TEXAS INSTRUMENTS
DRV5057
JAJSGG8A – NOVEMBER 2018 – REVISED AUGUST 2020

DRV5057 リニア・ホール効果センサ、PWM 出力対応

1 特長

- 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/Z1：2%D/mT、±21mT 範囲
  - A2/Z2：1%D/mT、±42mT 範囲
  - A3/Z3：0.5%D/mT、±84mT 範囲
  - A4/Z4：0.25%D/mT、±168mT 範囲
- シンク能力 20mA のオープンドレイン出力
- 磁石温度ドリフト補償ありの A1/A2/A3/A4 バージョン、なしの Z1/Z2/Z3/Z4 バージョン
- 業界標準のパッケージ
  - 表面実装 SOT-23
  - スルーホール TO-92

2 アプリケーション

- 高精度の位置センシング
- 産業用オートメーションおよびロボティクス
- 家電製品
- ゲームパッド、ペダル、キーボード、トリガ
- 高さレベリング、傾き、重量の測定
- 液体の流量測定
- 医療機器
- 絶対角度のエンコード
- 電流センシング

3 説明

DRV5057 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。

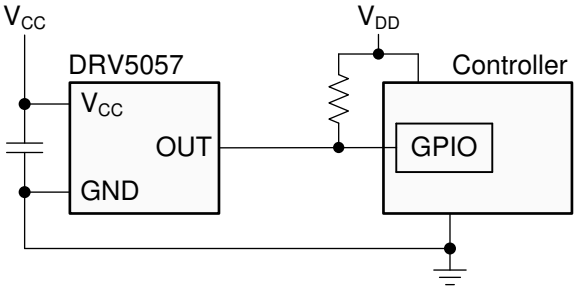
パッケージの上面に垂直な磁束が検出され、2 つのパッケージ・オプションでセンシング方向が異なります。

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℃～+125℃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。磁石のドリフトの温度補償を行わないデバイス・オプションも選択できます。

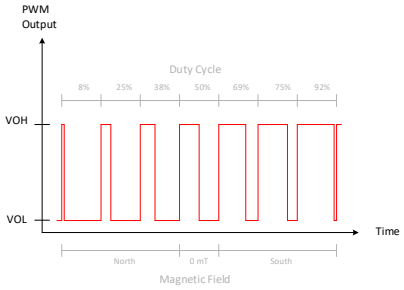
製品情報

部品番号	パッケージ (1)	本体サイズ (公称)
DRV5057	SOT-23 (3)	2.92mm × 1.30mm
	TO-92 (3)	4.00mm × 3.15mm

(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

英語版の TI 製品についての情報を翻訳したこの資料は、製品の概要を確認する目的で便宜的に提供しているものです。該当する正式な英語版の最新情報は、www.ti.com で閲覧でき、その内容が常に優先されます。TI では翻訳の正確性および妥当性につきましては一切保証いたしません。実際の設計などの前には、必ず最新版の英語版をご参照くださいますようお願いいたします。

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4 Revision History

Changes from Revision * (November 2018) to Revision A (August 2020)	Page
• ドキュメント全体にわたって表、図、相互参照の採番方法を更新	1
• ゼロ TC 感度オプションを追加	1
• Added Zero TC information to *セクション 6.6*	4
• Fixed labels for some of the plots for graphs for DRV5057 A1/A2/A3/A4 devices and added Zero TC characteristics plots for DRV5057 Z1/Z2/Z3/Z4 devices in セクション 6.7	6
• Updated セクション 7.3.4 section for Zero TC options	12

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5 Pin Configuration and Functions

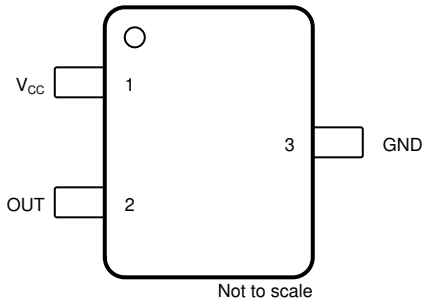


図 5-1. DBZ Package 3-Pin SOT-23 Top View

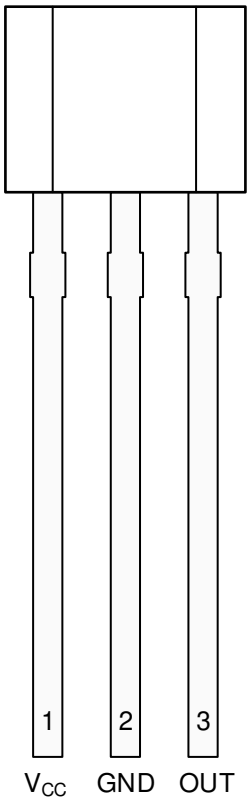


図 5-2. LPG Package 3-Pin TO-92 Top View

Pin Functions

PIN			TYPE	DESCRIPTION
NAME	SOT-23	TO-92		
GND	3	2	Ground	Ground reference
OUT	2	3	Output	Analog output
V_{CC}	1	1	Power	Power supply. Connect this pin to a ceramic capacitor to ground with a value of at least 0.01 µF.

6 Specifications

6.1 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	150	°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.

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6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±3000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±750	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V 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)	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	125	°C

(1) There are two isolated operating V_{CC} ranges. For more information see the *セクション 7.3.3* section.
(2) Power dissipation and thermal limits must be observed.

6.4 Thermal Information

THERMAL METRIC(1)		DRV5057		UNIT
		SOT-23 (DBZ)	TO-92 (LPG)	
		3 PINS	3 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	170	121	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	66	67	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	49	97	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	1.7	7.6	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	48	97	°C/W

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

6.5 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 7-4)(2)	B(1) = 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(1)
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) This unit is a percentage of duty cycle.
(2) t_{ON} is the time from when V_{CC} goes above 3 V until the first rising edge of the first valid pulse.

6.6 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)

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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)

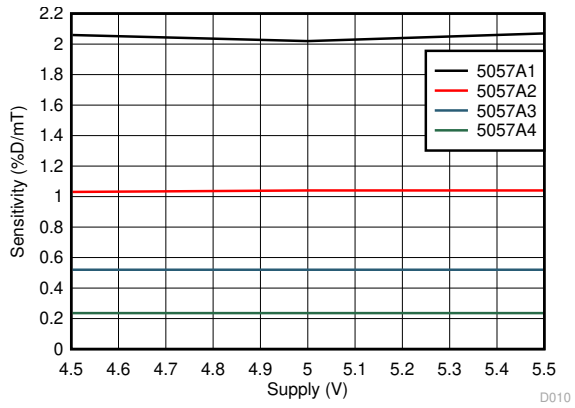
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
D_{CL}	Clamped-low duty cycle	B(1) < –250 mT		5.3	6	6.7	%D
D_{CH}	Clamped-high duty cycle	B > 250 mT		93.3	94	94.7	
D_Q	Quiescent duty cycle(2)	B = 0 mT, T_A = 25°C, V_{CC} = 3.3 V or 5 V		46	50	54	%D
$V_{Q\Delta L}$	Quiescent duty cycle lifetime drift	High-temperature operating stress for 1000 hours			< 0.5		%
S	Sensitivity(5)	V_{CC} = 5 V, T_A = 25°C	DRV5057A1/Z1	1.88	2	2.12	%D/mT
			DRV5057A2/Z2	0.94	1	1.06	
			DRV5057A3/Z3	0.47	0.5	0.53	
			DRV5057A4/Z4	0.23	0.25	0.27	
		V_{CC} = 3.3 V, T_A = 25°C	DRV5057A1/Z1	1.13	1.2	1.27	
			DRV5057A2/Z2	0.56	0.6	0.64	
			DRV5057A3/Z3	0.28	0.3	0.32	
			DRV5057A4/Z4	0.138	0.15	0.162	
B_L	Linear magnetic flux density sensing range(2) (3) (5)	V_{CC} = 5 V, T_A = 25°C	DRV5057A1/Z1		±21		mT
			DRV5057A2/Z2		±42		
			DRV5057A3/Z3		±84		
			DRV5057A4/Z4		±168		
S_{TC}	Sensitivity temperature compensation for magnets(4)	DRV5057A1, DRV5057A2, DRV5057A3, DRV5057A4			0.12		%/°C
S_{TCz}	Sensitivity temperature compensation for magnets(4) (5)	DRV5057Z1, DRV5057Z2, DRV5057Z3, DRV5057Z4			0		%/°C
S_{LE}	Sensitivity linearity error(2)	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) B is the applied magnetic flux density.
(2) See the *セクション 7.3.2* section.
(3) B_L describes the minimum linear sensing range at 25°C taking into account the maximum V_Q and sensitivity tolerances.
(4) S_{TC} describes the rate the device increases Sensitivity with temperature. For more information, see the *セクション 7.3.4* section and 図 6-7 to 図 6-20.
(5) Product Preview data only for DRV5055Z1 - DRV5055Z4 device options.

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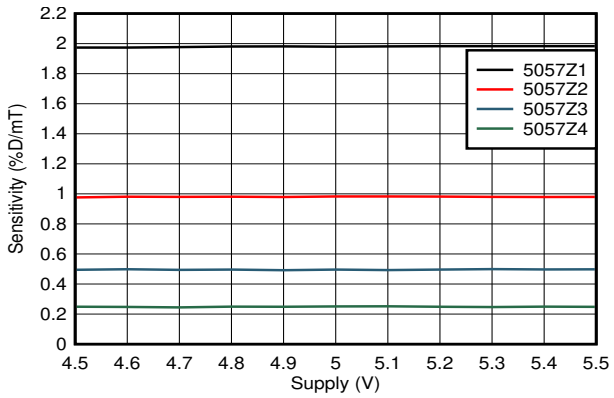
6.7 Typical Characteristics

for T_A = 25°C (unless otherwise noted)



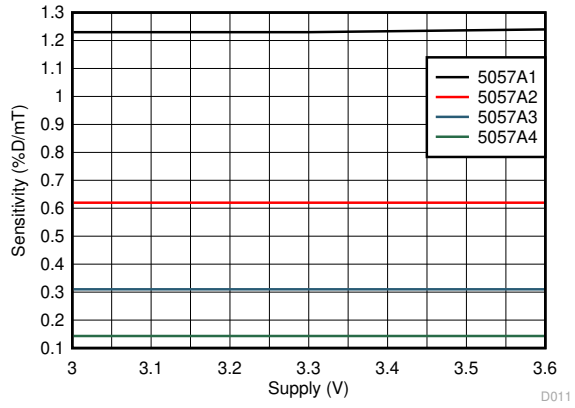
V_{CC} = 5.0 V

図 6-1. Sensitivity vs Supply Voltage



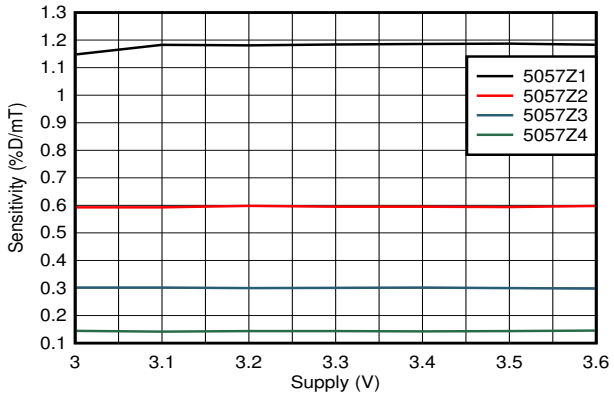
V_{CC} = 5.0 V

図 6-2. Sensitivity vs Supply Voltage



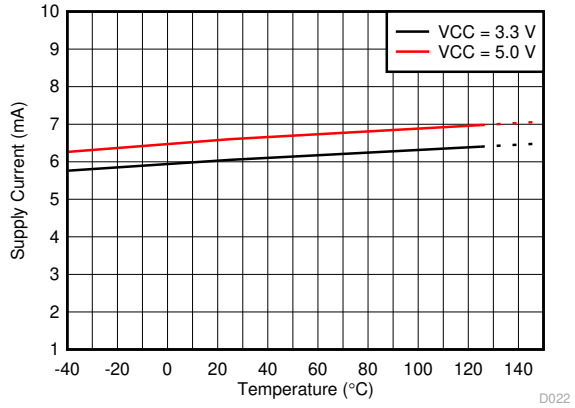
V_{CC} = 3.3 V

図 6-3. Sensitivity vs Supply Voltage



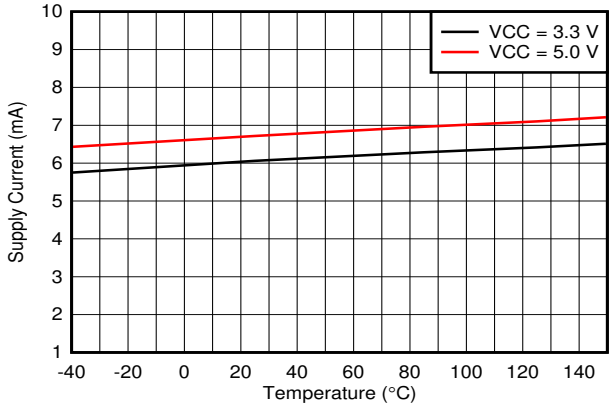
V_{CC} = 3.3 V

図 6-4. Sensitivity vs Supply Voltage



DRV5057A1/A2/A3/A4

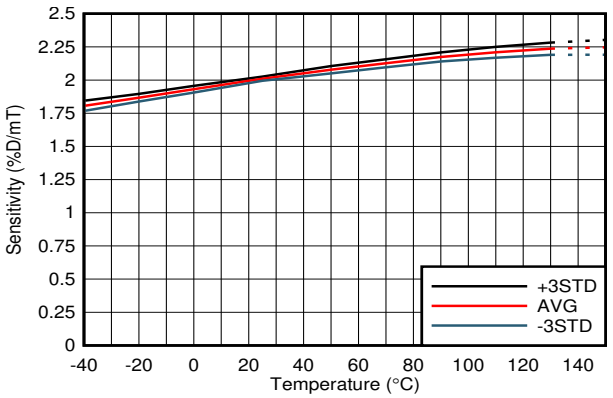
図 6-5. Supply Current vs Temperature



DRV5057Z1/Z2/Z3/Z4

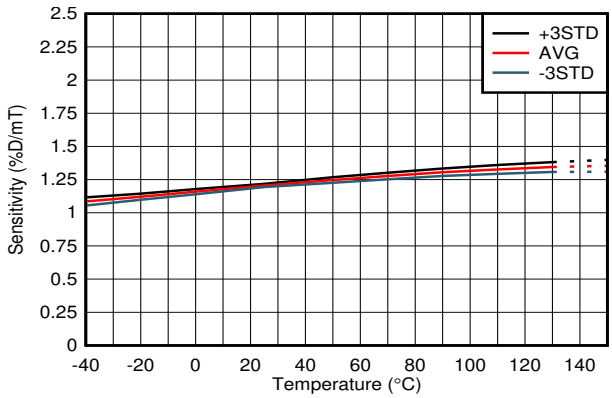
図 6-6. Supply Current vs Temperature

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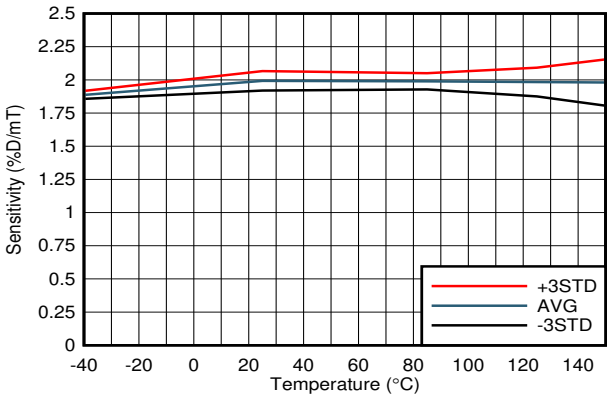
DRV5057A1, V_{CC} = 5.0 V

図 6-7. Sensitivity vs Temperature



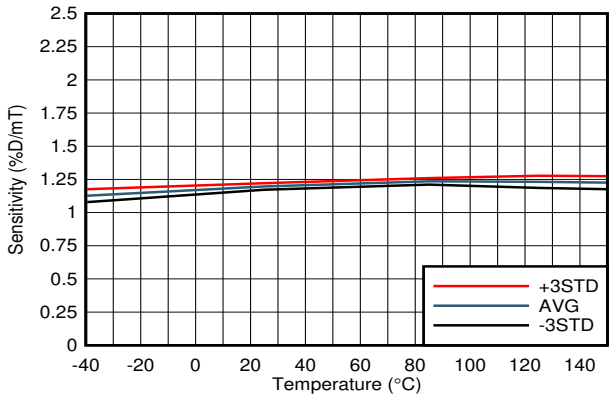
DRV5057A1, V_{CC} = 3.3 V

図 6-8. Sensitivity vs Temperature



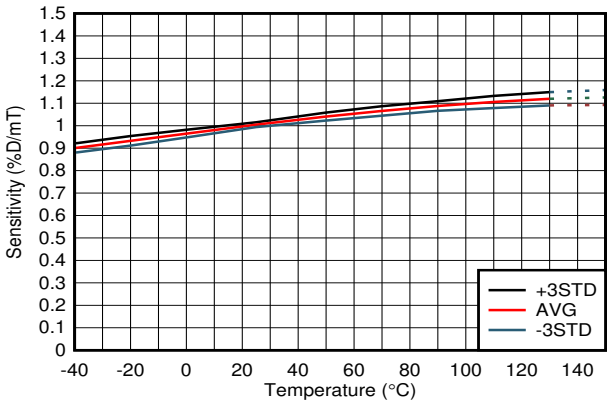
DRV5057Z1, V_{CC} = 5.0 V

図 6-9. Sensitivity vs Temperature



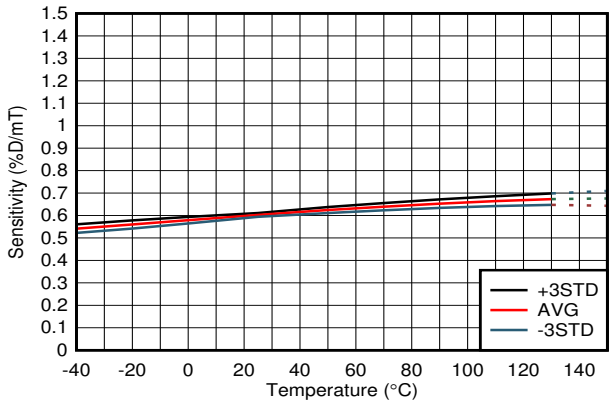
DRV5057Z1, V_{CC} = 3.3 V

図 6-10. Sensitivity vs Temperature



DRV5057A2, V_{CC} = 5.0 V

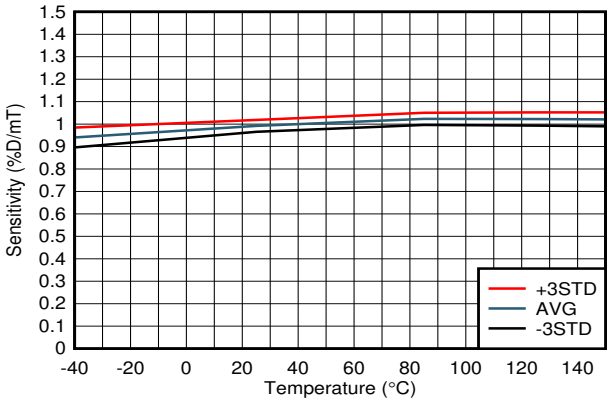
図 6-11. Sensitivity vs Temperature



DRV5057A2, V_{CC} = 3.3 V

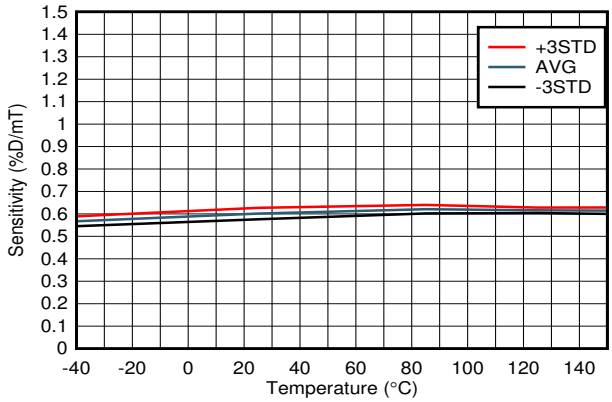
図 6-12. Sensitivity vs Temperature

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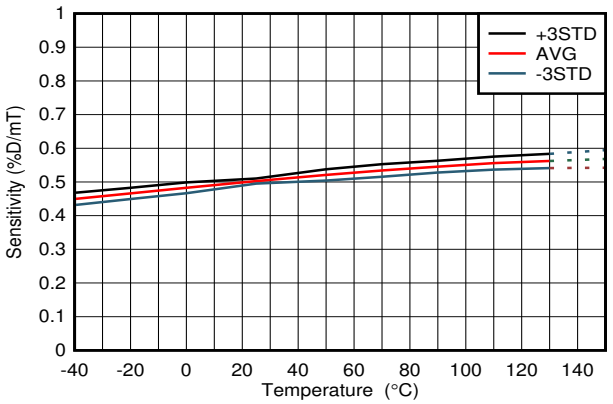
DRV5057Z2, V_{CC} = 5.0 V

図 6-13. Sensitivity vs Temperature



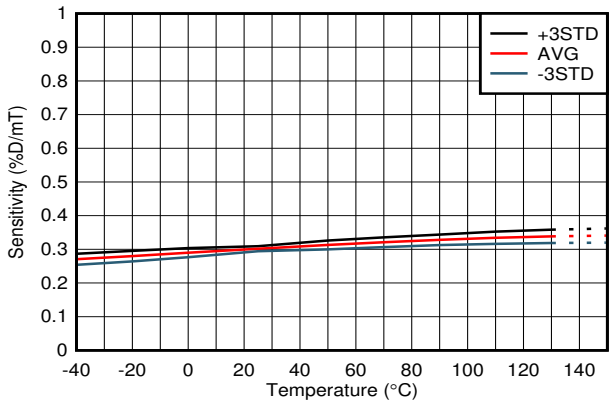
DRV5057Z2, V_{CC} = 3.3 V

図 6-14. Sensitivity vs Temperature



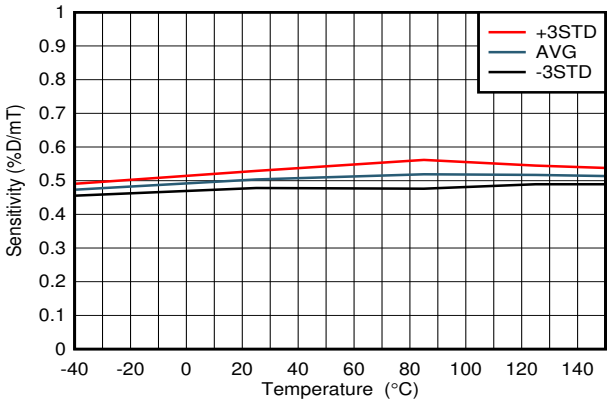
DRV5057A3, V_{CC} = 5.0 V

図 6-15. Sensitivity vs Temperature



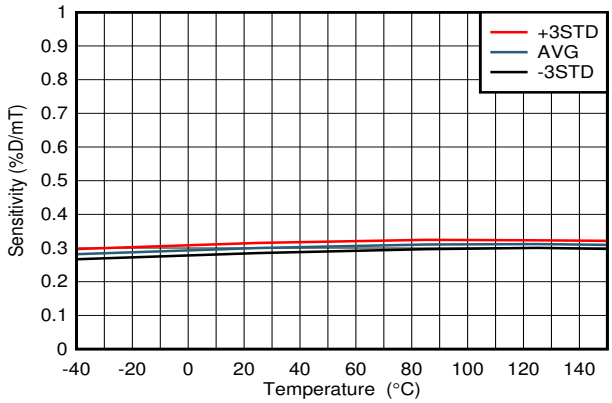
DRV5057A3, V_{CC} = 3.3 V

図 6-16. Sensitivity vs Temperature



DRV5057Z3, V_{CC} = 5.0 V

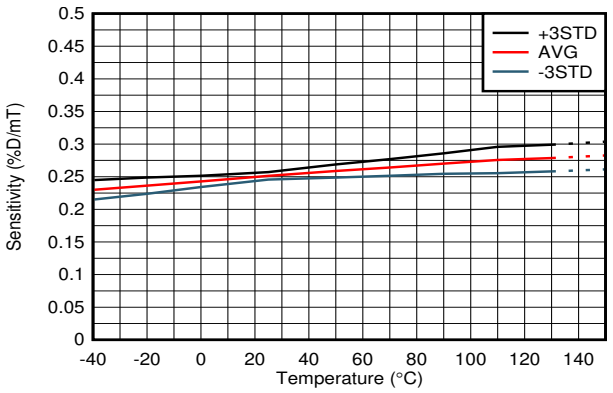
図 6-17. Sensitivity vs Temperature



DRV5057Z3, V_{CC} = 3.3 V

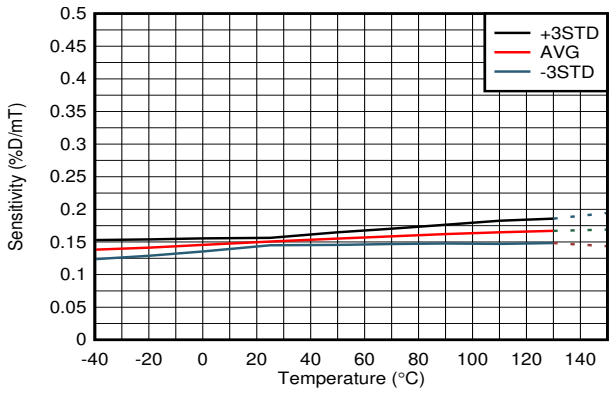
図 6-18. Sensitivity vs Temperature

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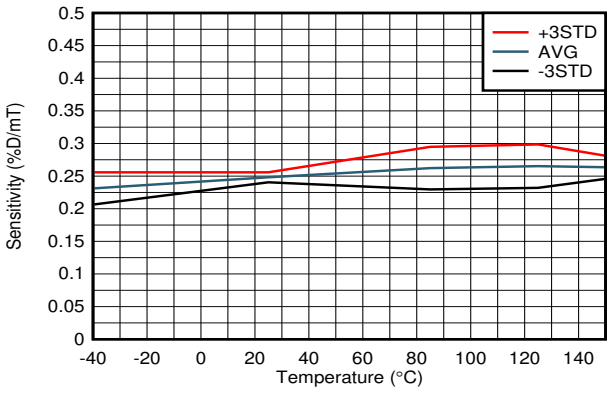
DRV5057A4, V_{CC} = 5.0 V

図 6-19. Sensitivity vs Temperature



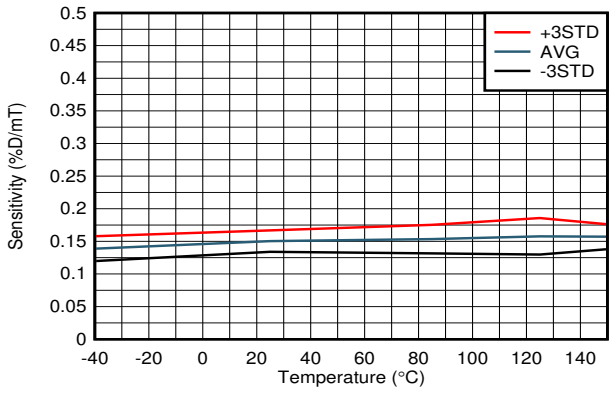
DRV5057A4, V_{CC} = 3.3 V

図 6-20. Sensitivity vs Temperature



DRV5057Z4, V_{CC} = 5.0 V

図 6-21. Sensitivity vs Temperature



DRV5057Z4, V_{CC} = 3.3 V

図 6-22. Sensitivity vs Temperature

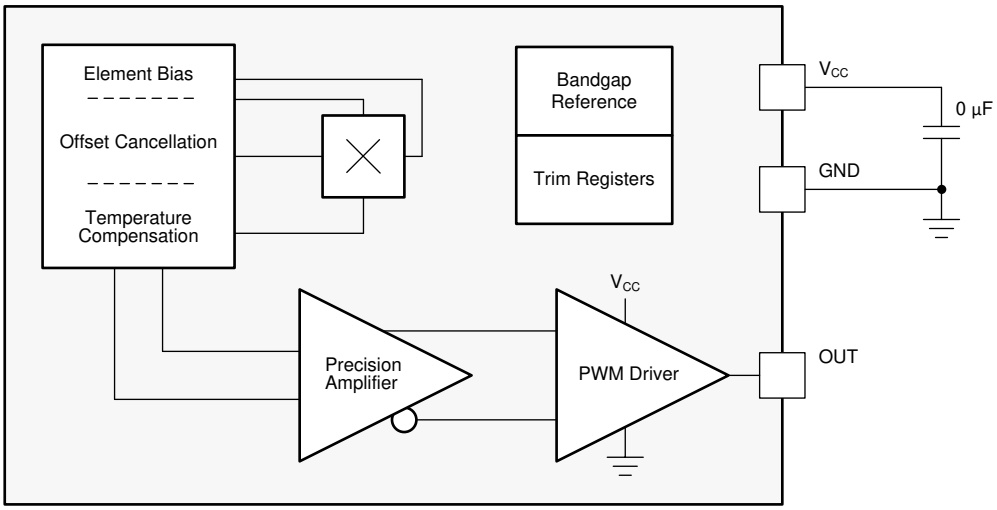
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7 Detailed Description

7.1 Overview

The DRV5057 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.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Magnetic Flux Direction

As shown in 図 7-1, the DRV5057 is sensitive to the magnetic field component that is perpendicular to the top of the package.

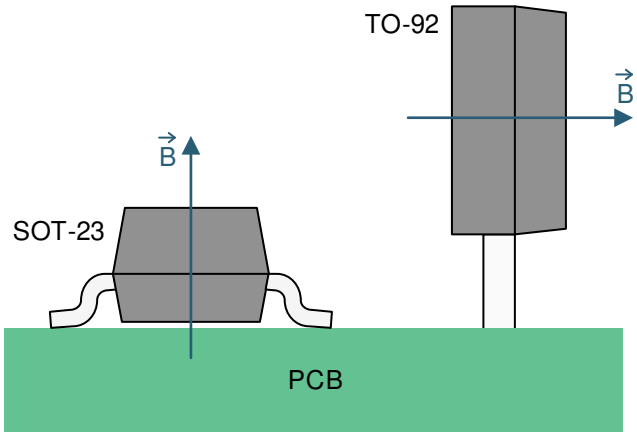


図 7-1. Direction of Sensitivity

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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 7-2 shows flux direction.

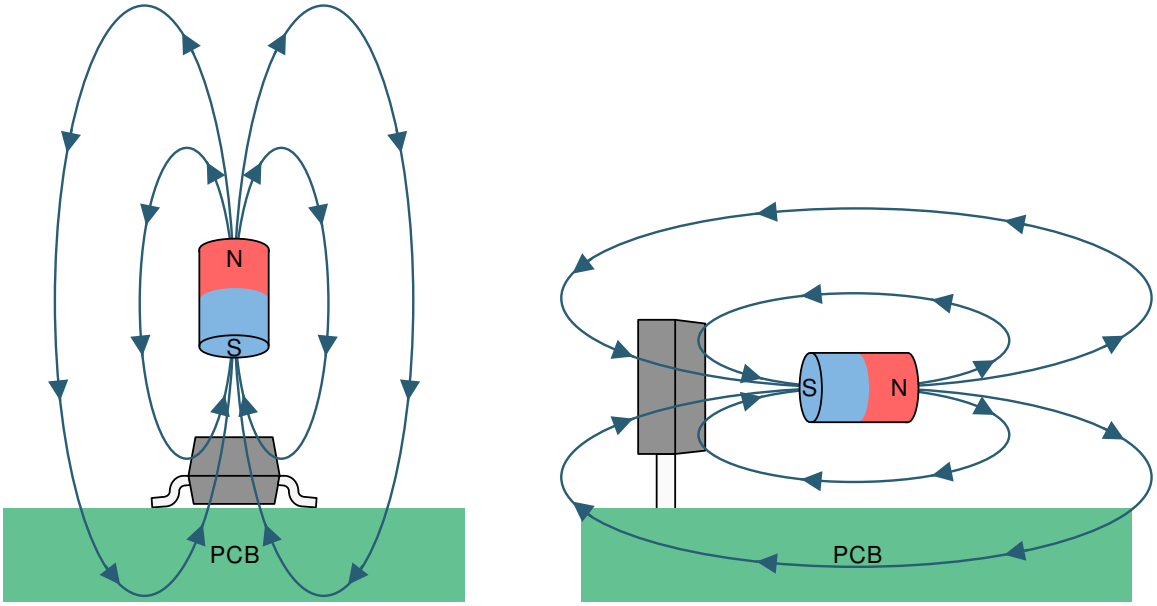


図 7-2. Flux Direction for Positive B

7.3.2 Sensitivity Linearity

The device produces a pulse-width modulated digital signal output. As shown in 図 7-3, 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 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%.

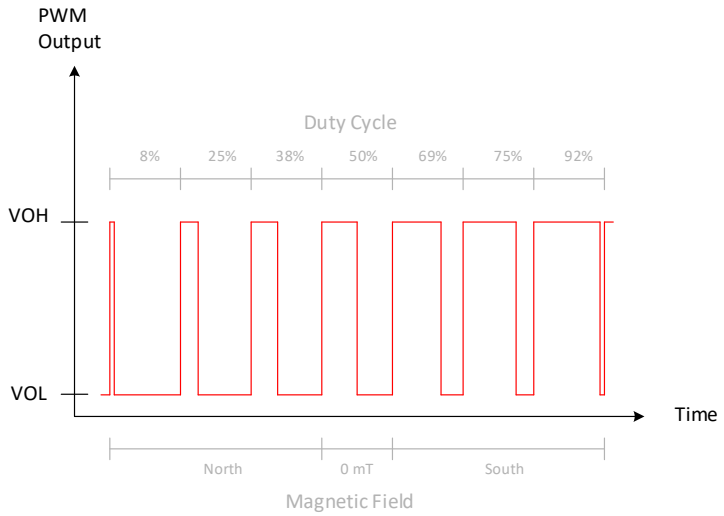


図 7-3. Magnetic Response

7.3.3 Operating V_{CC} Ranges

The DRV5057 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.

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7.3.4 Sensitivity Temperature Compensation for Magnets

Magnets generally produce weaker fields as temperature increases. The DRV5057A1 - DRV5057A4 device options have 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. The DRV5057Z1 - DRV5057Z4 devices options do not compensate for the drift external magnets

7.3.5 Power-On Time

After the V_{CC} voltage is applied, the DRV5057 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 7-4 shows this timing diagram.

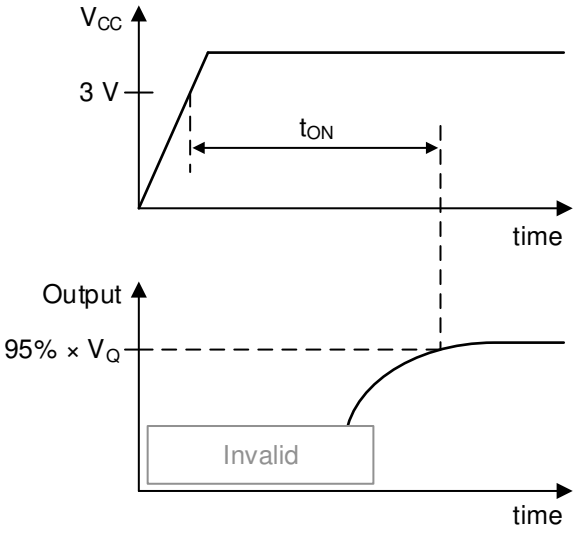


図 7-4. t_{ON} Definition

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7.3.6 Hall Element Location

図 7-5 shows the location of the sensing element inside each package option.

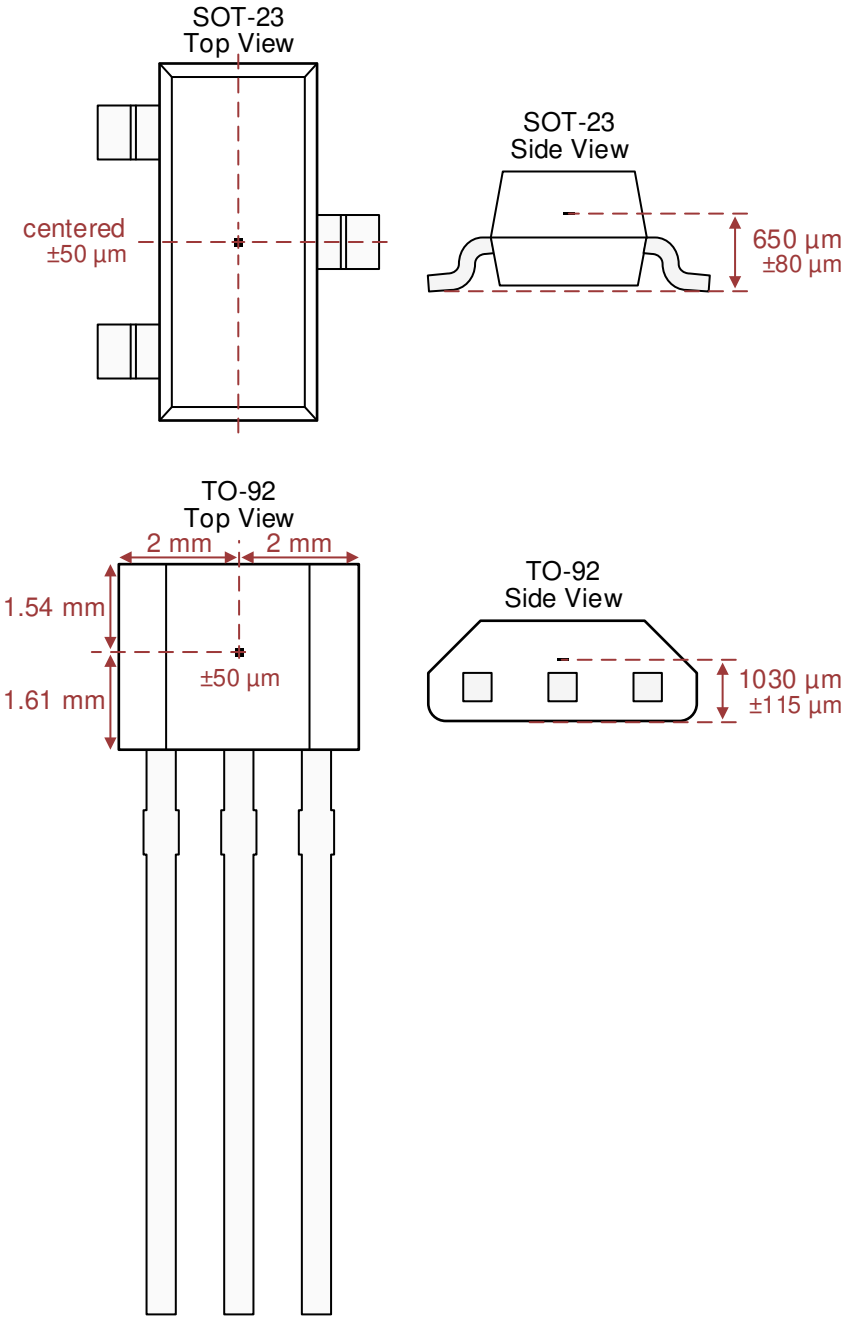


図 7-5. Hall Element Location

7.4 Device Functional Modes

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

8 Application and Implementation

注

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8.1 Application Information

8.1.1 Selecting the Sensitivity Option

Select the highest DRV5057 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 product folder.

8.1.2 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.

8.1.2.1 Decoding a PWM (Digital)

8.1.2.1.1 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.

$$\%D = \frac{\text{OnTime}}{\text{OnTime} + \text{OffTime}} \times 100 \tag{1}$$

8.1.2.1.2 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.

8.1.2.1.3 Accuracy and Resolution

The accuracy and resolution for the methods described in the セクション 8.1.2.1.1 and セクション 8.1.2.1.2 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.

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

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 = $0.1\%D_{LSB}$

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

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8.1.2.2 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.

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 8-1. 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.

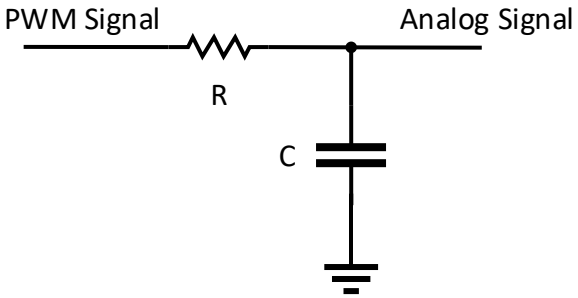


図 8-1. Low-Pass RC Filter

8.2 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.

8.2.1 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.

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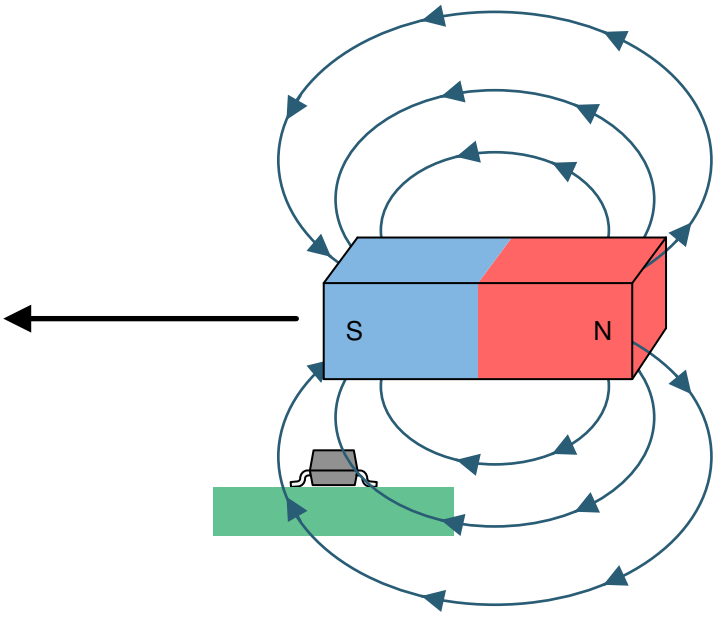


図 8-2. Full-Swing Orientation Example

8.2.1.1 Design Requirements

Use the parameters listed in 表 8-1 for this design example.

表 8-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Device	DRV5057
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

8.2.1.2 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 8-2 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 8-3 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 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).

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

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.

8.2.1.3 Application Curve

図 8-3 shows the magnetic field present at the sensor as the magnet passes by as described in 図 8-2. 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.

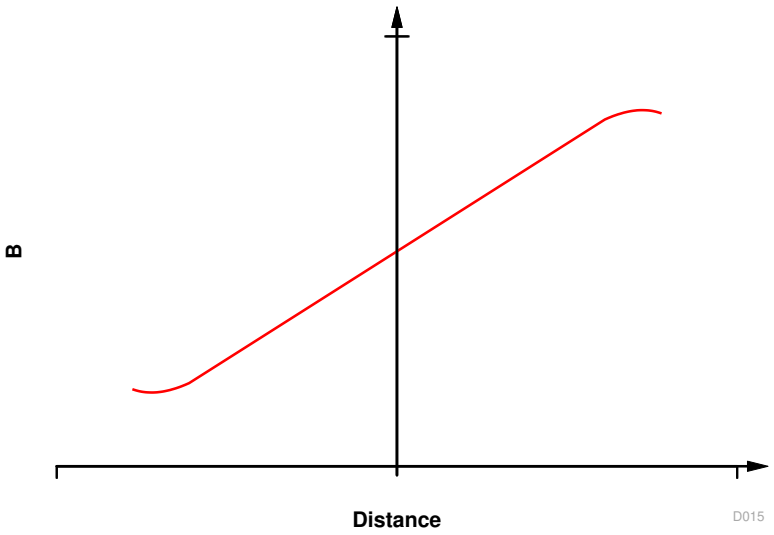


図 8-3. Magnetic Field vs Distance

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8.2.2 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.

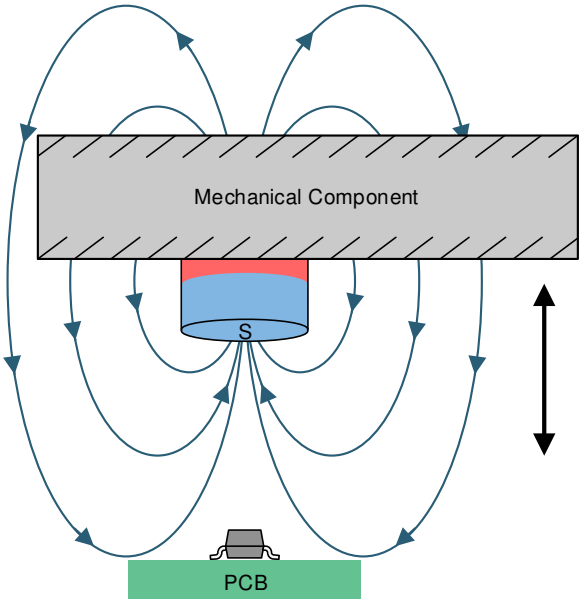


図 8-4. Half-Swing Orientation Example

8.2.2.1 Design Requirements

Use the parameters listed in 表 8-2 for this design example.

表 8-2. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Device	DRV5057
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

8.2.2.2 Detailed Design Procedure

As illustrated in 図 8-4, 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. The DRV5057 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 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

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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 8-5 shows diagrams for 式 4 and 式 5.

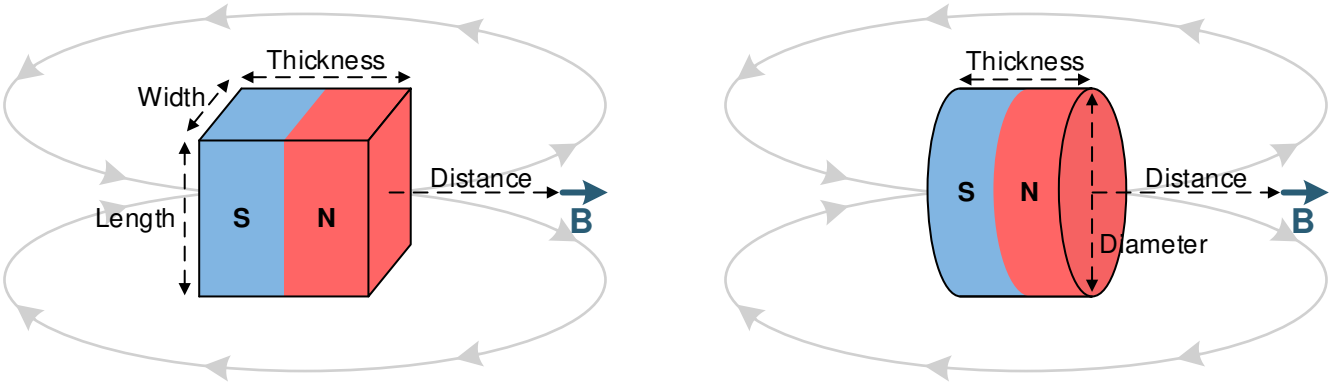


図 8-5. Rectangular Block and Cylinder Magnets

Use 式 4 for the rectangular block shown in 図 8-5:

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

Use 式 5 for the cylinder illustrated in 図 8-5:

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

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 8-6 shows a magnetic field from 0 mm to 16 mm with the magnet defined in 表 8-2 as C = 4.7625 mm, T = 12.7 mm, and B_r = 1480 mT.

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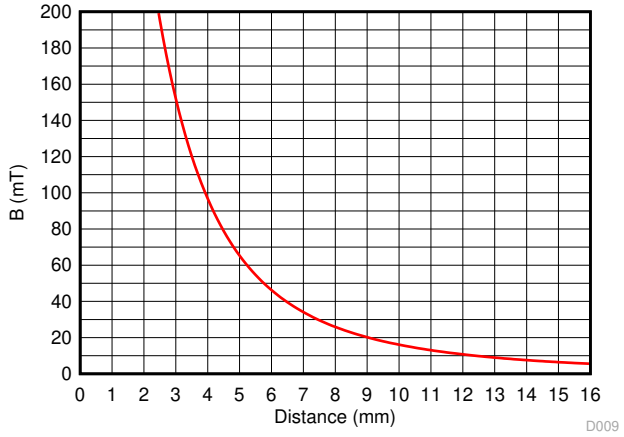


図 8-6. Magnetic Field vs Distance

In this setup, each gain version of the sensor produces the corresponding duty cycle shown in 図 8-7 for 0 mm to 16 mm.

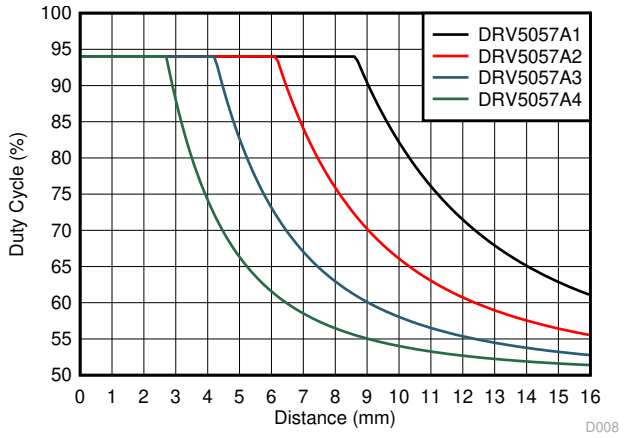


図 8-7. %D vs South Pole Distance (All Gains)

With a desired 5-mm movement swing, select the DRV5057 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 8-8 shows the %D response at the sensor across the full movement range.

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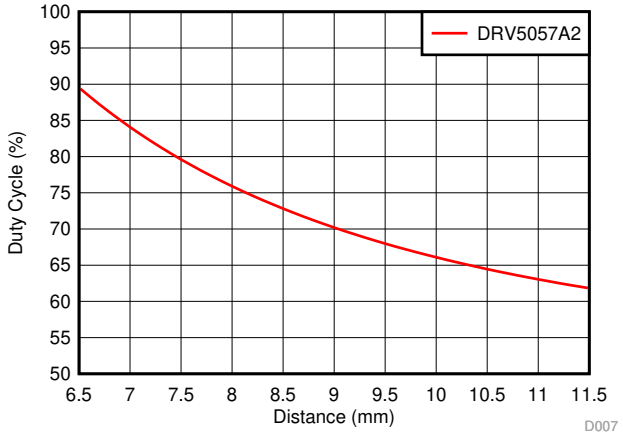


図 8-8. %D vs South Pole Distance (Gain A2)

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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).

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

For example, if the A2 version of the DRV5057 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 8-6, 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 8-8 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.

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8.3 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 8-9 shows correct and incorrect orientation.

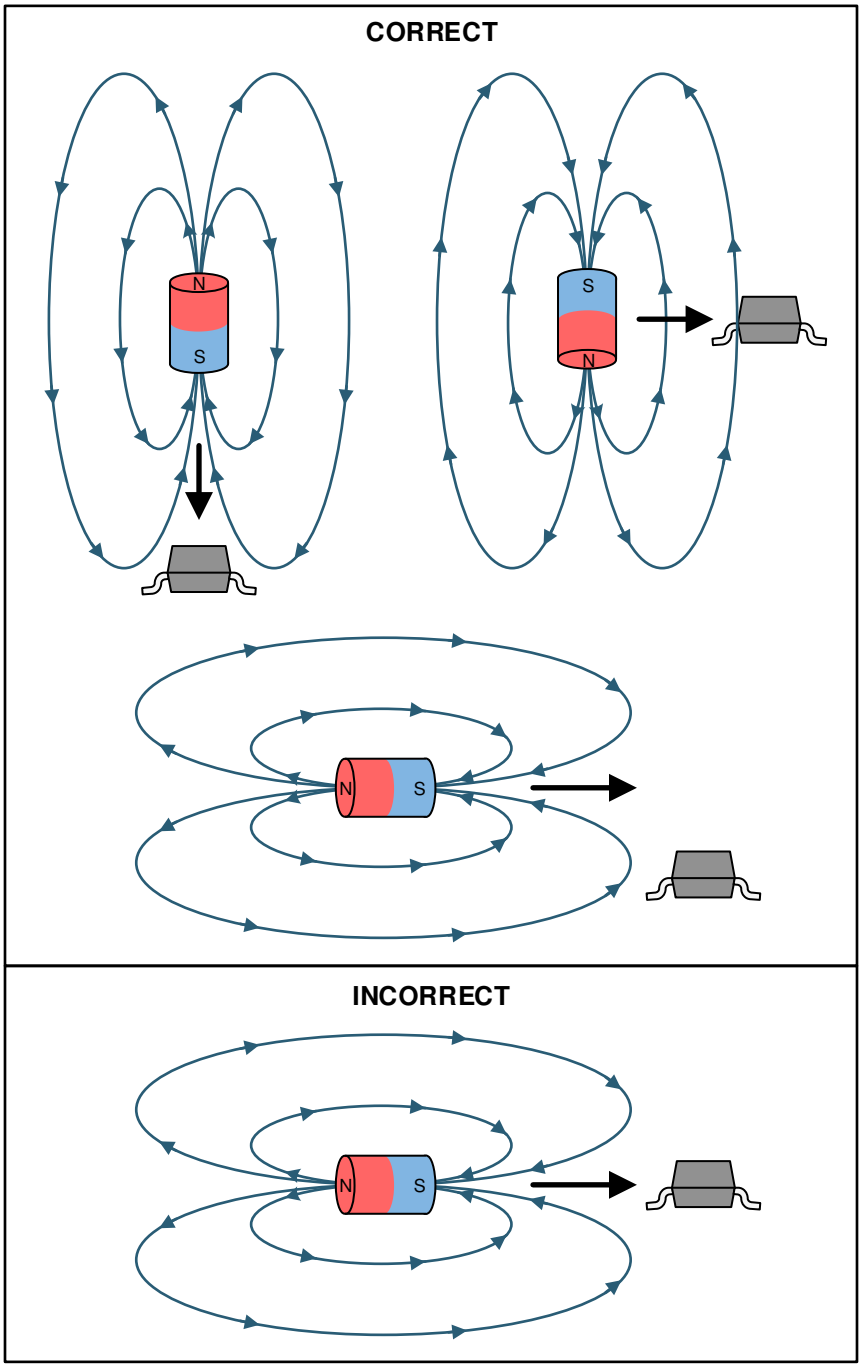


図 8-9. Correct and Incorrect Magnet Orientation

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9 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.

10 Layout

10.1 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.

10.2 Layout Examples

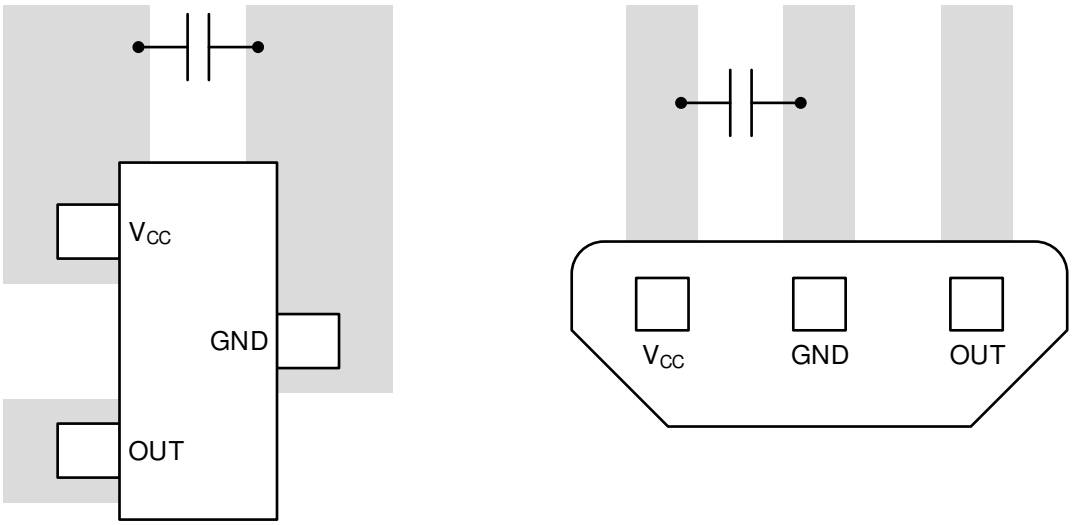


図 10-1. Layout Examples

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, *Using Linear Hall Effect Sensors to Measure Angle* tech note
- Texas Instruments, *Incremental Rotary Encoder Design Considerations* tech note
- Texas Instruments, *DRV5055 Ratiometric Linear Hall Effect Sensor* data sheet

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11.5 静電気放電に関する注意事項



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ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

11.6 用語集

テキサス・インスツルメンツ用語集　　この用語集には、用語や略語の一覧および定義が記載されています。

12 Mechanical, Packaging, and Orderable Information

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

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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)
DRV5057A1QDBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57A1
DRV5057A1QDBZR.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57A1
DRV5057A1QDBZT	Obsolete	Production	SOT-23 (DBZ) | 3	-	-	Call TI	Call TI	-40 to 125	57A1
DRV5057A1QLPG	Active	Production	TO-92 (LPG) | 3	1000 | BULK	Yes	SN	N/A for Pkg Type	-40 to 125	57A1
DRV5057A1QLPG.B	Active	Production	TO-92 (LPG) | 3	1000 | BULK	Yes	SN	N/A for Pkg Type	-40 to 125	57A1
DRV5057A1QLPGM	Active	Production	TO-92 (LPG) | 3	3000 | AMMO	Yes	SN	N/A for Pkg Type	-40 to 125	57A1
DRV5057A1QLPGM.B	Active	Production	TO-92 (LPG) | 3	3000 | AMMO	Yes	SN	N/A for Pkg Type	-40 to 125	57A1
DRV5057A2QDBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57A2
DRV5057A2QDBZR.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57A2
DRV5057A2QLPG	Active	Production	TO-92 (LPG) | 3	1000 | BULK	Yes	SN	N/A for Pkg Type	-40 to 125	57A2
DRV5057A2QLPG.B	Active	Production	TO-92 (LPG) | 3	1000 | BULK	Yes	SN	N/A for Pkg Type	-40 to 125	57A2
DRV5057A2QLPGM	Active	Production	TO-92 (LPG) | 3	3000 | AMMO	Yes	SN	N/A for Pkg Type	-40 to 125	57A2
DRV5057A2QLPGM.B	Active	Production	TO-92 (LPG) | 3	3000 | AMMO	Yes	SN	N/A for Pkg Type	-40 to 125	57A2
DRV5057A3QDBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57A3
DRV5057A3QDBZR.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57A3
DRV5057A3QDBZT	Obsolete	Production	SOT-23 (DBZ) | 3	-	-	Call TI	Call TI	-40 to 125	57A3
DRV5057A3QLPG	Active	Production	TO-92 (LPG) | 3	1000 | BULK	Yes	SN	N/A for Pkg Type	-40 to 125	57A3
DRV5057A3QLPG.B	Active	Production	TO-92 (LPG) | 3	1000 | BULK	Yes	SN	N/A for Pkg Type	-40 to 125	57A3
DRV5057A3QLPGM	Active	Production	TO-92 (LPG) | 3	3000 | AMMO	Yes	SN	N/A for Pkg Type	-40 to 125	57A3
DRV5057A3QLPGM.B	Active	Production	TO-92 (LPG) | 3	3000 | AMMO	Yes	SN	N/A for Pkg Type	-40 to 125	57A3
DRV5057A4QDBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57A4
DRV5057A4QDBZR.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57A4
DRV5057A4QDBZT	Obsolete	Production	SOT-23 (DBZ) | 3	-	-	Call TI	Call TI	-40 to 125	57A4
DRV5057A4QLPG	Active	Production	TO-92 (LPG) | 3	1000 | BULK	Yes	SN	N/A for Pkg Type	-40 to 125	57A4
DRV5057A4QLPG.B	Active	Production	TO-92 (LPG) | 3	1000 | BULK	Yes	SN	N/A for Pkg Type	-40 to 125	57A4
DRV5057A4QLPGM	Active	Production	TO-92 (LPG) | 3	3000 | AMMO	Yes	SN	N/A for Pkg Type	-40 to 125	57A4
DRV5057A4QLPGM.B	Active	Production	TO-92 (LPG) | 3	3000 | AMMO	Yes	SN	N/A for Pkg Type	-40 to 125	57A4
DRV5057Z1QDBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57Z1
DRV5057Z1QDBZR.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57Z1

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)
DRV5057Z1QDBZT	Obsolete	Production	SOT-23 (DBZ) | 3	-	-	Call TI	Call TI	-40 to 125	57Z1
DRV5057Z2QDBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57Z2
DRV5057Z2QDBZR.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57Z2
DRV5057Z2QDBZT	Obsolete	Production	SOT-23 (DBZ) | 3	-	-	Call TI	Call TI	-40 to 125	57Z2
DRV5057Z3QDBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57Z3
DRV5057Z3QDBZR.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57Z3
DRV5057Z3QDBZT	Obsolete	Production	SOT-23 (DBZ) | 3	-	-	Call TI	Call TI	-40 to 125	57Z3
DRV5057Z4QDBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57Z4
DRV5057Z4QDBZR.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	57Z4
DRV5057Z4QDBZT	Obsolete	Production	SOT-23 (DBZ) | 3	-	-	Call TI	Call TI	-40 to 125	57Z4

(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.

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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.

OTHER QUALIFIED VERSIONS OF DRV5057 :

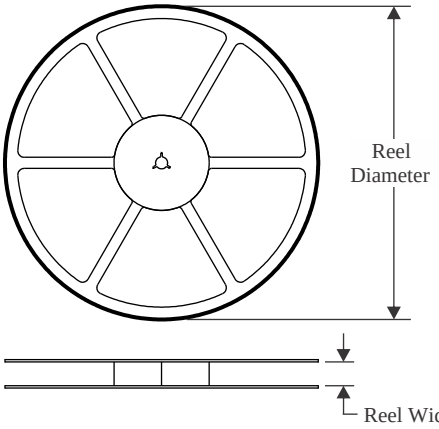
- Automotive : DRV5057-Q1

NOTE: Qualified Version Definitions:

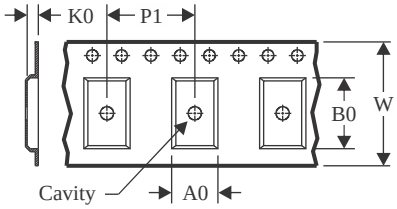
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

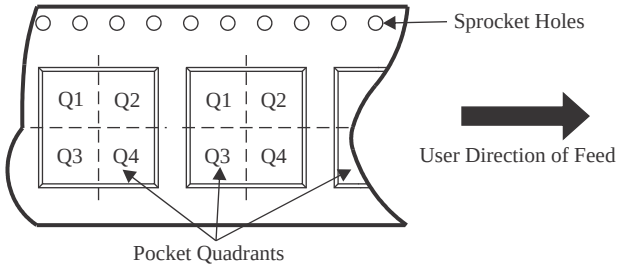


TAPE DIMENSIONS



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

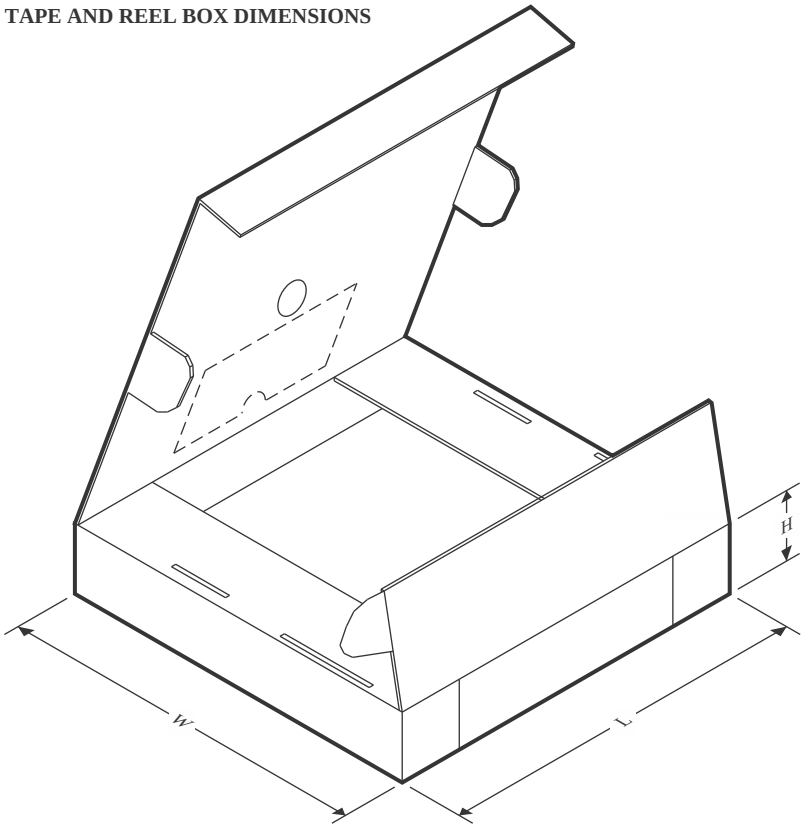
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
DRV5057A1QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3
DRV5057A1QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3
DRV5057A2QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3
DRV5057A2QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3
DRV5057A3QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3
DRV5057A3QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3
DRV5057A4QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3
DRV5057Z1QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3
DRV5057Z1QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3
DRV5057Z2QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3
DRV5057Z3QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3
DRV5057Z4QDBZR	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	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)
DRV5057A1QDBZR	SOT-23	DBZ	3	3000	213.0	191.0	35.0
DRV5057A1QDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
DRV5057A2QDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
DRV5057A2QDBZR	SOT-23	DBZ	3	3000	213.0	191.0	35.0
DRV5057A3QDBZR	SOT-23	DBZ	3	3000	213.0	191.0	35.0
DRV5057A3QDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
DRV5057A4QDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
DRV5057Z1QDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
DRV5057Z1QDBZR	SOT-23	DBZ	3	3000	213.0	191.0	35.0
DRV5057Z2QDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
DRV5057Z3QDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
DRV5057Z4QDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0

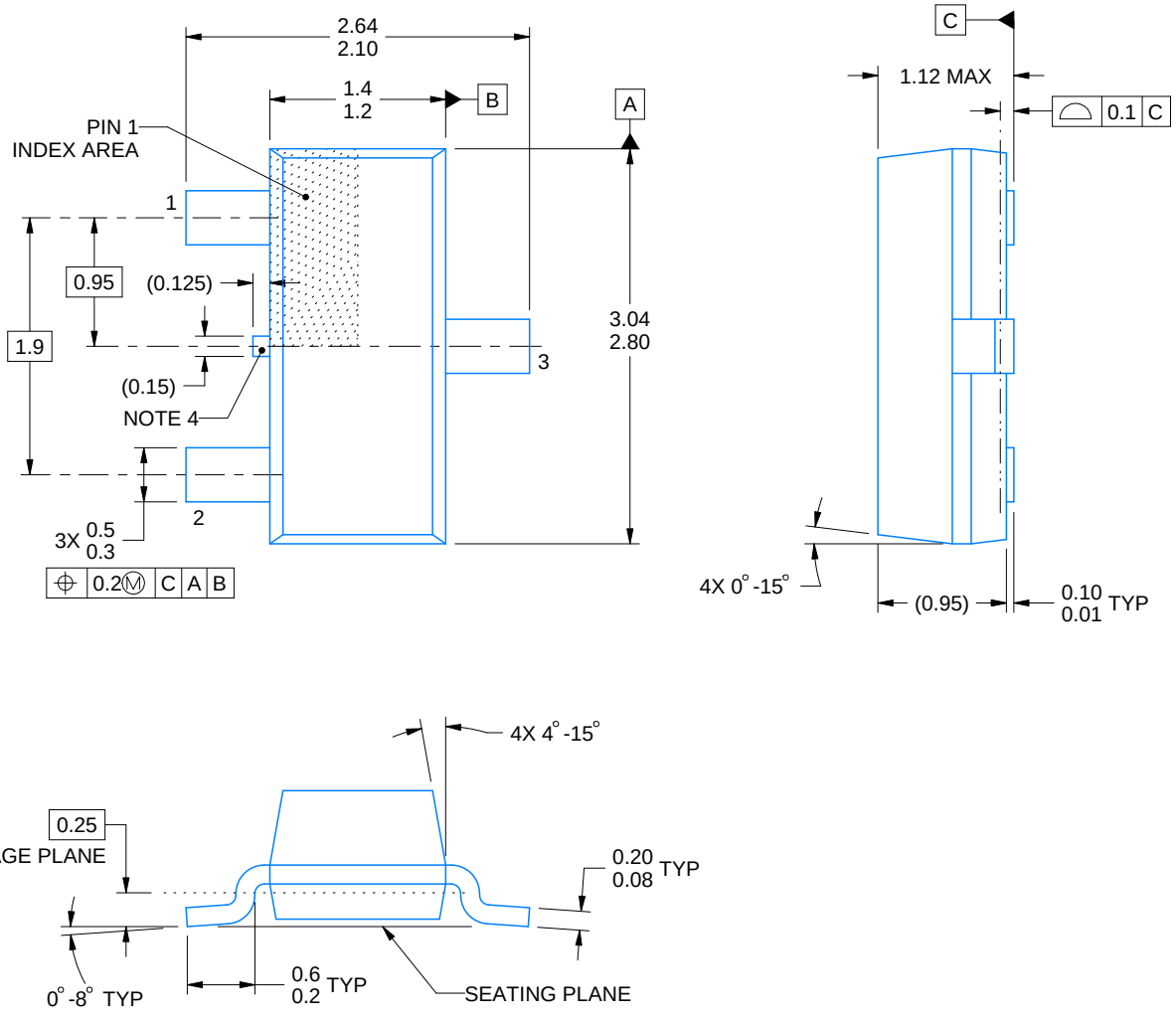
PACKAGE OUTLINE

DBZ0003A



SOT-23 - 1.12 mm max height

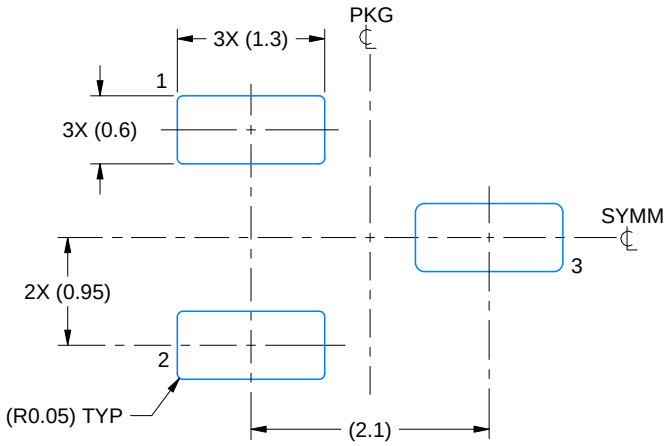
SMALL OUTLINE TRANSISTOR



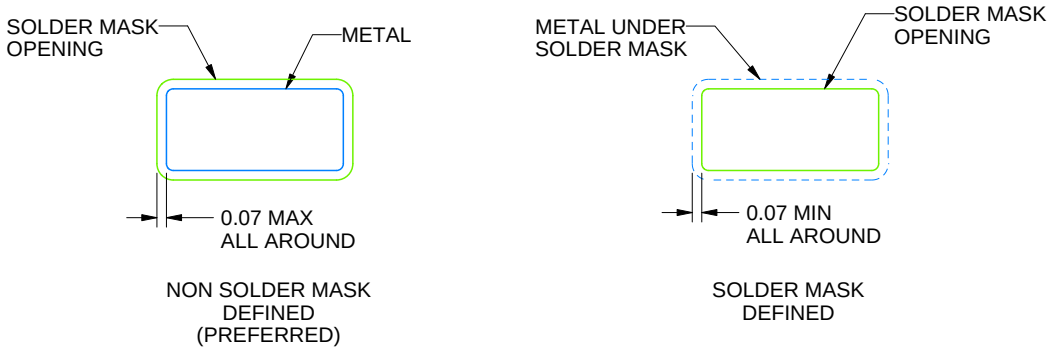
4214838/F 08/2024

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. 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

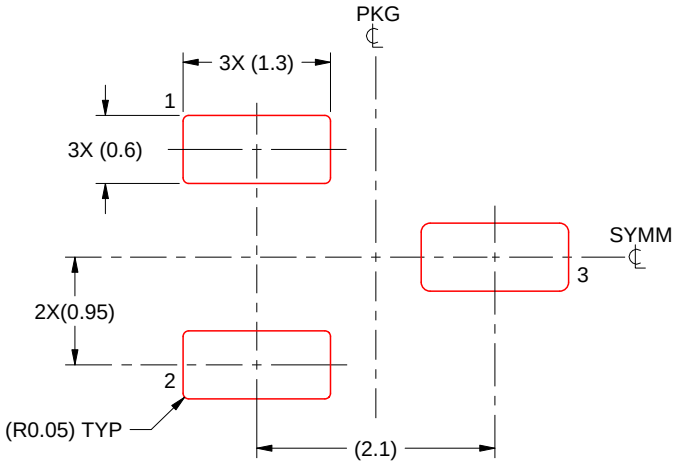


SOLDER MASK DETAILS

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

4214838/F 08/2024

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.

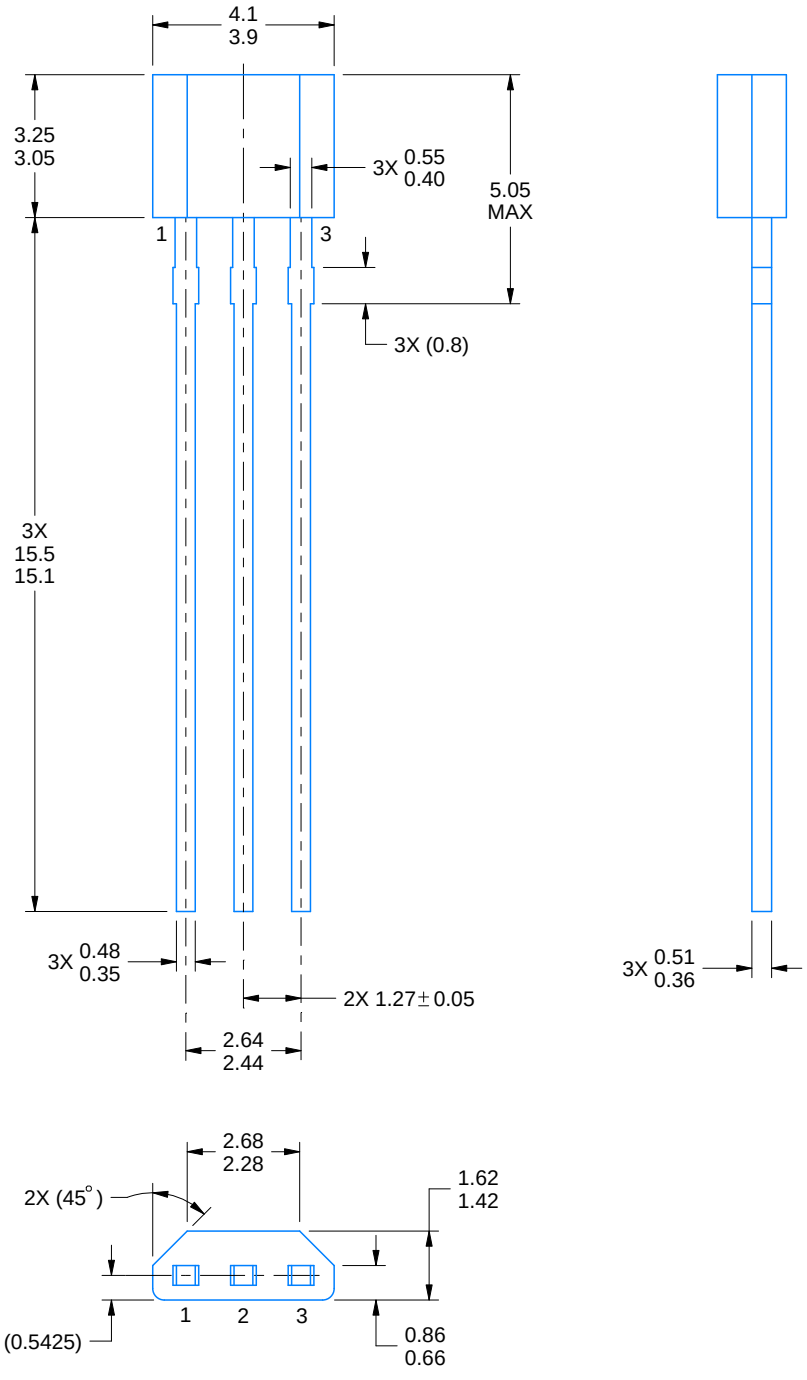


PACKAGE OUTLINE

LPG0003A

TO-92 - 5.05 mm max height

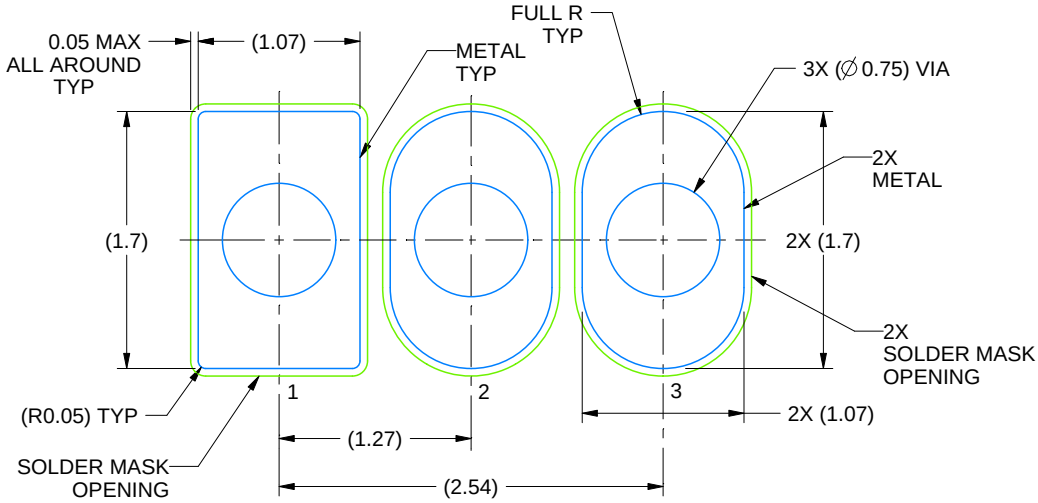
TRANSISTOR OUTLINE



4221343/C 01/2018

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.



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE:20X

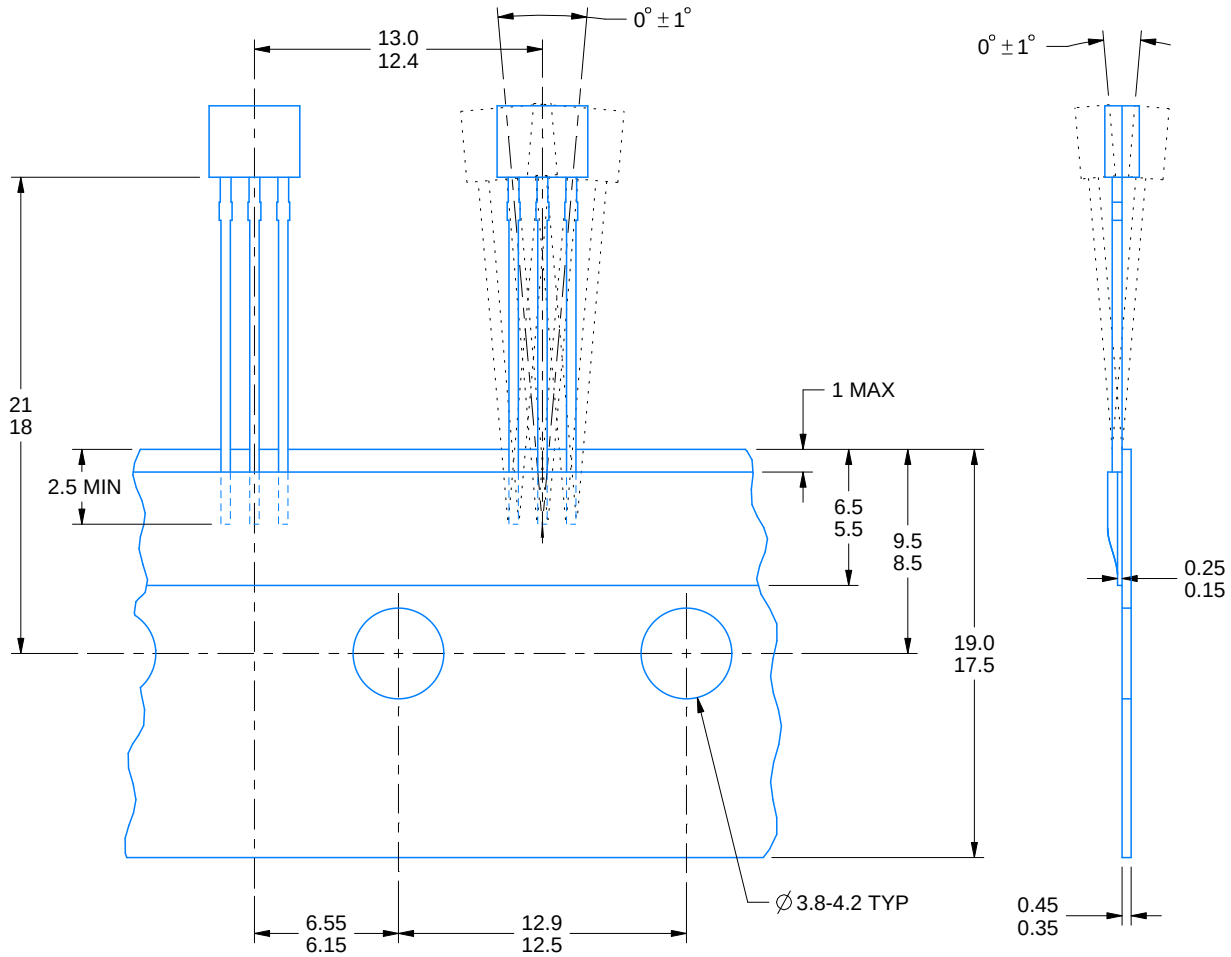
4221343/C 01/2018

TAPE SPECIFICATIONS

LPG0003A

TO-92 - 5.05 mm max height

TRANSISTOR OUTLINE



4221343/C 01/2018

重要なお知らせと免責事項

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最終更新日：2025 年 10 月