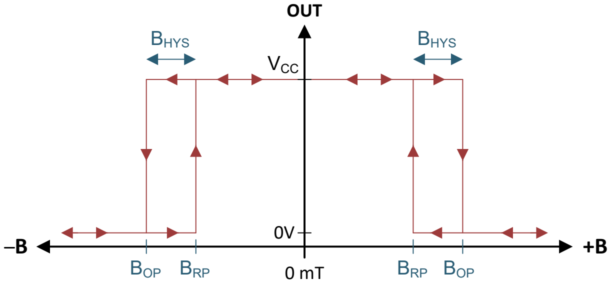
TMAG5233 In-Plane Hall-Effect Switch for Cost-Optimized Designs

1 Features

- Supply voltage range:
  - From –40°C to 85°C: 1.65V to 5.5V
- In-plane axis of sensitivity
- Magnetic pole detection:
  - Omnipolar (±)
- Output type:
  - Push-pull (CMOS)
- Active output state (when $B > B_{OP}$): low (V_{OL})
- Magnetic operate point (B_{OP}): ±3mT
- Magnetic release point (B_{RP}): ±2.2mT
- Duty cycle operation to minimize I_{CC}
  - 5Hz: 0.55μA
  - 40Hz: 2.7μA
- Industry standard package and pinout
  - 3-pin SOT-23 (V_{CC}, GND, OUT)

2 Applications

- Door and window sensors
- Appliance door open/close
- Electricity meter tamper detection
- Electronic smart locks
- Smoke detector push buttons
- Food processor accessory detection
- Laptops



Omnipolar Active Low Functionality

3 Description

The TMAG5233 is an in-plane Hall-effect switch designed to replace TMR, AMR and Reed switches used in applications where cost is a priority.

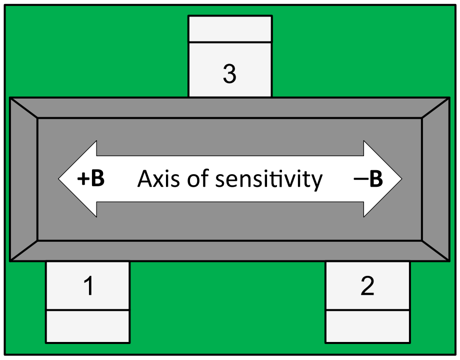
The TMAG5233 has an omnipolar magnetic response and enables the device to react to both north and south magnetic poles. When the applied magnetic flux density through the sensor axis of sensitivity exceeds the operate point threshold (B_{OP}), the device outputs a low voltage. The output stays low until the magnetic flux density decreases to less than the release point threshold (B_{RP}), after which the device outputs a high voltage.

To minimize power consumption, the TMAG5233 is internally duty-cycled. The device has a push-pull (CMOS) output which eliminates the need for an external pullup resistor, and is available in an industry-standard SOT-23 package.

Package Information

PART NUMBER	PACKAGE[1]	PACKAGE SIZE[2]
TMAG5233	DBV (SOT-23, 3)	2.9mm × 2.8mm

(1) For all available packages, see Section 11.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Top View

In-Plane Axis of Sensitivity

Table of Contents

4 Device Comparison

Table 4-1. Device Comparison

VERSION	TYPICAL THRESHOLD	TYPICAL HYSTERESIS	MAGNETIC RESPONSE	OUTPUT TYPE	SAMPLING RATE	PACKAGES AVAILABLE
TMAG5233D1B	3mT	0.8mT	Omnipolar, active low	Push-pull	5Hz	SOT-23 (DBV)
TMAG5233D1E	3mT	0.8mT	Omnipolar, active low	Push-pull	40Hz	SOT-23 (DBV)

5 Pin Configuration and Functions

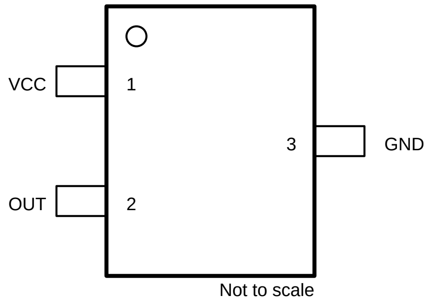


Figure 5-1. DBV Package 3-Pin SOT-23 Top View

Table 5-1. Pin Functions

PIN		TYPE	DESCRIPTION
NAME	SOT-23		
VCC	1	P	Supply voltage
OUT	2	O	Omnipolar output, responds to both positive and negative magnetic flux density through the package.
GND	3	G	Ground

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1]

		MIN	MAX	UNIT
Power supply voltage	V_{CC} T_A = –40°C to 85°C	–0.3	6	V
Output pin voltage	OUT	GND – 0.3	V_{CC} + 0.3	V
Output pin current	OUT	–5.5	5.5	mA
Magnetic flux density, B_{MAX}		Unlimited		T
Junction temperature, T_J		–65	150	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[1]	±2000	V
		Charged device model (CDM), ANSI/ESDA/JEDEC JS-002[2]	±500	

(1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{CC}	Power supply voltage	1.65	5.5	V
T_A	Ambient temperature	–40	85	°C
V_O	Output voltage	GND	V_{CC}	V
I_O	Output current	–5	5	mA

6.4 Thermal Information

THERMAL METRIC[1]		TMAG5233	UNIT
		SOT-23 (DBV)	
		3 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	264.5	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	125.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	108.9	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	66.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	108	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application note.

6.5 Electrical Characteristics

Over free-air temperature range and supply (unless otherwise noted); Typical specifications are at T_A = 25°C (unless otherwise noted)

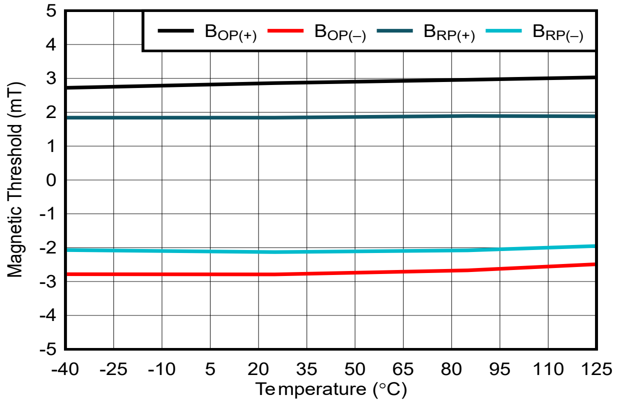
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
PUSH-PULL (CMOS) OUTPUT						
V_{OH}	High-level output voltage	I_O = –0.5mA	V_{CC} – 0.4		V_{CC}	V
V_{OL}	Low-level output voltage	I_O = 0.5mA	0		0.4	V
ALL VERSIONS						
$I_{CC(ACTIVE)}$	Supply current during measurement			2.6		mA
$I_{CC(SLEEP)}$	Sleep current			315		nA
t_{ON}	Power-on time	V_{CC} = 5.5V		32		µs
t_{ACTIVE}	Active time period			26		µs
TMAG5233xxB 5Hz						
f_S	Frequency of magnetic sampling		3	5	7	Hz
t_S	Period of magnetic sampling		143	200	333	ms
I_{CCAVG}	Average current consumption	T_A = 25°C		0.55	0.78	µA
		T_A = –40°C to 85°C			1.08	
TMAG5233xxE 40Hz						
f_S	Frequency of magnetic sampling		28	40	53	Hz
t_S	Period of magnetic sampling		18	25	36	ms
I_{CCAVG}	Average current consumption	T_A = 25°C		2.7	3.7	µA
		T_A = –40°C to 85°C			4	

6.6 Magnetic Characteristics

Over free-air temperature range and supply (unless otherwise noted); Typical specifications are at T_A = 25°C (unless otherwise noted)

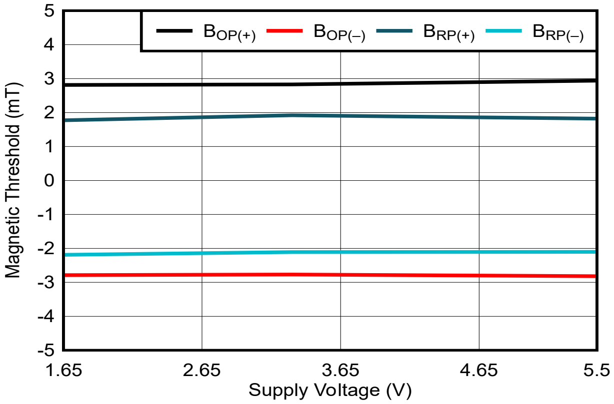
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
TMAG5233Dxx 3 mT						
B_{OP}	Magnetic operate point	T_A = 25°C	±1.6	±3	±4.3	mT
		T_A = –40°C to 85°C	±1.2	±3	±4.5	
B_{RP}	Magnetic release point	T_A = 25°C	±0.6	±2.2	±3.5	mT
		T_A = –40°C to 85°C	±0.6	±2.2	±3.5	
B_{HYS}	Magnetic hysteresis: $\lvert B_{OP} - B_{RP} \rvert$	T_A = –40°C to 85°C		0.8		mT

6.7 Typical Characteristics



Version: D1E

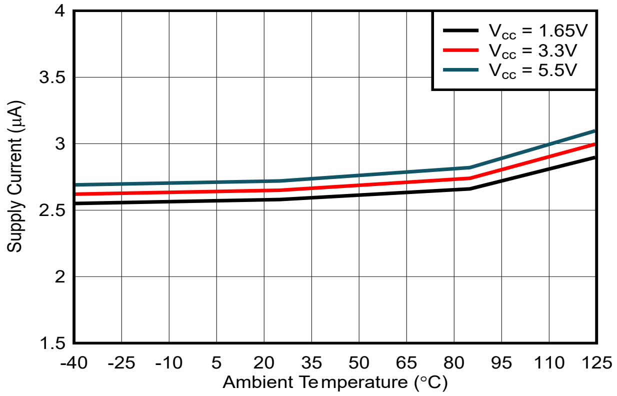
Figure 6-1. Magnetic Thresholds vs Temperature



T_A = 25°C

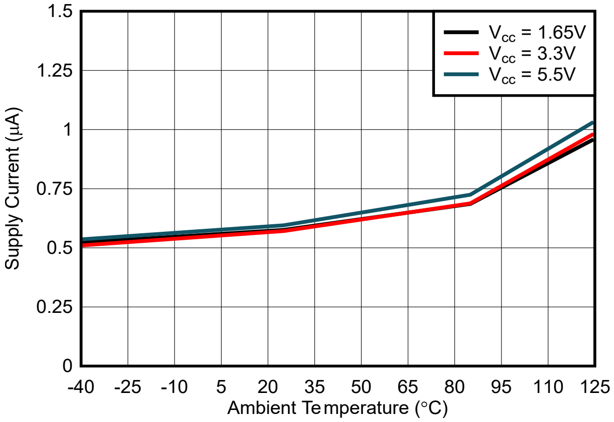
Version: D1E

Figure 6-2. Magnetic Thresholds vs Supply Voltage



Version: D1E

Figure 6-3. 40Hz: Average I_{CC} vs Temperature



Version: D1B

Figure 6-4. 5Hz: Average I_{CC} vs Temperature

7 Detailed Description

7.1 Overview

The TMAG5233 is an alternative to expensive TMR, AMR and Reed switches, enabling magnetic position sensing for cost-optimized designs. The TMAG5233 is a Hall-effect sensor with a single digital output that indicates when the magnetic flux density thresholds (B_{OP} and B_{RP}) have been crossed. The output features a push-pull (CMOS) architecture that allows the device to drive the output high or pull the output low, eliminating the need for an external pullup resistor.

As an omnipolar switch, the TMAG5233 OUT pin responds to both positive and negative magnetic flux density along the axis of sensitivity on the sensor. As seen in Figure 7-2, a south pole near pin 1 of the DBV package induces a positive magnetic flux density, while a north pole near pin 1 of the DBV package induces a negative magnetic flux density. The output type is active low, meaning the device pulls the output pin low when the magnetic flux density exceeds B_{OP} and drives the output high when the magnetic flux density falls below B_{RP} .

The TMAG5233 integrates a Hall-effect element, analog signal conditioning, and a low-frequency oscillator. The TMAG5233 operates as a duty-cycled device, periodically measuring the magnetic flux density, updating the output, and entering a low-power sleep state between measurements to conserve power.

7.2 Functional Block Diagram

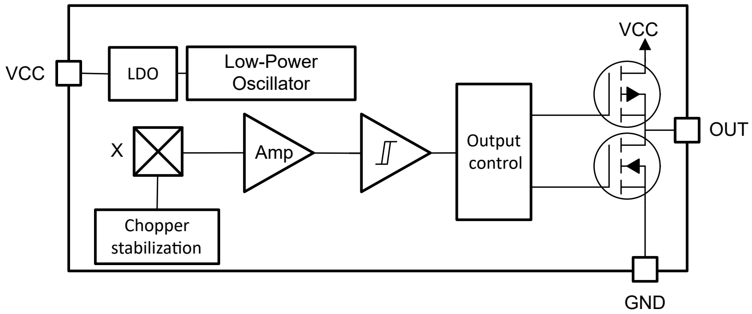


Figure 7-1. SOT-23 Block Diagram

7.3 Feature Description

7.3.1 SOT-23 Magnetic Flux Density Direction

The TMAG5233 SOT-23 detects the magnetic flux density which is horizontal to the package marking surface.

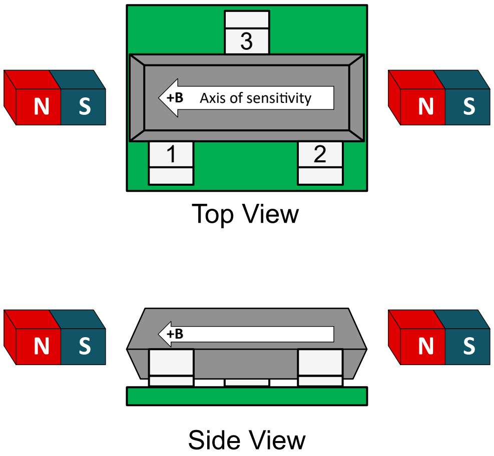


Figure 7-2. Positive Magnetic Flux Density

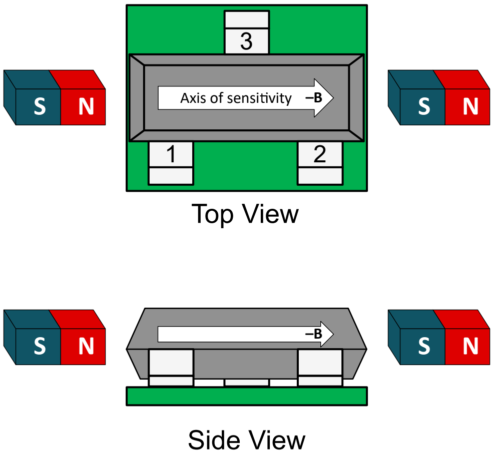


Figure 7-3. Negative Magnetic Flux Density

Magnetic flux density traveling from the pin 2 side of the package to the pin 1 side of the package is considered positive, while magnetic flux density traveling from the pin 1 side of the package to the pin 2 side of the package is considered negative.

A magnet creates a three-dimensional magnetic field that permeates the surrounding space, with field strength and direction varying at different points. This variation allows for multiple ways to induce a positive (or negative) magnetic flux density, as illustrated in Figure 7-4 and Figure 7-5.

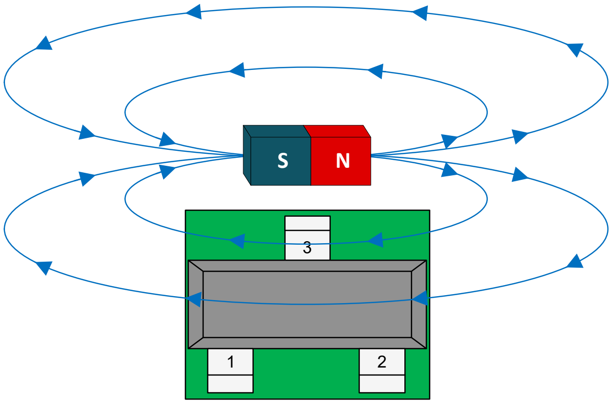


Figure 7-4. Positive Magnetic Flux Density: Magnet Offset

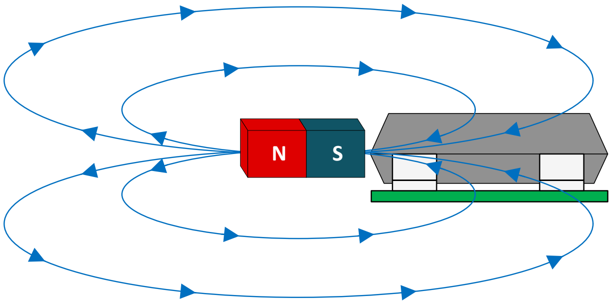


Figure 7-5. Positive Magnetic Flux Density: Magnet In-Line

7.3.2 Output Type

The TMAG5233 is an omnipolar switch, meaning the OUT pin responds to both positive and negative magnetic flux densities. As an active low, push-pull (CMOS) output device, the TMAG5233 pulls the output low when the magnetic flux density exceeds the magnetic operate point (B_{OP}). The output remains low until the magnetic flux density falls below the magnetic release point (B_{RP}). Figure 7-6 shows this omnipolar, active low output behavior. Figure 7-7 shows a simplified diagram of the push-pull CMOS architecture that allows the device to drive the output high or pull the output low, eliminating the need for an external pullup resistor.

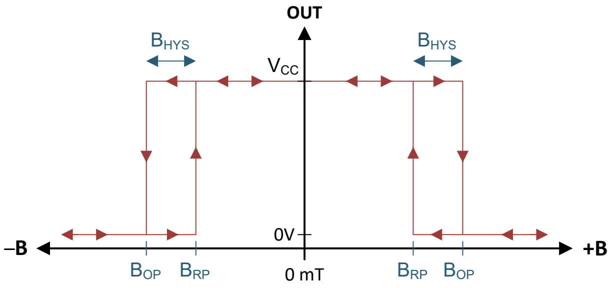


Figure 7-6. Omnipolar Output Response

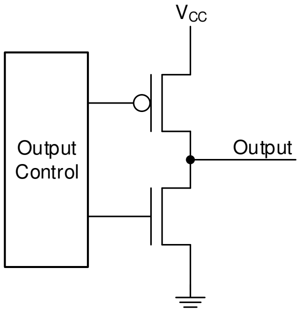
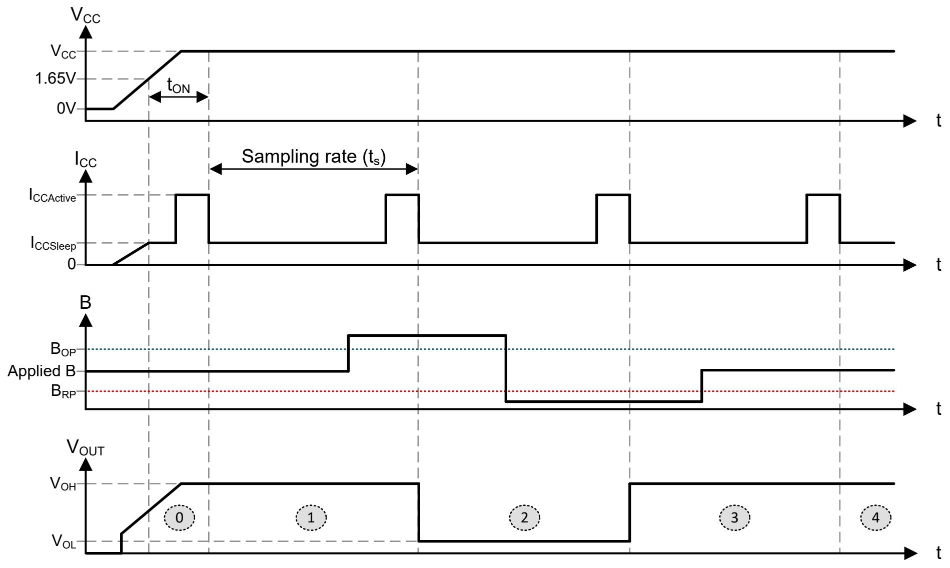


Figure 7-7. Push-Pull (CMOS) Output (Simplified)

7.3.3 Timing

Figure 7-8 displays the start-up behavior of the TMAG5233 and some examples of the output pin voltage based on different magnetic flux density scenarios. When the minimum value for V_{CC} is reached, the TMAG5233 takes time (t_{ON}) to power up, measure the first magnetic sample, and set the output value. When the output value is set, the output is latched and the device enters a low power sleep state. After each t_S time has passed, the device measures a new sample and updates the output if necessary. If the magnetic field does not change between periods, the output also does not change.



⓪ The default start-up state for V_{OUT} is V_{OH} regardless of the B flux density through the package.

① 1st Sample: B flux density sampled was $B_{RP} < B < B_{OP}$, therefore V_{OUT} remains in its default start-up state (V_{OH}).

② 2nd Sample: B Flux density sampled was $B > B_{OP}$, therefore V_{OUT} is driven to V_{OL}.

③ 3rd Sample: B Flux density sampled was $B < B_{RP}$, therefore V_{OUT} is driven to V_{OH}.

④ 4th Sample: B Flux density sampled was $B_{RP} < B < B_{OP}$, therefore V_{OUT} continues its previous state (V_{OH} from sample 3).

Figure 7-8. Timing and Output Diagram

7.3.4 Hall Element Location

The sensing element inside the device is in the center of the SOT-23 package when viewed from the top. Figure 7-9 shows the tolerances and side-view dimensions.

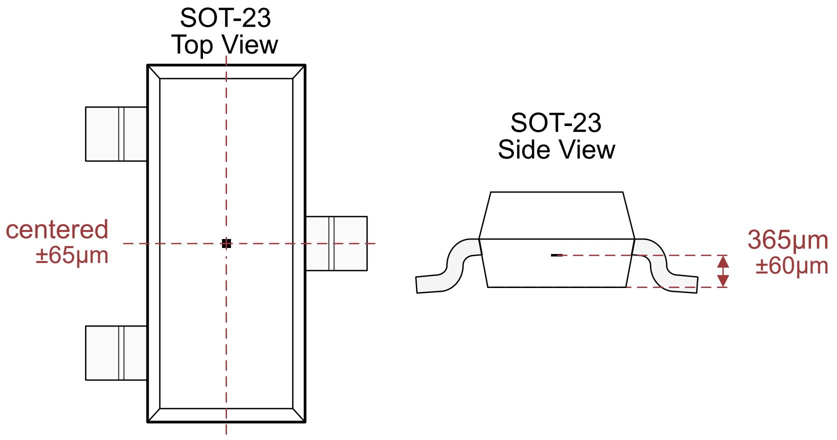


Figure 7-9. Hall Element Location

7.4 Device Functional Modes

The TMAG5233 always operates in a duty-cycled mode as described in the *Timing* section when the *Recommended Operating Conditions* are met.

8 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The TMAG5233 is a Hall-effect switch used to detect the proximity of a magnet, which is often attached to a movable component within the system. When the magnet comes sufficiently close to the sensor and induces a magnetic flux density that exceeds the B_{OP} threshold along the TMAG5233 axis of sensitivity, the output of the sensor is pulled low to GND. This low output can be read by a GPIO pin on a controller, enabling the system to recognize that the magnet has crossed the threshold, thereby indicating the position or movement of the component. This application is common in various fields, such as industrial automation and consumer electronics, where precise detection of position or movement is critical.

Due to the complex, non-linear behavior of magnets, it may be difficult to determine the appropriate magnet characteristics required to ensure the system works as intended. Therefore, TI recommends to begin the design process with experimentation to solve for a design that will work. To help facilitate rapid design iteration, the *TI Magnetic Sense Simulator (TIMSS)* web tool provides a visual interface that emulates typical sensor performance in system designs. TIMSS simulations provide an understanding of expected magnetic field behavior across a range of motion, and the simulations are run in a few seconds.

8.2 Typical Application

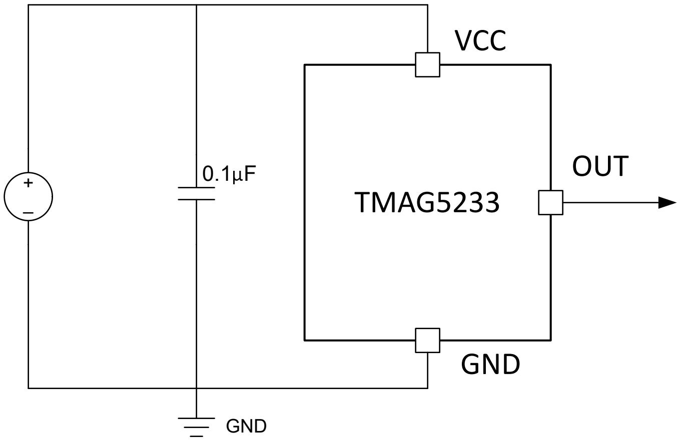


Figure 8-1. Typical Application Schematic

8.2.1 Design Requirements

This section provides an example using the *TI Magnetic Sense Simulator (TIMSS)* web tool for a magnet slide-by application. Table 8-1 lists the design parameters related to the movement of the magnet on the X-axis as seen in Figure 8-2 and Figure 8-3.

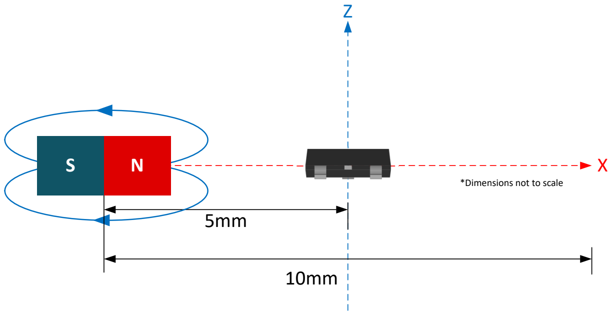


Figure 8-2. Side View

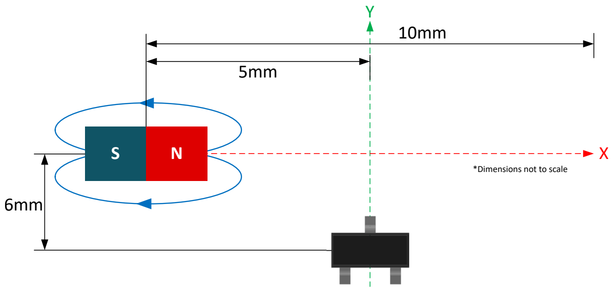


Figure 8-3. Top View

Table 8-1. Design Parameters

PARAMETER	VALUE
Supply voltage (V_{CC})	3.3V
Bypass capacitor	0.1µF
Part number	TMAG5233D1EDBVR
Magnet range of motion	10mm
Magnet length	3mm
Magnet width	3mm
Magnet height	3mm
Magnet type	N35

8.2.2 Detailed Design Procedure

As the magnet travels from the starting position (–5mm on X-axis) to the final position (5mm on X-axis), the magnetic flux density seen by the TMAG5233 across the axis of sensitivity changes (see Figure 8-4). Figure 8-5 shows the TMAG5233 output across the same interval.

At the magnet starting position, the TMAG5233 output is high because the magnetic flux density is less than B_{OP} . As the magnet moves along the X-axis towards the sensor, the magnetic flux density crosses the B_{OP} threshold of the TMAG5233 at a displacement of –3.1mm, making the output go low. As the magnet continues to move along the X-axis past the origin, the magnetic flux density begins to decrease. At a displacement of 3.4mm the B_{RP} threshold is crossed and the output goes high.

8.2.3 Application Curves

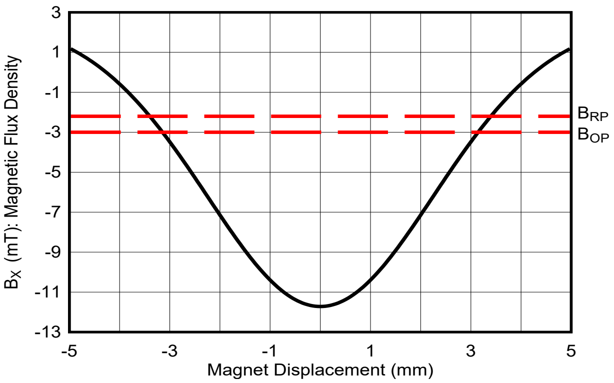


Figure 8-4. Magnetic Flux Density vs Magnet Displacement

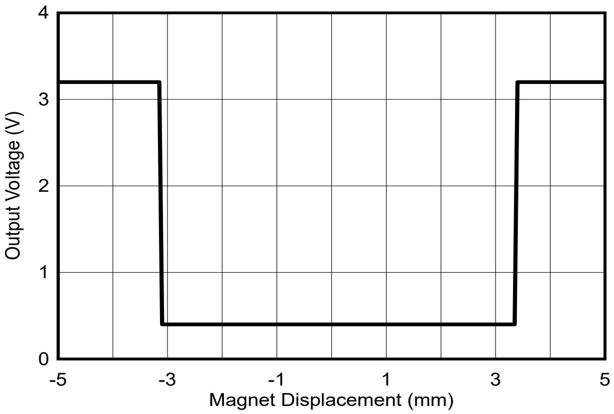


Figure 8-5. Output Voltage vs Magnet Displacement

8.3 Power Supply Recommendations

The TMAG5233 is powered on by supplying voltage to the V_{CC} pin in the range of 1.65V to 5.5V. TI recommends a bypass capacitor of at least 0.1µF between the sensor power supply and ground to help filter out voltage fluctuations and noise in the power supply. Best practice is to place this bypass capacitor as close to the supply pin of the sensor as possible.

8.4 Layout

8.4.1 Layout Guidelines

Magnetic fields pass through most non-ferromagnetic materials with no significant disturbance. Embedding Hall effect sensors within plastic or aluminum enclosures and sensing magnets on the outside is common practice. Magnetic fields also easily pass through most printed circuit boards (PCBs), which makes the placement of the magnet on the opposite side of the board possible.

8.4.2 Layout Example

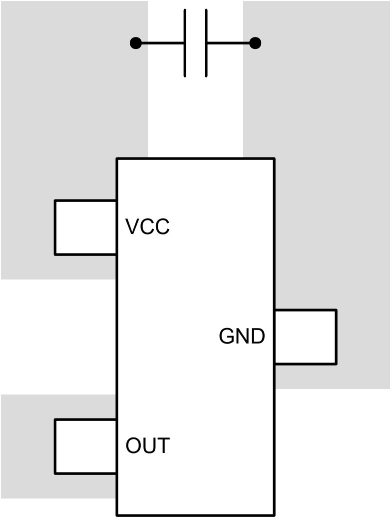


Figure 8-6. SOT-23 Layout Example

9 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed on the TMAG5233 product folder.

9.1 Device Nomenclature

Figure 9-1 shows a legend for reading the complete orderable part numbers for the TMAG5233.

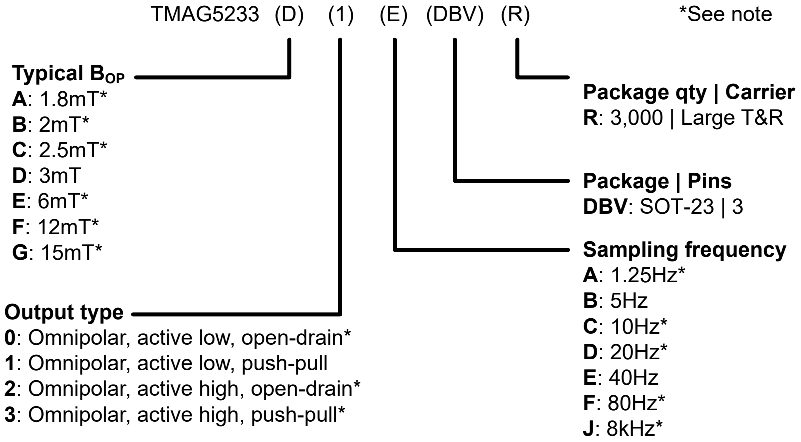


Figure 9-1. Device Nomenclature

Note

Device version in preview, not released. For additional magnetic threshold, output type, and frequency versions please contact your local Texas Instruments representative.

9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

9.4 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.5 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (September 2024) to Revision B (December 2024)	**Page**
• Changed the status of the D1B device version from *Preview* to *Active*	1
• Corrected the Y axis unit from mA to µA for the 40Hz Average I_{CC} vs Temperature graph	5

Changes from Revision * (August 2024) to Revision A (September 2024)	**Page**
• Changed data sheet status from: Advanced Information to: Production Data	1

11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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