DRV5057-Q1 車載リニア・ホール効果センサ、PWM 出力対応

1 特長

- **車載アプリケーション用に AEC-Q100 認定済み**
  - 温度グレード 0:-40℃～150℃
- **PWM 出力リニア・ホール効果磁気センサ**
- **3.3V および 5V の電源で動作**
- **静止デューティ・サイクル 50% で 2kHz のクロック出力**
- **磁気感度オプション (V_{CC} = 5V 時)**
  - A1:2%D/mT、±21mT 範囲
  - A2:1%D/mT、±42mT 範囲
  - A3:0.5%D/mT、±84mT 範囲
  - A4:0.25%D/mT、±168mT 範囲
- **シンク能力 20mA のオープンドレイン出力**
- **磁石の温度ドリフトの補償**
- **業界標準のパッケージ**
  - 表面実装 SOT-23

2 アプリケーション

- **車載用位置センシング**
- **ブレーキ、アクセル、クラッチ・ペダル**
- **トルク・センサ、ギア・シフタ**
- **スロットル位置、高さレベリング**
- **パワートレインおよびトランスミッション・コンポーネント**
- **絶対角度のエンコード**
- **電流センシング**

3 概要

DRV5057-Q1デバイスは、リニア・ホール効果センサで、磁束密度に正比例して応答します。このデバイスは、広範なアプリケーションにおいて、正確な位置センシングに使用できます。

このデバイスは、3.3Vまたは5Vの電源で動作します。磁界が存在しないとき、デューティ・サイクル50%のクロックが出力されます。出力のデューティ・サイクルは、印加される磁束密度に対して直線的に変化し、4つの感度オプションによって、必要なセンシング範囲に基づいて出力ダイナミック・レンジを最大化できます。磁界のN極とS極がそれぞれ固有の出力を生成します。標準的なパルス幅変調(PWM)搬送波周波数は2kHzです。

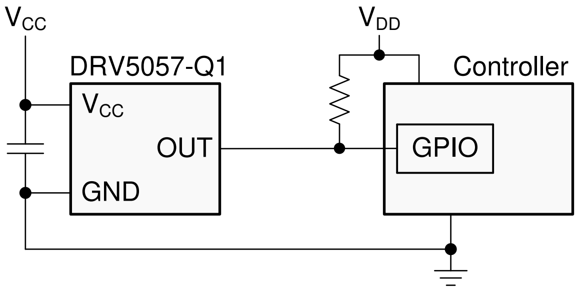
パッケージの上面に垂直な磁束が検出され、2つのパッケージ・オプションでセンシング方向が異なります。

製品情報(1)

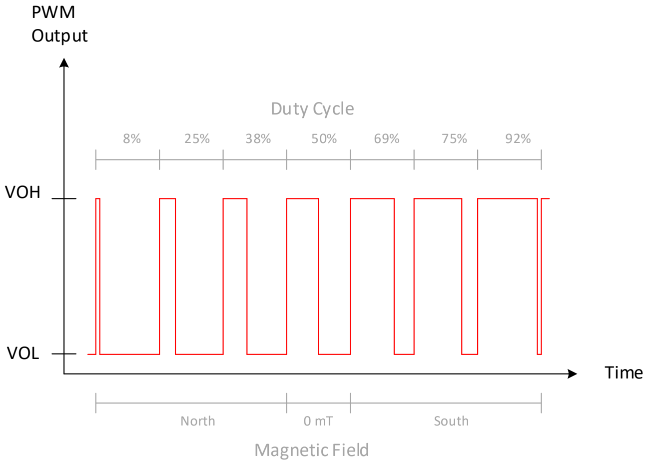
型番	パッケージ	本体サイズ(公称)
DRV5057-Q1	SOT-23 (3)	2.92mm×1.30mm

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にあるパッケージ・オプションについての付録を参照してください。

代表的な回路図



磁気応答



目次

4 改訂履歴

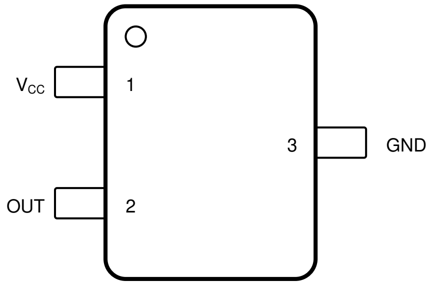
日付	リビジョン	注
2019 年 8 月	*	初版

5 概要 (続き)

PWM信号はエッジ間タイミングに基づくため、電圧ノイズやGND電位の不一致があっても信号完全性を確保できます。この信号はノイズ環境での長距離伝送に適しています。また、常に存在するクロックを使って、システム・コントローラは相互接続が正常であることを確認できます。さらに、デバイスには磁石温度補償が搭載されており、磁石のドリフトを補償することで、-40℃～+150℃の広い温度範囲にわたって線形のパフォーマンスを実現します。

6 Pin Configuration and Functions

DBZ Package
3-Pin SOT-23
Top View



Not to scale

Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
GND	3	Ground	Ground reference
OUT	2	Output	Analog output
V_{CC}	1	Power	Power supply. Connect this pin to a ceramic capacitor to ground with a value of at least 0.01 µF.

7 Specifications

7.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
V_{CC}	Power supply voltage	V_{CC}	–0.3	7	V
	Output voltage	OUT	–0.3	6	V
	Output current	OUT		30	mA
B	Magnetic flux density		Unlimited		T
T_J	Operating junction temperature		–40	170	°C
T_{stg}	Storage temperature		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q100-002(1) HBM ESD classification level 2	±3000	V
		Charged device model (CDM), per AEC Q100-011 CDM ESD classification level C5	±750	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

7.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
V_{CC}	Power-supply voltage(1)	3	3.63	V
		4.5	5.5	
V_O	Output pullup voltage	0	5.5	V
I_O	Output continuous current	0	20	mA
T_A	Operating ambient temperature(2)	–40	150	°C

(1) There are two isolated operating V_{CC} ranges. For more information see the *Operating V_{CC} Ranges* section.
(2) Power dissipation and thermal limits must be observed.

7.4 Thermal Information

THERMAL METRIC(1)		DRV5057-Q1	UNIT
		SOT-23 (DBZ)	
		3 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	170	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	66	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	49	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	1.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	48	°C/W

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

7.5 Electrical Characteristics

for V_{CC} = 3 V to 3.63 V and 4.5 V to 5.5 V, over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}	Operating supply current			6	10	mA
t_{ON}	Power-on time (see 図 15)(1)	B(2) = 0 mT, no load on OUT		0.6	0.9	ms
f_{PWM}	PWM carrier frequency		1.8	2.0	2.2	kHz
D_J	Duty cycle peak-to-peak jitter	From change in B to change in OUT		±0.1		%D(3)
I_{OZ}	High-impedance output leakage current	V_{CC} = 5 V			100	nA
V_{OL}	Low-level output voltage	I_{OUT} = 20 mA		0.15	0.4	V

(1) t_{ON} is the time from when V_{CC} goes above 3 V until the first rising edge of the first valid pulse.
(2) B is the applied magnetic flux density.
(3) This unit is a percentage of duty cycle.

7.6 Magnetic Characteristics

for V_{CC} = 3 V to 3.63 V and 4.5 V to 5.5 V, over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
D_L	Linear duty cycle range			8		92	%D(1)
D_{CL}	Clamped-low duty cycle	B(2) < –250 mT		5.3	6	6.7	%D
D_{CH}	Clamped-high duty cycle	B > 250 mT		93.3	94	94.7	
D_Q	Quiescent duty cycle(3)	B = 0 mT, T_A = 25°C, V_{CC} = 3.3 V or 5 V		43	50	57	%D
$V_{Q\Delta L}$	Quiescent duty cycle lifetime drift	High-temperature operating stress for 1000 hours			< 0.5		%
S	Sensitivity	V_{CC} = 5 V, T_A = 25°C	DRV5057A1-Q1	1.88	2	2.12	%D/mT
			DRV5057A2-Q1	0.94	1	1.06	
			DRV5057A3-Q1	0.47	0.5	0.53	
			DRV5057A4-Q1	0.23	0.25	0.27	
		V_{CC} = 3.3 V, T_A = 25°C	DRV5057A1-Q1	1.13	1.2	1.27	
			DRV5057A2-Q1	0.56	0.6	0.64	
			DRV5057A3-Q1	0.28	0.3	0.32	
			DRV5057A4-Q1	0.138	0.15	0.162	
B_L	Linear magnetic flux density sensing range(3)(4)	V_{CC} = 5 V, T_A = 25°C	DRV5057A1-Q1		±21		mT
			DRV5057A2-Q1		±42		
			DRV5057A3-Q1		±84		
			DRV5057A4-Q1		±168		
S_{TC}	Sensitivity temperature compensation for magnets(5)				0.12		%/°C
S_{LE}	Sensitivity linearity error(3)	Output duty cycle is within D_L			±1		%
R_{SE}	Sensitivity error over operating VCC range	Output duty cycle is within D_L			±1		%
$S_{\Delta L}$	Quiescent error over operating VCC range				< 0.5		%

(1) This unit is a percentage of duty cycle.
(2) B is the applied magnetic flux density.
(3) See the *Sensitivity Linearity* section.
(4) B_L describes the minimum linear sensing range at 25°C taking into account the maximum V_Q and sensitivity tolerances.
(5) S_{TC} describes the rate the device increases Sensitivity with temperature. For more information, see the *Sensitivity Temperature Compensation for Magnets* section and 図 4 to 図 11.

7.7 Typical Characteristics

for T_A = 25°C (unless otherwise noted)

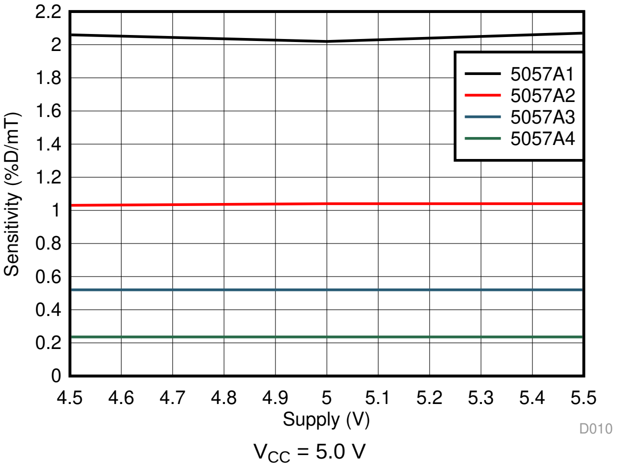


図 1. Sensitivity vs Supply Voltage

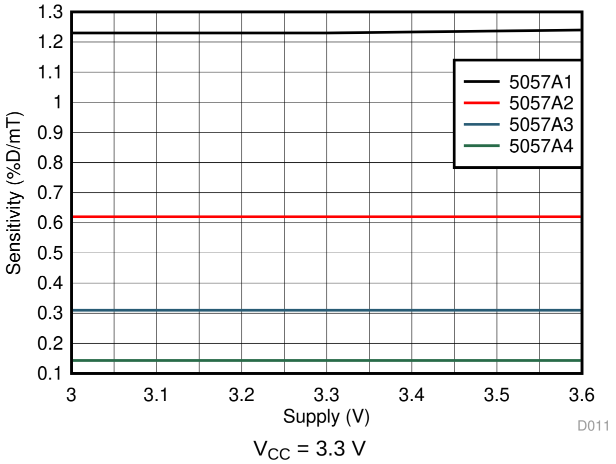


図 2. Sensitivity vs Supply Voltage

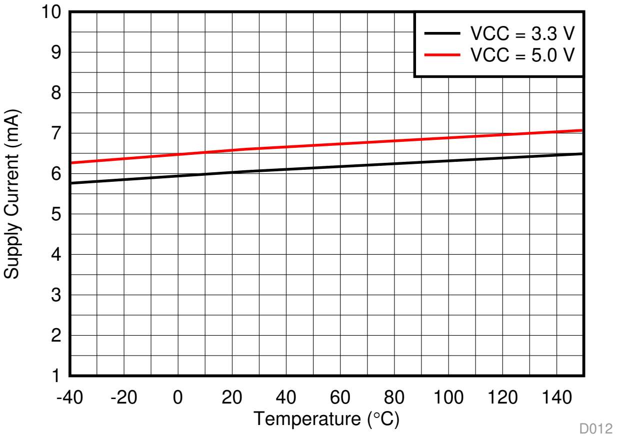


図 3. Supply Current vs Temperature

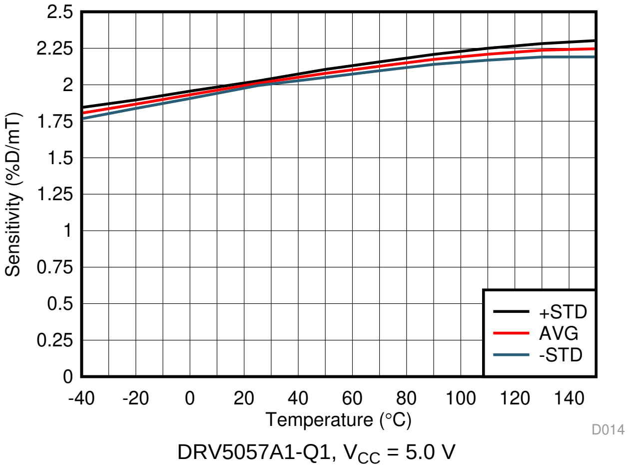


図 4. Sensitivity vs Temperature

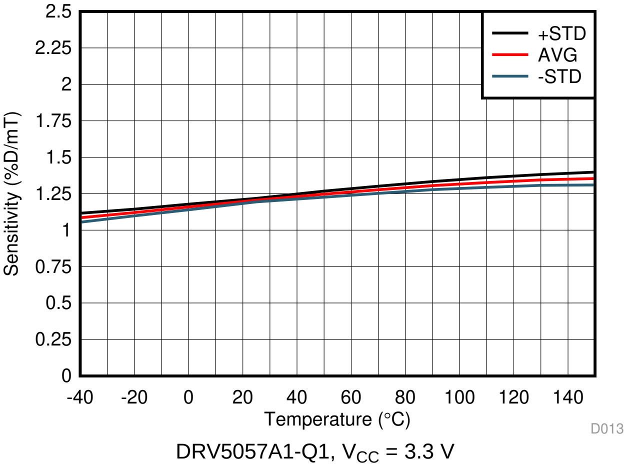


図 5. Sensitivity vs Temperature

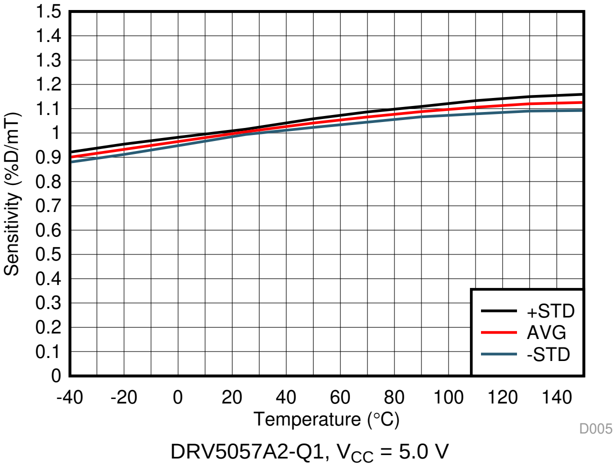
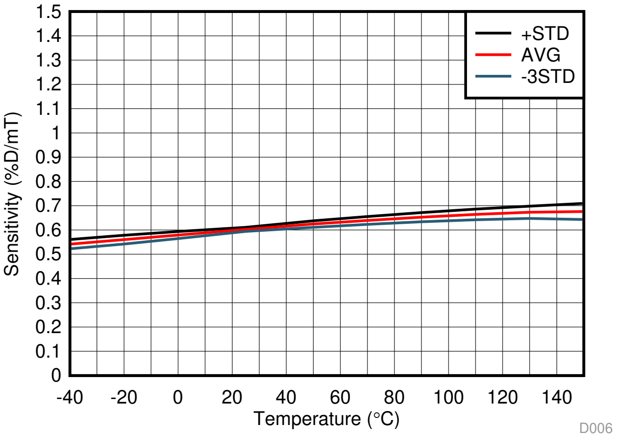


図 6. Sensitivity vs Temperature

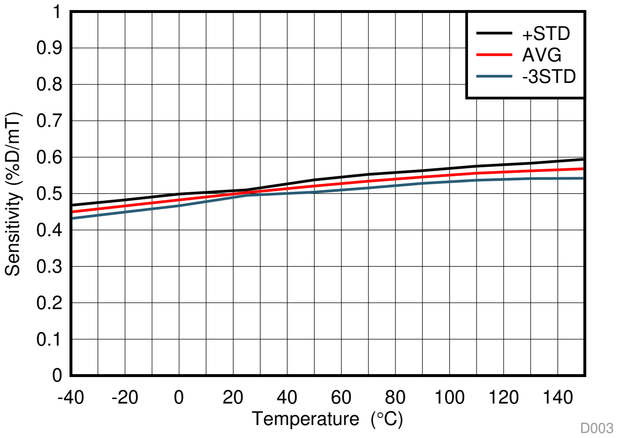
Typical Characteristics (continued)

for T_A = 25°C (unless otherwise noted)



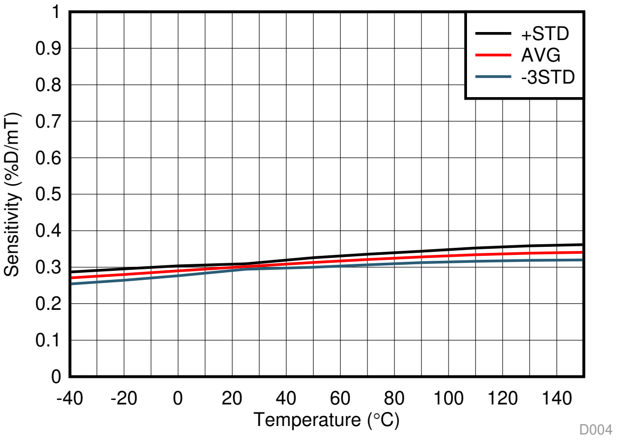
DRV5057A2-Q1, V_{CC} = 3.3 V

図 7. Sensitivity vs Temperature



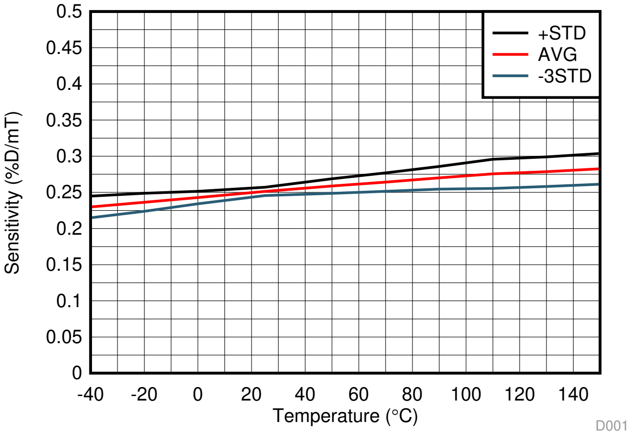
DRV5057A3-Q1, V_{CC} = 5.0 V

図 8. Sensitivity vs Temperature



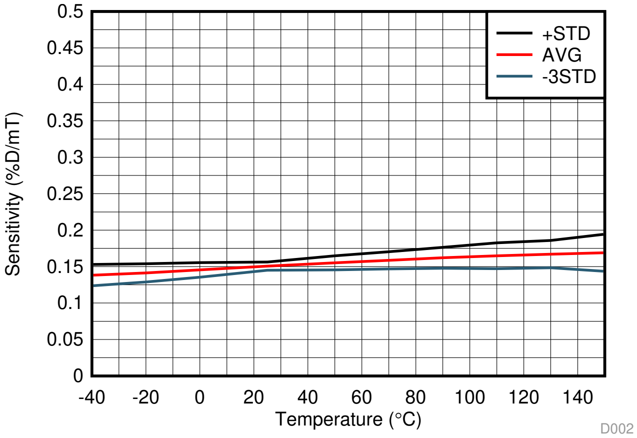
DRV5057A3-Q1, V_{CC} = 3.3 V

図 9. Sensitivity vs Temperature



DRV5057A4-Q1, V_{CC} = 5.0 V

図 10. Sensitivity vs Temperature



DRV5057A4-Q1, V_{CC} = 3.3 V

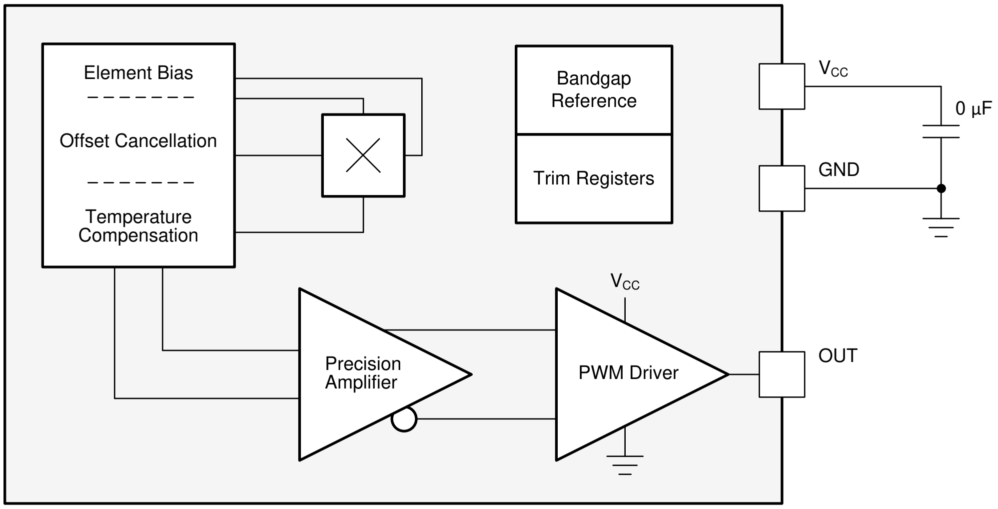
図 11. Sensitivity vs Temperature

8 Detailed Description

8.1 Overview

The DRV5057-Q1 is a 3-pin pulse-width modulation (PWM) output Hall effect sensor with fully integrated signal conditioning, temperature compensation circuits, mechanical stress cancellation, and amplifiers. The device operates from 3.3-V and 5-V (±10%) power supplies, measures magnetic flux density, and outputs a pulse-width modulated, 2-kHz digital signal.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Magnetic Flux Direction

As shown in 図 12, the DRV5057-Q1 is sensitive to the magnetic field component that is perpendicular to the top of the package.

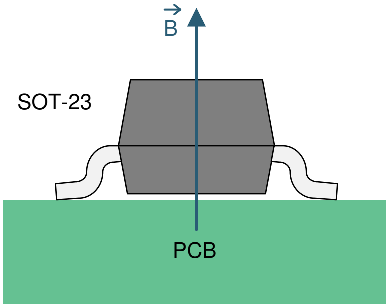


図 12. Direction of Sensitivity

Feature Description (continued)

Magnetic flux that travels from the bottom to the top of the package is considered positive in this document. This condition exists when a south magnetic pole is near the top (marked-side) of the package. Magnetic flux that travels from the top to the bottom of the package results in negative millitesla values. 図 13 shows flux direction.

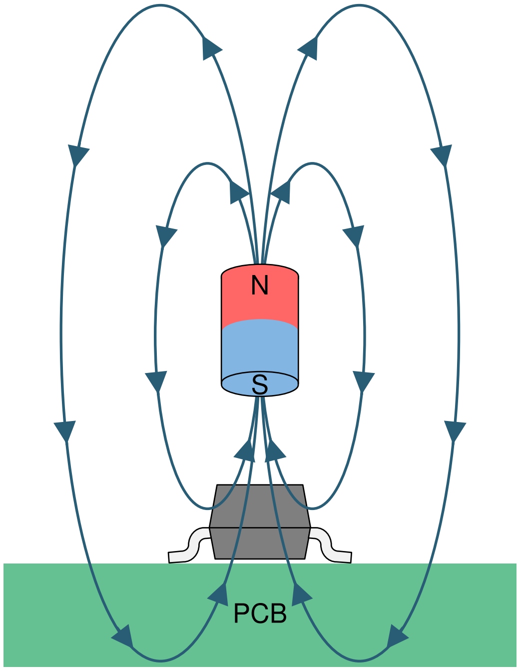


図 13. Flux Direction for Positive B

8.3.2 Sensitivity Linearity

The device produces a pulse-width modulated digital signal output. As shown in 図 14, the duty-cycle of the PWM output signal is proportional to the magnetic field detected by the Hall element of the device. If there is no magnetic field present, the duty cycle is 50%. The DRV5057-Q1 can detect both magnetic north and south poles. The output duty cycle maintains a linear relationship with the input magnetic field from 8% to 92%.

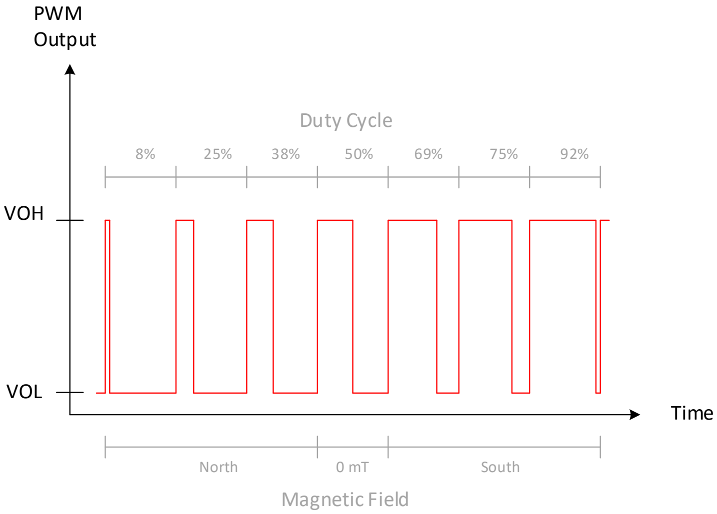


図 14. Magnetic Response

Feature Description (continued)

8.3.3 Operating V_{CC} Ranges

The DRV5057-Q1 has two recommended operating V_{CC} ranges: 3 V to 3.63 V and 4.5 V to 5.5 V. When V_{CC} is in the middle region between 3.63 V to 4.5 V, the device continues to function but sensitivity is less known because there is a crossover threshold near 4 V that adjusts device characteristics.

8.3.4 Sensitivity Temperature Compensation for Magnets

Magnets generally produce weaker fields as temperature increases. The DRV5057-Q1 has a temperature compensation feature that is designed to directly compensate the average drift of neodymium (NdFeB) magnets and partially compensate ferrite magnets. The residual induction (B_r) of a magnet typically reduces by 0.12%/°C for NdFeB, and 0.20%/°C for ferrite. When the operating temperature of a system is reduced, temperature drift errors are also reduced.

8.3.5 Power-On Time

After the V_{CC} voltage is applied, the DRV5057-Q1 requires a short initialization time before the output is set. The parameter t_{ON} describes the time from when V_{CC} crosses 3 V until OUT is within 5% of V_Q, with 0 mT applied and no load attached to OUT. 図 15 shows this timing diagram.

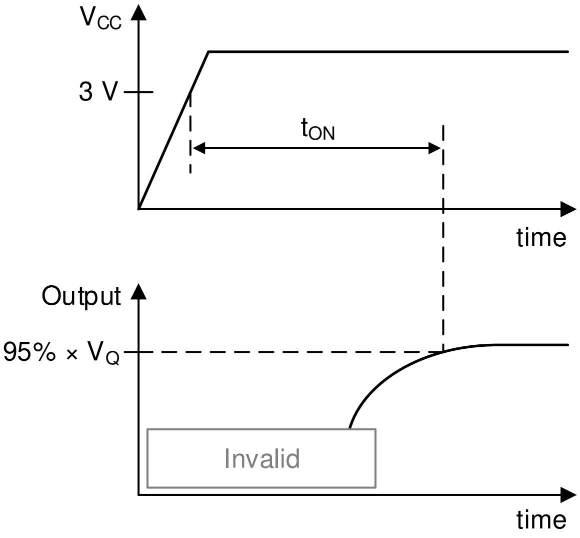


図 15. t_{ON} Definition

Feature Description (continued)

8.3.6 Hall Element Location

図 16 shows the location of the sensing element inside each package option.

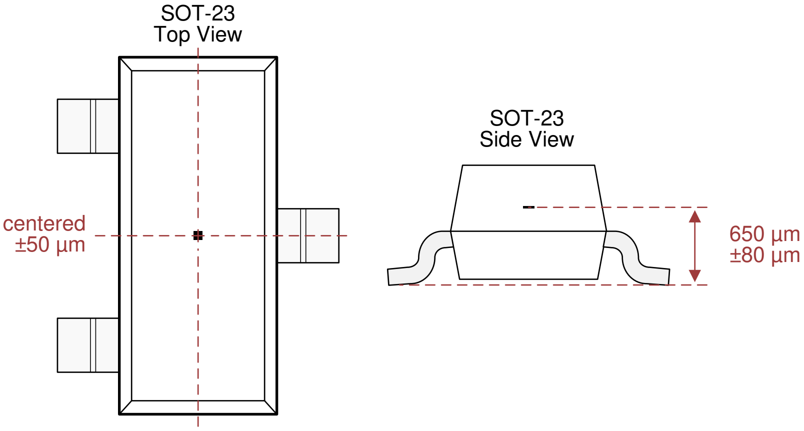


図 16. Hall Element Location

8.4 Device Functional Modes

The DRV5057-Q1 has one mode of operation that applies when the *Recommended Operating Conditions* are met.

9 Application and Implementation

注

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. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

9.1.1 Selecting the Sensitivity Option

Select the highest DRV5057-Q1 sensitivity option that can measure the required range of magnetic flux density so that the output voltage swing is maximized.

Larger-sized magnets and farther sensing distances can generally enable better positional accuracy than very small magnets at close distances, because magnetic flux density increases exponentially with the proximity to a magnet. TI created an online tool to help with simple magnet calculations on the DRV5057-Q1 product folder.

9.1.2 Decoding a PWM

A PWM output helps system designers drive signals for long distances in noisy environments, with the ability to retrieve the signal accurately. A decoder is employed at the load to retrieve the analog magnetic signal. Two different methods of decoding are discussed in this section.

9.1.2.1 Decoding a PWM (Digital)

9.1.2.1.1 Capture and Compare Timer Interrupt

Many microcontrollers have a capture and compare timer mode that can simplify the PWM decoding process. Use the timer in capture and compare mode with an interrupt that triggers on both the rising and falling edges of the signal to obtain both the relative high (on) and low (off) time of the PWM. Make sure that the timer period is significantly faster than the period of the PWM, based on the desired resolution. Calculate the percent duty cycle (%D) of the PWM with 式 1 by using the relative on and off time of the signal.

$$\%D = \frac{\text{OnTime}}{\text{OnTime} + \text{OffTime}} \times 100 \quad (1)$$

9.1.2.1.2 Oversampling and Counting With a Timer Interrupt

If a capture and compare timer is not available, a standard timer interrupt and a counter can be used. Configure the timer interrupt to be significantly faster than the period of the PWM, based on the desired resolution. Count how many times the timer interrupts while the signal is high (OnTime), then count how many times the timer interrupts while the signal is low (OffTime). Then use 式 1 to calculate the duty cycle.

9.1.2.1.3 Accuracy and Resolution

The accuracy and resolution for the methods described in the *Capture and Compare Timer Interrupt* and *Oversampling and Counting With a Timer Interrupt* sections depends significantly on the timer sampling frequency. 式 2 calculates the least significant bit of the duty cycle ($\%D_{LSB}$) based on the chosen timer sampling frequency.

$$\%D_{LSB} = \frac{\text{PWM}_{\text{frequency}}}{\text{TIMER}_{\text{frequency}}} \times 100 \quad (2)$$

For example, with a 2-kHz PWM and a 400-kHz sampling frequency, the $\%D_{LSB}$ is:

(2 kHz / 400 kHz) × 100 = 0.5$\%D_{LSB}$

If the sampling frequency in increased to 2-MHz, the $\%D_{LSB}$ is improved to be:

(2 MHz / 400 kHz) × 100 = 0.1$\%D_{LSB}$

However, accuracy and resolution are still subject to noise and sensitivity.

Application Information (continued)

9.1.2.2 Decoding a PWM (Analog)

If an analog signal is needed at the end of a large travel distance, first use a microcontroller to digitally decode the PWM, then use a DAC to produce the analog signal. If an analog signal is needed after a short signal travel distance, use an analog output device, such as the DRV5055-Q1.

If an analog signal is needed at the end of a large travel distance and a microcontroller is unavailable, use a low-pass filter to convert the PWM signal into an analog voltage, as shown in 図 17. When using this method, note the following:

- A ripple appears at the analog voltage output, causing a decrease in accuracy. The ripple intensity and frequency depend on the values chosen for R and C in the filter.
- The minimum and maximum voltages of the PWM must be known to calculate the magnetic field strength from the analog voltage. Thus, if the signal is traveling a large distance, then the minimum and maximum values must be either measured or buffered back to a known value.

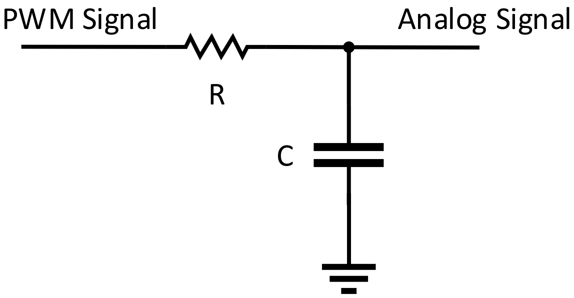


図 17. Low-Pass RC Filter

9.2 Typical Applications

The DRV557-Q1 is a very robust linear position sensor for applications such as throttle positions, brakes, and clutch pedals. In linear position applications, depending on the mechanical placement and design limitations, two common types of magnet orientations are selected: full-swing and half-swing.

9.2.1 Full-Swing Orientation Example

In the full-swing orientation, a magnet travels in parallel to the DRV5057-Q1 surface. In this case, the magnetic range extends from south polarity to north polarity, and allows the DRV5057-Q1 to use the full linear magnetic flux density sensing range.

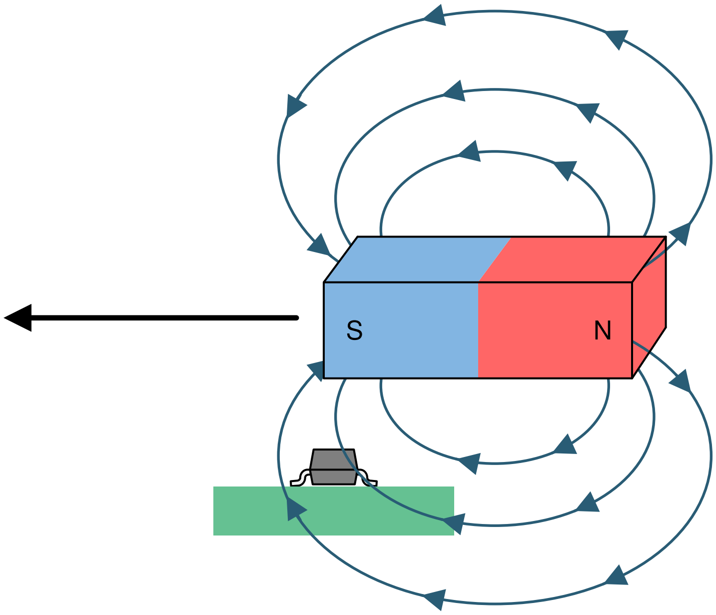


図 18. Full-Swing Orientation Example

9.2.1.1 *Design Requirements*

Use the parameters listed in 表 1 for this design example.

表 1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Device	DRV5057-Q1
V_{CC}	5 V
Magnet	Cylinder: 4.7625-mm diameter, 12.7-mm thick, neodymium N52, Br = 1480 mT
Travel distance	10 mm
Desired accuracy	< 0.1 mm

9.2.1.2 Detailed Design Procedure

Linear Hall effect sensors provide flexibility in mechanical design because many possible magnet orientations and movements produce a usable response from the sensor. 図 18 illustrates one of the most common orientations that uses the full north to south range of the sensor and causes a close-to-linear change in magnetic flux density as the magnet moves across the sensor. 図 19 illustrates the close-to-linear change in magnetic field present at the sensor as the magnet moves a given distance across the sensor. The usable linear region is close to but less than the length (thickness) of the magnet.

When designing a linear magnetic sensing system, always consider these three variables: the magnet, sensing distance, and the range of the sensor. Select the DRV5057-Q1 with the highest sensitivity possible based on the system distance requirements without railing the sensor PWM output. To determine the magnetic flux density the sensor receives at the various positions of the magnet, use a magnetic field calculator or simulation software, referring to magnet specifications, and testing.

Determine if the desired accuracy is met by comparing the maximum allowed duty cycle least significant bit ($\%D_{LSBmax}$) with the noise level (PWM jitter) of the device. 式 3 calculates the $\%D_{LSBmax}$ by taking into account the used length of the linear region (travel distance), the desired resolution, and the output PWM swing (within the linear duty cycle range).

$$\%D_{LSBmax} = \frac{\%D_{swing}}{\text{Travel Distance}} \times \text{Resolution} \quad (3)$$

Thus, with this example (and a linear duty cycle range of 8%D to 92%D), using 式 3 gives (92 – 8) / (10) × 0.1 = $0.84\%D_{LSBmax}$. This value is larger than the 0.1%D jitter, and therefore the desired accuracy can be achieved by using 式 2 to select a $\%D_{LSB}$ that is equal to or less than 0.84. Then, simply calibrate the magnet position to align the sensor output along the movement path.

9.2.1.3 Application Curve

図 19 shows the magnetic field present at the sensor as the magnet passes by as described in 図 18. The change in distance from the trough to the peak is approximately the length (thickness) of the magnet. B changes based on the strength of the magnet and how close the magnet is to the sensor.

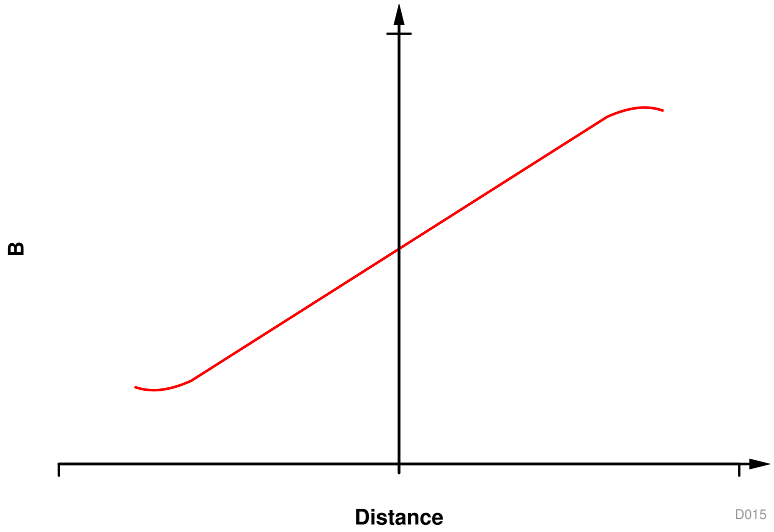


図 19. Magnetic Field vs Distance

9.2.2 Half-Swing Orientation Example

In the half-swing orientation, a magnet travels perpendicular to the DRV5057-Q1 surface. In this case, the magnetic range extends only to either the south or north pole, using only half of the DRV5057-Q1 linear magnetic flux density sensing range.

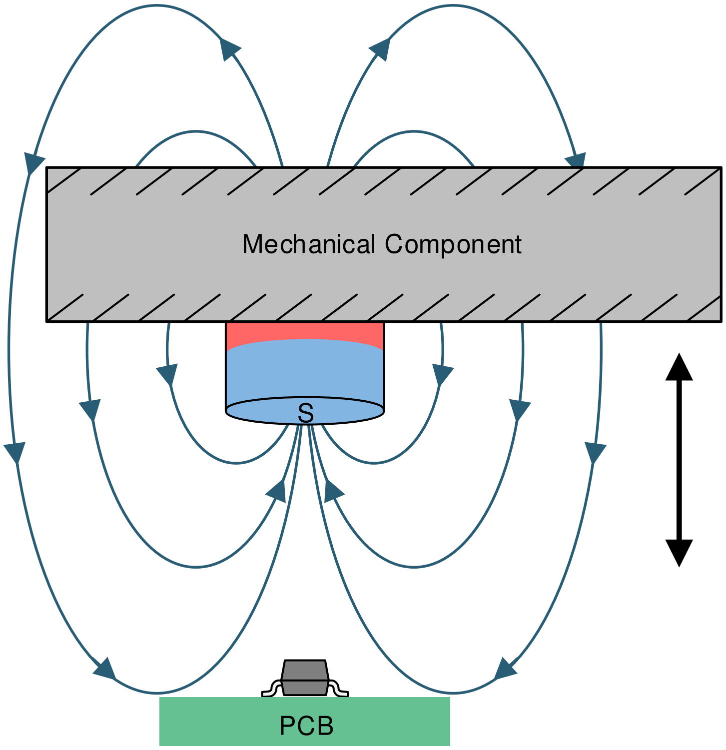


図 20. Half-Swing Orientation Example

9.2.2.1 Design Requirements

Use the parameters listed in 表 2 for this design example.

表 2. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Device	DRV5057-Q1
V_{CC}	5 V
Magnet	Cylinder: 4.7625 mm diameter, 12.7 mm thick, Neodymium N52, Br = 1480 mT
Travel distance	5 mm
Desired accuracy	< 0.1 mm

9.2.2.2 Detailed Design Procedure

As illustrated in 図 20, this design example consists of a mechanical component that moves back and forth, an embedded magnet with the south pole facing the printed-circuit board, and a DRV5057-Q1. The DRV5057-Q1 outputs a PWM that describes the precise position of the component. The component must not contain ferromagnetic materials such as iron, nickel, and cobalt because these materials change the magnetic flux density at the sensor.

When designing a linear magnetic sensing system, always consider these three variables: the magnet, sensing distance, and the range of the sensor. Select the DRV5057-Q1 with the highest sensitivity possible based on the system distance requirements without railing the sensor PWM output. To determine the magnetic flux density the sensor receives at the various positions of the magnet, use a magnetic field calculator or simulation software, referring to magnet specifications, and testing.

Magnets are made from various ferromagnetic materials that have tradeoffs in cost, drift with temperature, absolute maximum temperature ratings, remanence or residual induction (B_r), and coercivity (H_c). The B_r and the dimensions of a magnet determine the magnetic flux density (B) produced in 3-dimensional space. For simple magnet shapes, such as rectangular blocks and cylinders, there are simple equations that solve B at a given distance centered with the magnet. 図 21 shows diagrams for 式 4 and 式 5.

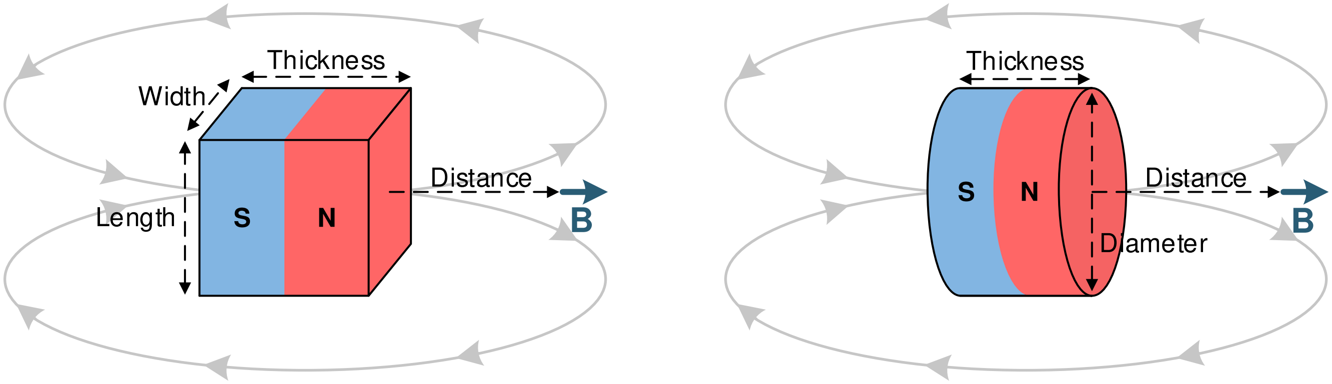


図 21. Rectangular Block and Cylinder Magnets

Use 式 4 for the rectangular block shown in 図 21:

$$\vec{B} = \frac{B_r}{\pi}\left(\arctan\left(\frac{WL}{2D\sqrt{4D^2 + W^2 + L^2}}\right) - \arctan\left(\frac{WL}{2(D + T)\sqrt{4(D + T)^2 + W^2 + L^2}}\right)\right) \tag{4}$$

Use 式 5 for the cylinder illustrated in 図 21:

$$\vec{B} = \frac{B_r}{2}\left(\frac{D + T}{\sqrt{(0.5C)^2 + (D + T)^2}} - \frac{D}{\sqrt{(0.5C)^2 + D^2}}\right) \tag{5}$$

where:

- W is width
- L is length
- T is thickness (the direction of magnetization)
- D is distance
- C is diameter

This example uses a cylinder magnet; therefore, 式 5 can be used to create a lookup table for the distances from a specific magnet based on a magnetic field strength. 図 22 shows a magnetic field from 0 mm to 16 mm with the magnet defined in 表 2 as C = 4.7625 mm, T = 12.7 mm, and B_r = 1480 mT.

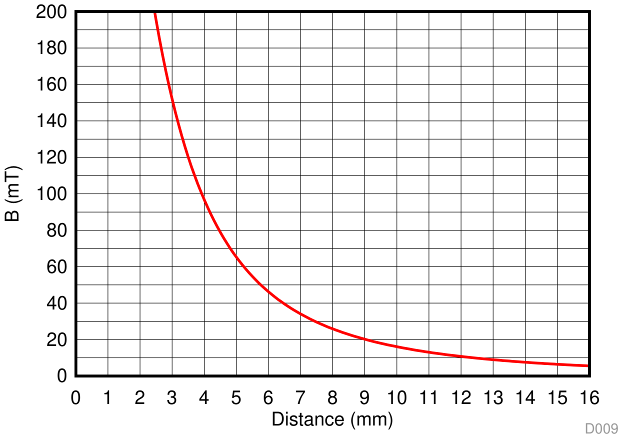


図 22. Magnetic Field vs Distance

In this setup, each gain version of the sensor produces the corresponding duty cycle shown in 図 23 for 0 mm to 16 mm.

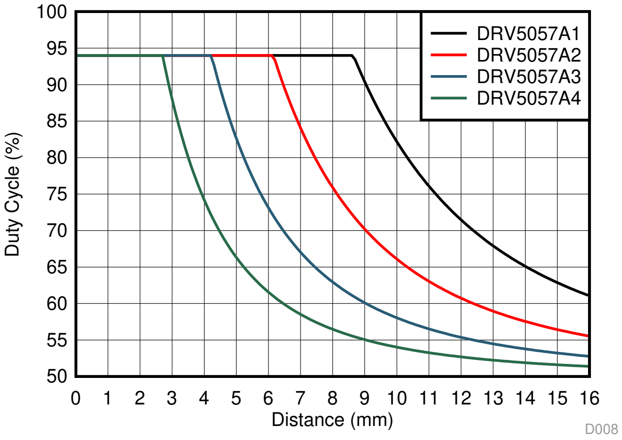


図 23. %D vs South Pole Distance (All Gains)

With a desired 5-mm movement swing, select the DRV5057-Q1 with the largest possible sensitivity that fits the system requirements for the magnet distance to the sensor. Assume that for this example, because of mechanical restrictions, the magnet at the nearest point to the sensor must be selected to be within 5 mm to 8 mm. The largest sensitivity option (A1) does not work in this situation because the device output is railed at the farthest allowed distance of 8 mm. The A2 version is not railed at this point, and is therefore the sensor selected for this example. Choose the closest point of the magnet to the sensor to be a distance that allows the magnet to get as close to the sensor as possible without railing but stays within the selectable 5-mm to 8-mm allowed range. Because the A2 version rails at approximately 6 mm, choose a closest distance of 6.5 mm to allow for a little bit of margin. With this choice, 図 24 shows the %D response at the sensor across the full movement range.

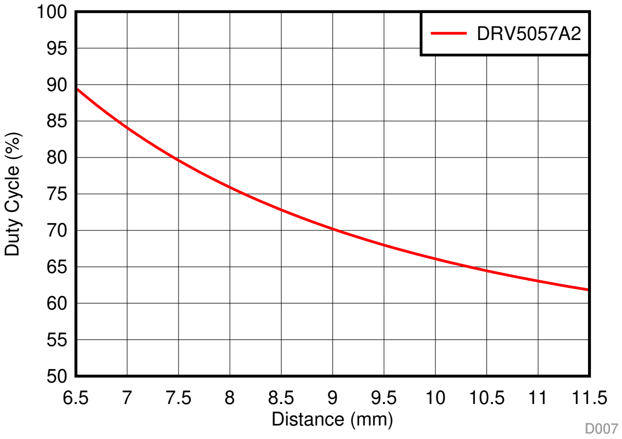


図 24. %D vs South Pole Distance (Gain A2)

The magnetic field strength is calculated using 式 6, where a negative number represents the opposite pole (in this example a south pole is over the sensor, causing the results to be a positive number).

$$B = \frac{(\%D - 50)}{\text{Gain}} \tag{6}$$

For example, if the A2 version of the DRV5057-Q1 measured a duty cycle of %D = 74.6% using 式 1 , then the magnetic field strength present at the sensor is (74.6 – 50) / 1 = 24.6 mT.

Using the lookup table that was used to create the plot in 図 22, the distance from the magnet at 24.6 mT is D ≈ 8.2 mm.

For more accurate results, the lookup table can be calibrated along the movement path of the magnet. Additionally, instead of using the calibrated lookup table for each measurement, consider using a best-fit polynomial equation from the curve for the desired movement range to calculate D in terms of B.

The curve in 図 24 is not linear; therefore, the achievable accuracy varies for each position along the movement path. The location with the worst accuracy is where there is the smallest change in output for a given amount of movement, which in this example is where the magnet is farthest from the sensor (at 11.5 mm). Determine if the desired accuracy is met by checking if the needed $\%D_{LSB}$ at this location for the specified accuracy is greater than the noise level (PWM jitter) of 0.1%D. Thus, with a desired accuracy of 0.1 mm, the needed $\%D_{LSB}$ is the change in %D between 11.4 mm and 11.5 mm. Using the lookup table to find B and then solving for %D in 式 6, at 11.5 mm, B = 11.815 mT (which equates to 61.815%D), and at 11.4 mm B = 12.048 mT (which equates to 62.048%D). The difference in %D between these two points is 62.048 – 61.815 = $0.223\%D_{LSB}$. This value is larger than the 0.1%D jitter, so the desired accuracy can be met as long as a $\%D_{LSB}$ is selected that is equal to or less than 0.223 using 式 2.

9.3 What to Do and What Not to Do

The Hall element is sensitive to magnetic fields that are perpendicular to the top of the package. Therefore, to correctly detect the magnetic field, make sure to use the correct magnet orientation for the sensor. 図 25 shows correct and incorrect orientation.

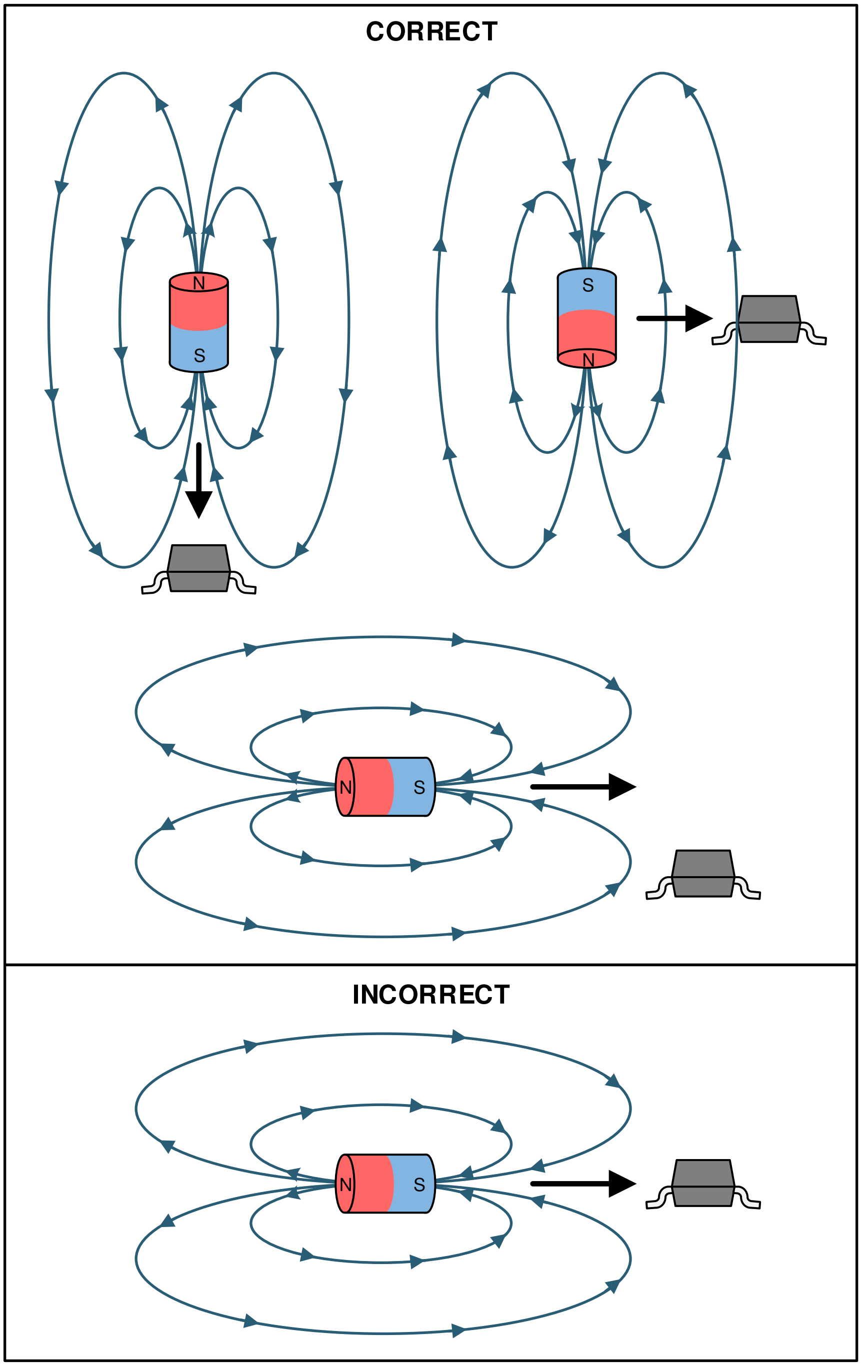


図 25. Correct and Incorrect Magnet Orientation

10 Power Supply Recommendations

Use a decoupling capacitor placed close to the device to provide local energy with minimal inductance. Use a ceramic capacitor with a value of at least 0.01 µF.

11 Layout

11.1 Layout Guidelines

Magnetic fields pass through most nonferromagnetic 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.

11.2 Layout Example

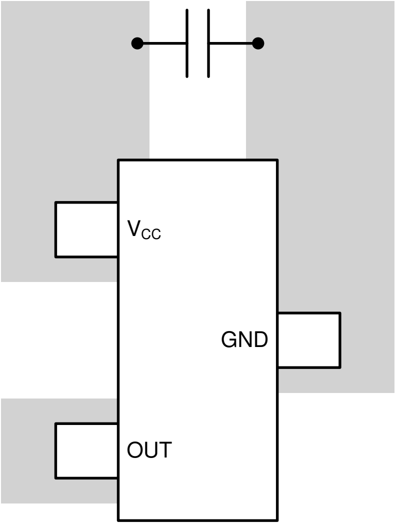


図 26. Layout Example

12 デバイスおよびドキュメントのサポート

12.1 ドキュメントのサポート

12.1.1 関連資料

関連資料については、以下を参照してください。

- テキサス・インスツルメンツ、『リニア・ホール効果センサによる角度の測定』TechNotes
- テキサス・インスツルメンツ、『増分式ロータリー・エンコーダ設計の考慮事項』TechNotes
- テキサス・インスツルメンツ、『DRV5055レシオメトリック・リニア・ホール効果センサ』データシート

12.2 ドキュメントの更新通知を受け取る方法

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12.3 コミュニティ・リソース

The following links connect to TI community resources. Linked contents are 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.

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Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.4 商標

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12.6 Glossary

SLYZ022 — *TI Glossary*.

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

13 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

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
DRV5057A1EDBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-3-260C-168 HR	-40 to 150	57A1Z	Samples
DRV5057A2EDBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-3-260C-168 HR	-40 to 150	57A2Z	Samples
DRV5057A3EDBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-3-260C-168 HR	-40 to 150	57A3Z	Samples
DRV5057A4EDBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-3-260C-168 HR	-40 to 150	57A4Z	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.

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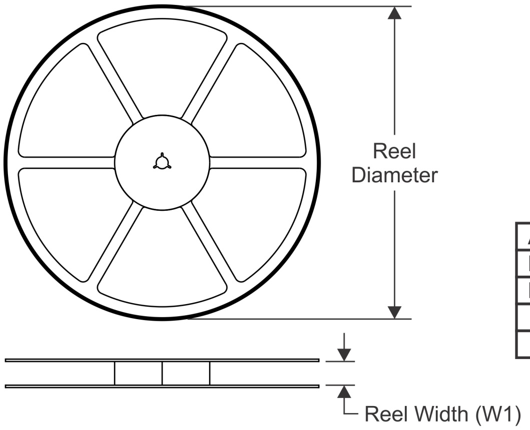
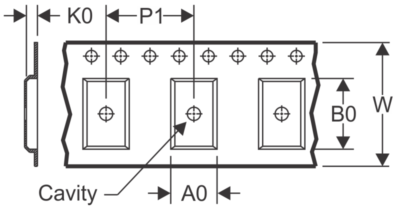
TAPE AND REEL INFORMATION

REEL DIMENSIONS

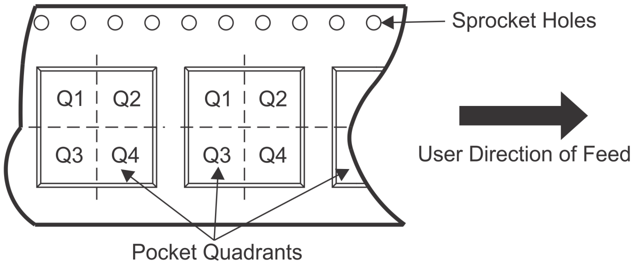


TAPE DIMENSIONS



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

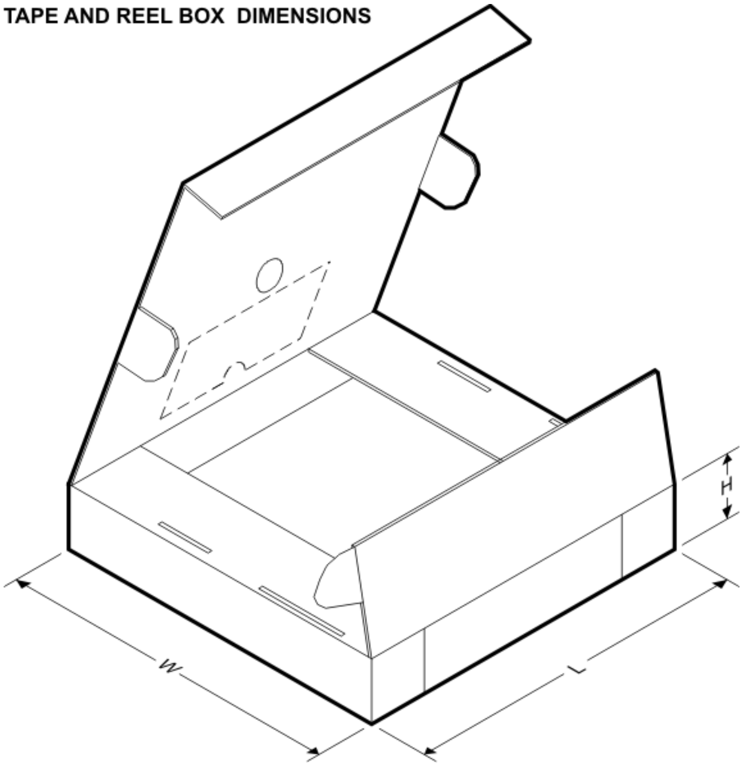
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

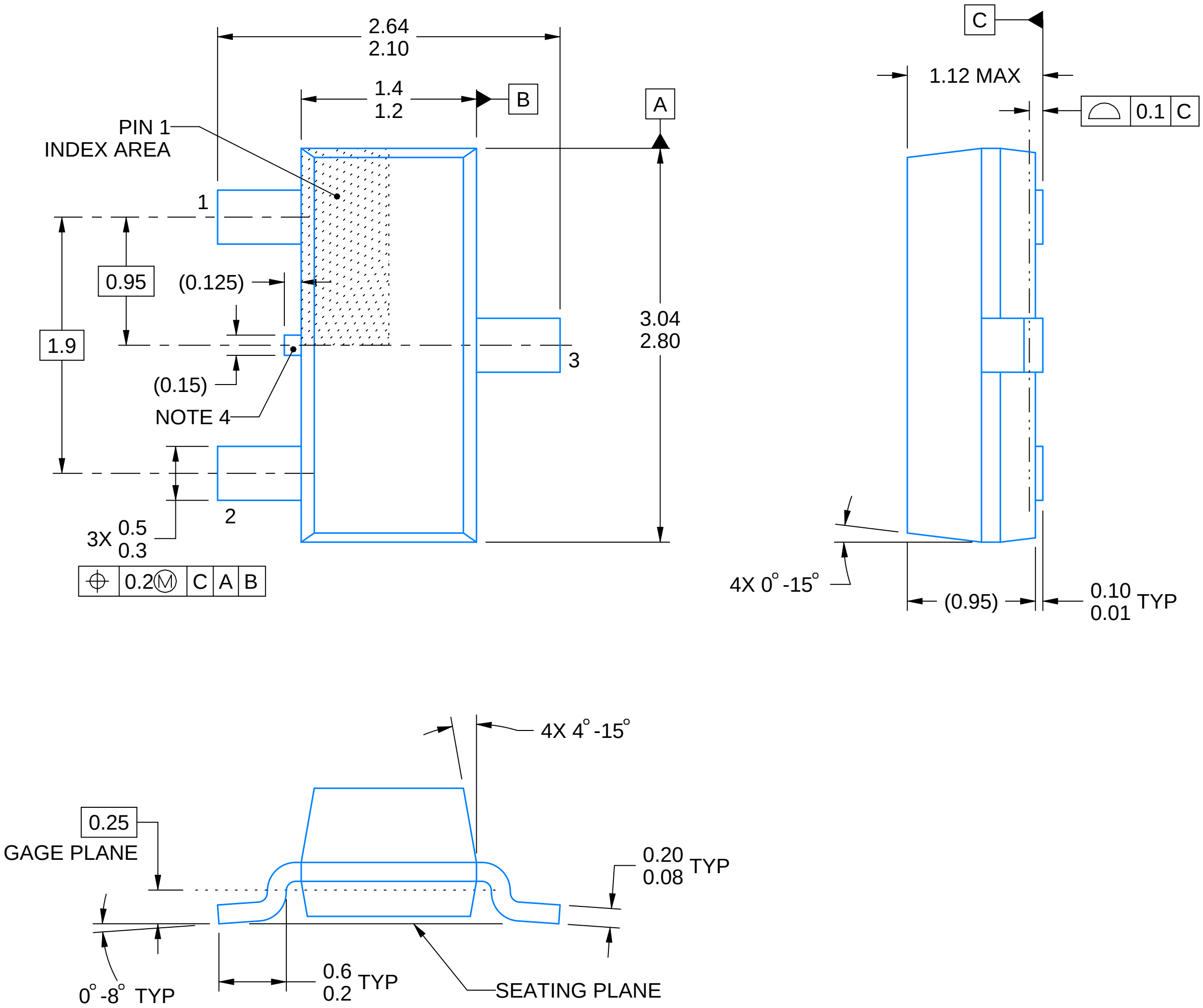
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DRV5057A1EDBZRQ1	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3
DRV5057A2EDBZRQ1	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3
DRV5057A3EDBZRQ1	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3
DRV5057A4EDBZRQ1	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



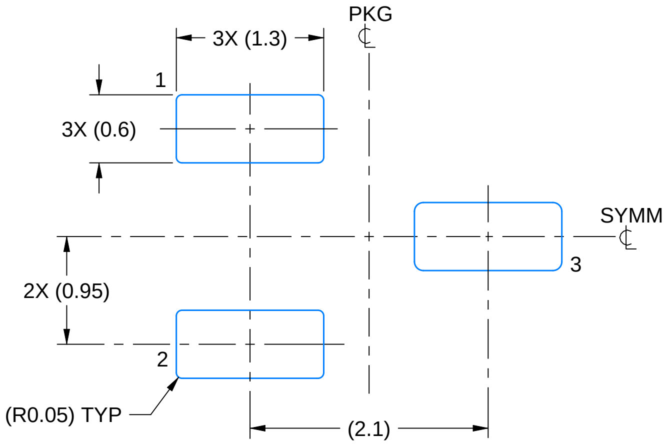
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DRV5057A1EDBZRQ1	SOT-23	DBZ	3	3000	213.0	191.0	35.0
DRV5057A2EDBZRQ1	SOT-23	DBZ	3	3000	213.0	191.0	35.0
DRV5057A3EDBZRQ1	SOT-23	DBZ	3	3000	213.0	191.0	35.0
DRV5057A4EDBZRQ1	SOT-23	DBZ	3	3000	213.0	191.0	35.0

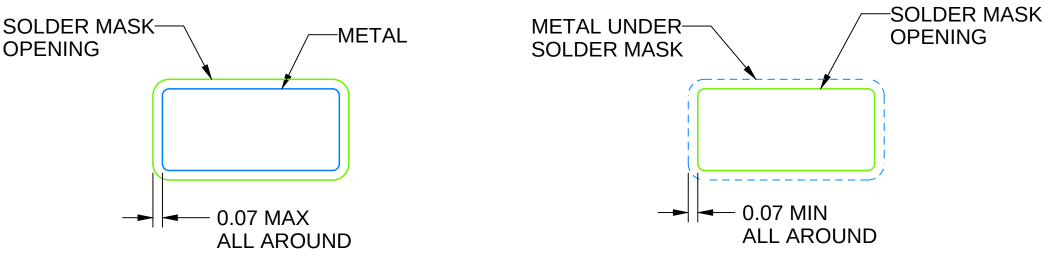


NOTES:

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. Reference JEDEC registration TO-236, except minimum foot length.
4. Support pin may differ or may not be present.
5. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side



LAND PATTERN EXAMPLE
SCALE:15X



NON SOLDER MASK
DEFINED
(PREFERRED)

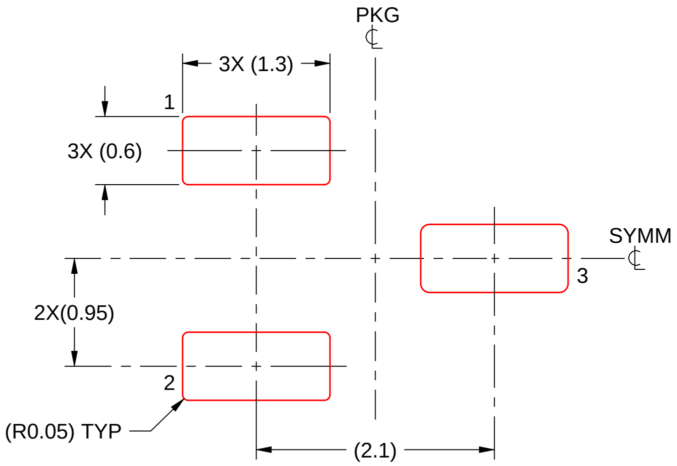
SOLDER MASK
DEFINED

SOLDER MASK DETAILS

4214838/F 08/2024

NOTES: (continued)

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



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

NOTES: (continued)

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

重要なお知らせと免責事項

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