DRV8601 Haptic Driver for DC Motors (ERMs) and Linear Vibrators (LRAs) With Ultra-Fast Turnon

1 Features

- High Current Output: 400 mA
- Wide Supply Voltage Range (2.5 V to 5.5 V) for Direct Battery Operation
- Low Quiescent Current: 1.7 mA (Typical)
- Fast Startup Time: 100 µs
- Low Shutdown Current: 10 nA
- Output Short-Circuit Protection
- Thermal Protection
- Enable Pin is 1.8-V Compatible
- Available in a 3-mm x 3-mm VQFN Package (DRB) and 2-mm x 2-mm MicroStar Junior™ PBGA Package (ZQV)

2 Applications

- Mobile Phones
- Tablets
- Portable Gaming Consoles
- Portable Navigation Devices
- Appliance Consoles

3 Description

The DRV8601 is a single-supply haptic driver that is optimized to drive a DC motor (also known as Eccentric Rotating Mass or ERM in haptics terminology) or a linear vibrator (also known as Linear Resonant Actuator or LRA in haptics terminology) using a single-ended PWM input signal. With a fast turn-on time of 100 µs, the DRV8601 is an excellent haptic driver for use in mobile phones and other portable electronic devices.

The DRV8601 drives up to 400 mA from a 3.3-V supply. Near rail-to-rail output swing under load ensures sufficient voltage drive for most DC motors. Differential output drive allows the polarity of the voltage across the output to be reversed quickly, thereby enabling motor speed control in both clockwise and counter-clockwise directions, allowing quick motor stopping. A wide input voltage range allows precise speed control of both DC motors and linear vibrators.

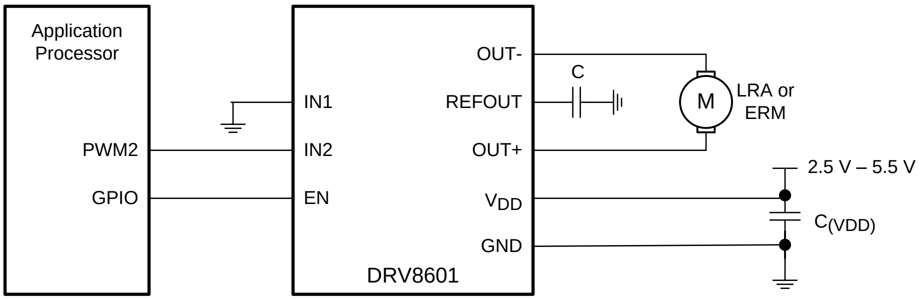
With a typical quiescent current of 1.7 mA and a shutdown current of 10 nA, the DRV8601 is ideal for portable applications. The DRV8601 has thermal and output short-circuit protection to prevent the device from being damaged during fault conditions.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
DRV8601	DRB (8)	3.00 mm × 3.00 mm
	ZQV (8)	2.00 mm × 2.00 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Block Diagram



Copyright © 2016, Texas Instruments Incorporated

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

Table of Contents

4 Revision History

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

Changes from Revision C (January 2016) to Revision D — Page

- Added the ZQV package to the *Features* list and the *Device Information* table ... 1
- Added the ZQV pinout to the *Pin Configuration and Functions* section ... 3
- Added ZQV values to the *Thermal Information* table ... 4
- Added Figure 20 ... 16

Changes from Revision B (January 2012) to Revision C — Page

- Added *ESD Rating* table, *Feature Description* section, *Device Functional Modes* section, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1

Changes from Revision A (May 2011) to Revision B — Page

- Changed R_I value from 49.9 kΩ to 100 kΩ in Conditions statement in *Typical Characteristics* ... 5

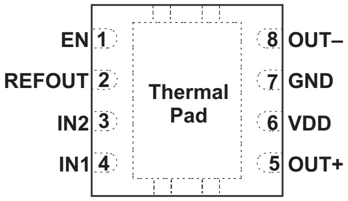
Changes from Original (July 2010) to Revision A — Page

- Added the DRB package to the *Features* list ... 1
- Updated *Application Information* section ... 11
- Added polarity to motor in application diagrams in Figure 16, Figure 17, and Figure 18 ... 11

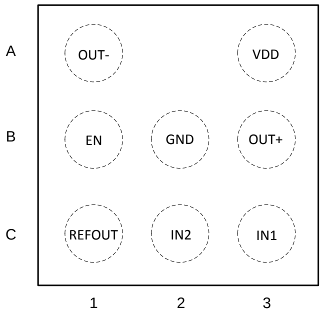
Copyright © 2010–2016, Texas Instruments Incorporated

5 Pin Configuration and Functions

DRB Package
8-Pin VQFN
Top View



ZQV Package
8-Ball
Top View



Pin Functions

PIN			TYPE(1)	DESCRIPTION
NAME	DRB NO.	ZQV NO.		
EN	1	B1	I	Chip enable
GND	7	B2	P	Ground
IN1	4	C3	I	Input to driver
IN2	3	C2	I	Input to driver
OUT+	5	B3	O	Positive output
OUT–	8	A1	O	Negative output
REFOUT	2	C1	O	Reference voltage output
VDD	6	A3	P	Supply voltage

(1) I = Input, O = Output, P = Power

Copyright © 2010–2016, Texas Instruments Incorporated

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range, $T_A \leq 25°C$ (unless otherwise noted)(1)

		MIN	MAX	UNIT
V_{DD}	Supply voltage	–0.3	6	V
V_I	Input voltage, INx, EN	–0.3	V_{DD} + 0.3	V
	Output continuous total power dissipation	See *Thermal Information*		
T_A	Operating free-air temperature	–40	85	°C
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.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±4000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±1500	

(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

			MIN	NOM	MAX	UNIT
V_{DD}	Supply voltage		2.5		5.5	V
V_{IH}	High-level input voltage	EN	1.15			V
V_{IL}	Low-level input voltage	EN			0.5	V
T_A	Operating free-air temperature		–40		85	°C
Z_L	Load impedance		6.4			Ω

6.4 Thermal Information

THERMAL METRIC(1)		DRV8601		UNIT
		DRB	ZQV	
		8 PINS	8 BALLS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	52.8	78	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	63	155	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	28.4	65	°C/W
ψ_{JT}	Junction-to-top characterization parameter	2.7	5	°C/W
ψ_{JB}	Junction-to-board characterization parameter	28.6	50	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	11.4	n/a	°C/W

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

Copyright © 2010–2016, Texas Instruments Incorporated

6.5 Electrical Characteristics

at T_A = 25°C, Gain = 2 V/V, R_L= 10 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$\|V_{OO}\|$	Output offset voltage (measured differentially)	V_I = 0 V, V_{DD} = 2.5 V to 5.5 V				9	mV
$V_{OD,N}$	Negative differential output voltage (V_{OUT+}–$V_{OUT–}$)	V_{IN+} = V_{DD}, $V_{IN–}$ = 0 V or V_{IN+} = 0 V, $V_{IN–}$ = V_{DD}	V_{DD} = 5.0 V, I_o = 400 mA		–4.55		V
			V_{DD} = 3.3 V, I_o = 300 mA		–2.87		
			V_{DD} = 2.5 V, I_o = 200 mA		–2.15		
$V_{OD,P}$	Positive differential output voltage (V_{OUT+}–$V_{OUT–}$)	V_{IN+} = V_{DD}, $V_{IN–}$ = 0 V or V_{IN+} = 0 V, $V_{IN–}$ = V_{DD}	V_{DD} = 5.0 V, I_o = 400 mA		4.55		V
			V_{DD} = 3.3 V, I_o = 300 mA		2.87		
			V_{DD} = 2.5 V, I_o = 200 mA		2.15		
$\|I_{IH}\|$	High-level EN input current	V_{DD} = 5.5 V, V_I = 5.8 V				1.2	µA
$\|I_{IL}\|$	Low-level EN input current	V_{DD} = 5.5 V, V_I = –0.3 V				1.2	µA
$I_{DD(Q)}$	Supply current	V_{DD} = 2.5 V to 5.5 V, No load, EN = V_{IH}			1.7	2	mA
$I_{DD(SD)}$	Supply current in shutdown mode	EN = V_{IL}, V_{DD} = 2.5 V to 5.5 V, No load			0.01	0.9	µA

6.6 Operating Characteristics

at T_A = 25°C, Gain = 2 V/V, R_L = 10 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Z_I	Input impedance			2		MΩ
Z_O	Output impedance	Shutdown mode (EN = V_{IL})	>10			kΩ

6.7 Typical Characteristics

Table 1. Table of Graphs

		FIGURE
Output voltage (High)	vs Load current	Figure 1
Output voltage (Low)	vs Load current	Figure 2
Output voltage	vs Input voltage, R_L = 10 Ω	Figure 3
Output voltage	vs Input voltage, R_L = 20 Ω	Figure 4
Supply current	vs Supply voltage	Figure 5
Shutdown supply current	vs Supply voltage	Figure 6
Power dissipation	vs Supply voltage	Figure 7
Slew rate	vs Supply voltage	Figure 8
Output transition	vs Time	Figure 9, Figure 10
Startup	vs Time	Figure 11
Shutdown	vs Time	Figure 12

Copyright © 2010–2016, Texas Instruments Incorporated

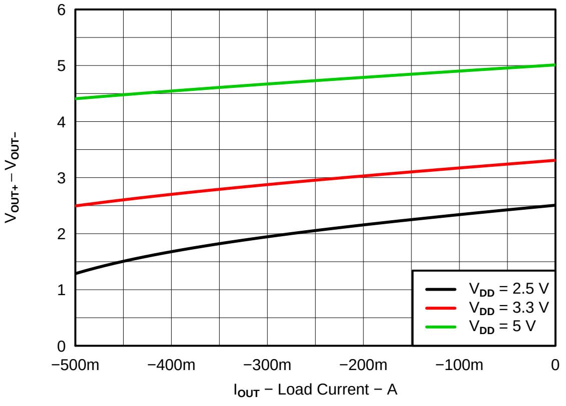


Figure 1. Output Voltage (High) vs Load Current

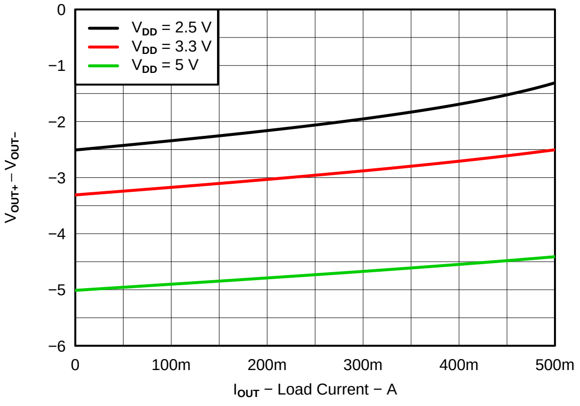


Figure 2. Output Voltage (Low) vs Load Current

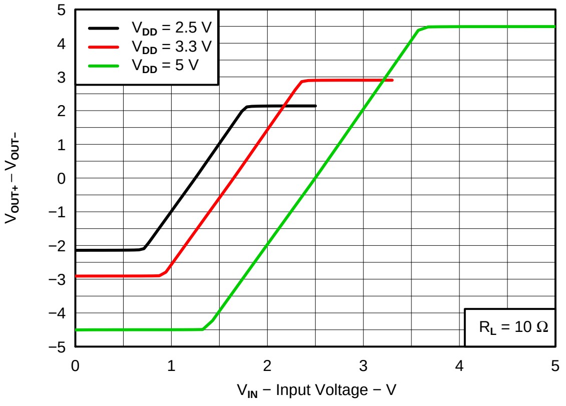


Figure 3. Output Voltage vs Input Voltage

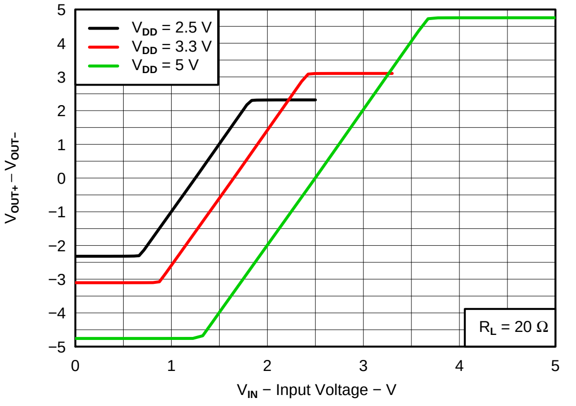


Figure 4. Output Voltage vs Input Voltage

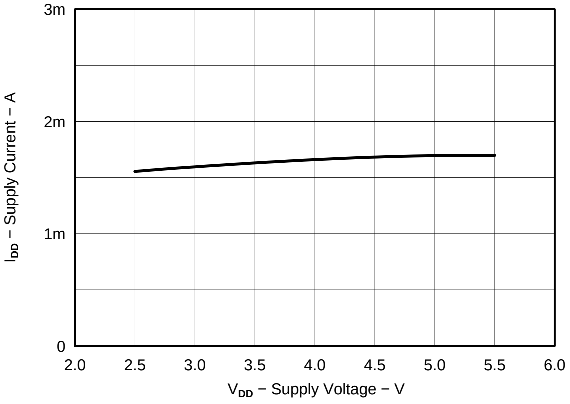


Figure 5. Supply Current vs Supply Voltage

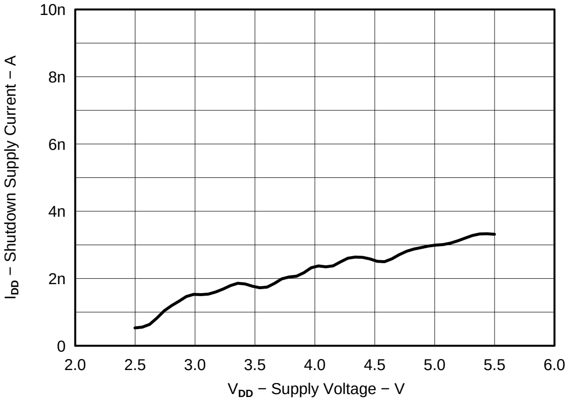


Figure 6. Shutdown Supply Current vs Supply Voltage

Copyright © 2010–2016, Texas Instruments Incorporated

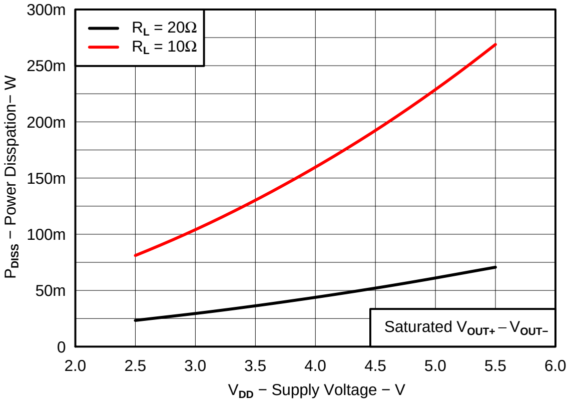


Figure 7. Power Dissipation vs Supply Voltage

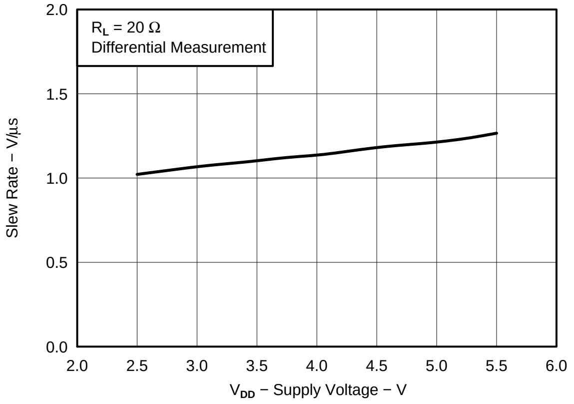


Figure 8. Slew Rate vs Supply Voltage

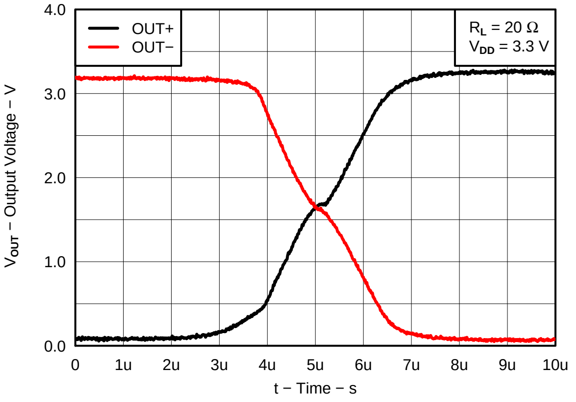


Figure 9. Output Transition vs Time

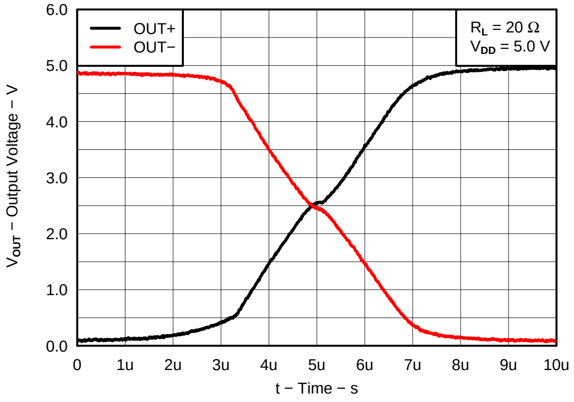


Figure 10. Output Transition vs Time

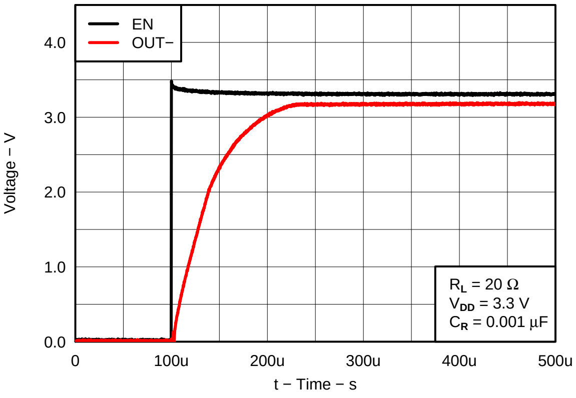


Figure 11. Startup vs Time

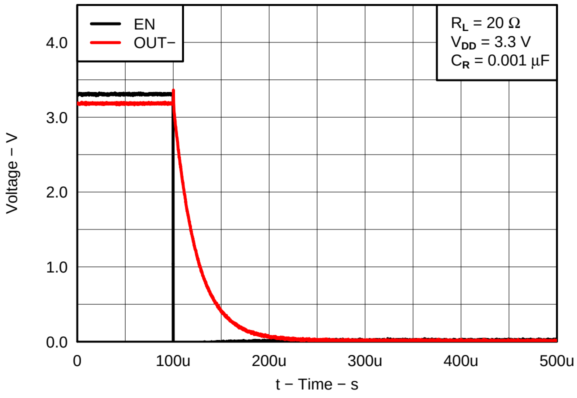


Figure 12. Shutdown vs Time

Copyright © 2010–2016, Texas Instruments Incorporated

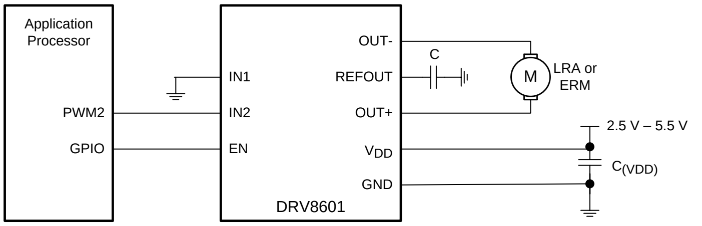
7 Detailed Description

7.1 Overview

DRV8601 is a single-supply haptic driver that is optimized to drive ERM or LRAs. DRV8601 can drive in both clockwise and counter-clockwise directions, as well as stop the motor quickly. This is possible due to the fact that outputs are driven differentially and are capable of driving or sinking current. DRV8601 also eliminates long vibration tails which are undesirable in haptic feedback systems.

The DRV8601 can accept a single-ended PWM source or single-ended DC control voltage and perform single-ended to differential conversion. A PWM signal is typically generated using software, and many different advanced haptic sensations can be produced by inputting different types of PWM signals into the DRV8601.

7.2 Functional Block Diagram



Copyright © 2016, Texas Instruments Incorporated

7.3 Feature Description

7.3.1 Support for ERM and LRA Actuators

Linear vibrators (also known as Linear Resonant Actuators or LRA in haptics terminology) vibrate only at their resonant frequency. Usually, linear vibrators have a high-Q frequency response, due to which there is a rapid drop in vibration performance at offsets of 3 to 5 Hz from the resonant frequency. Therefore, while driving a linear vibrator with the DRV8601, ensure that the commutation of the input PWM signal is within the prescribed frequency range for the chosen linear vibrator. Vary the duty cycle of the PWM signal symmetrically above and below 50% to vary the strength of the vibration. As in the case of DC motors, the PWM signal is typically generated using software, and many different advanced haptic sensations can be produced by applying different PWM signals into the DRV8601.

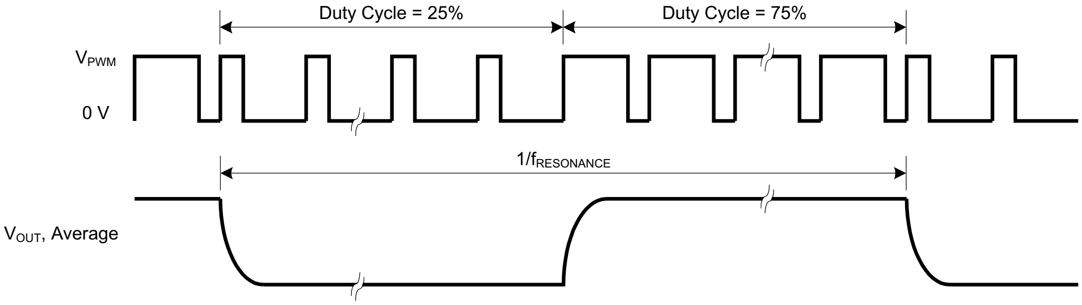
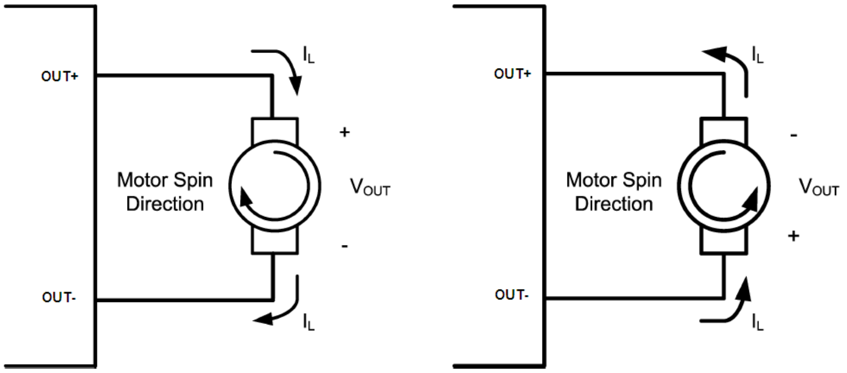


Figure 13. LRA Example for 1/2 Full-Scale Drive

The DRV8601 is designed to drive a DC motor (also known as Eccentric Rotating Mass or ERM in haptics terminology) in both clockwise and counter-clockwise directions, as well as to stop the motor quickly. This is made possible because the outputs are fully differential and capable of sourcing and sinking current. This feature helps eliminate long vibration tails which are undesirable in haptic feedback systems.

Copyright © 2010–2016, Texas Instruments Incorporated

Feature Description (continued)



Copyright © 2016, Texas Instruments Incorporated

Figure 14. Reversal of Direction of Motor Spin Using DRV8601

Another common approach to driving DC motors is the concept of overdrive voltage. To overcome the inertia of the mass of the motor, they are often overdriven for a short amount of time before returning to the rated voltage of the motor in order to sustain the rotation of the motor. The DRV8601 can overdrive a motor up to the V_{DD} voltage. Overdrive is also used to stop (or brake) a motor quickly. The DRV8601 can brake up to a voltage of $–V_{DD}$. For safe and reliable overdrive voltage and duration, refer to the data sheet of the motor.

7.3.2 Internal Reference

The internal voltage divider at the REFOUT pin of this device sets a mid-supply voltage for internal references and sets the output common mode voltage to VDD/2. Adding a capacitor to this pin filters any noise into this pin and increases the PSRR. REFOUT also determines the rise time of VO+ and VO when the device is taken out of shutdown. The larger the capacitor, the slower the rise time. Although the output rise time depends on the bypass capacitor value.

7.3.3 Shutdown Mode

DRV8601 has a shutdown mode which is controlled using the EN pin. EN pin is 1.8-V compatible. By pulling EN pin low, the device enters low power state, consuming only 10 nA of shutdown current.

7.4 Device Functional Modes

DRV8601 is an analog input with differential output. DRV8601 does not require any digital interface to set up the device. DRV8601 can be configured in various modes by configuring the device in differential or single ended mode as described in *Application and Implementation*.

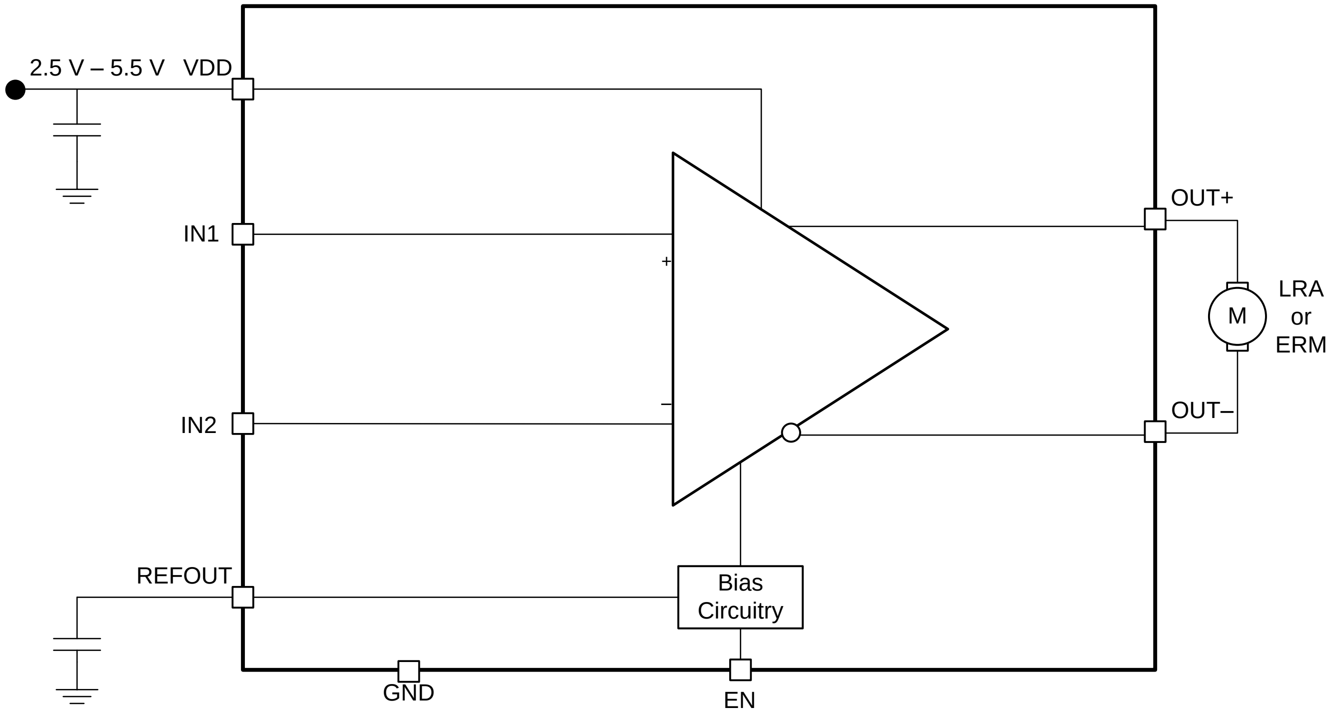
8 Application and Implementation

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

8.1 Application Information

The DRV8601 is intended to be used for haptic applications in a portable product that already has an application processor with analog output interface. As DRV8601 accepts PWM input, it can be directly hooked up to the processor GPIO and can drive PWM outputs.



Copyright © 2016, Texas Instruments Incorporated

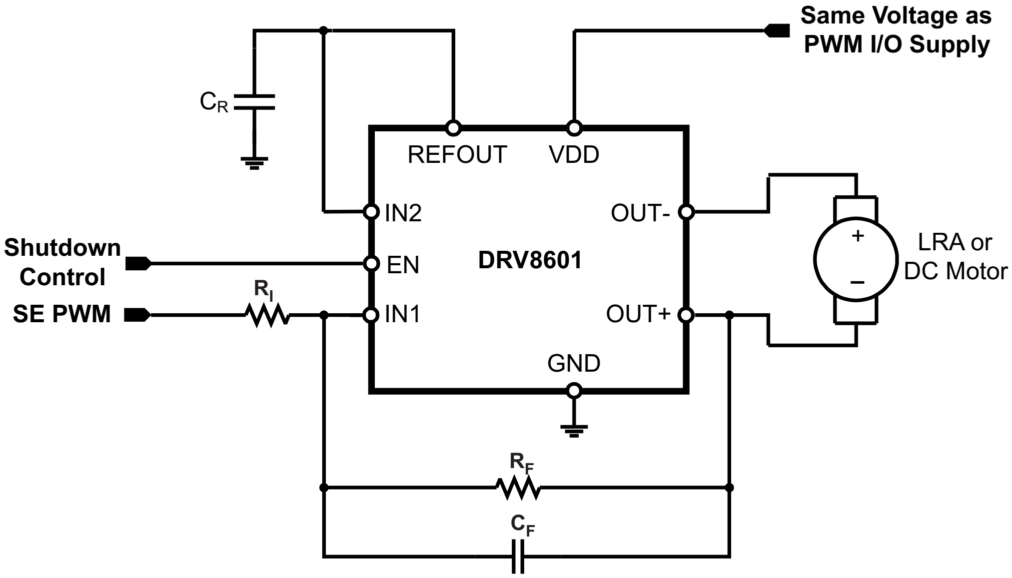
Figure 15. Typical Application Block Diagram

DRV8601 can be operated in different instances as listed in *Typical Applications* which facilitates in the design process for system engineers.

Copyright © 2010–2016, Texas Instruments Incorporated

8.2 Typical Applications

8.2.1 Pseudo-Differential Feedback with Internal Reference



Copyright © 2016, Texas Instruments Incorporated

Figure 16. Pseudo-Differential Feedback with Internal Reference

Typical Applications (continued)

8.2.1.1 Design Requirements

The parameters are located in Table 2.

Table 2. Design Parameters

PARAMETER	EXAMPLE
Power supply	2.5 V – 5.5 V
Host processor	PWM output
	GPIO control
Actuator type	LRA or ERMs

8.2.1.2 Detailed Design Procedure

In the pseudo-differential feedback configuration (Figure 16), feedback is taken from only one of the output pins, thereby reducing the number of external components required for the solution. The DRV8601 has an internal reference voltage generator which keeps the REFOUT voltage at $V_{DD}/2$. The internal reference voltage can be used if and only if the PWM voltage is the same as the supply voltage of the DRV8601 (if $V_{PWM} = V_{DD}$, as assumed in this section).

Having $V_{PWM} = V_{DD}$ ensures that there is no voltage signal applied to the motor at a PWM duty cycle of 50%. This is a convenient way of temporarily stopping the motor without powering off the DRV8601. Also, this configuration ensures that the direction of rotation of the motor changes when crossing a PWM duty cycle of 50% in both directions. For example, if an ERM motor rotates in the clockwise direction at 20% duty cycle, it will rotate in the counter-clockwise direction at 80% duty cycle at nearly the same speed.

Mathematically, the output voltage is given by Equation 1:

$$V_{O,DIFF} = 2 \times \left(V_{IN} - \frac{Vdd}{2}\right) \times \frac{R_F}{R_I} \times \frac{1}{1 + sR_FC_F}$$

where

- sR_FC_F is the Laplace Transform variable
- V_{IN} is the single-ended input voltage (1)

R_F is normally set equal to R_I ($R_F = R_I$) so that an overdrive voltage of V_{DD} is achieved when the PWM duty cycle is set to 100%. The optional feedback capacitor, C_F, forms a low-pass filter together with the feedback resistor R_F, and therefore, the output differential voltage is a function of the average value of the input PWM signal. When driving a motor, design the cutoff frequency of the low-pass filter to be sufficiently *lower than* the PWM frequency in order to eliminate the PWM frequency and its harmonics from entering the motor. This is desirable when driving motors which do not sufficiently reject the PWM frequency by themselves. When driving a linear vibrator in this configuration, if the feedback capacitor C_F is used, care must be taken to make sure that the low-pass cutoff frequency is *higher than* the resonant frequency of the linear vibrator.

When driving motors which can sufficiently reject the PWM frequency by themselves, the feedback capacitor may be eliminated. For this example, the output voltage is given by Equation 2:

$$V_{O,DIFF} = 2 \times \left(V_{IN} - \frac{Vdd}{2}\right) \times \frac{R_F}{R_I} \quad (2)$$

where the only difference from Equation 1 is that the filtering action of the capacitor is not present.

Table 3. Component Design Table

COMPONENT	VALUE
CR	10 nF / 6.3 V
RI	50 K / 0.01%
RF	50 K / 0.01%
CF	0.01 µF / 6.3 V

Copyright © 2010–2016, Texas Instruments Incorporated

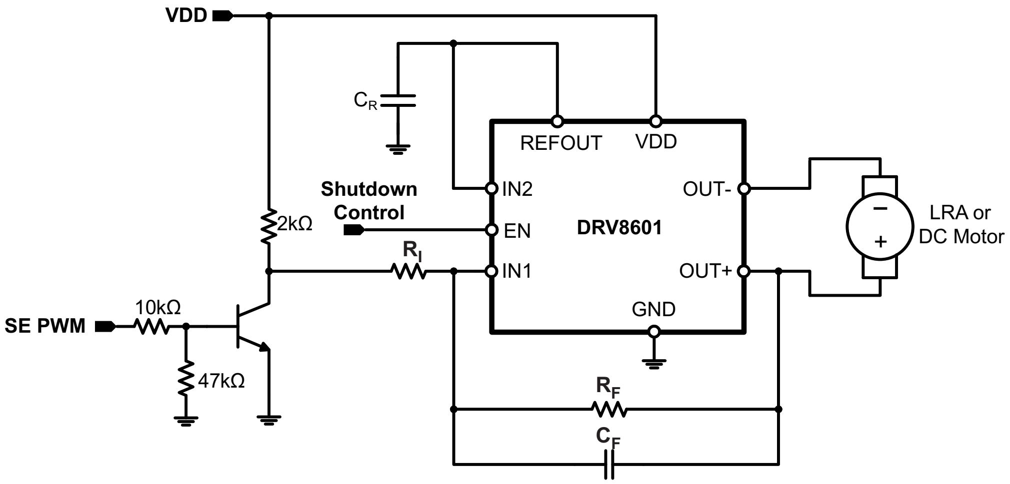
8.2.1.3 *Application Curves*

Table 4 lists the application curves for this application and following applications from *Typical Characteristics*.

Table 4. Table of Graphs

		FIGURE
Output voltage (High)	vs Load current	Figure 1
Output voltage (Low)	vs Load current	Figure 2
Output voltage	vs Input voltage, R_L = 10 Ω	Figure 3
Output voltage	vs Input voltage, R_L = 20 Ω	Figure 4
Supply current	vs Supply voltage	Figure 5
Shutdown supply current	vs Supply voltage	Figure 6
Power dissipation	vs Supply voltage	Figure 7
Slew rate	vs Supply voltage	Figure 8
Output transition	vs Time	Figure 9, Figure 10
Startup	vs Time	Figure 11
Shutdown	vs Time	Figure 12

8.2.2 Pseudo-Differential Feedback with Level-Shifter



Copyright © 2016, Texas Instruments Incorporated

Figure 17. Pseudo-Differential Feedback with Level-Shifter

8.2.2.1 *Design Requirements*

The parameters are located in Table 5.

Table 5. Design Parameters

PARAMETER	EXAMPLE
Power supply	2.5 V – 5.5 V
Host processor	PWM output
	GPIO control
Actuator type	LRA or ERMs

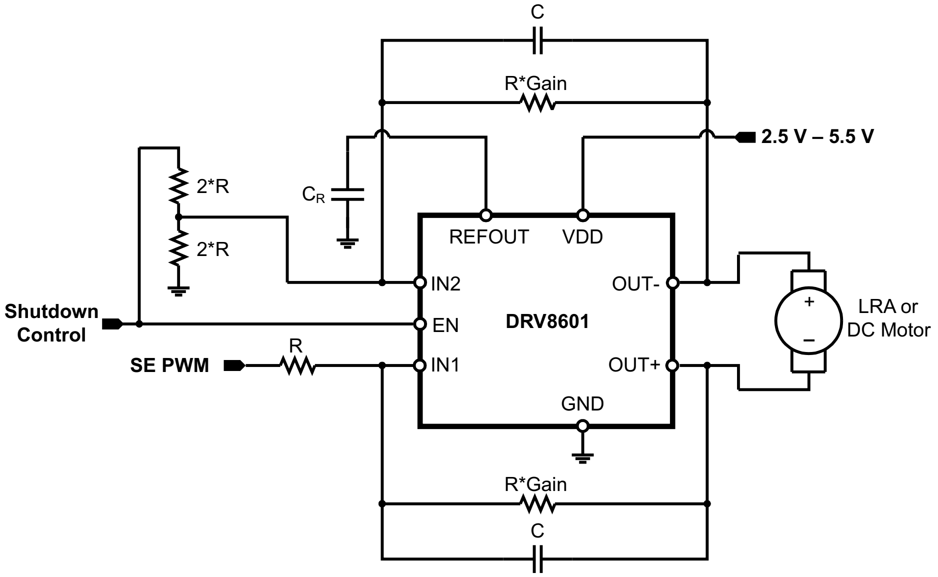
8.2.2.2 Detailed Design Procedure

This configuration is desirable when a regulated supply voltage for the DRV8601 (V_{DD}) is availble, but that voltage is different than the PWM input voltage (V_{PWM}). A single NPN transistor can be used as a low-cost level shifting solution. This ensures that $V_{IN} = V_{DD}$ even when $V_{PWM} \neq V_{DD}$. A regulated supply for the DRV8601 is still recommended in this scenario. If the supply voltage varies, the PWM level shifter output will follow, and this will, in turn, cause a change in vibration strength. However, if the variance is acceptable, the DRV8601 will still operate properly when connected directly to a battery, for example. A 50% duty cycle will still translate to zero vibration strength across the life cycle of the battery. R_F is normally set equal to R_I ($R_F = R_I$) so that an overdrive voltage of V_{DD} is achieved when the PWM duty cycle is set to 100%.

Table 6. Component Design Table

COMPONENT	VALUE
CR	10 nF / 6.3 V
RI	50 K / 0.01%
RF	50 K / 0.01%
CF	0.01 µF / 6.3 V

8.2.3 Differential Feedback With External Reference



Copyright © 2016, Texas Instruments Incorporated

Figure 18. Differential Feedback with External Reference

8.2.3.1 Design Requirements

The parameters are located in Table 7.

Table 7. Design Parameters

PARAMETER	EXAMPLE
Power supply	2.5 V – 5.5 V
Host processor	PWM output
	GPIO control
Gain	1
Actuator type	LRA or ERMs

8.2.3.2 Detailed Design Procedure

This configuration is useful for connecting the DRV8601 to an unregulated power supply, most commonly a battery. The gain can then be independently set so that the required motor overdrive voltage can be achieved even when $V_{PWM} < V_{DD}$. This is often the case when V_{PWM} = 1.8 V, and the desired overdrive voltage is 3.0 V or above. Note that V_{DD} must be greater than or equal to the desired overdrive voltage. A resistor divider can be used to create a $V_{PWM}/2$ reference for the DRV8601. If the shutdown control voltage is driven by a GPIO in the same supply domain as V_{PWM}, it can be used to supply the resistor divider as in Figure 18 so that no current is drawn by the divider in shutdown.

In this configuration, feedback is taken from both output pins. The output voltage is given by Equation 3:

$$V_{O,DIFF} = \left(V_{IN} - \frac{V_{PWM}}{2}\right) \times \frac{R_F}{R_I} \times \frac{1}{1 + sR_FC_F}$$

where

- sR_FC_F is the Laplace Transform variable
- V_{IN} is the single-ended input voltage (3)

Note that this differs from Equation 1 for the pseudo-differential configuration by a factor of 2 because of differential feedback. The optional feedback capacitor C_F forms a low-pass filter together with the feedback resistor R_F, and therefore, the output differential voltage is a function of the average value of the input PWM signal V_{IN}. When driving a motor, design the cutoff frequency of the low-pass filter to be sufficiently *lower than* the PWM frequency in order to eliminate the PWM frequency and its harmonics from entering the motor. This is desirable when driving motors which do not sufficiently reject the PWM frequency by themselves. When driving a linear vibrator in this configuration, if the feedback capacitor C_F is used, care must be taken to make sure that the low-pass cutoff frequency is *higher than* the resonant frequency of the linear vibrator.

When driving motors which can sufficiently reject the PWM frequency by themselves, the feedback capacitor may be eliminated. For this example, the output voltage is given by Equation 4:

$$V_{O,DIFF} = \left(V_{IN} - \frac{V_{PWM}}{2}\right) \times \frac{R_F}{R_I} \tag{4}$$

Where the only difference from Equation 3 is that the filtering action of the capacitor is not present.

8.2.3.2.1 Selecting Components

8.2.3.2.1.1 Resistors R_I and R_F

Choose R_F and R_I in the range of 20 kΩ to 100 kΩ for stable operation.

8.2.3.2.1.2 Capacitor C_R

This capacitor filters any noise on the reference voltage generated by the DRV8601 on the REFOUT pin, thereby increasing noise immunity. However, a high value of capacitance results in a large turn-on time. A typical value of 1 nF is recommended for a fast turn-on time. All capacitors should be X5R dielectric or better.

Table 8. Component Design Table

COMPONENT	VALUE
CR	10 nF / 6.3 V
RI	50 K / 0.01%
RF	50 K / 0.01%
CF	0.01 µF / 6.3 V

9 Power Supply Recommendations

The DRV8601 device is designed to operate from an input-voltage supply range between 2.5 to 5.5 V. The decoupling capacitor for the power supply should be placed closed to the device pin.

10 Layout

10.1 Layout Guidelines

Use the following guidelines for the DRV8601 layout:

- The decoupling capacitor for the power supply (V_{DD}) should be placed closed to the device pin.
- The REFOUT capacitor should be placed close to the device REFOUT pin.

10.2 Layout Example

Figure 19 shows a typical example of the layout for DRV8601. It is important that the power supply decoupling caps and the REFOUT external capacitance be connected as close to the device as possible.

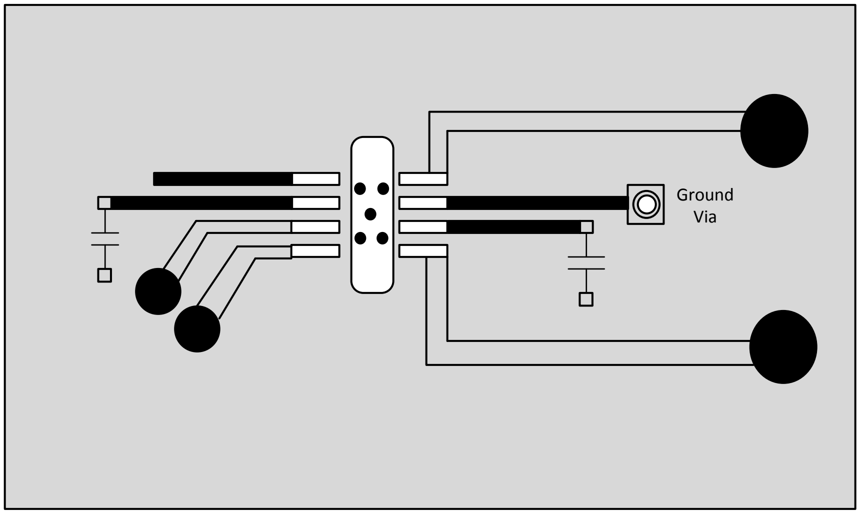


Figure 19. Typical Layout Example

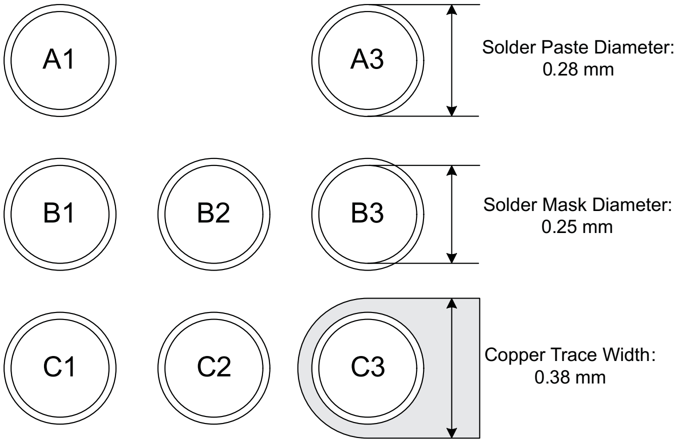


Figure 20. ZQV Land Pattern

Copyright © 2010–2016, Texas Instruments Incorporated

11 Device and Documentation Support

11.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

11.2 Community Resources

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.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

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

11.3 Trademarks

MicroStar Junior, E2E are trademarks of Texas Instruments.
All other trademarks are the property of their respective owners.

11.4 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.5 Glossary

SLYZ022 — *TI Glossary*.

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

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.

Copyright © 2010–2016, Texas Instruments Incorporated

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DRV8601DRBR	ACTIVE	SON	DRB	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	8601	Samples
DRV8601DRBT	ACTIVE	SON	DRB	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	8601	Samples
DRV8601ZQVR	ACTIVE	BGA MICROSTAR JUNIOR	ZQV	8	2500	Green (RoHS & no Sb/Br)	SNAGCU	Level-2-260C-1 YEAR	-40 to 85	HSMI	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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(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.

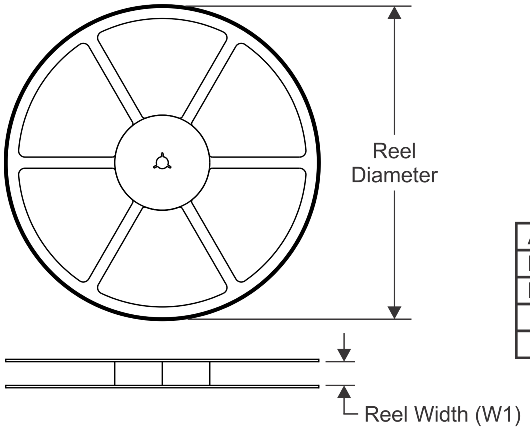
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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.

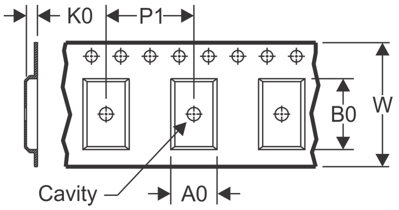
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

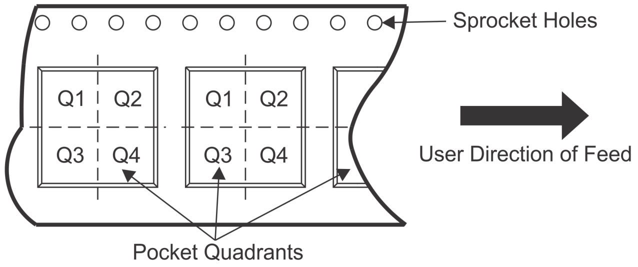


TAPE DIMENSIONS



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

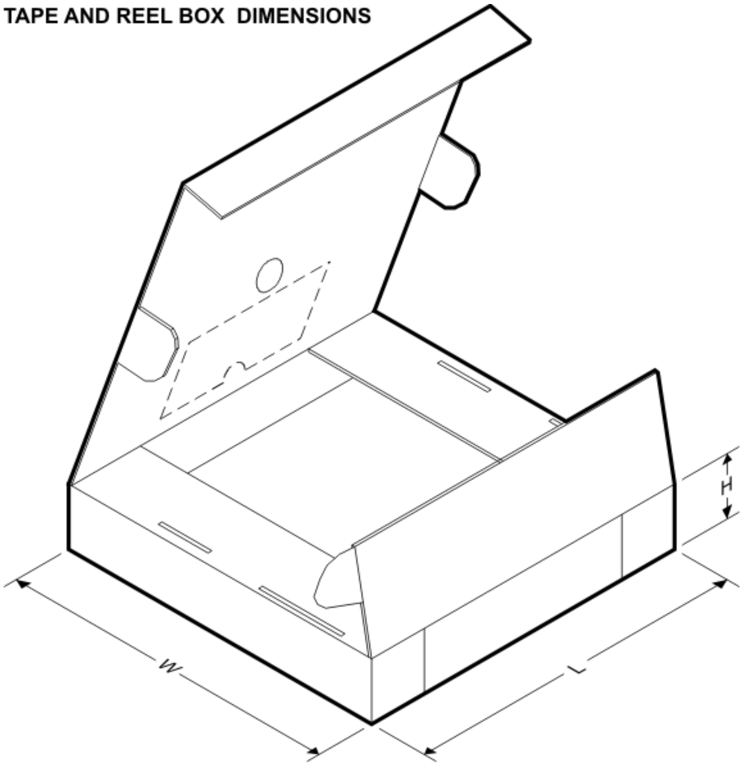
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
DRV8601DRBR	SON	DRB	8	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
DRV8601DRBT	SON	DRB	8	250	180.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
DRV8601ZQVR	BGA MICROSTAR JUNIOR	ZQV	8	2500	330.0	8.4	2.3	2.3	1.4	4.0	8.0	Q1
DRV8601ZQVR	BGA MICROSTAR JUNIOR	ZQV	8	2500	330.0	8.4	2.3	2.3	1.4	4.0	8.0	Q1

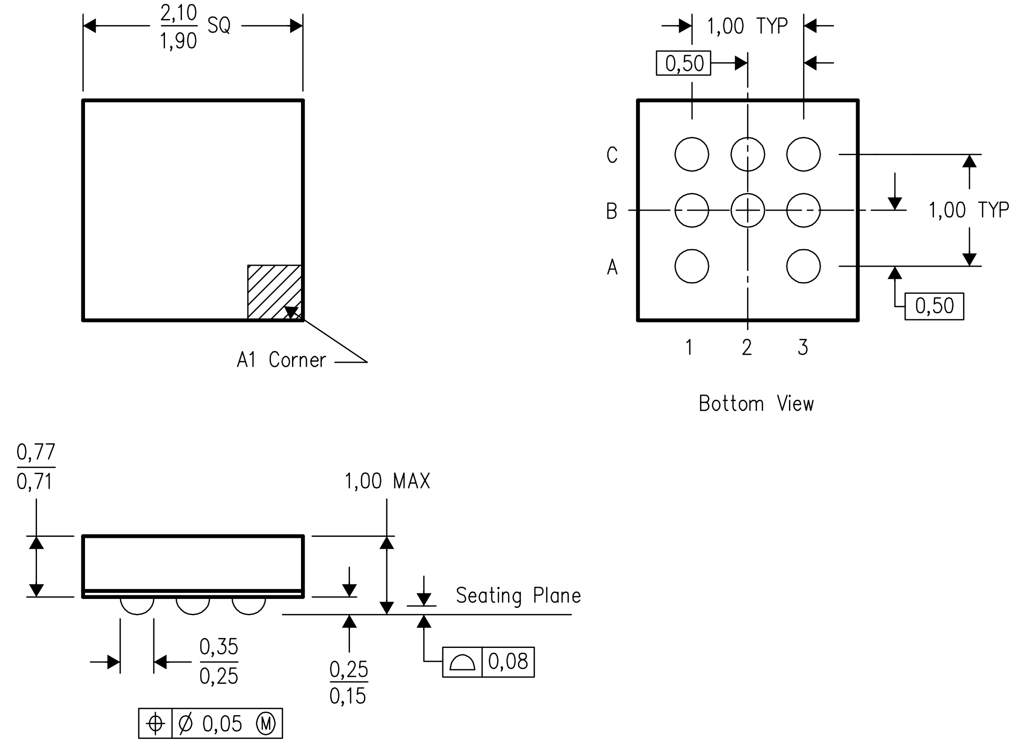
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DRV8601DRBR	SON	DRB	8	3000	367.0	367.0	35.0
DRV8601DRBT	SON	DRB	8	250	210.0	185.0	35.0
DRV8601ZQVR	BGA MICROSTAR JUNIOR	ZQV	8	2500	336.6	336.6	28.6
DRV8601ZQVR	BGA MICROSTAR JUNIOR	ZQV	8	2500	338.1	338.1	20.6

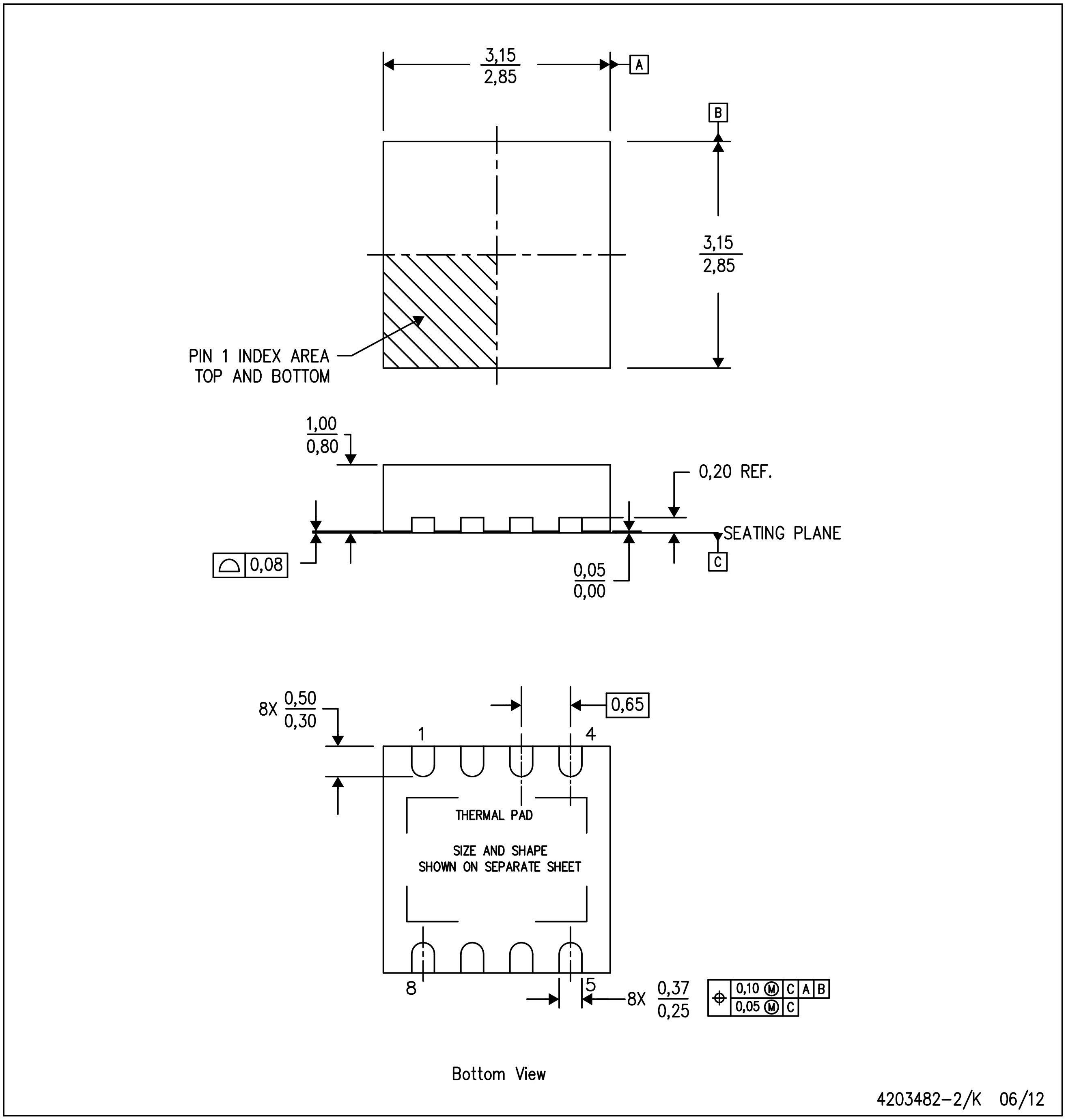
ZQV (S–PBGA–N8) PLASTIC BALL GRID ARRAY



4205131/A 05/03

NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. MicroStar Junior configuration
- D. Falls within JEDEC MO–225
- E. This package is lead–free.

DRB (S–PVSON–N8) PLASTIC SMALL OUTLINE NO–LEAD



NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
- B. This drawing is subject to change without notice.
- C. Small Outline No–Lead (SON) package configuration.
- D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
- E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

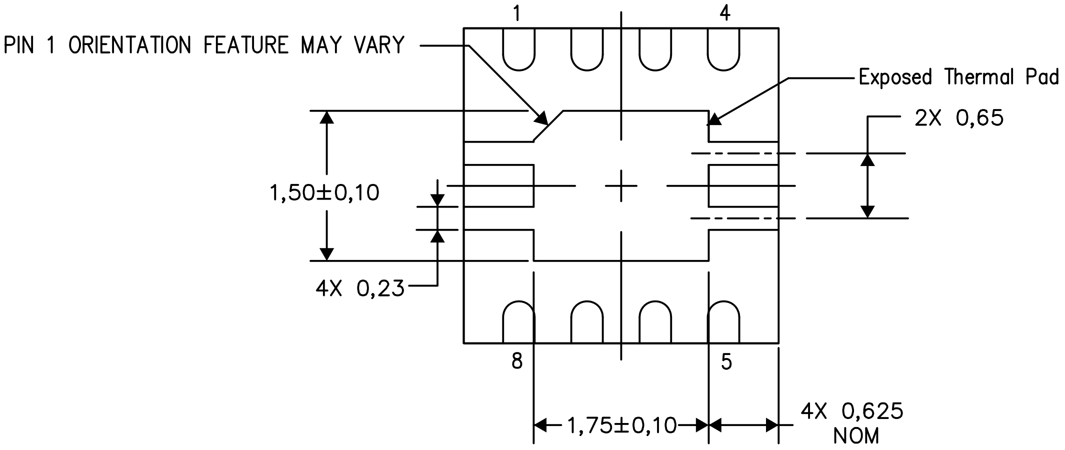
DRB (S–PVSON–N8) PLASTIC SMALL OUTLINE NO–LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



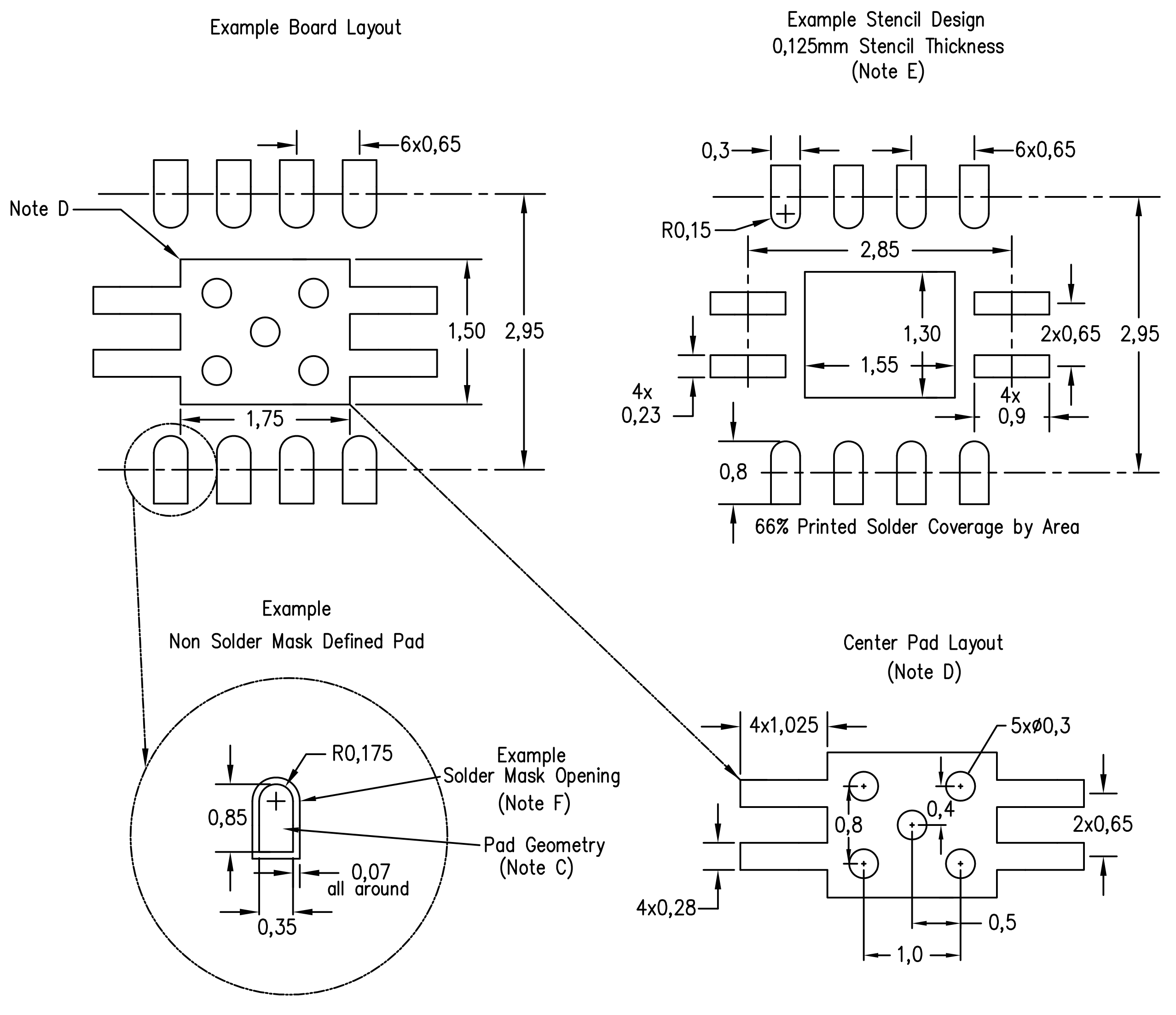
Bottom View

Exposed Thermal Pad Dimensions

4206340–2/T 08/15

NOTE: All linear dimensions are in millimeters

DRB (S-PVSON-N8) PLASTIC SMALL OUTLINE NO-LEAD



4207048-2/O 08/15

NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>.
- E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
- F. Customers should contact their board fabrication site for solder mask tolerances.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2016, Texas Instruments Incorporated