TMAG5328 Resistor and Voltage Adjustable, Low-Power Hall-Effect Switch

1 Features

- Supply range: 1.65V to 5.5V
- Operating temperature: –40°C to 125°C
- Adjustable B_{OP} threshold through ADJ pin:
  - 2mT to 15mT range (A1D, A1Z versions)
  - 8mT to 60mT range (D1E version)
- Omnipolar Hall switch
- Push-pull (CMOS) output
- Low power consumption:
  - 20Hz duty cycle (A1D version): 1.4µA
  - 40Hz duty cycle (D1E version): 2.6µA
  - Continuous time (A1Z version): 1.8mA
- Industry-standard SOT-23 package and pinout

2 Applications

- Battery-critical position sensing
- Electricity meter tamper detection
- Cell phone, laptop, or tablet case sensing
- E-locks, smoke detectors, appliances
- Medical devices, IoT systems
- Valve or solenoid position detection
- Contactless diagnostics or activation

3 Description

The TMAG5328 device is a high precision, low-power, resistor adjustable Hall-effect switch sensor operating at low voltage.

The external resistor sets the B_{OP} value for device operation. By following a simple formula, users can calculate the resistor value needed to set up the right B_{OP} value for their designs. The Hysteresis value is fixed and therefore the B_{RP} value is defined as B_{OP}-Hysteresis.

The adjustable threshold feature of the TMAG5328 can help users prototype designs quickly and make last minute modifications in case of unexpected changes, enabling reuse across different platforms.

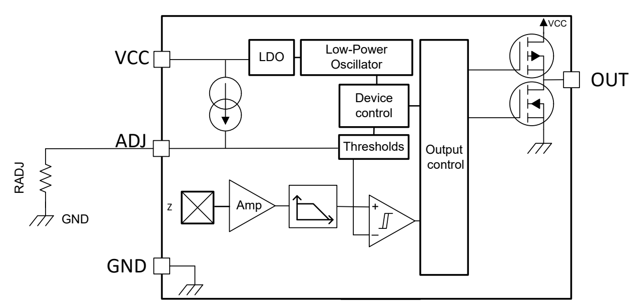
When the applied magnetic flux density exceeds the B_{OP} threshold, the device outputs a low voltage. The output stays low until the flux density decreases to less than B_{RP}, and then the output drives a high voltage. By incorporating an internal oscillator, the device samples the magnetic field and updates the output at a specified rate. The TMAG5328 features an omnipolar magnetic response.

The device operates from a V_{CC} range of 1.65V to 5.5V, and is packaged in a standard SOT-23-6 package.

Package Information

PART NUMBER	PACKAGE (1)	PACKAGE SIZE(2)
TMAG5328	DBV (SOT-23, 6)	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.



Typical Schematic

Table of Contents

4 Device Comparison

Table 4-1. Device Comparison

VERSION	ADJUSTABLE B_{OP} RANGE	TYPICAL HYSTERESIS	MAGNETIC RESPONSE	OUTPUT TYPE	SAMPLING RATE	PACKAGE AVAILABLE
TMAG5328A1D	2mT to 15mT	1mT	Omnipolar, active low	Push-pull	20Hz	SOT-23
TMAG5328A1Z	2mT to 15mT	0.5mT	Omnipolar, active low	Push-pull	Continuous	SOT-23
TMAG5328D1E	8mT to 60mT	4mT	Omnipolar, active low	Push-pull	40Hz	SOT-23

5 Pin Configuration and Functions

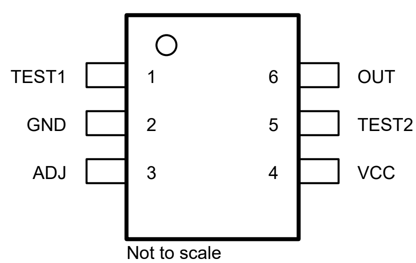


Figure 5-1. DBV Package 6-Pin SOT-23 Top View

Table 5-1. Pin Functions

PIN		I/O	DESCRIPTION
NAME	SOT-23		
ADJ	3	I	This pin is used to set the thresholds up. Can either be connected to a resistor or voltage source.
GND	2	—	Ground reference
OUT	6	O	Omnipolar output that responds to north and south magnetic poles
TEST1	1	—	TI recommends to leave this pin floating
TEST2	5	—	TI recommends connecting this pin to GND
VCC	4	—	1.65V to 5.5V power supply. TI recommends connecting this pin to a ceramic capacitor to ground with a value of at least 0.1µF

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}	–0.3	5.5	V
Pin Voltage	OUT, TEST1	–0.3	V_{CC} + 0.3	V
	TEST2	–0.3	0.3	
	ADJ	–0.3	5.5	
Pin current	OUT, TEST1	–5	5	mA
Magnetic Flux Density, BMAX		Unlimited		T
Junction temperature, T_J			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), per ANSI/ESDA/JEDEC JS-002, all pins[(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
V_{IO}	Pin Voltage. OUT, TEST1	0	V_{CC}	V
	Pin Voltage. TEST2	0	0	
	Pin Voltage. ADJ	0	5	
Io	Pin current. OUT, TEST1	–5	5	mA
T_A	Ambient temperature	–40	125	°C

6.4 Thermal Information

THERMAL METRIC[1]		TMAG5328 SOT-23 (DBV) 6 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	167.6	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	84.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	52.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	32	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	51.9	°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 operating free-air temperature range (unless otherwise noted)

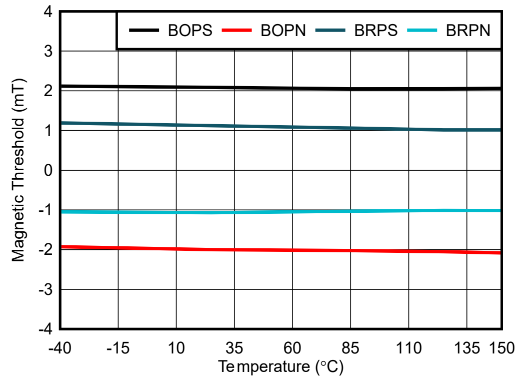
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
ADJ pin						
ADJ_ICC	Current output source			80		µA
ADJ_C	Maximum external capacitance				50	pF
PUSH-PULL OUTPUT DRIVER						
V_{OH}	High-level output voltage	I_{OUT} = –0.5mA	Vcc – 0.35	Vcc – 0.1		V
V_{OL}	Low-level output voltage	I_{OUT} = 0.5mA		0.1	0.3	V
TMAG5328A1D						
fs	Frequency of magnetic sampling			20		Hz
ts	Period of magnetic sampling			50		ms
t_{ACTIVE}	Active time period			65		µs
$I_{CC(PK)}$	Peak current consumption			1.8	3	mA
$I_{CC(SLP)}$	Sleep current consumption			300	600	nA
$I_{CC(AVG)}$	Average current consumption	V_{CC} = 3.3V, T_A = 25°C		1.4	1.6	µA
		V_{CC} = 1.65V to 5.5V			2.3	
TMAG5328A1Z						
f_{BW}	Signal bandwidth			20		kHz
$I_{CC(AVG)}$	Average current consumption	V_{CC} = 1.65V to 5.5V		1.8	2.1	mA
TMAG5328D1E						
fs	Frequency of magnetic sampling			40		Hz
ts	Period of magnetic sampling			25		ms
t_{ACTIVE}	Active time period			65		µs
$I_{CC(PK)}$	Peak current consumption			1.2	2.4	mA
$I_{CC(SLP)}$	Sleep current consumption			300	600	nA
$I_{CC(AVG)}$	Average current consumption	V_{CC} = 3.3V, T_A = 25°C		2.6	3.2	µA
		V_{CC} = 1.65V to 5.5V			3.7	
ALL VERSIONS						
P_{OS}	Power-on state without external magnetic field	$V_{CC} > V_{CCMIN}$		High		
t_{ON}	Power-on time			125		µs

6.6 Magnetic Characteristics

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

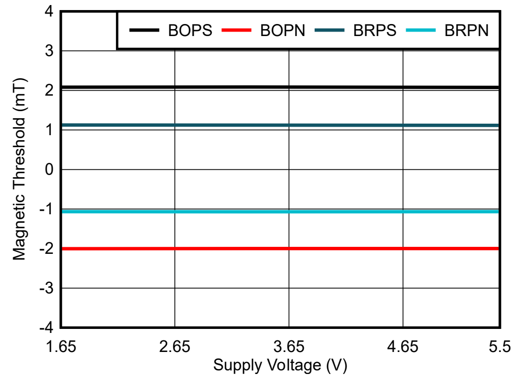
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
TMAG5328A1D						
$B_{OP(Range\ A)}$	Adjustable Operate Point		±2		±15	mT
$B_{RP(Range\ A)}$	Adjustable Release Point		±1		±14	mT
$V_{ADJ\ (Range\ A)}$	Voltage range		160		1200	mV
$R_{ADJ\ (Range\ A)}$	Resistor range		2		15	kOhm
$B_{OP}(R_{ADJ})$	B_{OP}/R			±1		mT/ kOhm
$B_{OP\_ACC}(R_{ADJ})$	B_{OP} Accuracy (B_{OPSET} ± B_{OP})	2mT ≤ B_{OPSET} < 6mT	–0.85		0.85	mT
		6mT ≤ B_{OPSET} ≤ 15mT	–1.75		1.75	
$B_{RP\_ACC}(R_{ADJ})$	B_{RP} Accuracy (B_{RPSET} ± B_{RP})	2mT ≤ B_{OPSET} < 6mT	–1		1	mT
		6mT ≤ B_{OPSET} ≤ 15mT	–2.1		2.1	
$B_{HYS}(R_{ADJ})$	Magnetic hysteresis	$\lvert B_{OP} – B_{RP}\rvert$	0.25	1	1.6	mT
TMAG5328A1Z						
$B_{OP(Range\ A)}$	Adjustable Operate Point		±2		±15	mT
$B_{RP(Range\ A)}$	Adjustable Release Point		±1.5		±14.5	mT
$V_{ADJ\ (Range\ A)}$	Voltage range		160		1200	mV
$R_{ADJ\ (Range\ A)}$	Resistor range		2		15	kOhm
$B_{OP}(R_{ADJ})$	B_{OP}/R			±1		mT/ kOhm
$B_{OP\_ACC}(R_{ADJ})$	B_{OP} Accuracy (B_{OPSET} ± B_{OP})	2mT ≤ B_{OPSET} < 6mT	–0.67		0.97	mT
		6mT ≤ B_{OPSET} ≤ 15mT	–1.37		2.42	
$B_{RP\_ACC}(R_{ADJ})$	B_{RP} Accuracy (B_{RPSET} ± B_{RP})	2mT ≤ B_{OPSET} < 6mT	–0.91		1.03	mT
		6mT ≤ B_{OPSET} ≤ 15mT	–1.42		2.36	
$B_{HYS}(R_{ADJ})$	Magnetic hysteresis	$\lvert B_{OP} – B_{RP}\rvert$	0.04	0.5	1.2	mT
TMAG5328D1E						
$B_{OP\ (Range)}$	Adjustable operate point range		±8		±60	mT
$B_{RP\ (Range)}$	Adjustable Release Point range		±4.5		±56.5	mT
$V_{ADJ\ (Range)}$	Voltage range		160		1200	mV
$R_{ADJ\ (Range)}$	Resistor range		2		15	kOhm
B_{OP}	B_{OP}/R			±4.256		mT/ kOhm
B_{OP_ACC}	B_{OP} Accuracy (B_{OPSET} ± B_{OP})	8mT ≤ B_{OPSET} < 30mT	–3.5		+3.8	mT
		30mT ≤ B_{OPSET} ≤ 60mT	–8.9		+7.6	
B_{RP_ACC}	B_{RP} Accuracy (B_{RPSET} ± B_{RP})	8mT ≤ B_{OPSET} < 30mT	–3.8		+4.0	mT
		30mT ≤ B_{OPSET} ≤ 60mT	–9.8		+7.3	
B_{HYS}	Magnetic hysteresis	$\lvert B_{OP} – B_{RP}\rvert$	2	4	5.9	mT

6.7 Typical Characteristics



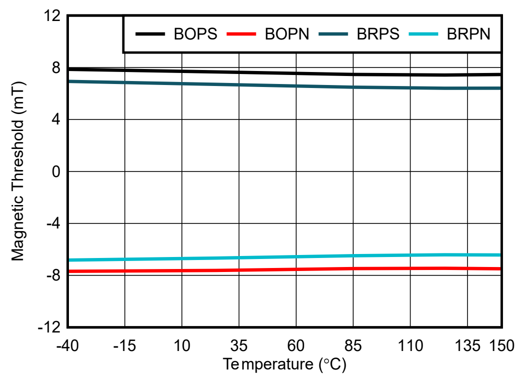
V_{CC} = 3.3V
Version: A1D

Figure 6-1. 2mT Magnetic Threshold vs Temperature



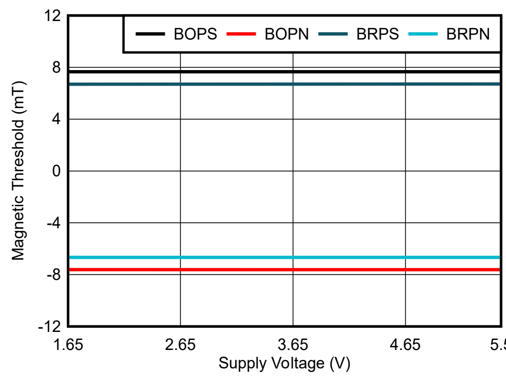
T_A = 25°C
Version: A1D

Figure 6-2. 2mT Magnetic Threshold vs Supply



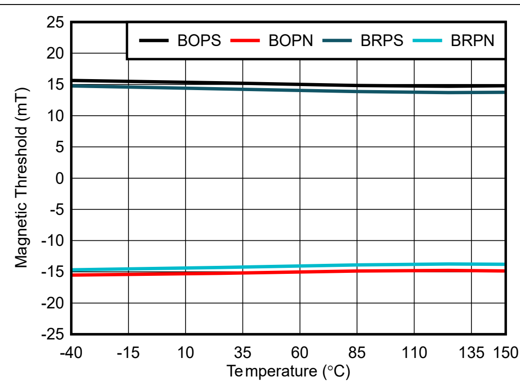
V_{CC} = 3.3V
Version: A1D

Figure 6-3. 7.5mT Magnetic Threshold vs Temperature



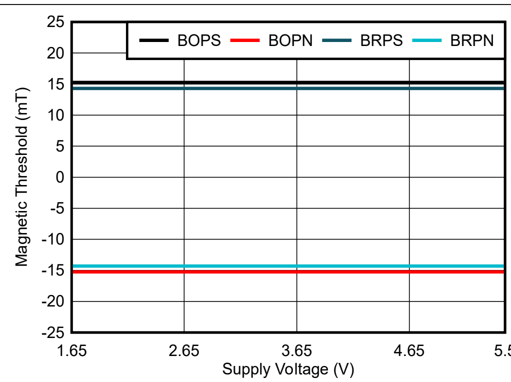
T_A = 25°C
Version: A1D

Figure 6-4. 7.5mT Magnetic Threshold vs Supply



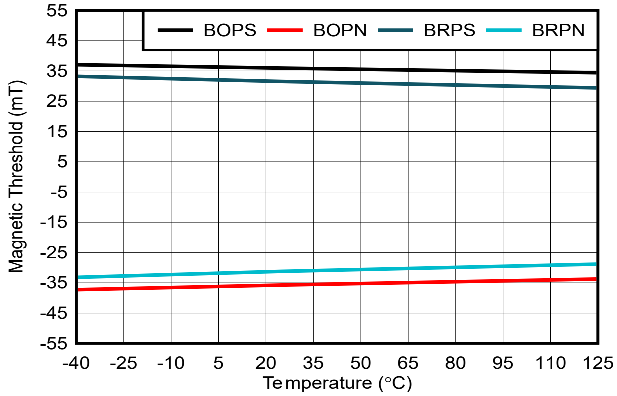
V_{CC} = 3.3V
Version: A1D

Figure 6-5. 15mT Magnetic Threshold vs Temperature



T_A = 25°C
Version: A1D

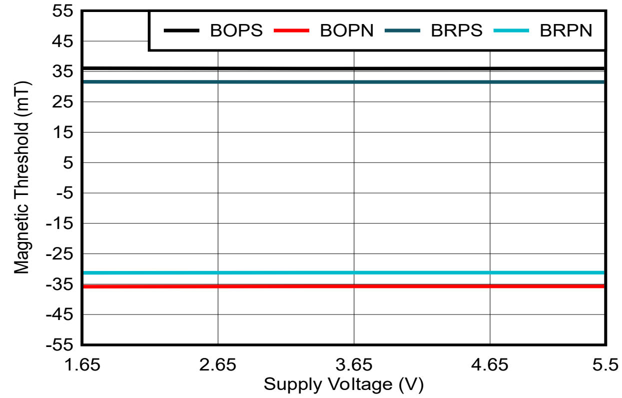
Figure 6-6. 15mT Magnetic Threshold vs Supply



V_{CC} = 3.3V

Version: D1E

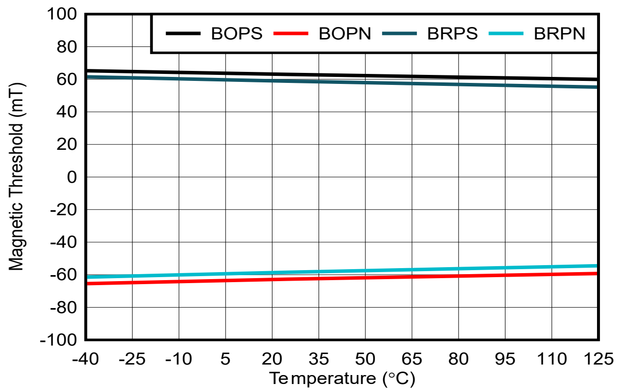
Figure 6-7. 30mT Magnetic Threshold vs Temperature



T_A = 25°C

Version: D1E

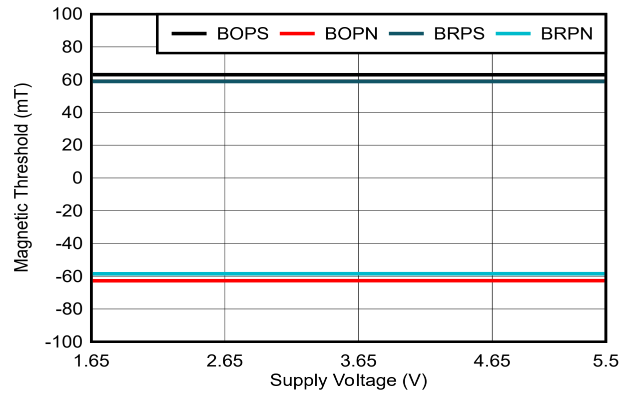
Figure 6-8. 30mT Magnetic Threshold vs Supply



V_{CC} = 3.3V

Version: D1E

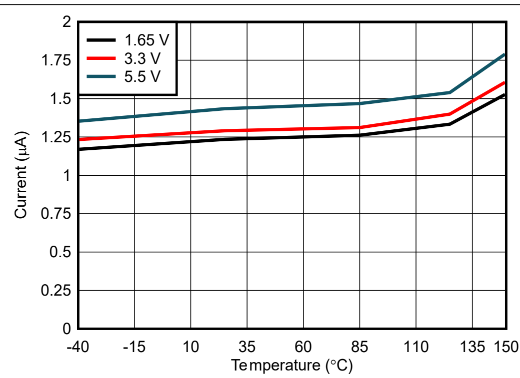
Figure 6-9. 60mT Magnetic Threshold vs Temperature



T_A = 25°C

Version: D1E

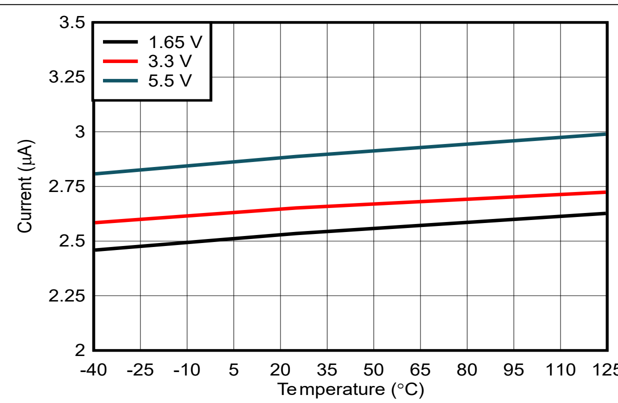
Figure 6-10. 60mT Magnetic Threshold vs Supply



Sampling Rate = 20Hz

Version: A1D

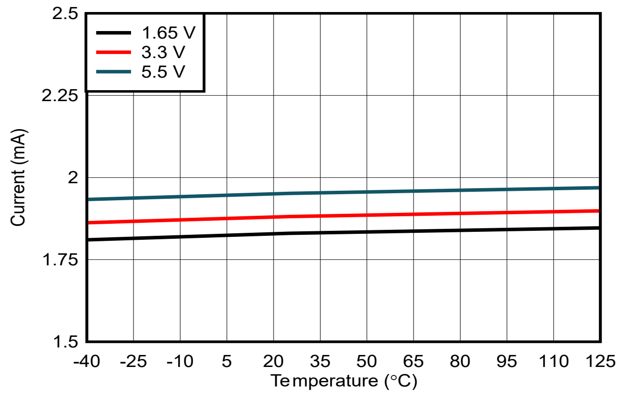
Figure 6-11. Average I_{CC} vs Temperature



Sampling Rate = 40Hz

Version: D1E

Figure 6-12. Average I_{CC} vs Temperature



Continuous sampling

Version: A1Z

Figure 6-13. Average I_{CC} vs Temperature

7 Detailed Description

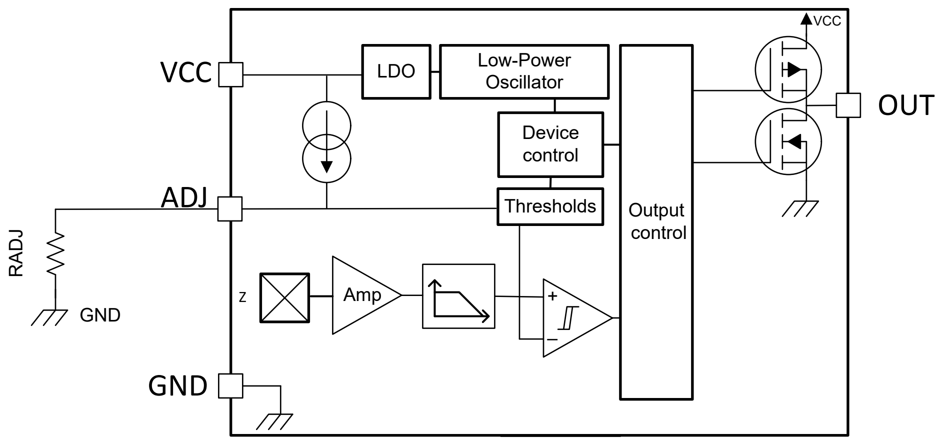
7.1 Overview

The TMAG5328 device is a magnetic sensor with a digital output that indicates when the magnetic flux density threshold has been crossed. The device integrates a Hall-effect element, analog signal conditioning, and a low-frequency oscillator that enables ultra-low average power consumption.

While most Hall-effect sensors have fixed thresholds, the TMAG5328 offers an extra pin that allows the user to set up a specific threshold of operation. This pin can either be connected to a resistor or a voltage source. While the value can be set at production, it is also possible to allow dynamic change of either the resistor value or the voltage value to dynamically change the threshold value.

Operating from a 1.65V to 5.5V supply, the device periodically measures magnetic flux density, updates the output, and enters into a low-power sleep state.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Magnetic Flux Direction

Magnetic flux that travels from the bottom to the top of the package is considered positive in this data sheet. This condition exists when a south magnetic pole is near the top of the package. Magnetic flux that travels from the top to the bottom of the package results in negative millitesla values.

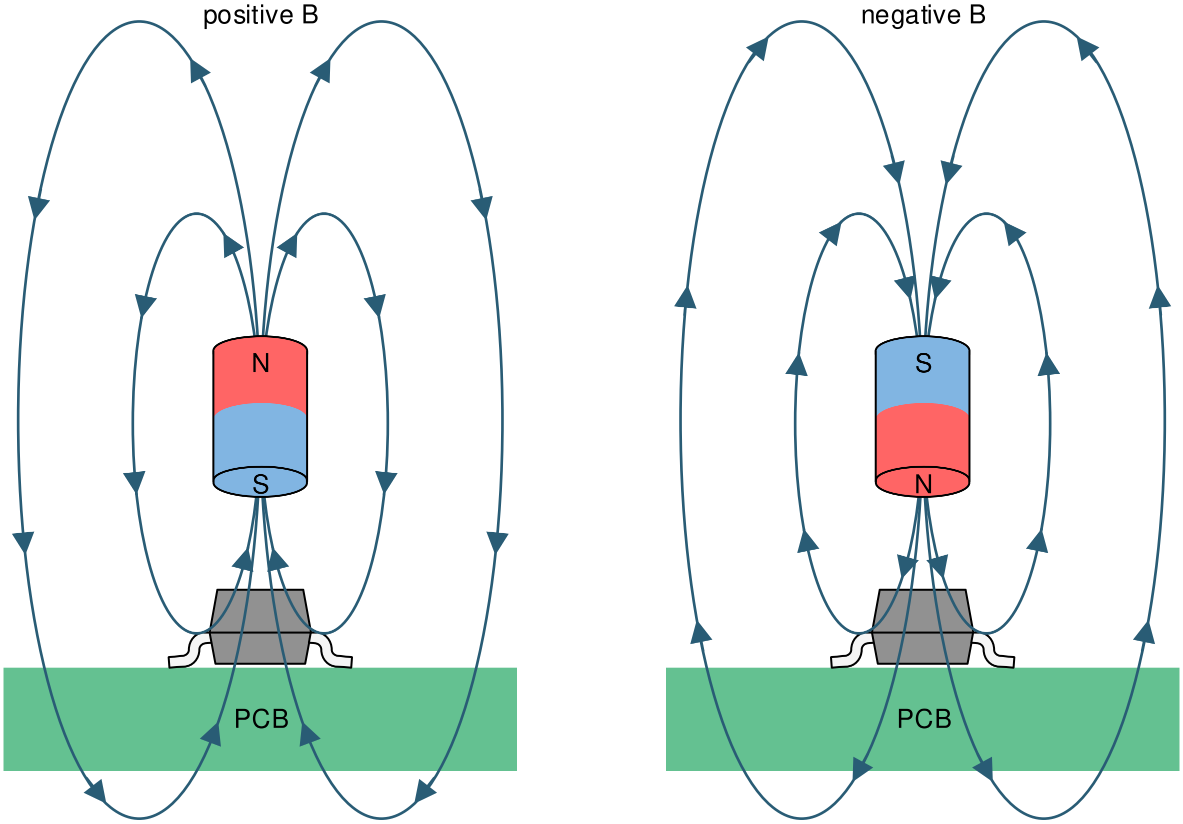


Figure 7-1. Flux Direction Polarity

7.3.2 Magnetic Response

The TMAG5328 has an omnipolar functionality, meaning the device responds to both positive and negative magnetic flux densities, as shown in Figure 7-2.

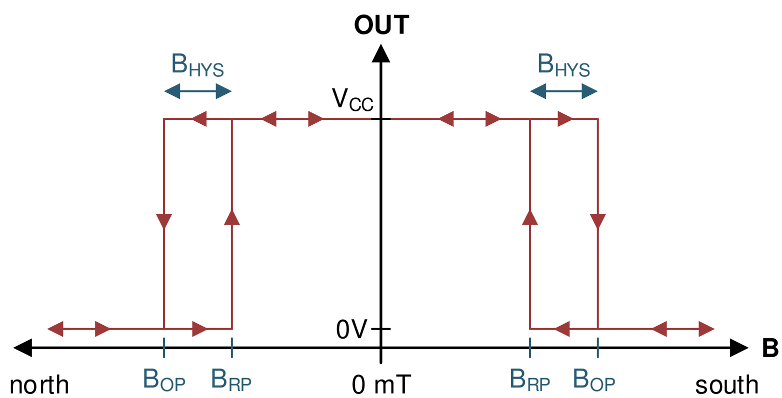


Figure 7-2. Omnipolar Functionality

7.3.3 Output Type

The TMAG5328 has a push-pull (CMOS) output. The push-pull output allows for the lowest system power consumption, because there is no current leakage path when the output drives high or low.

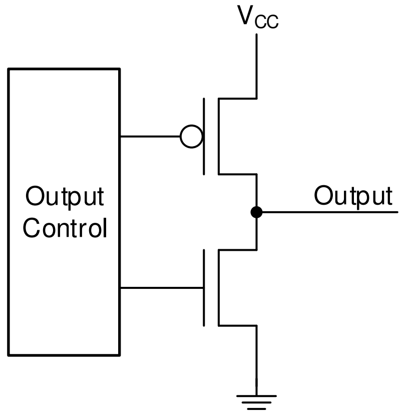


Figure 7-3. Push-Pull Output (Simplified)

7.3.4 Sampling Rate

When the TMAG5328 device powers up, the device measures the first magnetic sample and sets the output within the t_{ON} time. For the duty-cycled versions (A1D, D1E), the output is latched and the device enters an ultra-low-power sleep state. After each t_{Active} 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. While in active mode, the part goes through different steps. The content of the OTP (One-Time-Programmable Memory) is loaded first, and this step takes about 35µs and consumes around 350µA. For the next 5µs, the current source starts up and settles. The part now consumes around 650µA in this step. Finally, the part conducts the Hall sensor conversion for about 25µs and consumes the peak current of around 2mA.

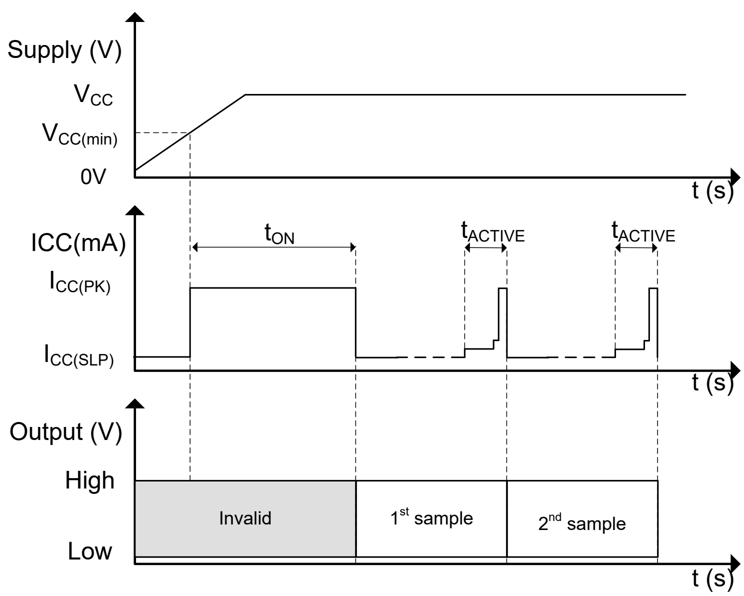


Figure 7-4. Timing Diagram for Duty-Cycled Versions

The continuous time version (A1Z) stays active after the t_{ON} time has passed (does not go to sleep), enabling a fast signal bandwidth of up to 20kHz (f_{BW}).

7.3.5 Adjustable Threshold

While most Hall-effect switch sensors have fixed magnetic characteristics, the TMAG5328 offers a wide range of adjustable thresholds. The user can use the ADJ pin to set the value of B_{OP} threshold. This pin can be used in two different ways. A resistor or a voltage source can be applied on ADJ. In both scenarios, the resistor or voltage value defines the position of the B_{OP}. While the B_{OP} can be adjusted, the hysteresis has a fixed value. B_{RP} is therefore defined as $B_{OP} – B_{HYS}$.

The duty-cycled versions (A1D, D1E) have an 80µA current generated on pin ADJ when the part goes into active mode. The device then reads the ADJ pin and defines the value of B_{OP}. The TMAG5328 supports adjusting the B_{OP} dynamically. If the ADJ pin value is adjusted while the sensor is in sleep mode, the B_{OP} updates at the next active period of the device. Consequently, the maximum time the internal B_{OP} threshold can take to update for duty-cycled versions is equal to the period of magnetic sampling, t_s.

The continuous time version (A1Z) has an 80µA current continuously generated on pin ADJ to dynamically adjust the B_{OP} threshold if desired. The maximum time the internal B_{OP} threshold can take to update for this continuous time version is 25µs.

7.3.5.1 Adjustable Resistor

One way to set up the B_{OP} is to connect a resistor to the ADJ pin. The device generates a fixed current that is injected in the external resistor, and this generates a voltage that represents the B_{OP} value. The relationship between B_{OP} and resistance is defined as B_{OP}(mT) = R_{ADJ}(kΩ) for the A1D and A1Z device versions, or B_{OP}(mT) = R_{ADJ}(kΩ) × 4 for the D1E version. Note that the generated current on the ADJ pin is only present when the device is in active mode and turns OFF when the device is in sleep mode. As a result, the voltage on the ADJ pin is only present when the device is in active mode, which is a small duration compared to the time the device is in sleep mode.

The device B_{OP} must be set to any value between 2mT and 15mT (A1D, A1Z versions) or 8mT to 60mT (D1E version). R_{ADJ} must be set between 2kΩ and 15kΩ to operate in this range. Operating above and beyond those limits is not recommended and can result in either getting the wrong threshold set or locking up the device into a specific state without the possibility of exiting.

Figure 7-5 and Figure 7-6 illustrate the relationship between B_{OP} and R_{ADJ}.

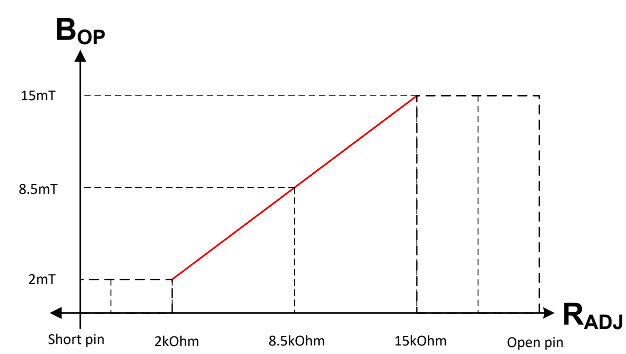


Figure 7-5. B_{OP} vs R_{ADJ} (A1D, A1Z versions)

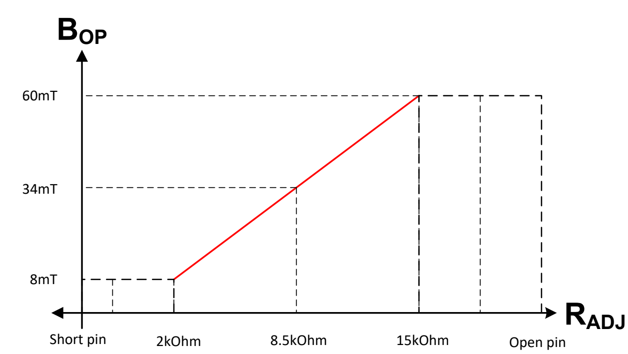


Figure 7-6. B_{OP} vs R_{ADJ} (D1E version)

7.3.5.2 Adjustable Voltage

One other way to setup the B_{OP} is to apply a voltage to the ADJ pin. This voltage is directly proportional to the B_{OP} value. The relationship between B_{OP} and voltage is defined as B_{OP}(mT)= V_{ADJ}(mV) × 0.0125 for the A1D and A1Z device versions, or B_{OP}(mT) = V_{ADJ}(mV) × 0.05 for the D1E version. To apply a voltage on the ADJ pin, the voltage source must be able to settle within 4µs after being exposed to a 80µA current on the ADJ pin.

The device B_{OP} must be set to any value between 2mT and 15mT (A1D, A1Z versions) or 8mT to 60mT (D1E version). V_{ADJ} must be set between 160mV and 1200mV to operate in this range. Operating above and beyond those limits is not recommended and can result in either getting the wrong threshold set or locking up the device into a specific state without the possibility of exiting.

Figure 7-7 and Figure 7-8 illustrate the relationship between B_{OP} and V_{ADJ}.

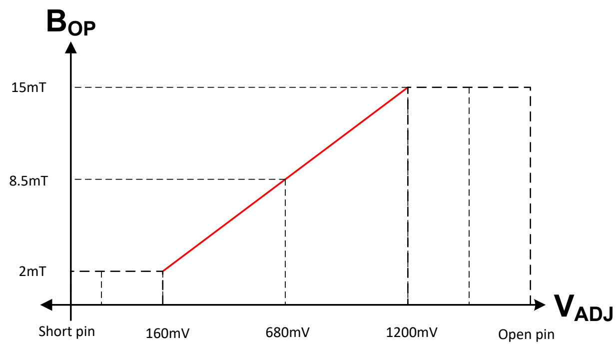


Figure 7-7. B_{OP} vs R_{ADJ} (A1D, A1Z versions)

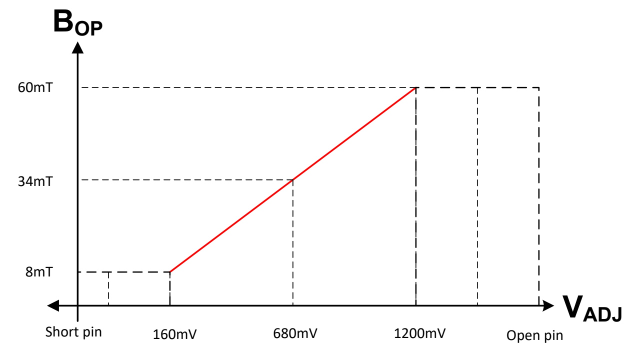


Figure 7-8. B_{OP} vs R_{ADJ} (D1E version)

7.3.6 Hall Element Location

Figure 7-9 shows the sensing element location inside the device.

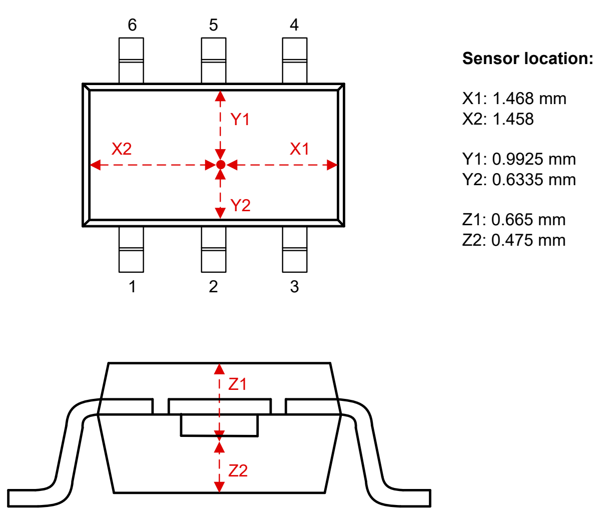


Figure 7-9. Hall Element Location

7.4 Device Functional Modes

The TMAG5328 device has one mode of operation that applies 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 TMAG5328 device is typically used to detect the proximity of a magnet. The magnet is often attached to a movable component in the system.

8.1.1 Valid TMAG5328 Configurations

The TMAG5328 B_{OP} is set by connecting a resistor or a voltage source to the ADJ pin. Figure 8-1 shows how to use resistor R1 to set the B_{OP}. Figure 8-2 shows hows to use a DAC as a voltage source for setting the B_{OP}. Using the DAC allows the user to dynamically change the B_{OP} with software. To use a DAC, the output of the DAC must settle within 4μs after the 80μA current source of the ADJ pin is turned ON.

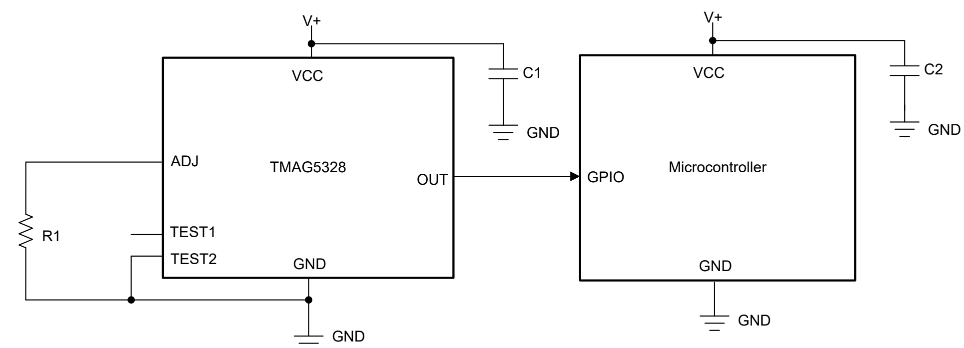


Figure 8-1. Setting B_{OP} of One TMAG5328 Device Using a Resistor

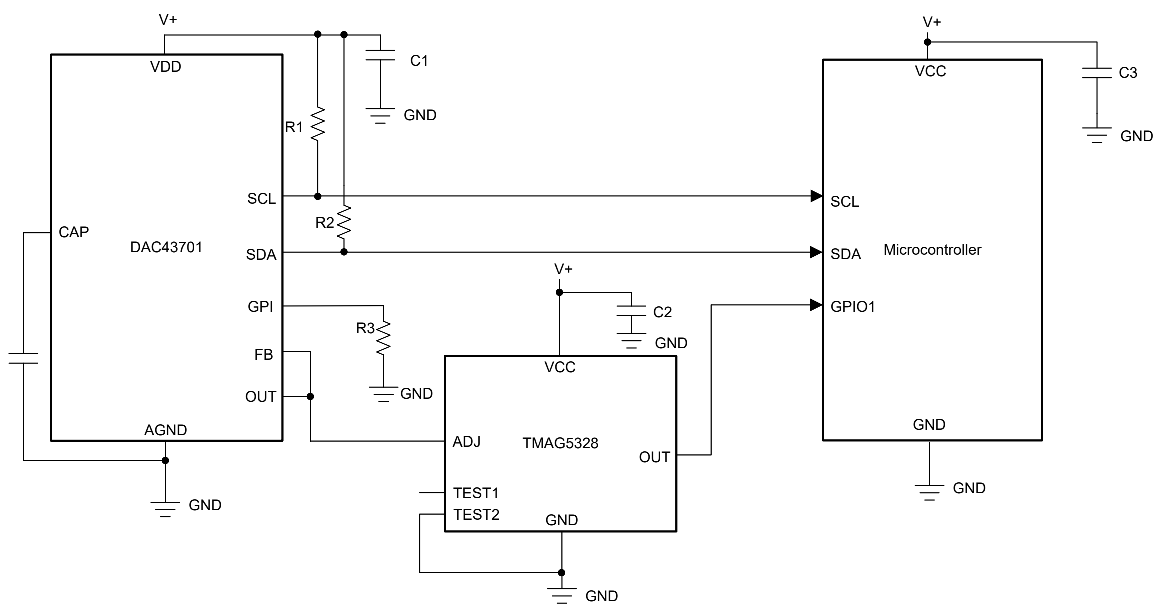


Figure 8-2. Setting B_{OP} of One TMAG5328 Device Using a DAC

As a DAC alternative, Figure 8-3 shows how a voltage divider can be used as a voltage source. In Figure 8-3, an operational amplifier is placed between the voltage divider and the ADJ pin so that the voltage fed to the ADJ pin is not impacted by the internal current source of the TMAG5328 when the current source is turned ON. To use an op amp, the output of the op amp must settle within 4µs after the 80µA current source of the ADJ pin is turned ON.

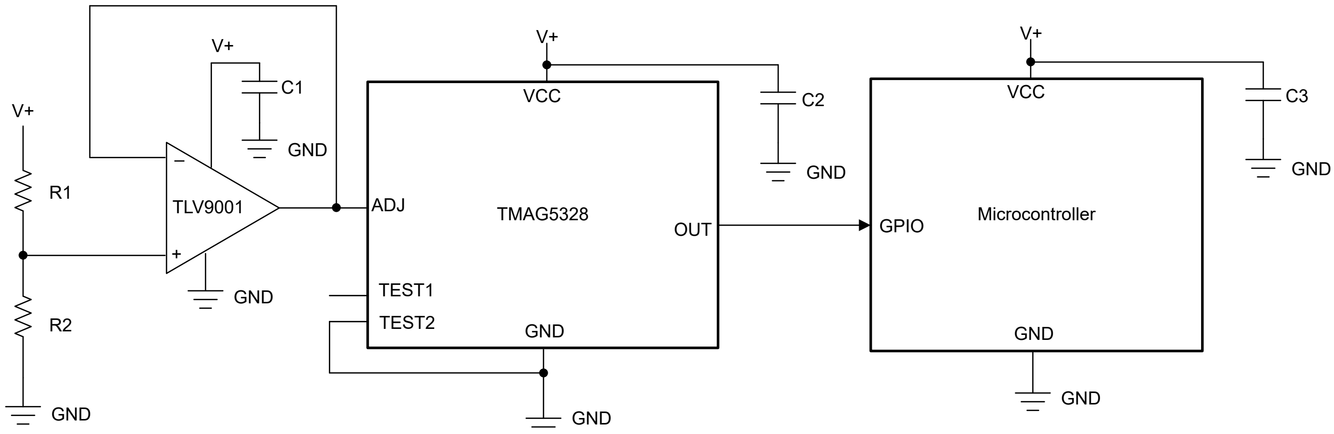


Figure 8-3. Setting B_{OP} of One TMAG5328 Device Using a Voltage Divider

A potentiometer or rheostat can be integrated into a voltage divider, and the user can adjust this potentiometer to dynamically update the B_{OP}. Figure 8-4 shows how to use a potentiometer in a voltage divider to set the B_{OP} of the TMAG5328. The maximum output voltage, which determines the maximum B_{OP}, is set based on the values of resistors R1 and R3. The minimum output voltage, which determines the minimum B_{OP}, is set based on the values of the maximum potentiometer resistance, R1 resistance, and R3 resistance. Select a minimum output voltage greater than 0.16V and a maximum output voltage less than 1.2V.

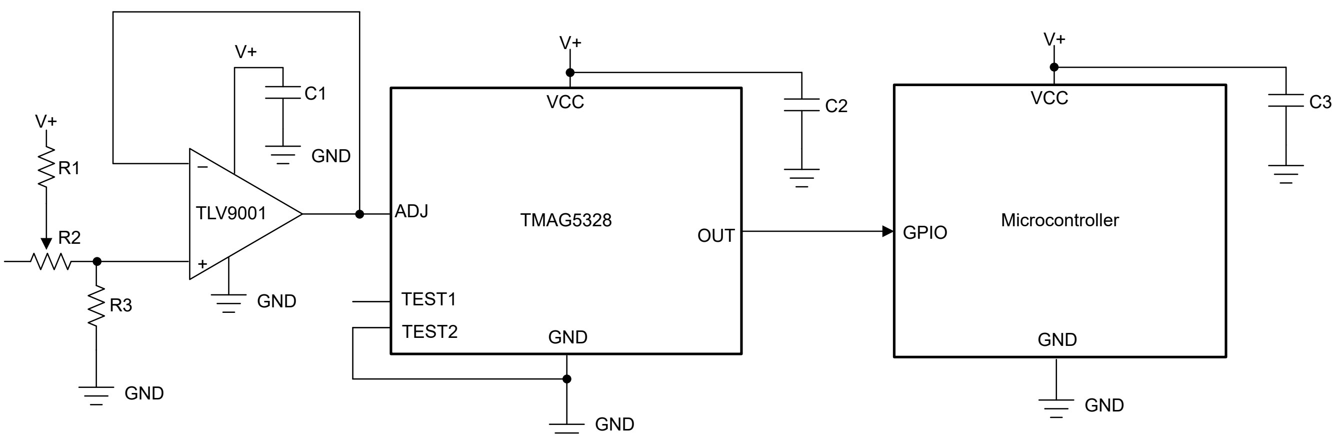


Figure 8-4. Setting B_{OP} of One TMAG5328 Device Using a Voltage Divider and Potentiometer

Figure 8-5 shows how the TMAG5328 internal current source can drive a potentiometer or rheostat instead of a voltage divider. In this implementation, make sure the resistor R2 is at least 2kΩ to ensure that the ADJ resistance is always above the minimum 2kΩ. The sum of the maximum potentiometer resistance and the resistance of R1 must also be less than 15kΩ.

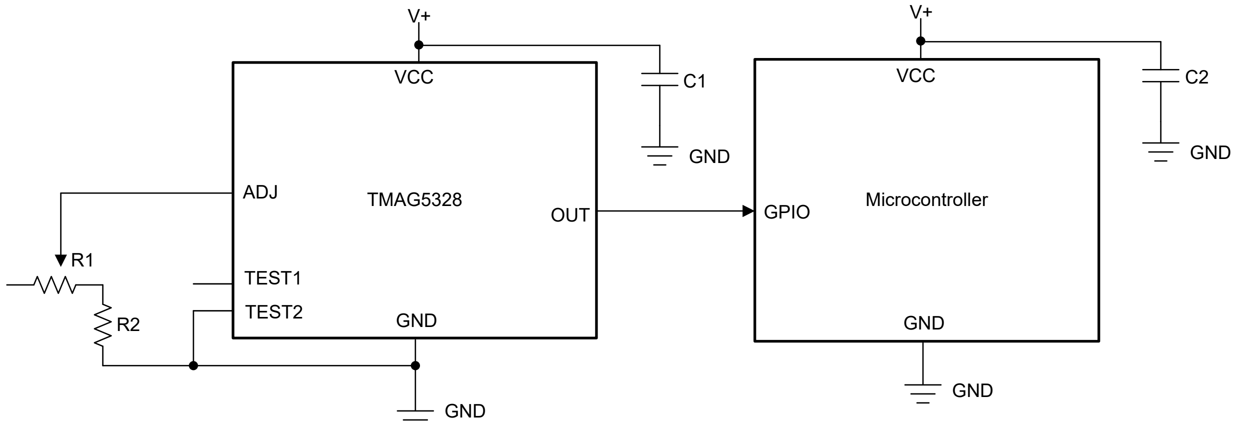


Figure 8-5. Setting B_{OP} of One TMAG5328 Device Using a Potentiometer and the TMAG5328 Internal Current Source

Multiple TMAG5328 devices can be used in the same system. When setting the B_{OP} using a resistor, TI recommends that each TMAG5328 has a ADJ resistor, even if multiple TMAG5328 devices have the same ADJ resistor value. Figure 8-6 shows an example implementation that has three TMAG5328 devices. If each device is set to the same B_{OP}, then the resistances of R1, R2, and R3 are equal.

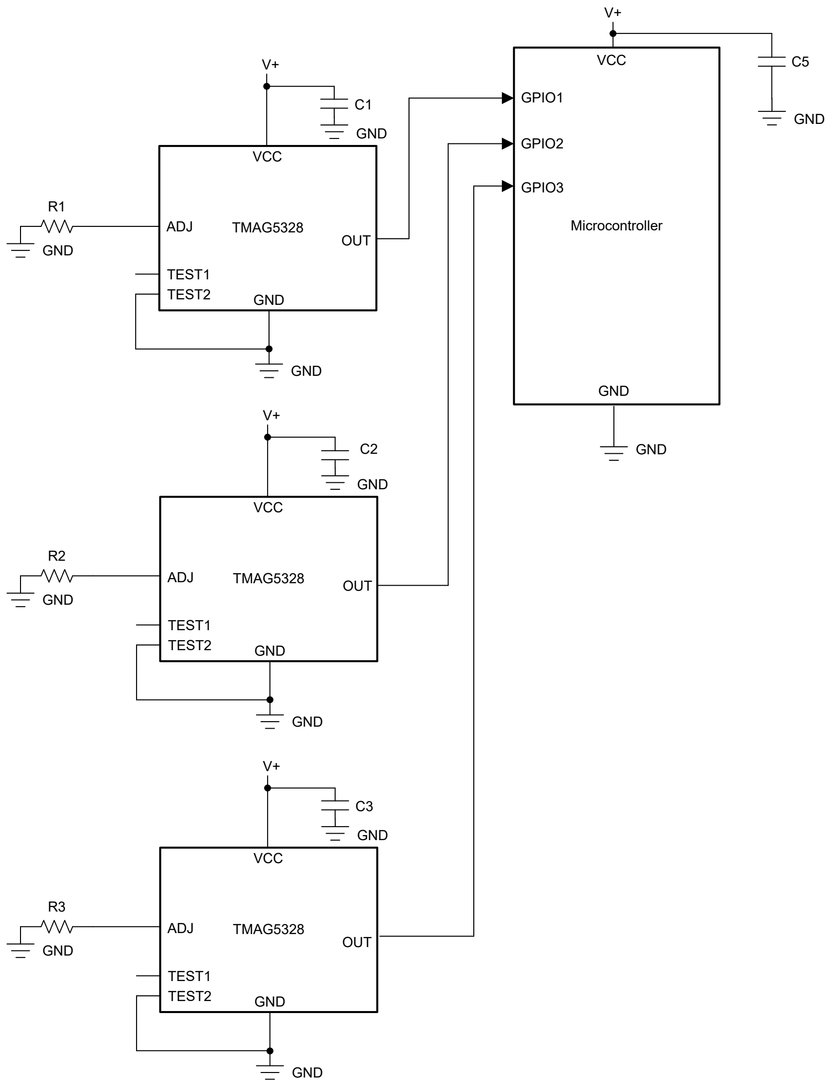


Figure 8-6. Setting B_{OP} of Three TMAG5328 Devices Using Three Resistors

When setting the B_{OP} using a DAC, one DAC can be used to set the ADJ pin voltage of multiple devices only if the output of the DAC can sink the current from all of the TMAG5328 devices. Figure 8-7 shows an example of a DAC driving the ADJ pin of three TMAG5328 devices. A DAC can only work reliably in this specific scenario if the output of the DAC can settle within 4µs after being exposed to the three ADJ current sources. Each current source is 80µA, therefore the DAC can only reliably work if the output of the DAC can settle within 4µs after being exposed to 80 x 3 = 240µA of current.

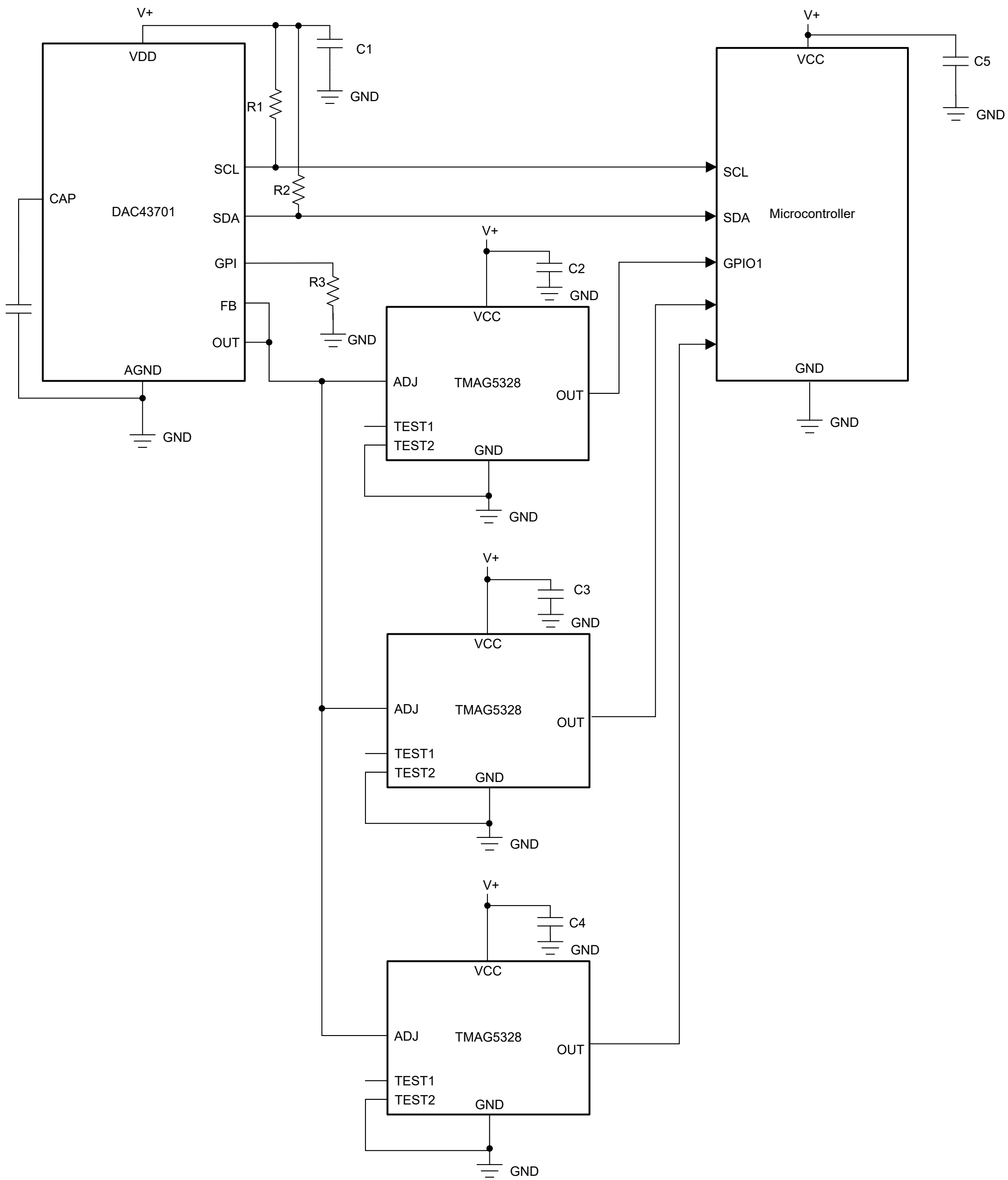


Figure 8-7. Setting B_{OP} of Three TMAG5328 Devices Using a DAC

8.2 Typical Applications

The TMAG5328 can be used in a large variety of industrial applications. For almost all these applications, the sensor is fixed and the magnet is attached to a movable component in the system.

8.2.1 Refrigerator Door Open/Close Detection

This application section describes how to use the same device for two identical applications with different mechanical characteristic.

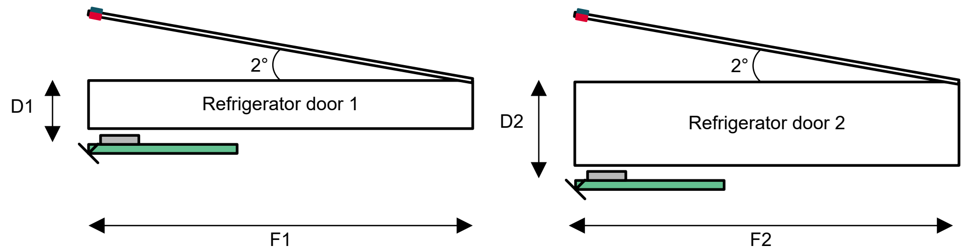


Figure 8-8. Refrigerator 1 and Refrigerator 2 Principal Diagram

8.2.1.1 Design Requirements

For this design example, use the parameters listed in Table 8-1.

Table 8-1. Design Parameters for Fridge 1

DESIGN PARAMETER	EXAMPLE VALUE
Hall-effect device	TMAG5328A1D
V_{CC}	5V
Magnet	10mm cubic N35
D1	7.025mm
F1	500mm
Door opening angle	2°
Calculated threshold needed (B_{OP})	7.87mT
R_{ADJ}	7.87kΩ

Table 8-2. Design Parameters for Fridge 2

DESIGN PARAMETER	EXAMPLE VALUE
Hall-effect device	TMAG5328A1D
V_{CC}	5V
Magnet	10mm cubic N35
D2	16.08mm
F2	500mm
Door opening angle	2°
Calculated threshold needed (B_{OP})	3.49mT
R_{ADJ}	3.48kΩ

8.2.1.2 Detailed Design Procedure

For both applications, the Hall sensor is used to detect if the refrigerator door is open or closed. Both refrigerator doors are different from each other and therefore have different mechanical design. This means the Hall sensor and the magnet are positioned differently from each other. In other terms, if the user wants to detect a specific distance for both refrigerator doors, they must use either a different magnet or a different sensor. For the purpose of this application, there is no flexibility in the choice of magnet. The electronic board can also be reused across platforms and therefore can use the same sensor.

The TMAG5328 is a resistor adjustable Hall-effect switch that allows the user to set up whatever threshold is needed between 2mT and 15mT.

For this application, the refrigerator door manufacturer can use the same printed circuit board (PCB) with the same semiconductor content and only has to change the resistor value depending on which refrigerator version is manufactured.

For both refrigerator doors, the opening angle is the same. Now refrigerator door 1 is a thinner model than refrigerator door 2. This means the PCB is located further away for refrigerator door 2 and therefore the sensitivity required to detect the position of the door is impacted.

Knowing the door dimensions, the door opening angle required, and the distance from the magnet to the PCB, it is possible to use a simulation tool that can calculate the magnet strength at the desired position. For refrigerator door 1, the sensitivity calculated is 7.87mT at a distance of 7.025mm. For Refrigerator 2, the sensitivity is 3.49mT at a distance of 16.08mm. Based on those values, a resistor value can be selected from the E48 series. A resistor of 7.87kΩ can be used for refrigerator door 1 and resistor of 3.48kΩ can be used for refrigerator door 2.

8.3 Power Supply Recommendations

The TMAG5328 device is powered from 1.65V to 5.5V DC power supplies. A decoupling capacitor close to the device must be used to provide local energy with minimal inductance. TI recommends using a ceramic capacitor with a value of at least 0.1µF.

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, which makes placing the magnet on the opposite side possible.

8.4.2 Layout Example

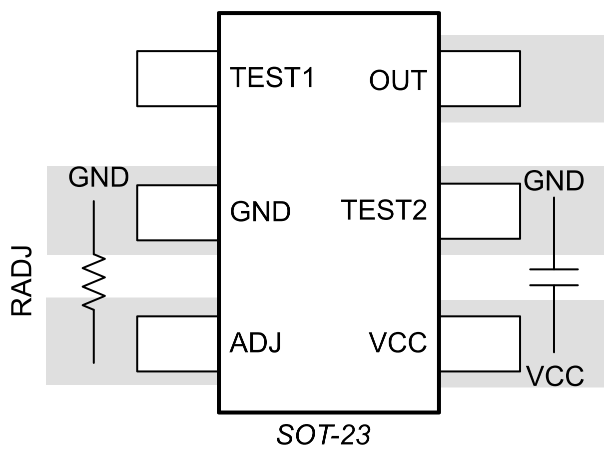


Figure 8-9. SOT-23 Layout Example

9 Device and Documentation Support

9.1 Device Nomenclature

Figure 9-1 shows a legend for reading the complete device name for the TMAG5328.

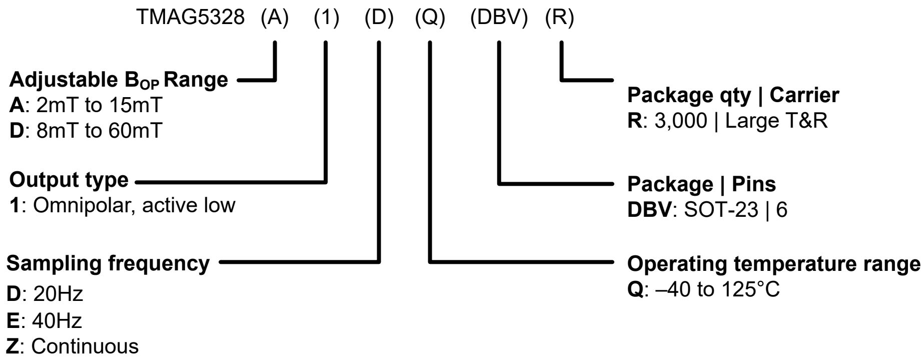


Figure 9-1. TMAG5328 Device Nomenclature

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 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

9.5 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.

9.6 Glossary

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

10 Revision History

Changes from Revision B (May 2024) to Revision C (April 2025) — **Page**

- Added D1E device version to the data sheet.......... 1
- Added the *Device Comparison* section.......... 2
- Removed the Junction-to-case (bottom) thermal metric in the *Thermal Information* table.......... 4
- Added D1E variant information to *Electrical Characteristics* 4
- Corrected A1D Parameter description for B_{OP_ACC} 5
- Corrected A1D Parameter description for B_{RP_ACC} 5

- Updated BOP and BRP accuracy values.......... 5
- Corrected A1Z parameter description for B_{OP_ACC}.......... 5
- Corrected A1Z parameter description for B_{RP_ACC}.......... 5
- Added D1E variant information to *Magnetic Characteristics*.......... 5
- Added *Average ICC vs Temperature* graphs for the A1Z and D1E device versions in the *Typical Characteristics* section.......... 6
- Added equations and graphs to the *Adjustable Resistor* section.......... 12
- Added equations and graphs to the *Adjustable Voltage* section.......... 13

Changes from Revision A (June 2022) to Revision B (May 2024) **Page**

- Added A1Z device version to the data sheet.......... 1

Changes from Revision * (December 2021) to Revision A (June 2022) **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.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TMAG5328A1DQDBVR	Active	Production	SOT-23 (DBV) | 6	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	A1D
TMAG5328A1DQDBVR.A	Active	Production	SOT-23 (DBV) | 6	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	A1D
TMAG5328A1ZQDBVR	Active	Production	SOT-23 (DBV) | 6	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	A1Z
TMAG5328A1ZQDBVR.A	Active	Production	SOT-23 (DBV) | 6	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	A1Z
TMAG5328D1EQDBVR	Active	Production	SOT-23 (DBV) | 6	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

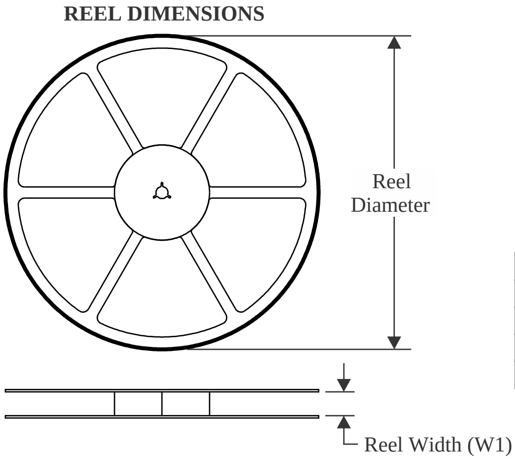
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

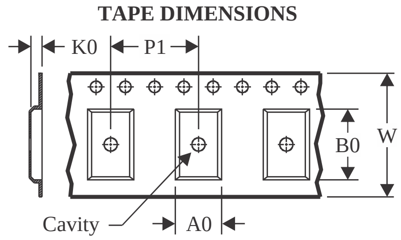
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

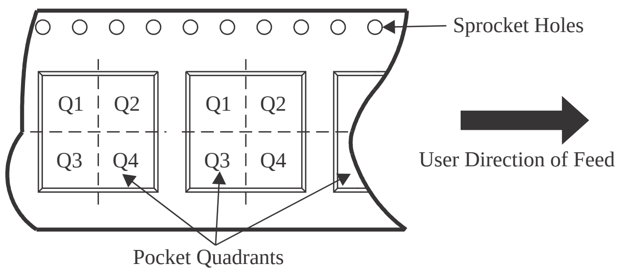
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION





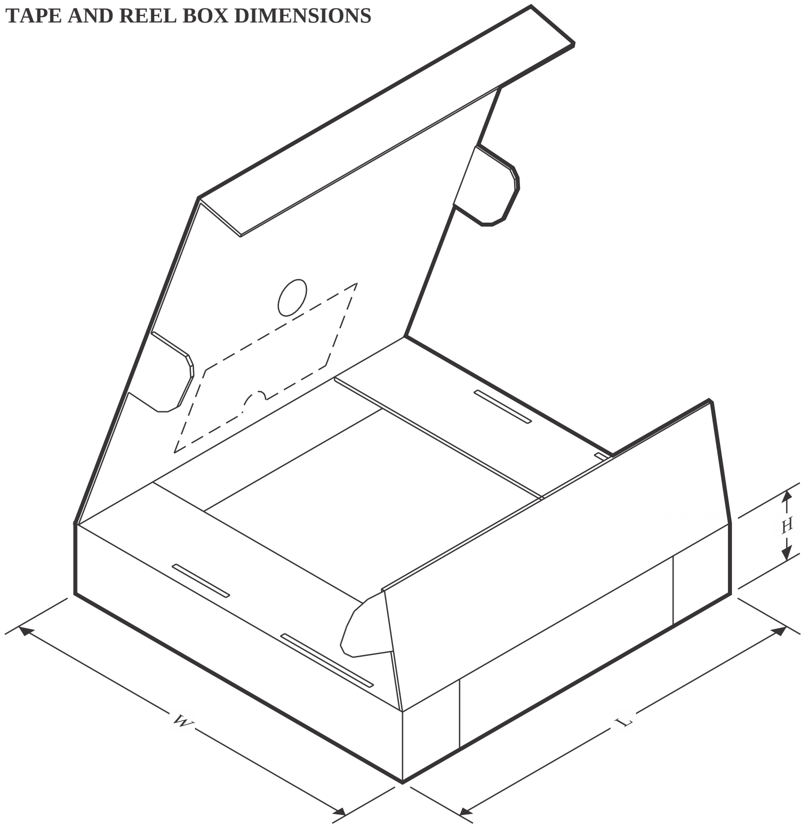
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*All dimensions are nominal

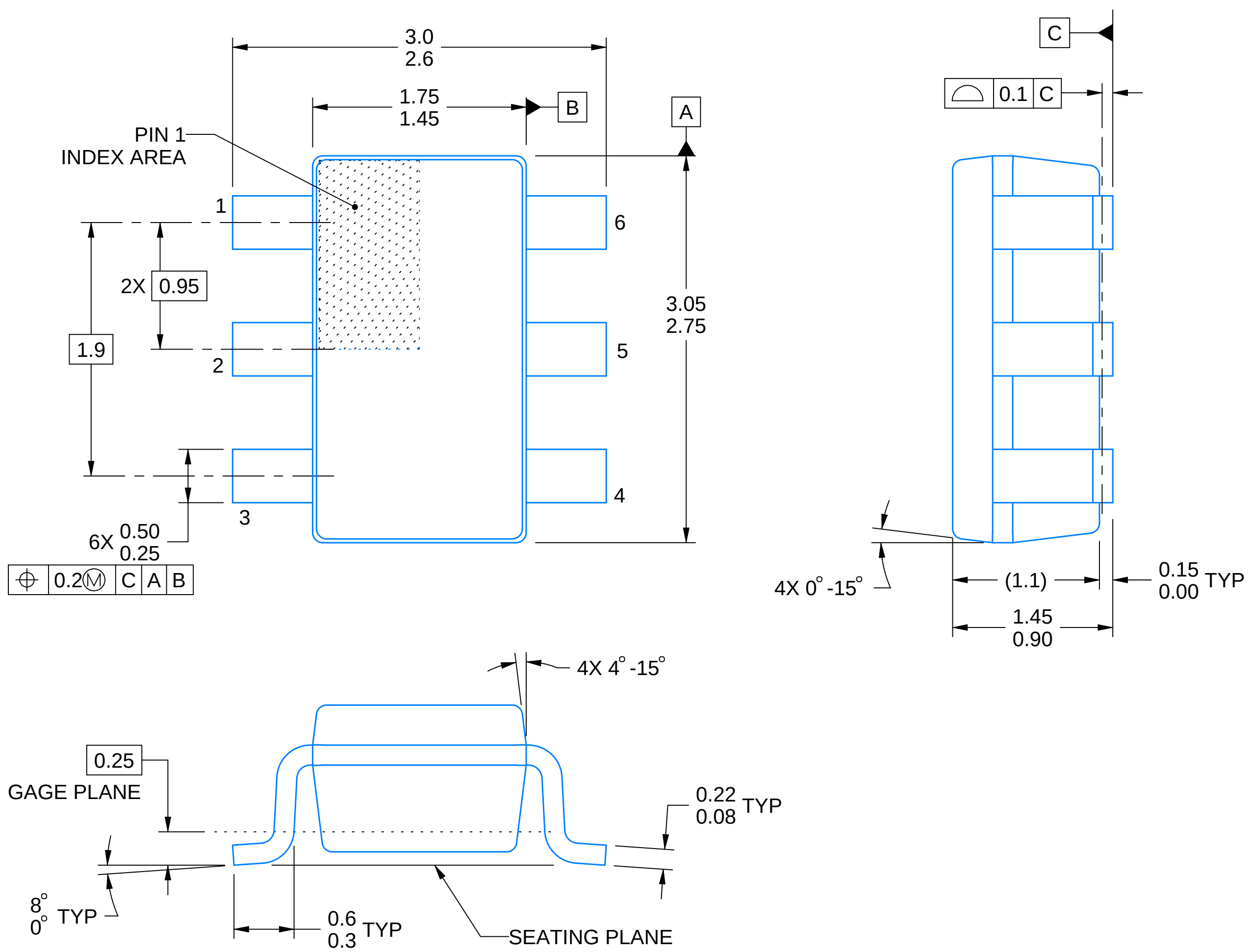
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMAG5328A1DQDBVR	SOT-23	DBV	6	3000	178.0	9.0	3.3	3.2	1.4	4.0	8.0	Q3
TMAG5328A1ZQDBVR	SOT-23	DBV	6	3000	178.0	9.0	3.3	3.2	1.4	4.0	8.0	Q3
TMAG5328D1EQDBVR	SOT-23	DBV	6	3000	178.0	9.0	3.3	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

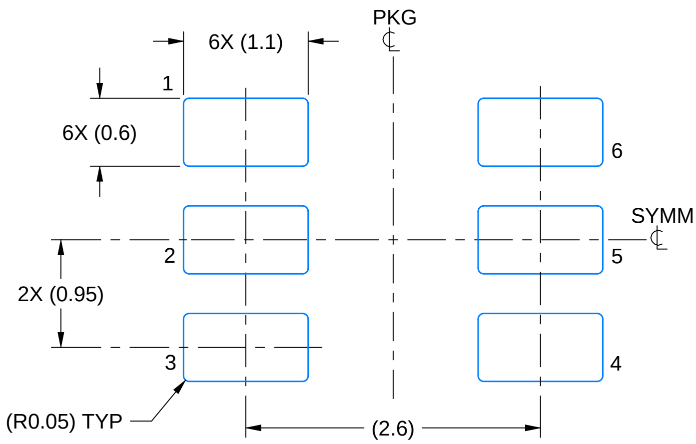
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMAG5328A1DQDBVR	SOT-23	DBV	6	3000	190.0	190.0	30.0
TMAG5328A1ZQDBVR	SOT-23	DBV	6	3000	190.0	190.0	30.0
TMAG5328D1EQDBVR	SOT-23	DBV	6	3000	190.0	190.0	30.0



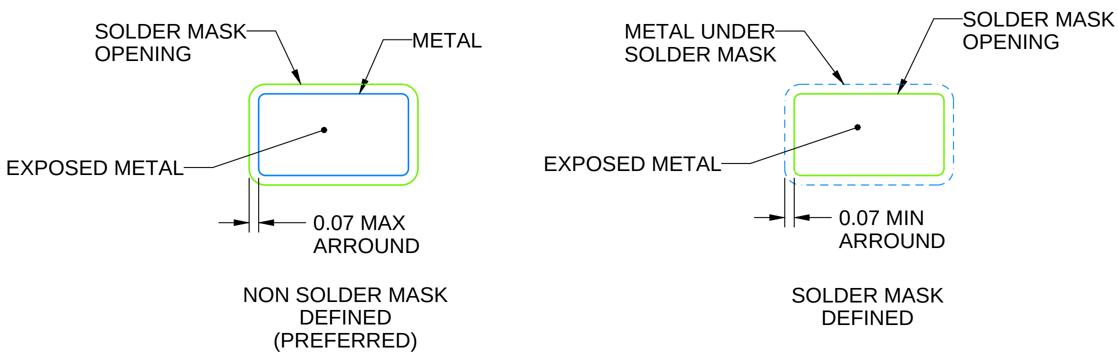
4214840/G 08/2024

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Refernce JEDEC MO-178.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

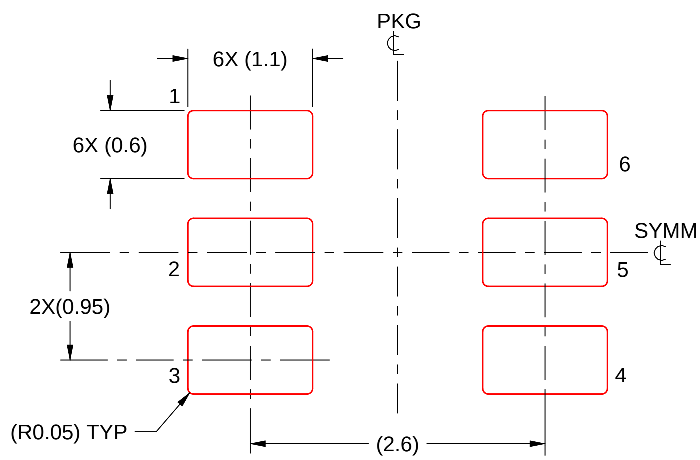


SOLDER MASK DETAILS

4214840/G 08/2024

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4214840/G 08/2024

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.