusoidal waveforms. This difference is converted to a fraction by dividing it by the entire period of the signals.

The fraction multiplied by 360° will provide the phase difference between the two sinusoidal waveforms. On the encoder board that was created, due to the rotation of the sensor (board image in Figure 9-2), a 65.45° offset was estimated from the simulation. The phase angle calculation is below.

$$65.45° = \frac{25 - 19}{33} \times 360° \quad (3)$$

With ideal Hall sensor placement, meaning a 90° angle is achieved, the signal should yield a 50% duty cycle on the output. When the offset is greater or lesser than 90°, it may lead to uneven periods in the duty cycle, as seen for this system in Figure 8-6.

8 Performance Comparison

This section explains the test setup used for each of the technologies (magnetic and optical), as well as the resulting data to provide a suitable comparison of performance. For all tests explained in the following sections, the same motor listed in the key specifications is used.

Another set of tests for these two technologies, which could be crucial for product designers, is the performance comparison in dusty environments. In the case of encoders, it is imperative that devices are able to accurately detect the speed accurately, because these devices are expected to perform in dirty environments in some cases. If the technology cannot perform well in these conditions it could cause unwanted system behavior resulting in poor system performance.

8.1 Speed and Direction

The speed tests were conducted by spinning the TI-RSLK motor at the maximum speed (150 RPM). In this case, the IR encoder did not show any performance advantages in comparison to the Hall-effect based solution. The main advantage of IR sensors is their ability to sense higher speeds than typically allowed by magnetic encoders. Hall-effect sensors contain a frequency bandwidth limit you should not exceed, or else the sensor might not detect changes in the B field appropriately. Figure 8-1 and Figure 8-2 show the encoder outputs.

One of the main benefits of using the TMAG5111 is to more easily tell which direction the motor is turning. Figure 8-2 shows that when the motor is rotating in the clockwise direction, the orange signal that indicates direction is high. Figure 8-3 shows that the output pulls low when the motor spins in the counterclockwise direction. To implement direction in an IR-based solution, you must add an additional IR sensor to the system. This could potentially add more problems to the system, such as possibly increasing the the solution size, each IR sensor being unable to distinguish the source of the light signal and affecting the output of the other sensors, and increasing the power consumption.

Copyright © 2022 Texas Instruments Incorporated

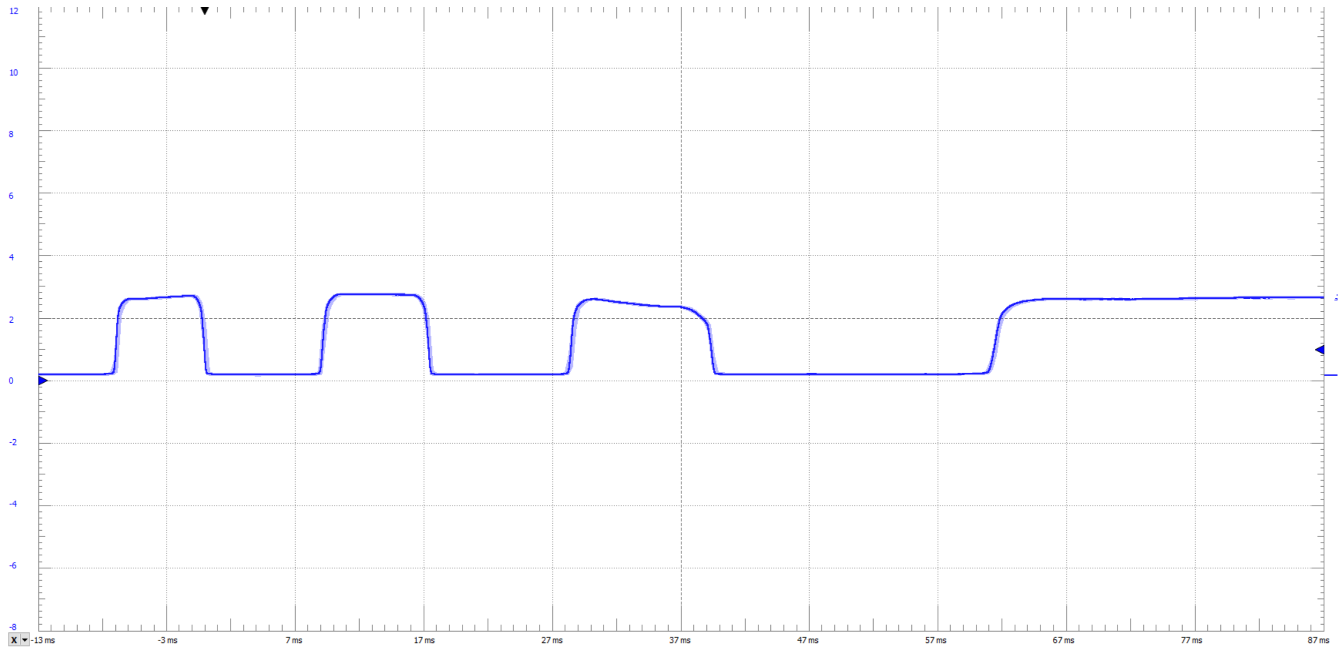

Figure 8-1. IR Encoder Output

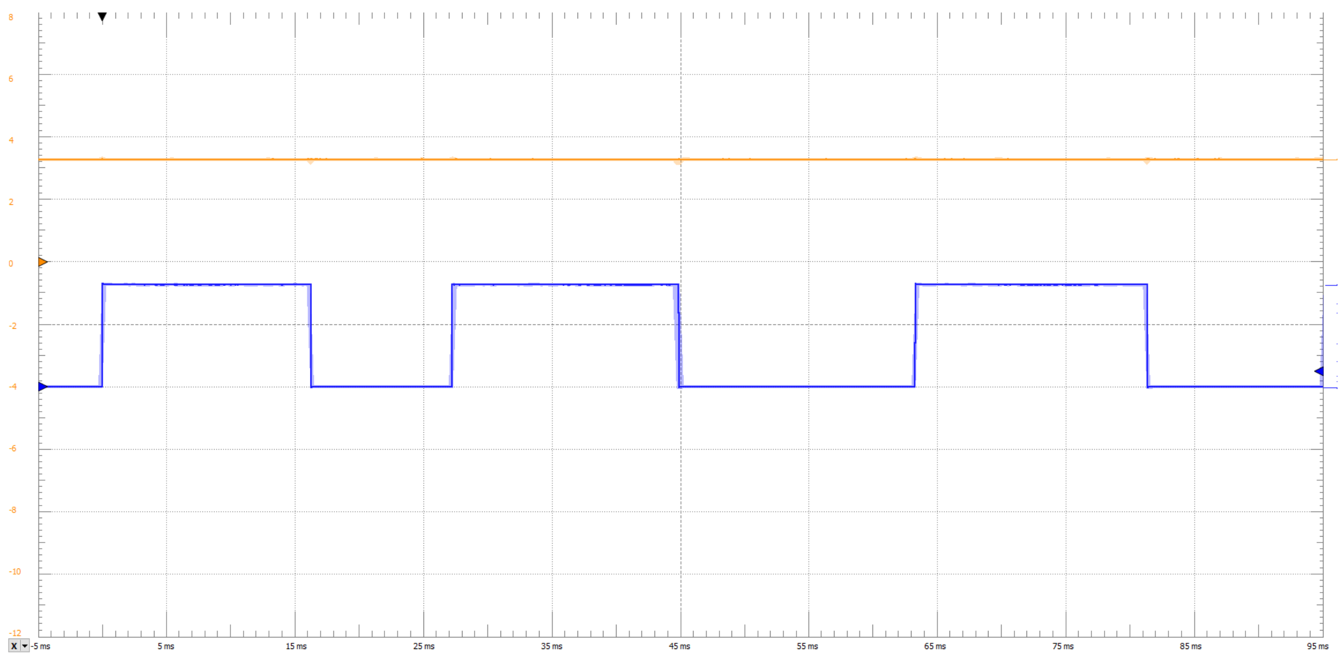

Figure 8-2. TMAG5111 Encoder Output Clockwise

Copyright © 2022 Texas Instruments Incorporated

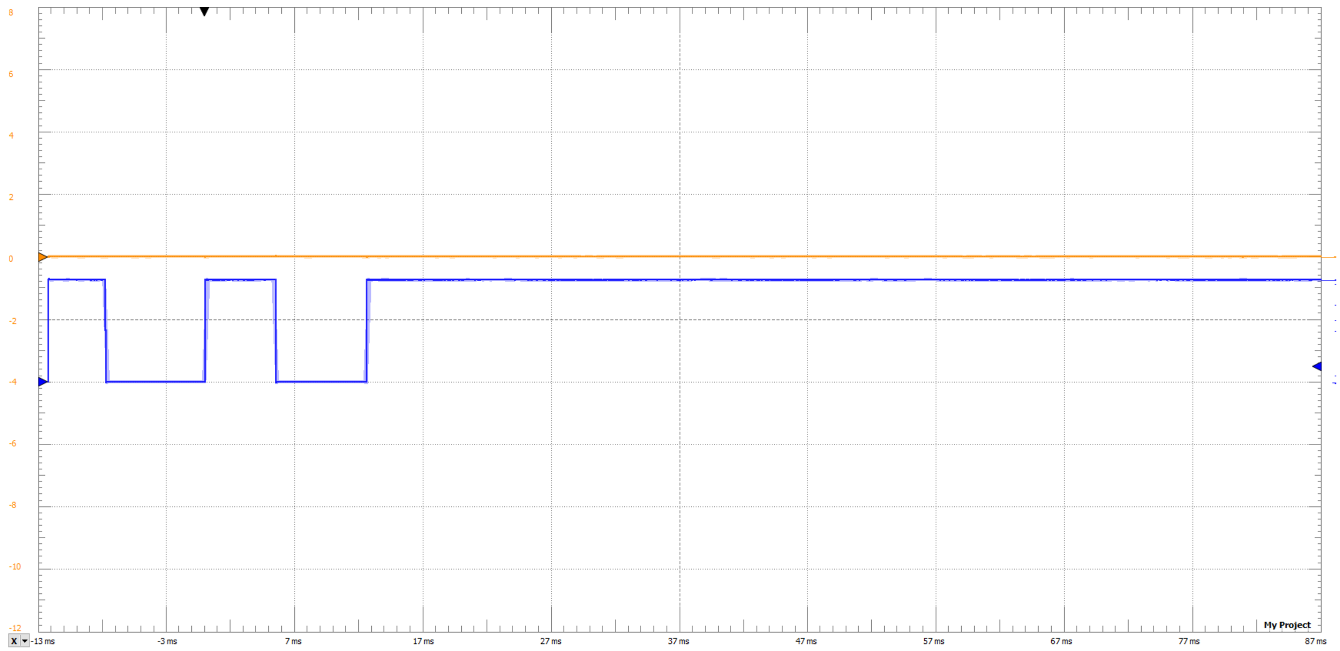

Figure 8-3. TMAG5111 Encoder Output Counterclockwise

8.2 Power Consumption

To test the power consumption of each encoder systems, we disconnected the encorders from the TI-RSLK system and powered them separately. In doing so, we are able to isolate the power consumption required by each encoder technology. The TMAG5111 encoder board showed a clear advantage over its optical counterpart, consuming 5 mA during operation (Figure 8-4), while the IR encoder board consumed a total of 20 mA during operation (Figure 8-5). Adding another IR encoder for direction would most likely double the power consumption, all while the Hall-effect board would remain at 5 mA because both the speed and direction are included in one device.

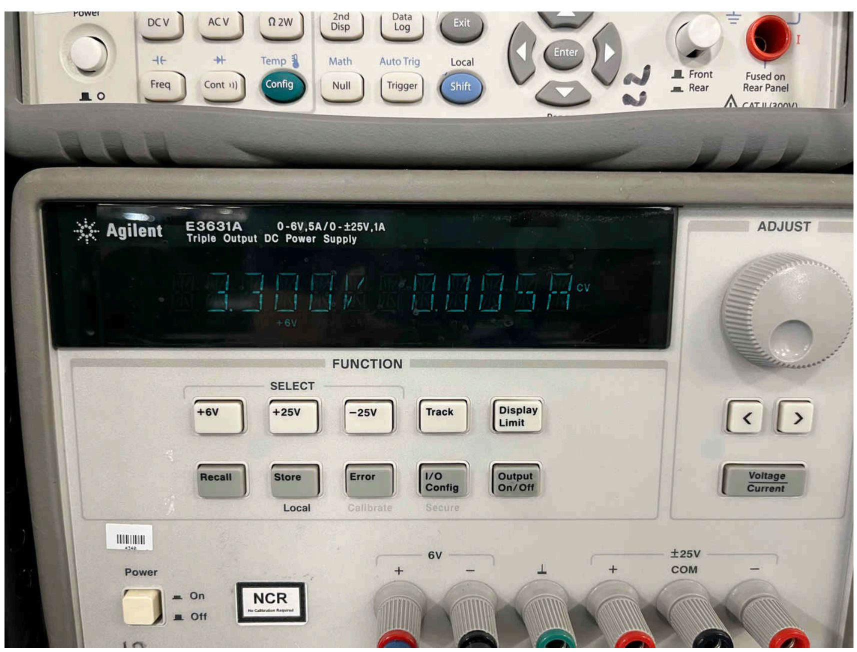

Figure 8-4. TMAG5111 Encoder Current Consumption

Copyright © 2022 Texas Instruments Incorporated

Figure 8-5. IR Encoder Current Consumption

8.3 Susceptibility to External Particles

The external particles susceptibility test was conducted by covering the top portion of the incremental rotary encoder with pet hair. These systems are oftentimes expected to perform in dirty environments, such as robot vacuum cleaners or robotic equipment in warehouses, therefore it is of paramount importance that these systems be immune to fragments that could be present in these harsh environments. The output was observed for missed outputs or changes in behavior.

Figure 8-6 shows the susceptibility of the Hall-effect based encoder, where the results demonstrate the behavior of both the encoder manipulated with the pet hair and the unaltered encoder. As seen in Figure 8-6, the magnetic encoder is not showing much of a difference in system behavior. This is due to the immunity of the magnetic field to external particles such as hair and dirt. The B field cannot be blocked, therefore the sensor still receives the same amount of magnetic flux to change the output accordingly.

Copyright © 2022 Texas Instruments Incorporated

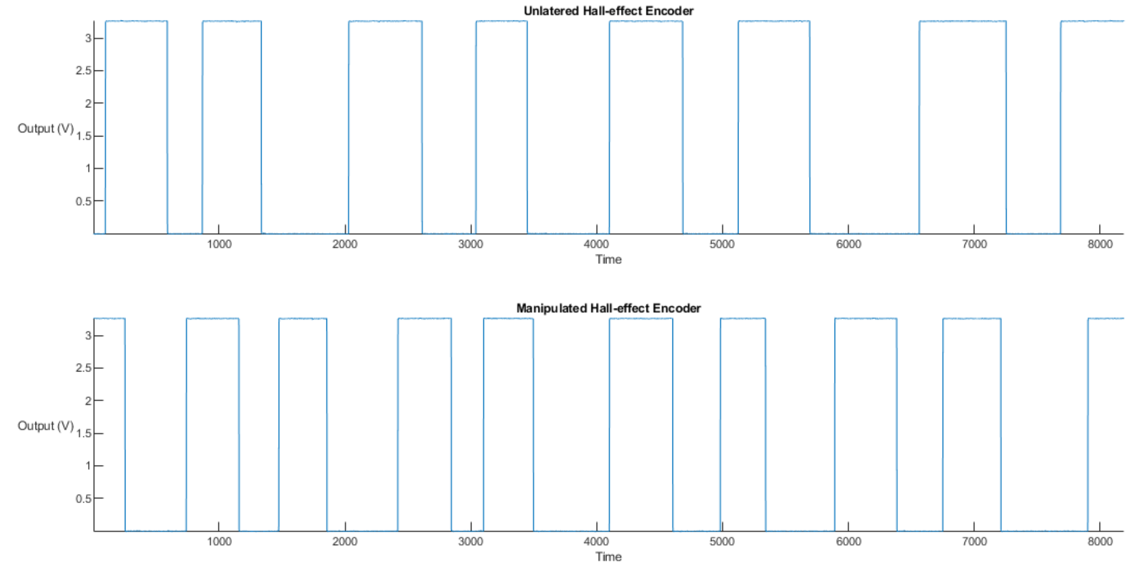

Figure 8-6. TMAG5111 Encoder Susceptibility Tests

Figure 8-7 shows the susceptibility of the optical-based encoder, where the results indicate the behavior of both the encoder manipulated with the pet hair and the unaltered encoder. Here there are a few discernible differences, the first one being that the encoder is missing some the pulses. It is noticeable that the signal may be slightly picked up by the receiver, but the hair is enough to prevent the light to completely come through. The next item to note is the amplitude of the signal. In the unaltered system, we can the signal goes beyond 2 V and reaches approximately a maximum of 3 V. In the manipulated system, however, the peak signal does not exceed 2 V. It seems like the more dirt and grime that build up inside the optical system would yield a reduction in signal amplitude, at some point perhaps never reaching the threshold to notify the system that it is moving.

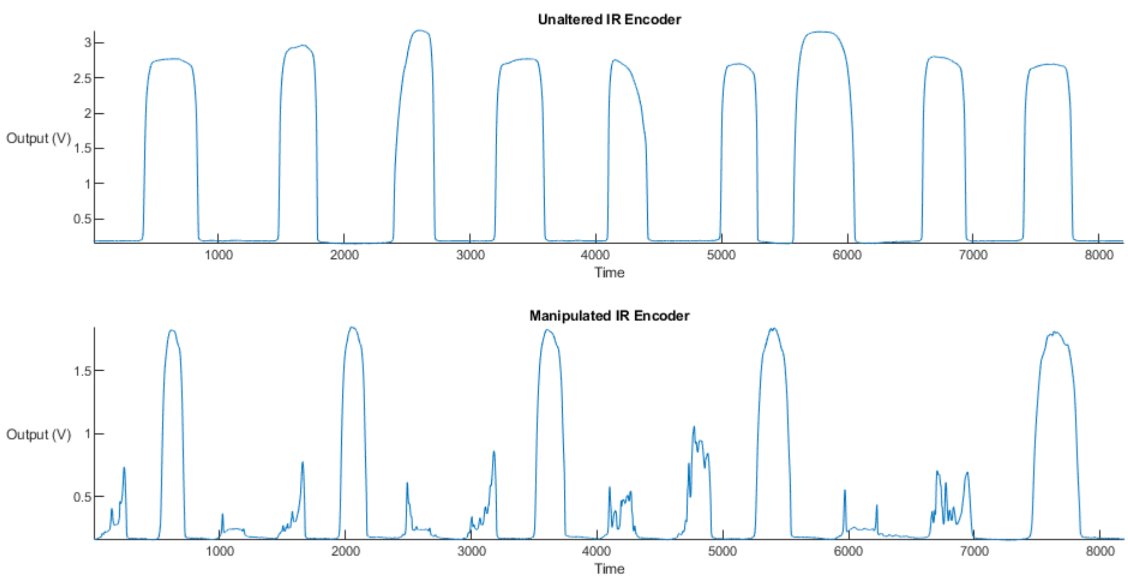

Figure 8-7. IR Encoder Susceptibility Tests

Copyright © 2022 Texas Instruments Incorporated

9 Encoder Board Schematic and Image

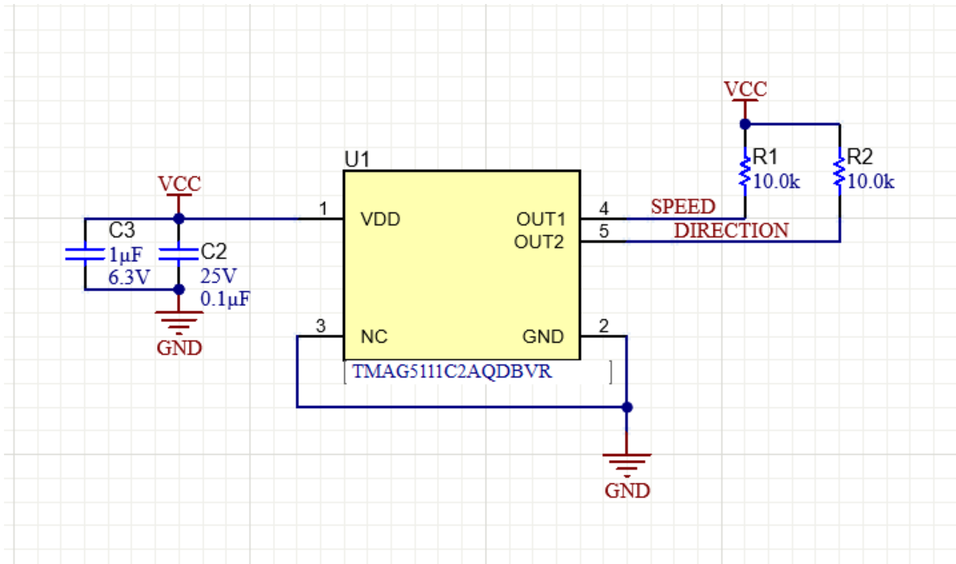

Figure 9-1. TMAG5111 Encoder Schematic

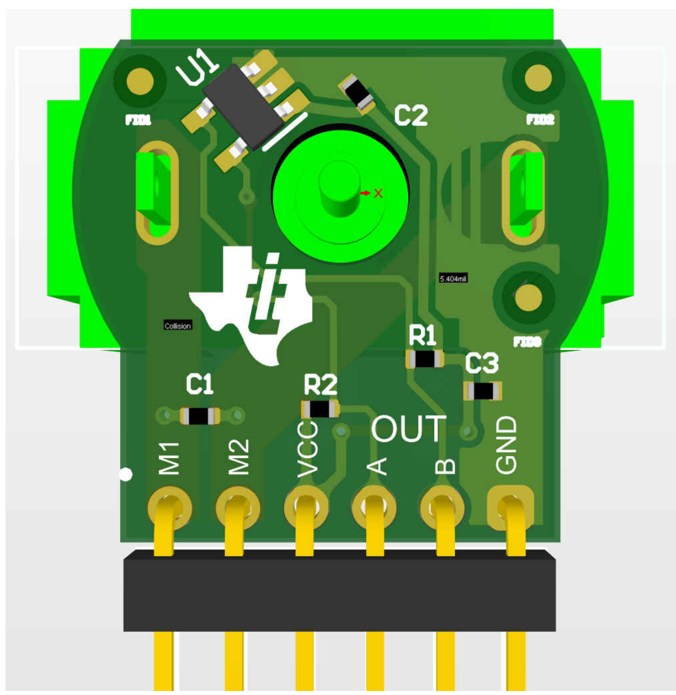

Figure 9-2. TMAG5111 Encoder Board Image

Copyright © 2022 Texas Instruments Incorporated

10 Summary

Although incremental rotary encoding can be achieved with either Hall-effect or optical sensors, there are several factors that need to be accounted for to create and offer the most robust solution. Optical encoding does not provide the natural immunity to external particles that is furnished by using Hall-effect sensors without needing to design costly sealed encoder modules required by its optical counterpart. Hall-effect sensors can also provide a much lower power consumption in comparison, which is a key care-about that is highly expected and necessary in battery-operated systems. 2D Hall-effect technology can also provide additional information such as motor direction. Ultimately, TI offers many robust solutions for incremental rotary encoding that are both low power and dependable.

Copyright © 2022 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), 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, regulatory 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 or other applicable terms available either on 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.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2022, Texas Instruments Incorporated