![Texas Instruments Logo] **TEXAS INSTRUMENTS**

TMAG5233 Low Cost, In-Plane Hall-Effect Switch

1 Features

- Supply range:
  - From –40°C to 85°C: 1.65V to 5.5V
  - From 85°C to 125°C: 1.65V to 3.6V
- In-plane magnetic field detection
- Omnipolar response
- Active low, push-pull output
- Magnetic operate point (B_{OP}): ±3mT
- Magnetic release point (B_{RP}): ±2.2mT
- Duty cycle operation to minimize I_{CC}
  - 5Hz: 0.55µA (preview)
  - 40Hz: 2.7µA
- Industry standard package and pinout
  - 3-pin SOT-23 (V_{CC}, GND, OUT)

2 Applications

- Door and window sensor
- Appliance door open/close
- Electricity meter tamper detection
- Electronic smart lock
- Smoke detector push button
- Food processor accessory detection

3 Description

The TMAG5233 is a low cost, in-plane Hall-effect switch designed to replace TMR, AMR and Reed switches used in magnetic position sensing applications.
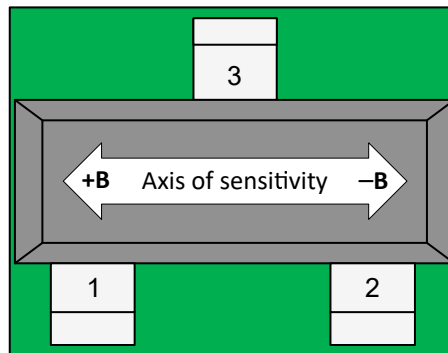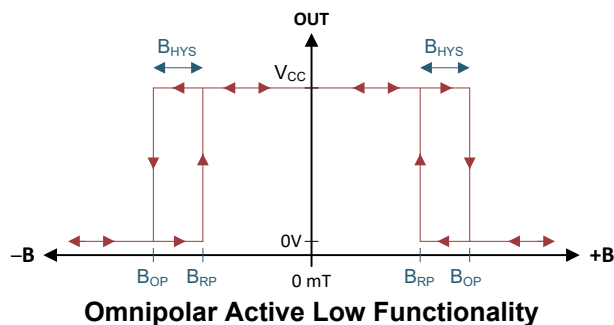
The TMAG5233 has an omnipolar magnetic response and enables the device to react to both north and south magnetic poles. When the applied magnetic flux density through the sensor axis of sensitivity exceeds the operate point threshold (B_{OP}), the device outputs a low voltage. The output stays low until the magnetic flux density decreases to less than the release point threshold (B_{RP}), after which the device outputs a high voltage. The D1E device version has a B_{OP} threshold of 3mT and B_{RP} threshold of 2.2mT.

To minimize power consumption, the TMAG5233 is internally duty-cycled at 40Hz (D1E device version) operating with an average current consumption of 2.7µA. 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.

Omnipolar Active Low Functionality

Top View
In-Plane Axis of Sensitivity

ADVANCE INFORMATION

Table of Contents

4 Device Comparison

Table 4-1. Device Comparison

VERSION	TYPICAL THRESHOLD	TYPICAL HYSTERESIS	MAGNETIC RESPONSE	OUTPUT TYPE	SENSOR ORIENTATION	SAMPLING RATE	PACKAGES AVAILABLE
TMAG5233D1B[1]	3mT	0.8mT	Omnipolar, active low	Push-pull	In-plane	5Hz	SOT-23
TMAG5233D1E						40Hz	

(1)   Preview only. For additional magnetic threshold, output type, and frequency versions please contact your local Texas Instruments representative.

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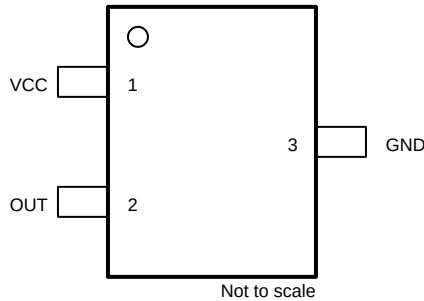
Figure 5-1. DBV Package 3-Pin SOT-23 Top View

Table 5-1. Pin Functions

PIN		TYPE	DESCRIPTION
NAME	SOT-23		
VCC	1	P	Supply voltage
OUT	2	O	Omnipolar output, responds to both south and north magnetic poles.
GND	3	G	Ground

Product Folder Links: *TMAG5233*

ADVANCE INFORMATION

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
Power supply voltage	V_{CC} T_A = 85°C to 125°C	–0.3	4	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	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, T_A = –40°C to 85°C	1.65	5.5	V
	Power supply voltage, T_A = 85°C to 125°C	1.65	3.6	
T_A	Ambient temperature	–40	125	°C
V_O	Output voltage	GND	V_{CC}	V
I_O	Output current	–5	5	mA

6.4 Thermal Information

THERMAL METRIC[1]		TMAG5233 SOT-23 (DBV) 3 PINS	UNIT
$R_{\theta JA}$	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.

ADVANCE INFORMATION

ADVANCE INFORMATION

6.5 Electrical Characteristics

Over free-air temperature range and supply (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
OUTPUT DRIVER						
V_{OH}	High-level output voltage	I_{OH} = 0.5mA	V_{CC} – 0.4		V_{CC}	V
V_{OL}	Low-level output voltage	I_{OL} = 0.5mA	0		0.4	V
ALL VERSIONS						
$I_{CCACTIVE}$	Supply current during measurement			2.6		mA
$I_{CCSLEEP}$	Sleep current			315		nA
t_{ON}	Power-on time	V_{CC} = 5.5V		32		µs
t_{ACTIVE}	Active time period			26		µs
TMAG5233xxB 5Hz (PRODUCT PREVIEW)						
f_S	Frequency of magnetic sampling		2	5	8	Hz
t_S	Period of magnetic sampling		125	200	500	ms
I_{CCAVG}	Average current consumption	T_A = 25°C		0.55	0.89	µA
		T_A = –40°C to 85°C			1.29	
		T_A = –40°C to 125°C			2	
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	
		T_A = –40°C to 125°C			4.1	

6.6 Magnetic Characteristics

Over free-air temperature range and supply (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
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	
		T_A = –40°C to 125°C	±1	±3	±4.7	
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	
		T_A = –40°C to 125°C	±0.5	±2.2	±3.6	
B_{HYS}	Magnetic hysteresis: |B_{OP} - B_{RP}|			0.8		mT

7 Detailed Description

7.1 Overview

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 field polarities. According to this data sheet (see 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.
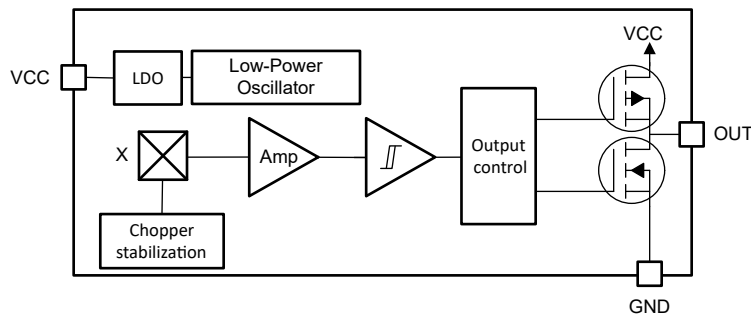
7.2 Functional Block Diagram

Figure 7-1. SOT-23 Block Diagram

7.3 Feature Description

7.3.1 SOT-23 Magnetic Flux Density Direction

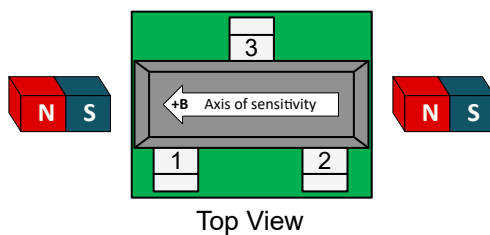The TMAG5233 SOT-23 detects the magnetic flux density which is horizontal to the package marking surface.

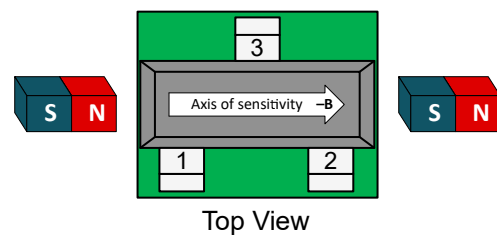Top View

Side View
Figure 7-2. Positive Magnetic Flux Density

Top View

Side View
Figure 7-3. Negative Magnetic Flux Density

ADVANCE INFORMATION

Product Folder Links: TMAG5233

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.
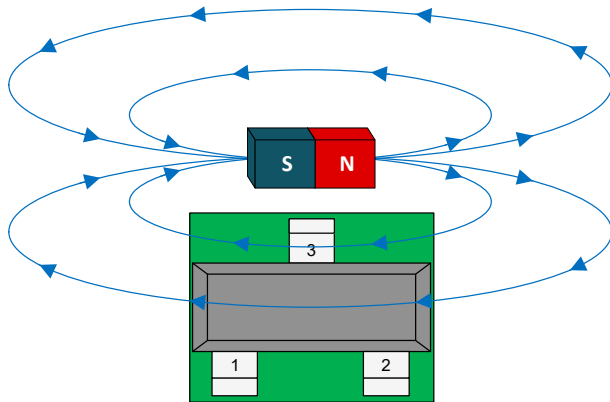

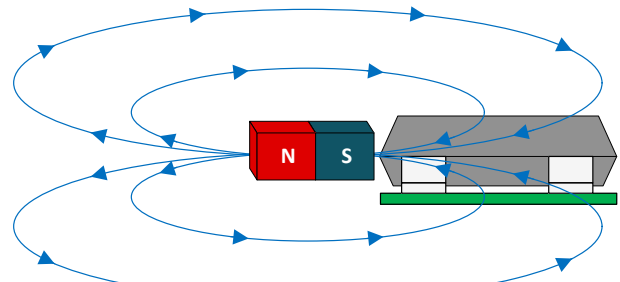**Figure 7-4. Positive Magnetic Flux Density: Magnet Offset**

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.
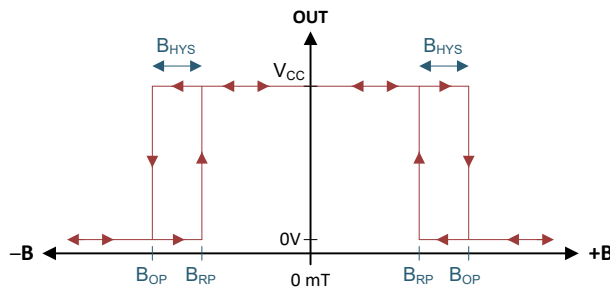
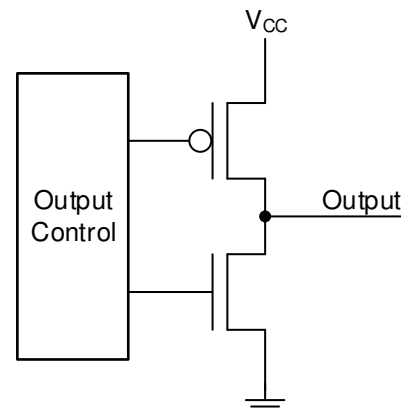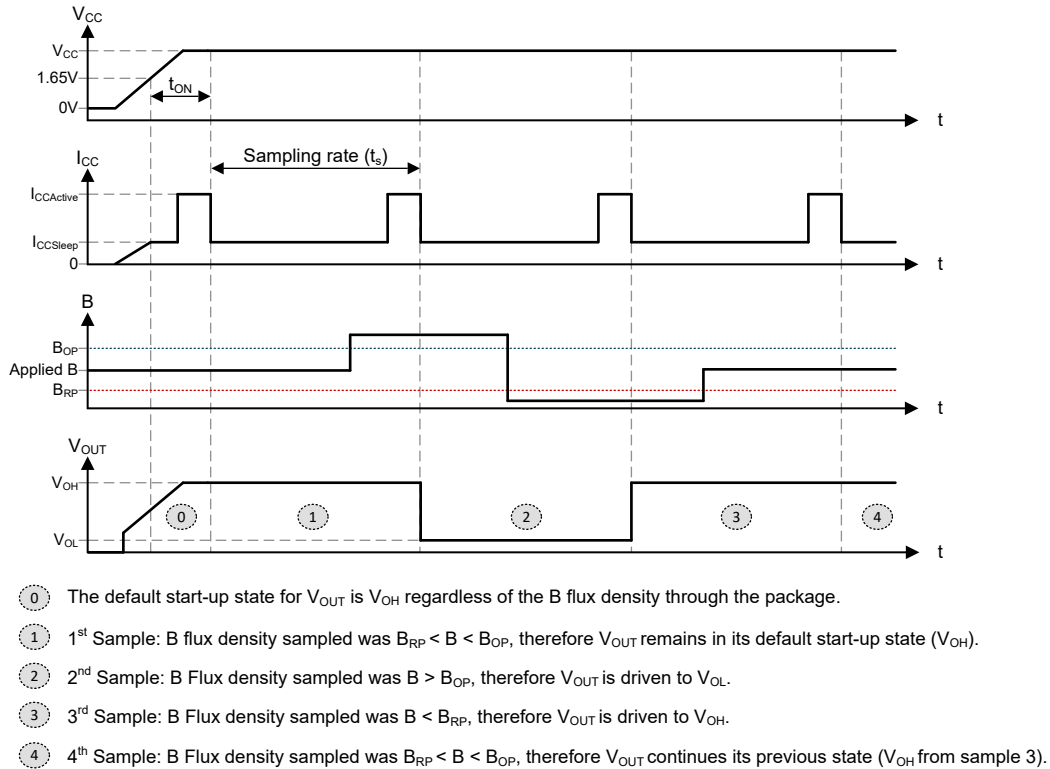

Figure 7-6. Omnipolar Output Response

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 value scenarios. When the minimum value for V_{CC} is reached, the TMAG5233 will take 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

7.4 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.

ADVANCE INFORMATION

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.
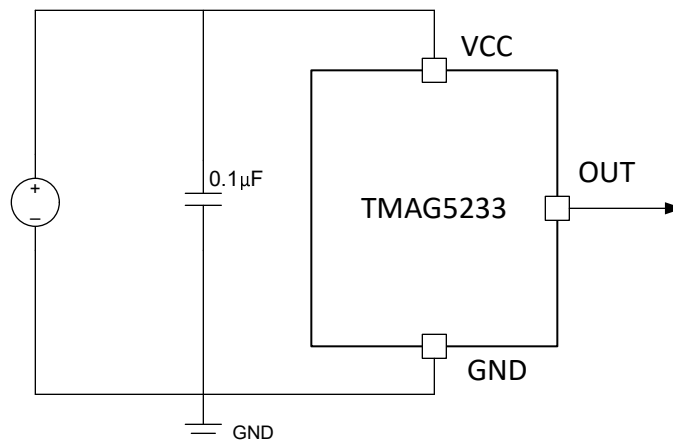
8.2 Typical Application

Figure 8-1. Typical Application Schematic

8.2.1 Design Requirements

Table 8-1 lists the related design parameters.

Table 8-1. Design Parameters

PARAMETER	VALUE
Supply voltage (V_{CC})	3.3V
Bypass capacitor	0.1µF

8.2.2 Detailed Design Procedure

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.

ADVANCE INFORMATION

8.3 Power Supply Recommendations

As seen in Table 8-2, the TMAG5233 power supply recommendation is temperature-dependent due to limitations of the device observed at higher voltages and temperatures. This specific voltage restriction helps the sensor function reliably.

Table 8-2. Power Supply Range

| AMBIENT TEMPERATURE CONDITIONS	RECOMMENDED POWER SUPPLY RANGE
T_A = –40°C to 85°C	V_{CC} = 1.65V to 5.5V
T_A = 85°C to 125°C	V_{CC} = 1.65V to 3.6V

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.
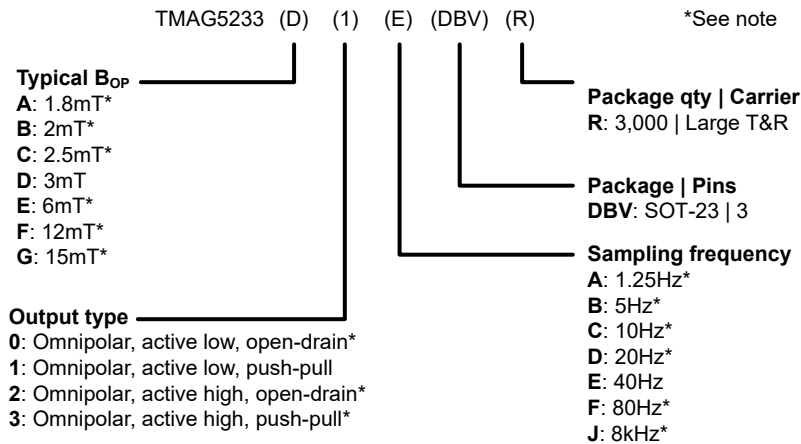
8.4.2 Layout Example
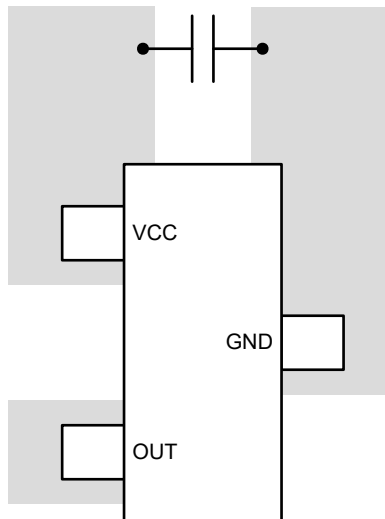
Figure 8-2. SOT-23 Layout Example

Product Folder Links: *TMAG5233*

ADVANCE INFORMATION

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.

TMAG5233 (D) (1) (E) (DBV) (R)   *See note

Typical B$_{OP}$
A: 1.8mT*
B: 2mT*
C: 2.5mT*
D: 3mT
E: 6mT*
F: 12mT*
G: 15mT*

Output type
0: Omnipolar, active low, open-drain*
1: Omnipolar, active low, push-pull
2: Omnipolar, active high, open-drain*
3: Omnipolar, active high, push-pull*

Package qty | Carrier
R: 3,000 | Large T&R

Package | Pins
DBV: SOT-23 | 3

Sampling frequency
A: 1.25Hz*
B: 5Hz*
C: 10Hz*
D: 20Hz*
E: 40Hz
F: 80Hz*
J: 8kHz*

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.

Product Folder Links: *TMAG5233*
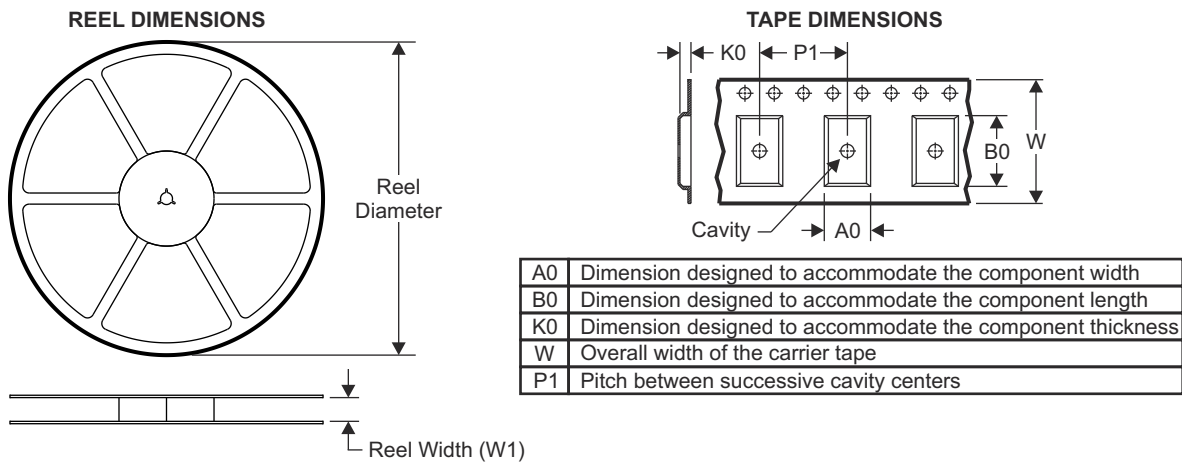
10 Revision History

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

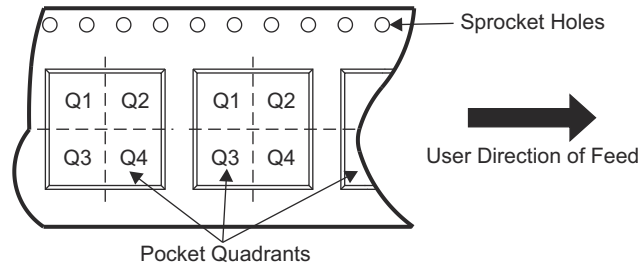| DATE	REVISION	NOTES
August 2024	*	Initial Release

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.

### 11.1 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

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
PTMAG5233D1EDBVR	SOT-23	DBV	3	3000	178	9	3.3	3.2	1.4	4	8	Q3

Product Folder Links: *TMAG5233*

ADVANCE INFORMATION

TEXAS INSTRUMENTS
www.ti.com

TAPE AND REEL BOX DIMENSIONS
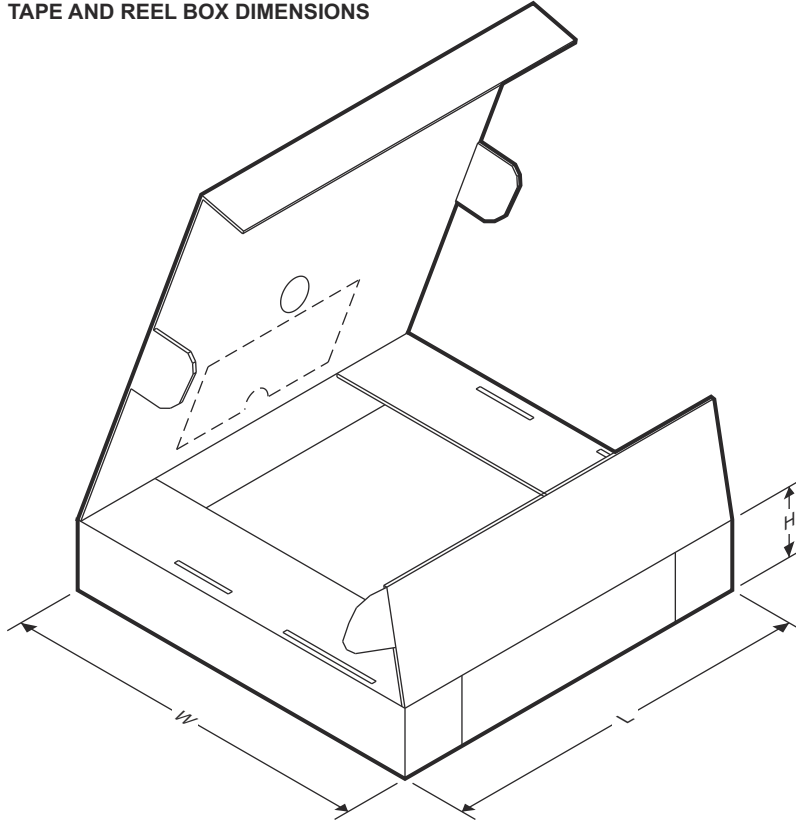
ADVANCE INFORMATION

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PTMAG5233D1EDBVR	SOT-23	DBV	3	3000	Call TI	Call TI	Call TI

Product Folder Links: *TMAG5233*

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
PTMAG5233D1EDBVR	ACTIVE	SOT-23	DBV	3	3000	TBD	Call TI	Call TI	-40 to 125		Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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.
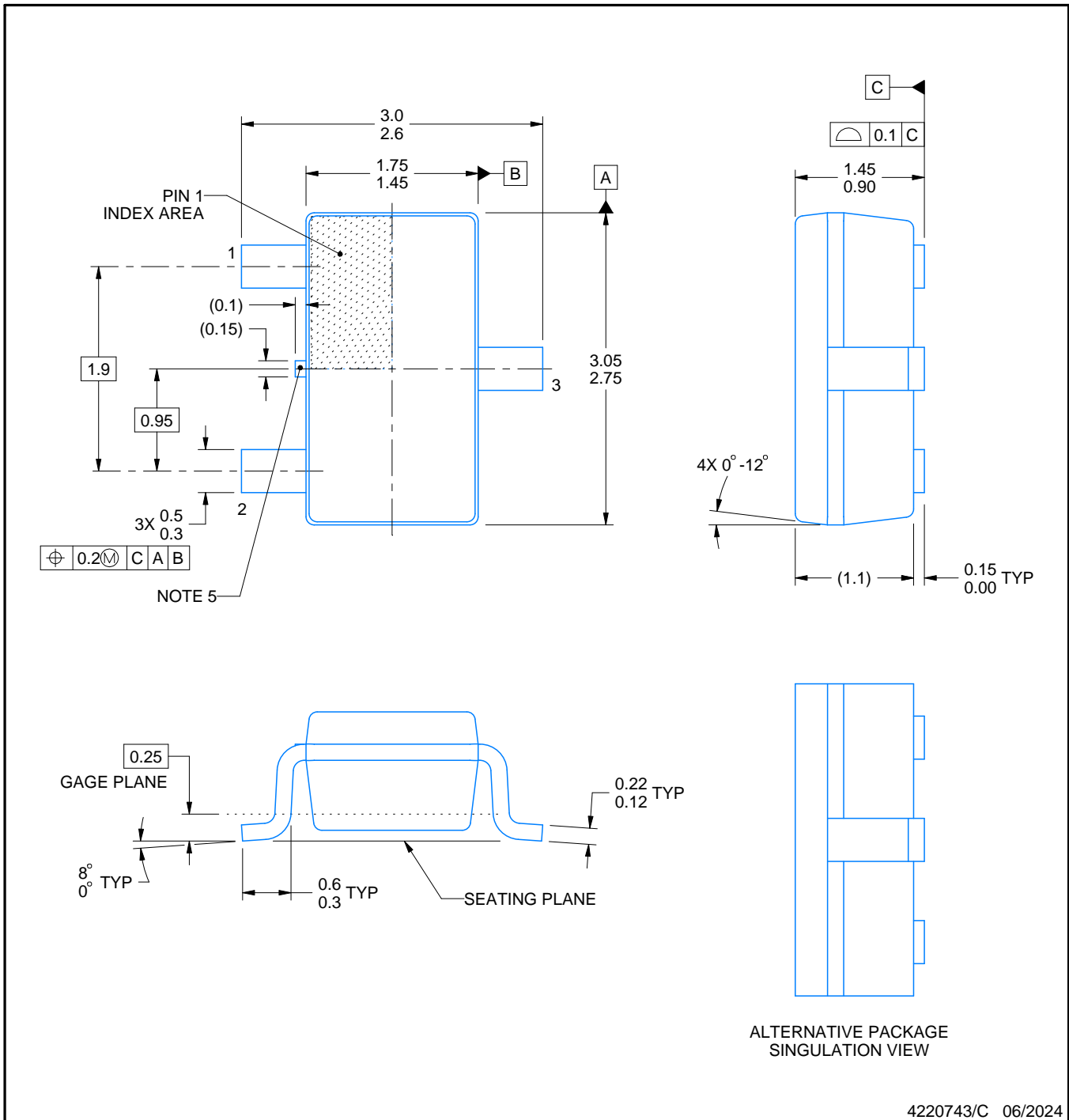
PIN 1
INDEX AREA

3.0
2.6

1.75
1.45

B

A

1

(0.1)

(0.15)

1.9

0.95

3X 0.5
0.3

2

⊕ 0.2Ⓜ C A B

NOTE 5

3.05
2.75

3

C

⌒ 0.1 C

1.45
0.90

4X 0°-12°

(1.1)

0.15 TYP
0.00

0.25

GAGE PLANE

8° TYP
0°

0.6 TYP
0.3

SEATING PLANE

0.22 TYP
0.12

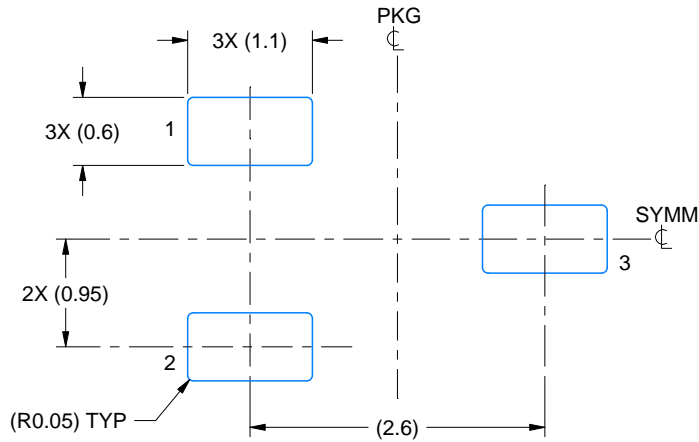ALTERNATIVE PACKAGE
SINGULATION VIEW

4220743/C   06/2024

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. Refernce JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.

3X (1.1)

PKG ℄

3X (0.6) 1

SYMM ℄
3

2X (0.95)

2

(R0.05) TYP

(2.6)

LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

SOLDER MASK
OPENING
METAL

EXPOSED METAL

0.07 MAX
ARROUND

NON SOLDER MASK
DEFINED
(PREFERRED)

METAL UNDER
SOLDER MASK
SOLDER MASK
OPENING

EXPOSED METAL

0.07 MIN
ARROUND

SOLDER MASK
DEFINED
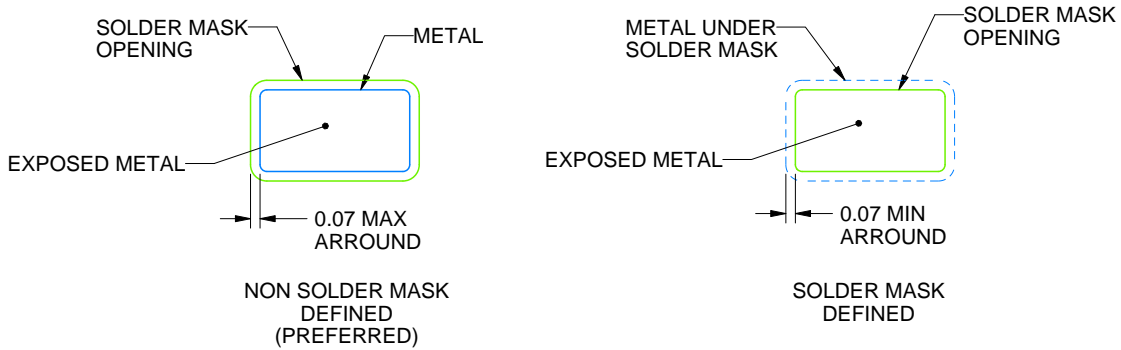
SOLDER MASK DETAILS

4220743/C 06/2024

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.

DBV0003A

SOT-23 - 1.45 mm max height

PKG

3X (1.1)

3X (0.6)   1

SYMM

3

2X(0.95)

2

(R0.05) TYP

(2.6)
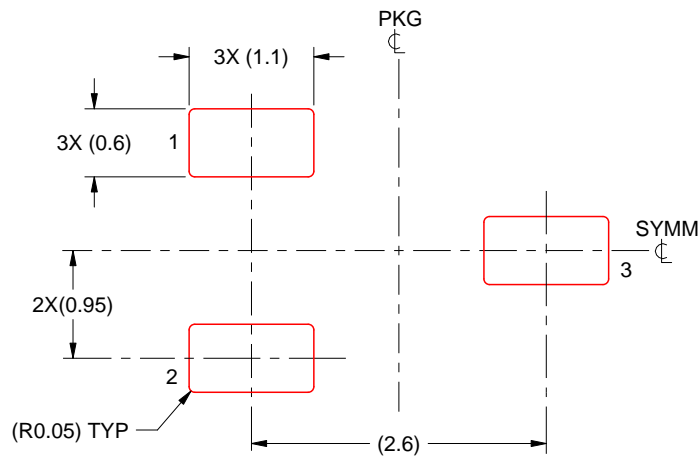
SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4220743/C   06/2024

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.

IMPORTANT NOTICE AND DISCLAIMER