TMAG5230 Low Power Z-Axis Hall-Effect Switch in WCSP

1 Features

- Supply voltage range: 1.65V to 5.5V
- Ambient temperature range: –40°C to 125°C
- Magnetic pole detection options:
  - Omnipolar
  - Dual-unipolar
- Output type:
  - Push-pull
  - Open-drain
- Active output state (when B > B_{OP}): low (V_{OL})
- Magnetic operate points(B_{OP}):
  - 2.4mT to 24mT
- Low average current consumption of 1.6μA
- Sampling rates:
  - 1.25Hz to 2.5kHz
- Industry standard 4-pin DSBGA package

2 Applications

- Tablets
- Smart phones
- Notebook computers
- Earbuds
- AR/VR glasses
- Digital still cameras

3 Description

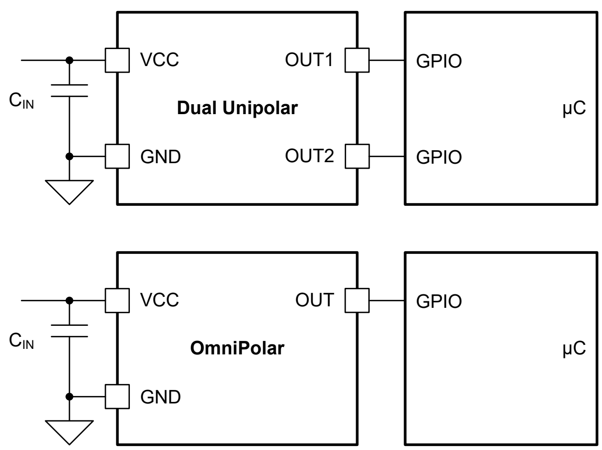
The TMAG5230 is a Hall-effect switch used in magnetic position sensing applications. The TMAG5230 product family is available in an ultra small form factor DSBGA(WCSP) package that supports both omnipolar and unipolar outputs. The device supports multiple combinations of high sensitivity thresholds with various sampling rates that allow flexible system design for magnet selection, sensitivity, and power requirements.

The device output type is available as a push-pull output to eliminate the need for an external pullup resistor, or as an open-drain output which allows the use of a IO voltage that is different than the TMAG5230 supply. The open-drain output can support voltages greater than V_{CC}, eliminating the need for power-sequencing.

Package Information

PART NUMBER	PACKAGE[(1)]	PACKAGE SIZE[(2)]
TMAG5230	YBK (DSBGA, 4)	0.74mm × 0.74mm

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



Simplified Schematic

Table of Contents

4 Device Comparison

Table 4-1. Device Comparison

VERSION	TYPICAL B_{OP}	TYPICAL B_{RP}	MAGNETIC DETECTION	OUTPUT TYPE	SAMPLING RATE	PACKAGES AVAILABLE
D4D	2.4mT	2mT	Dual-Unipolar	Open-Drain, Active Low	20Hz	DSBGA
D5D	2.4mT	2mT	Dual-Unipolar	Push-Pull, Active Low	20Hz	DSBGA
F1D	3.5mT	2.5mT	Omnipolar	Push-Pull, Active Low	20Hz	DSBGA
H1D	6mT	5mT	Omnipolar	Push-Pull, Active Low	20Hz	DSBGA
I1D	6.3mT	5.4mT	Omnipolar	Push-Pull, Active Low	20Hz	DSBGA
I5D	6.3mT	5.4mT	Dual-Unipolar	Push-Pull, Active Low	20Hz	DSBGA
J5D	9.5mT	8.6mT	Dual-Unipolar	Push-Pull, Active Low	20Hz	DSBGA
K4D	15mT	14.1mT	Dual-Unipolar	Open-Drain, Active Low	20Hz	DSBGA
L5D	15	13	Dual-Unipolar	Push-Pull, Active Low	20Hz	DSBGA
N5D	24	22.4	Dual-Unipolar	Push-Pull, Active Low	20Hz	DSBGA

indicates the B_{OP}, output configuration, and sampling rate options available for the TMAG5230xxx. For example, TMAG5230F2E is a 3.5mT BOP, Omnipolar, Active High, Open Drain, 40Hz version of the device. For new version samples, please contact your local representative. Additional sampling rates up to 20kHz available.

Table 4-2. Additional device configuration options

B_{OP} / B_{RP}	Output Configuration	Sampling Rate
D = 2.4mT / 2mT	**0** - Omnipolar, Active Low, Open-Drain	**A** = 1.25Hz
E = 3mT / 2.1mT	**1** - Omnipolar, Active Low, Push-pull	**B** = 5Hz
F = 3.5mT / 2.5mT	**2** - Omnipolar, Active High, Open-Drain	**C** = 10Hz
G = 4.1mT / 3.3mT	**3** - Omnipolar, Active High, Push-pull	**D** = 20Hz
H = 6mT / 5mT	**4** - Unipolar, Active Low, Open-Drain	**E** = 40Hz
I = 6.3mT / 5.4mT	**5** - Unipolar, Active Low, Push-pull	**F** = 80Hz
J = 9.5mT / 8.6mT	**6** - Unipolar, Active High, Open-Drain	
K = 15mT / 14.1mT	**7** - Unipolar, Active High, Push-pull	
L = 15mT / 13mT		
M = 20mT / 18mT		
N = 24mT / 22.4mT		
O = 30mT / 27mT		
P = 35mT / 31mT		
S = 18mT / 17mT		

5 Pin Configuration and Functions

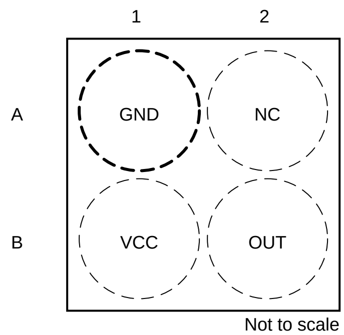


Figure 5-1. YBK Package 4-Pin DSBGA (Omnipolar) Top View

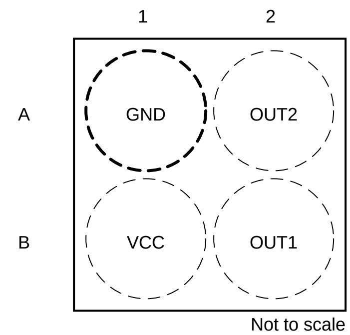


Figure 5-2. YBK Package 4-Pin DSBGA (Dual-Unipolar) Top View

Table 5-1. Pin Functions

PIN			TYPE	DESCRIPTION
NAME	DSBGA (Omnipolar)	DSBGA (Dual-Unipolar)		
GND	A1	A1	Ground	Ground pin.
NC	A2	—	No Connect	High impedance no-connect pin for Omnipolar versions. Can be left floating.
OUT2	—	A2	Output	Unipolar output, responds to negative magnetic flux density through the package.
VCC	B1	B1	Power	Supply voltage pin.
OUT	B2	—	Output	Omnipolar output, responds to both positive and negative magnetic flux density through the package.
OUT1	—	B2	Output	Unipolar output, responds to positive magnetic flux density through the package.

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Power supply voltage	V_{CC}	–0.3	7	V
Output pin voltage	OUT, OUT1, OUT2 push pull	GND – 0.3	V_{CC} + 0.3	V
Output pin voltage	OUT, OUT1, OUT2 open drain	0	7	V
Output pin current	OUT, OUT1, OUT2	–5	5	mA
Magnetic flux density, B_{MAX}		Unlimited		T
Junction temperature, T_J	Junction temperature, T_J	–50	150	°C
Storage temperature, T_{stg}		–65	150	°C

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[(1)]	±8000	V
		Charged device model (CDM), ANSI/ESDA/JEDEC JS-002[(2)]	±1000	

(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}	OUT, OUT1, OUT2 push pull pin voltage	0	V_{CC}	V
V_{IO}	OUT, OUT1, OUT2 open drain pin voltage	0	5.5	V
T_A	Ambient temperature	–40	125	°C
Output pin current	OUT, OUT1, OUT2	–3	3	mA

6.4 Thermal Information

THERMAL METRIC[(1)]		TMAG5230	UNIT
		WCSP (YBK)	
		4 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	208.0	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	1.8	
$R_{\theta JB}$	Junction-to-board thermal resistance	60.7	
Ψ_{JT}	Junction-to-top characterization parameter	1.0	
Ψ_{JB}	Junction-to-board characterization parameter	61.1	

(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 V_{CC} = 1.65V to 5.5V (unless otherwise noted). Typical specifications are at T_A = 25 °C and V_{CC} = 3.3V (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
DIGITAL INPUT/OUTPUT						
V_{OH}	Output high voltage	I_{OUT} = –3mA	V_{CC} – 0.2		V_{CC}	V
V_{OL}	Output low voltage	I_{OUT} = 3mA	0		0.2	V
POWER SUPPLY						
I_{SLEEP}	Supply current during sleep	T_A = 25°C		0.15	0.29	µA
		T_A = –40°C to 85°C			0.3	
		T_A = –40°C to 125°C			0.9	
t_{ON}	Power-on time	T_A = –40°C to 125°C		140	250	µs

6.6 Version Characteristics

over free-air temperature range and V_{CC} = 1.65V to 5.5V (unless otherwise noted). Typical specifications are at T_A = 25°C and V_{CC} = 3.3V (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
TMAG5230DxD						
f_S	Frequency of magnetic sampling	T_A = –40°C to 125°C	17	20	24	Hz
t_S	Period of magnetic sampling	T_A = –40°C to 125°C	41	50	59	ms
I_{ACTIVE}	Active supply current	T_A = –40°C to 125°C		1.85	2.4	mA
t_{ACTIVE}	Active current duration	T_A = –40°C to 125°C		45	75	µs
I_{CCAVG}	Average supply current	T_A = 25°C		2.2	3.3	µA
		T_A = –40°C to 85°C			3.8	
		T_A = –40°C to 125°C			4.5	
B_{OP}	Operate point	T_A = 25°C	±1.9	±2.4	±2.9	mT
		T_A = –40°C to 85°C	±1.7	±2.4	±3.1	
		T_A = –40°C to 125°C	±1.6	±2.4	±3.2	
B_{RP}	Release point	T_A = 25°C	±1.3	±2	±2.4	mT
		T_A = –40°C to 85°C	±1.1	±2	±2.7	
		T_A = –40°C to 125°C	±1.1	±2	±2.7	
B_{HYS}	Hysteresis: $\lvert B_{OP} – B_{RP}\rvert$	T_A = –40°C to 125°C	0.1	0.4		mT

7 Detailed Description

7.1 Overview

The TMAG5230 is a Hall-effect sensor with one or two digital outputs that indicate when the magnetic flux density thresholds (B_{OP} and B_{RP}) have been crossed. Based on the TMAG5230 orderable part number, the magnetic thresholds, magnetic pole detection, output type, active output state and sampling frequency can be selected to best fit the end application.

7.2 Functional Block Diagram

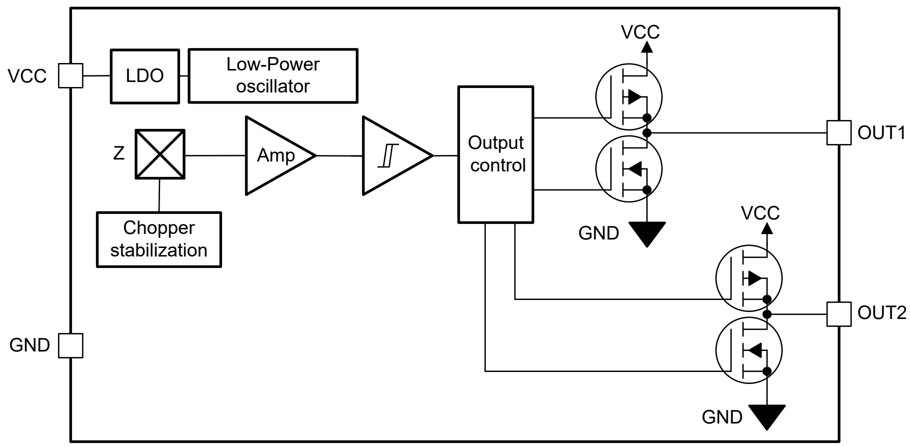


Figure 7-1. Block Diagram

7.3 Feature Description

7.3.1 Magnetic Flux Density Direction

The TMAG5230 detects the magnetic flux density which is perpendicular to the package. Magnetic flux density traveling from the bottom to the top of the package is considered positive, while magnetic flux density traveling from top to the bottom of the package is considered negative. As illustrated in Figure 7-2, a south pole near the top of the DSBGA package induces a positive magnetic flux density, while a north pole near the top of the DSBGA package induces a negative magnetic flux density.

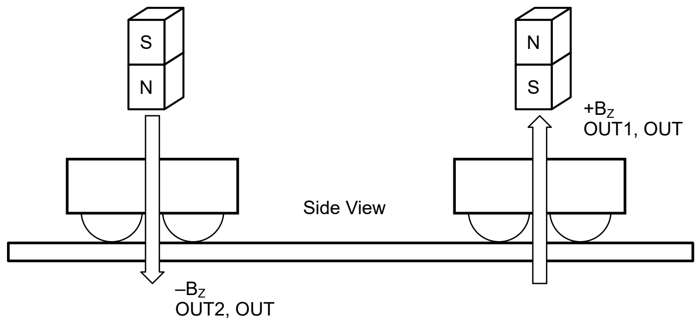


Figure 7-2. Magnetic Flux Density Axis of Sensitivity

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 7-3 and Figure 7-4.

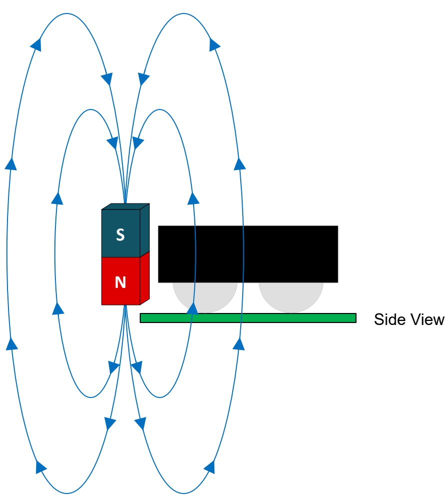


Figure 7-3. Positive Magnetic Flux Density: Magnet Offset

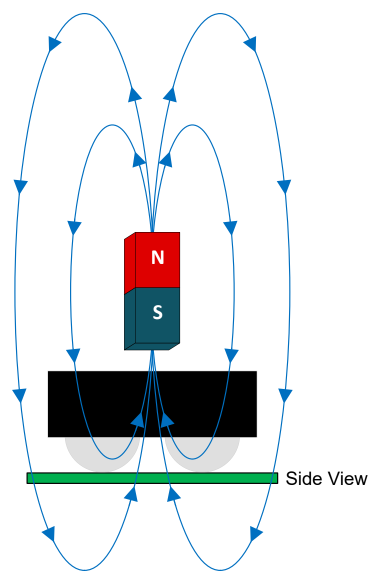


Figure 7-4. Positive Magnetic Flux Density: Magnet In-Line

7.3.2 Magnetic Response

The magnetic pole detection of the TMAG5230 can either be omnipolar or dual-unipolar depending on the orderable part number. As an omnipolar switch, the OUT pin responds to both positive and negative magnetic flux densities as illustrated in Figure 7-5.

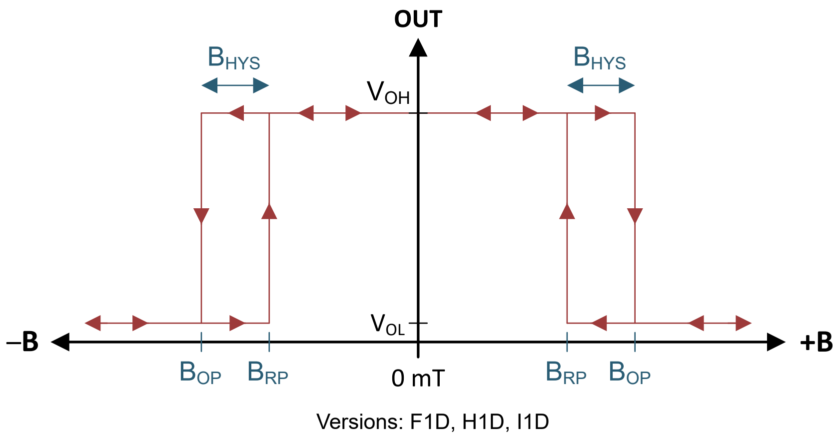


Figure 7-5. Omnipolar Active Low Functionality

As a dual-unipolar switch, the OUT1 pin responds to positive magnetic flux density through the package whereas the OUT2 pin responds to negative magnetic flux density through the package. Figure 7-6 shows this dual-unipolar output response.

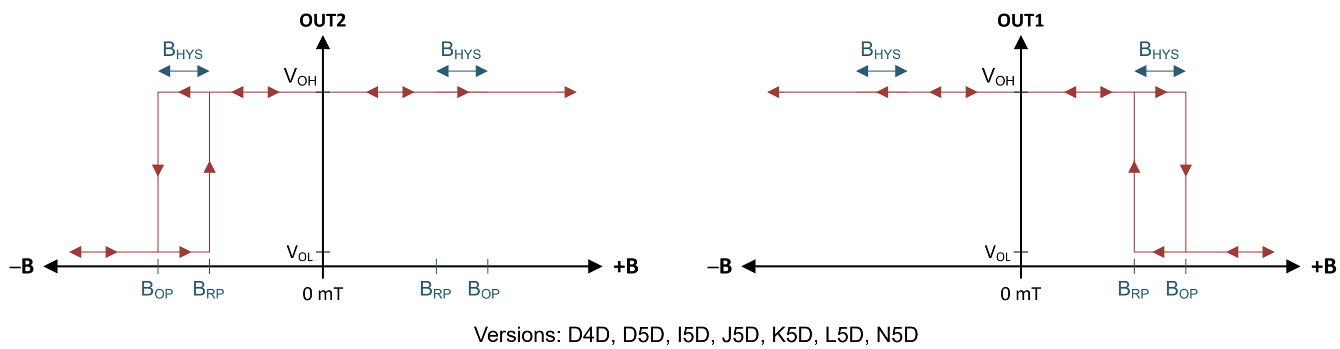
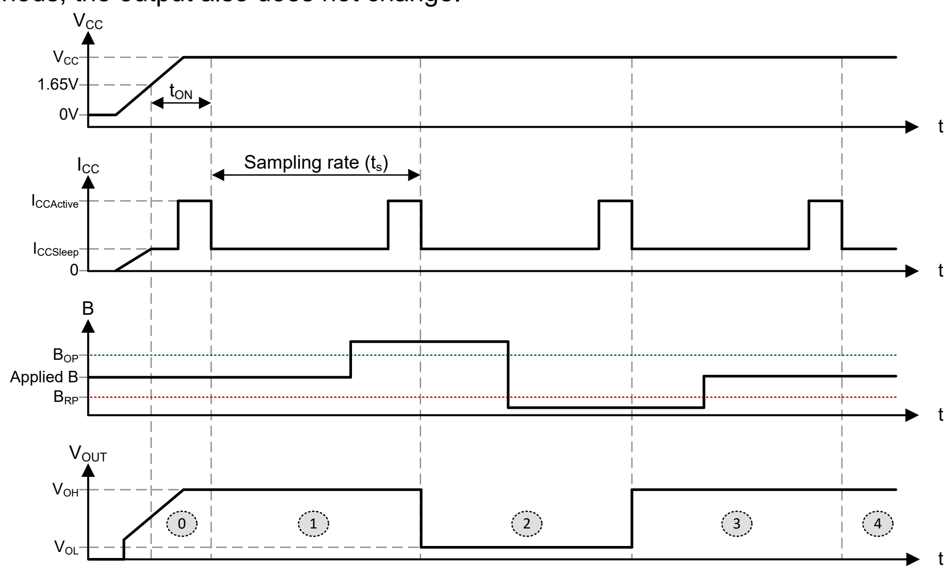


Figure 7-6. Dual-Unipolar Active Low Functionality

7.3.3 Timing

The TMAG5230 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. Figure 7-7 displays the start-up behavior of the TMAG5230 and some examples of the active low omnipolar output pin voltage based on different magnetic flux density value scenarios. When the minimum value for V_{CC} is reached, the TMAG5230 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 7-7. Timing and Output Diagram

7.3.4 Hall Element Location

The sensing element inside the device is shown in Figure 7-8.

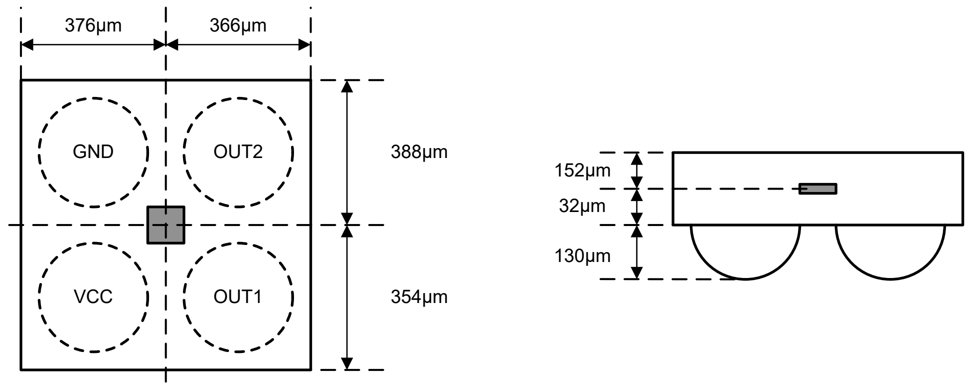


Figure 7-8. Hall Element Location (Top View)

7.4 Device Functional Modes

The TMAG5230 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 TMAG5230 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 TMAG5230 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 can be difficult to determine the appropriate magnet characteristics required to make sure the system works as intended. Therefore, TI recommends to begin the design process with experimentation to solve for a design that works. 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

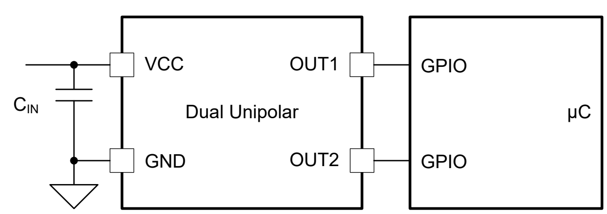


Figure 8-1. Typical Application Schematic

8.3 Design Requirements

This section provides an example using the *TI Magnetic Sense Simulator (TIMSS)* web tool for a magnet proximity detection application. The following table lists the design parameters related to the movement of the magnet on an accessory approaching a product container the TMAG5230.

Table 8-1. Design Parameters

PARAMETER	VALUE
Supply voltage (V_{CC})	1.8V
Bypass capacitor	0.1µF
Part number	TMAG5230D5D
Magnet range of motion	10mm Z
Magnet shape	Axial Cylinder
Magnet width	2mm
Magnet height	1mm
Magnet type	N35

>

8.4 Detailed Design Procedure

As the magnet travels from the starting position Z-height 22mm above the TMAG5230 to the final position Z-height 2mm, the magnetic flux density seen by the TMAG5230 changes. In this design example the TMAG5230 has a unipolar output allowing the system to determine to polarity of the magnetic field.

At the magnet starting position, the TMAG5230 OUTx output is high because the magnetic flux density is less than B_{OP}. As the magnet moves toward the sensor, the magnetic flux density crosses the negative B_{OP} threshold of the TMAG5230 at a distance of Xmm, making the OUTx output go low. If the magnet moves away from the TMAG5230, the magnetic flux density decreases, and at a distance of Ymm the B_{RP} threshold is crossed and the OUTx output goes high.

8.5 Application Curves

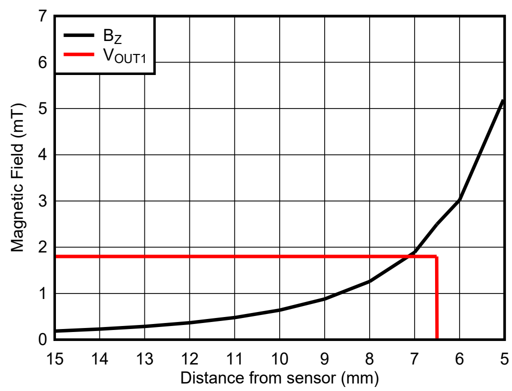


Figure 8-2. TMAG5230D5D Response to B_{EXT}

8.6 Power Supply Recommendations

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.

8.7 Layout

8.7.1 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.

8.7.2 Layout Example

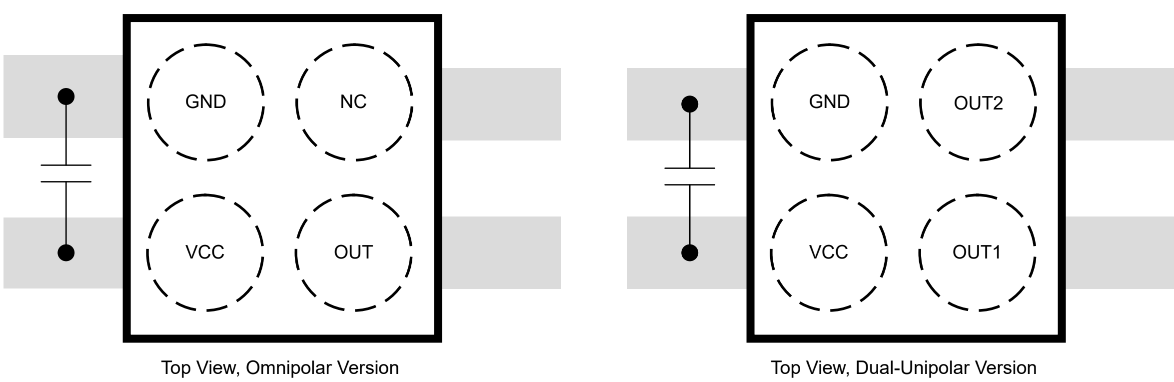


Figure 8-3. DSBGA Layout Example

9 Device and Documentation Support

9.1 Device Nomenclature

Figure 9-1 shows a legend for reading the complete orderable part numbers for the TMAG5230.

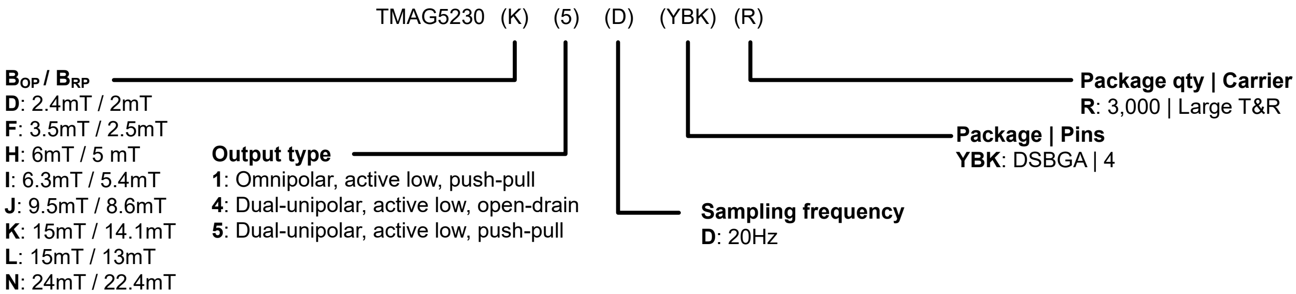


Figure 9-1. Device Nomenclature

Note

Contact Texas Instruments for options not listed in the Device Comparison Table.

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

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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

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

DATE	REVISION	NOTES
December 2025	*	Initial Release

11 Mechanical and Packaging 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)
TMAG5230D1DYBKR	Active	Production	DSBGA (YBK) | 4	3000 | LARGE T&R	-	SNAGCU	Level-1-260C-UNLIM	-	X

(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.

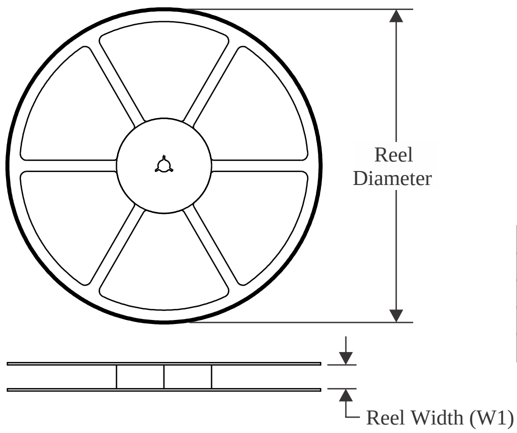
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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.

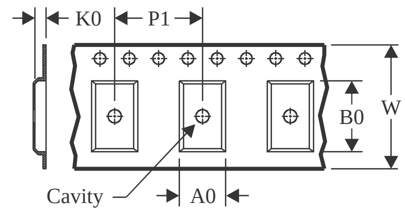
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

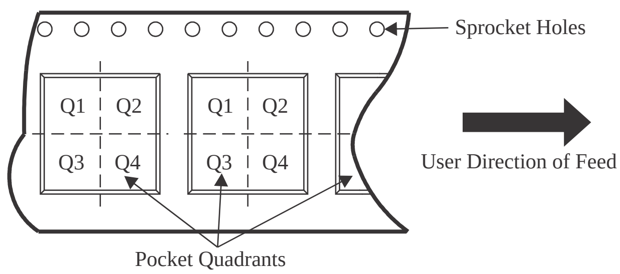


TAPE DIMENSIONS



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

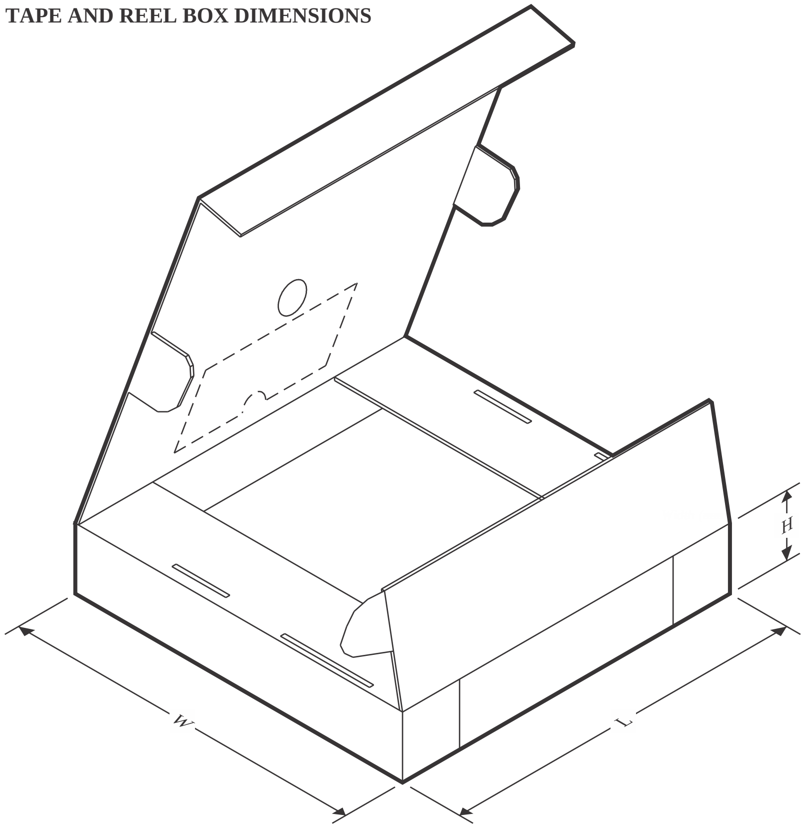
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TMAG5230D1DYBKR	DSBGA	YBK	4	3000	180.0	8.4	0.84	0.84	0.5	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMAG5230D1DYBKR	DSBGA	YBK	4	3000	182.0	182.0	20.0

IMPORTANT NOTICE AND DISCLAIMER