

## TPA6139A2 DirectPath™ 25-mW Headphone Amplifier With Programmable-Fixed Gain

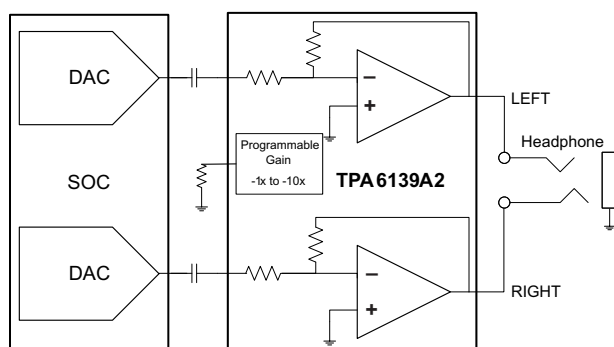
### 1 Features

- DirectPath™
  - Eliminates Pops and Clicks
  - Eliminates Output DC-Blocking Capacitors
  - 3-V to 3.6-V Supply Voltage
- Low Noise and THD
  - SNR > 105 dB at –1x Gain
  - Typical  $V_n < 15 \mu\text{Vms}$  20 to 20 kHz at –1x Gain
  - THD+N < 0.003% at 10-k $\Omega$  Load and –1x Gain
- 25 mW into 32- $\Omega$  Load
- 2-Vrms Output Voltage into 600- $\Omega$  Load
- Single-Ended Input and Output
- Programmable Gain Select Reduces Component Count
  - 13x Gain Values
- Active Mute With More Than 80-dB Attenuation
- Short-Circuit and Thermal Protection
- $\pm 8\text{-kV}$  HBM ESD Protected Outputs

### 2 Applications

- PDP and LCD TVs
- Blu-ray Discs™, DVD Players
- Mini and Micro Combo Systems
- Soundcards

Functional Block Diagram



Copyright © 2016 Texas Instruments Incorporated

### 3 Description

The TPA6139A2 is a 25-mW, pop-free stereo headphone driver designed to reduce component count, board space and cost. It is ideal for single-supply electronics where size and cost are critical design parameters.

The TPA6139A2 device does not require a power supply greater than 3.3 V to generate its 25 mW, nor does it require a split rail power supply.

The TPA6139A2 device was designed using TI's patented DirectPath™ technology, which integrates a charge pump to generate a negative supply rail that provides a clean, pop-free ground biased output. The TPA6139A2 is capable of driving 25 mW into a 32- $\Omega$  load and 2 Vrms into a 600- $\Omega$  load. DirectPath also allows the removal of the costly output DC-blocking capacitors.

The device has fixed gain single-ended inputs with a gain select pin. Using a single resistor on this pin, the designer can choose from 13 internal programmable gain settings to match the line driver with the CODEC output level. It also reduces the component count and board space.

Headphone outputs have  $\pm 8\text{-kV}$  HBM ESD protection enabling a simple ESD protection circuit. The TPA6139A2 has built-in active mute control with more than 80-dB attenuation for pop-free mute ON and OFF control.

The TPA6139A2 device is available in a 14-pin TSSOP and a 16-pin QFN. For a pin-compatible, 2-Vrms line driver see [DRV612](#).

Device Information<sup>(1)</sup>

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPA6139A2	TSSOP (14)	5.00 mm × 4.40 mm
	VQFN (16)	3.00 mm × 3.00 mm

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



## Table of Contents

<b>1 Features</b> .....	<b>1</b>	9.3 Feature Description .....	<b>9</b>
<b>2 Applications</b> .....	<b>1</b>	9.4 Device Functional Modes .....	<b>10</b>
<b>3 Description</b> .....	<b>1</b>	<b>10 Application and Implementation</b> .....	<b>12</b>
<b>4 Revision History</b> .....	<b>2</b>	10.1 Application Information .....	<b>12</b>
<b>5 Device Comparison Table</b> .....	<b>3</b>	10.2 Typical Application .....	<b>13</b>
<b>6 Pin Configuration and Functions</b> .....	<b>3</b>	<b>11 Power Supply Recommendations</b> .....	<b>15</b>
<b>7 Specifications</b> .....	<b>4</b>	<b>12 Layout</b> .....	<b>15</b>
7.1 Absolute Maximum Ratings .....	<b>4</b>	12.1 Layout Guidelines .....	<b>15</b>
7.2 ESD Ratings .....	<b>4</b>	12.2 Layout Example .....	<b>16</b>
7.3 Recommended Operating Conditions .....	<b>4</b>	<b>13 Device and Documentation Support</b> .....	<b>18</b>
7.4 Thermal Information .....	<b>4</b>	13.1 Device Support .....	<b>18</b>
7.5 Electrical Characteristics .....	<b>5</b>	13.2 Documentation Support .....	<b>18</b>
7.6 Programmable Gain Settings .....	<b>6</b>	13.3 Community Resources .....	<b>18</b>
7.7 Typical Characteristics, Line Driver .....	<b>7</b>	13.4 Trademarks .....	<b>18</b>
<b>8 Parameter Measurement Information</b> .....	<b>8</b>	13.5 Electrostatic Discharge Caution .....	<b>18</b>
<b>9 Detailed Description</b> .....	<b>9</b>	13.6 Glossary .....	<b>18</b>
9.1 Overview .....	<b>9</b>	<b>14 Mechanical, Packaging, and Orderable Information</b> .....	<b>18</b>
9.2 Functional Block Diagram .....	<b>9</b>		

## 4 Revision History

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

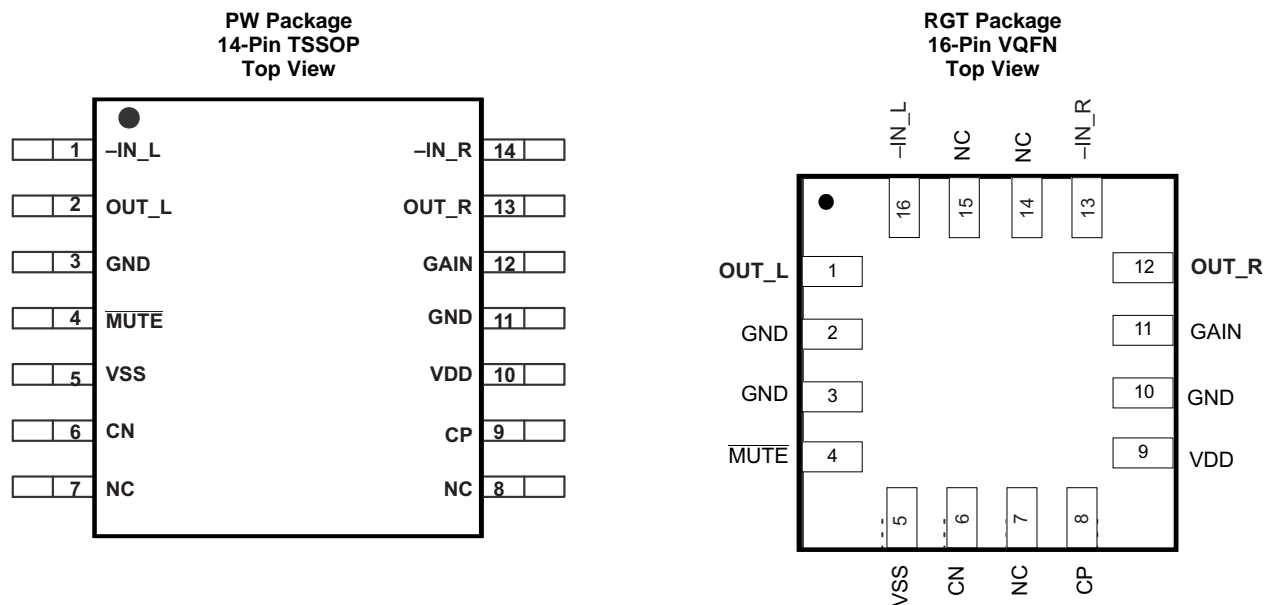
<b>Changes from Revision A (May 2011) to Revision C</b>	<b>Page</b>
• Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section. ....	<b>1</b>
• Removed <i>Ordering Information</i> table .....	<b>1</b>
• Changed 600-Ω Load value to 32-Ω Load in <i>Features</i> .....	<b>1</b>
• Changed 5-kΩ Load value to 600-Ω Load in <i>Features</i> .....	<b>1</b>
• Changed 2 V <sub>ms</sub> to 2 V <sub>rms</sub> in <i>Description</i> .....	<b>1</b>
• Added R <sub>L</sub> valuse for the MIN and MAX columns and changed the TYP value from 5 to 32 in the <i>Recommended Operating Conditions</i> .....	<b>4</b>
• Changed <i>Line Driver Amplifiers</i> subsection title to <i>DirectPath Headphone Driver</i> .....	<b>9</b>

<b>Changes from Original (January 2011) to Revision A</b>	<b>Page</b>
• Changed "2.5-mW" to "25-mW" in Title line and added revision A - May 2011 pub date to Header information .....	<b>1</b>
• Changed conditions statement from "R <sub>IN</sub> = 10 kΩ, R <sub>fb</sub> = 20 kΩ" to "Step = -2V/V" for TYP CHARA, LINE DRIVER section .....	<b>7</b>

## 5 Device Comparison Table

	TPA6132A2	TPA6136A2	TPA6139A2	TPA6141A2
Headphone Channels	Stereo	Stereo	Stereo	Stereo
Output Power (W)	0.025	0.025	0.025	0.025
Supply Voltage Range	2.3 to 5.5	2.3 to 5.5	3 to 3.6	2.5 to 5.5
PSRR (dB)	100	100	80	105
Pin and Package	16-pin WQFN	16-pin DSBGA	16-pin VQFN, 14-pin TSSOP	16-pin DSBGA

## 6 Pin Configuration and Functions



### Pin Functions

NAME	PIN		TYPE <sup>(1)</sup>	DESCRIPTION
	TSSOP	VQFN		
CN	6	6	I/O	Charge Pump flying capacitor negative connection
CP	9	8	I/O	Charge Pump flying capacitor positive connection
GAIN	12	11	I	Gain set programming pin; connect a resistor to ground. See <a href="#">Table 2</a> for recommended resistor values
GND	3, 11	2, 3, 10	P	Ground
-IN_L	1	16	I	Negative input, left channel
-IN_R	14	13	I	Negative input, right channel
MUTE	4	4	I	MUTE, active low
NC	7, 8	7, 14, 15	—	No internal connection
OUT_L	2	1	O	Output, left channel
OUT_R	13	12	O	Output, right channel
VDD	10	9	P	Supply voltage, connect to positive supply
VSS	5	5	O	Change Pump negative supply voltage

(1) I = input, O = output, P = power

## 7 Specifications

### 7.1 Absolute Maximum Ratings

 over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

	MIN	MAX	UNIT
VDD to GND	−0.3	4	V
Input voltage, $V_I$	VSS − 0.3	VDD + 0.3	V
$\overline{\text{MUTE}}$ to GND	−0.3	VDD + 0.3	V
Maximum operating junction temperature, $T_J$	−40	150	°C
Lead temperature		260	°C
Storage temperature, $T_{\text{stg}}$	−40	150	°C

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

### 7.2 ESD Ratings

			VALUE	UNIT	
<b>TPA6139A2 IN PW PACKAGE</b>					
$V_{\text{(ESD)}}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	All pins except 2 and 13	±4000	V
			Pins 2 and 13	±8000	
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>		±1500	
<b>TPA6139A2 IN RGT PACKAGE</b>					
$V_{\text{(ESD)}}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	All pins except 1 and 12	±4000	V
			Pins 1 and 12	±8000	
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>		±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.

### 7.3 Recommended Operating Conditions

over operating free-air temperature range unless otherwise noted

			MIN	NOM	MAX	UNIT
VDD	Supply voltage	DC supply voltage	3	3.3	3.6	V
$R_L$	Load resistance		16	32	10000	$\Omega$
$V_{\text{IL}}$	Low-level input voltage	$\overline{\text{MUTE}}$	38	40	43	%PVDD
$V_{\text{IH}}$	High-level input voltage	$\overline{\text{MUTE}}$	57	60	66	%PVDD
$T_A$	Free-air temperature		−40	25	85	°C

### 7.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TPA6139A2		UNIT
		PW (TSSOP)	RGT (VQFN)	
		14 PINS	16 PINS	
$R_{\theta\text{JA}}$	Junction-to-ambient thermal resistance	130	52	°C/W
$R_{\theta\text{JC(top)}}$	Junction-to-case (top) thermal resistance	49	71	°C/W
$R_{\theta\text{JB}}$	Junction-to-board thermal resistance	63	26	°C/W
$\Psi_{\text{JT}}$	Junction-to-top characterization parameter	3.6	3	°C/W
$\Psi_{\text{JB}}$	Junction-to-board characterization parameter	62	26	°C/W
$R_{\theta\text{JC(bot)}}$	Junction-to-case (bottom) thermal resistance	—	9.8	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

## 7.5 Electrical Characteristics

VDD = 3.3 V, R<sub>Load</sub> = 32 Ω, T<sub>A</sub> = 25°C, Charge pump: C<sub>CP</sub> = 1 μF (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V <sub>OS</sub>	Output offset voltage	VDD = 3.3 V, input AC-coupled		0.5	1	mV
PSRR	Power-supply rejection ratio		70	80		dB
V <sub>OH</sub>	High-level output voltage	VDD = 3.3 V	3.1			V
V <sub>OL</sub>	Low-level output voltage	VDD = 3.3 V			-3.05	V
V <sub>uvp_on</sub>	PVDD, under voltage detection				2.8	V
V <sub>uvp_hysteresis</sub>	PVDD, under voltage detection, hysteresis			200		mV
F <sub>cp</sub>	Charge pump switching frequency			350		kHz
I <sub>IH</sub>	High-level input current, $\overline{\text{MUTE}}$	VDD = 3.3 V, V <sub>IH</sub> = VDD			1	μA
I <sub>IL</sub>	Low-level input current, $\overline{\text{MUTE}}$	VDD = 3.3 V, V <sub>IL</sub> = 0 V			1	μA
I (VDD)	Supply current, no load	VDD, $\overline{\text{MUTE}} = 3.3 \text{ V}$		25		mA
	Supply current, MUTED	VDD = 3.3 V, $\overline{\text{MUTE}} = \text{GND}$		25		mA
T <sub>sd</sub>	Thermal shutdown			150		°C
	Thermal shutdown hysteresis			15		°C
P <sub>O</sub>	Output Power, outputs in phase	THD+N = 1%, f = 1 kHz, 32-Ω load		25		mW
V <sub>O</sub>	Output Voltage, outputs in phase	THD+N = 1%, f = 1 kHz, 32-Ω load		0.9		V <sub>rms</sub>
		THD+N = 1%, f = 1 kHz, 600-Ω load		2		
THD+N	Total Harmonic distortion plus noise	f = 1kHz, 32-Ω load, P <sub>o</sub> = 25 mW, -1x gain		0.03%		
THD+N	Total Harmonic distortion plus noise	f = 1kHz, 10-kΩ load, V <sub>o</sub> = 2 V <sub>rms</sub> , -1x gain		0.005%		
ΔA <sub>V</sub>	Gain matching	Between left and right channels		0.25		dB
Z <sub>O</sub>	Output impedance when muted	$\overline{\text{MUTE}} = \text{GND}$			1	Ω
	Input to output attenuation when muted	$\overline{\text{MUTE}} = \text{GND}$		80		dB
SNR	Signal to noise ratio	A-weighted, AES17 filter, 1-V <sub>rms</sub> ref 32-Ω load, -1x gain		99		dB
	Signal to noise ratio	A-weighted, AES17 filter, 2-V <sub>rms</sub> ref 600-Ω load, -1x gain		105		dB
V <sub>n</sub>	Noise voltage	A-weighted, AES17 filter, Gain = -2x		12		μV
	Slew rate			4.5		V/μs
G <sub>bw</sub>	Unity gain bandwidth			8		MHz
Crosstalk	Channel to channel	f = 1 kHz, R <sub>load</sub> = 32 Ω, P <sub>o</sub> = 25 mW		-85		dB
V <sub>incm_pos</sub>	Positive common-mode input voltage			+2		V
V <sub>incm_neg</sub>	Negative common-mode input voltage			-2		V
I <sub>lim</sub>	Output current limit			60		mA

## 7.6 Programmable Gain Settings

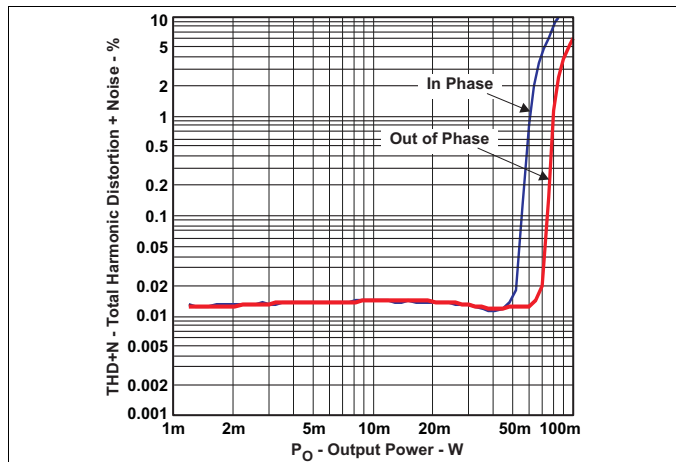
 $V_{DD} = 3.3\text{ V}$ ,  $R_{load} = 32\text{ k}\Omega$ ,  $T_A = 25^\circ\text{C}$ , Charge pump:=  $C_{CP} = 1\text{ }\mu\text{F}$ ,  $C_{IN} = 1\text{ }\mu\text{F}$ , 1x gain select (unless otherwise noted)<sup>(1)</sup>

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
R_Tol	Gain programming resistor tolerance				2%	
$\Delta A_V$	Gain matching	Between left and right channels		0.25		dB
	Gain step tolerance			0.1		dB
Gain steps	Gain resistor 2% tolerance	249k or higher		-2		V/V
		82k0		-1		
		49k2		-1.5		
		35k1		-2.3		
		27k3		-2.5		
		20k5		-3		
		15k4		-3.5		
		11k5		-4		
		9k09		-5		
		7k50		-5.6		
		6k19		-6.4		
		5k11		-8.3		
Input impedance	Gain resistor 2% tolerance	249k or higher		37		k $\Omega$
		82k0		55		
		49k2		44		
		35k1		33		
		27k3		31		
		20k5		28		
		15k4		24		
		11k5		22		
		9k09		18		
		7k50		17		
		6k19		15		
		5k11		12		
3k90		10				

(1) If pin 12, GAIN, is left floating an internal pullup sets the gain to -2x. Gain setting is latched during power up.

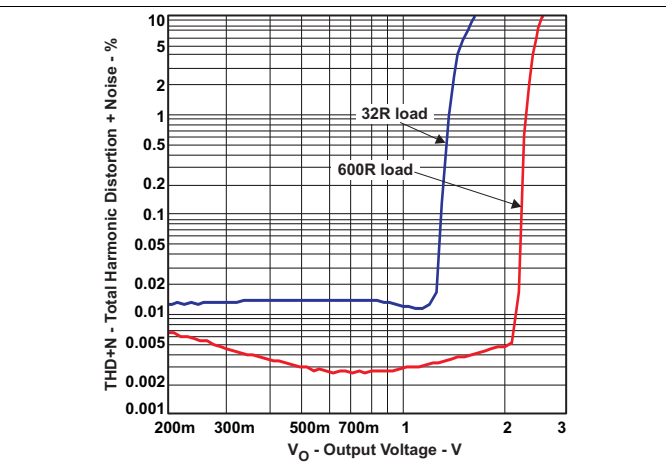
### 7.7 Typical Characteristics, Line Driver

$V_{DD} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $R_L = 2.5\text{ k}\Omega$ ,  $C_{PUMP} = C_{(VSS)} = 10\text{ }\mu\text{F}$ , Gain Step =  $-2\text{ V/V}$  (unless otherwise noted)



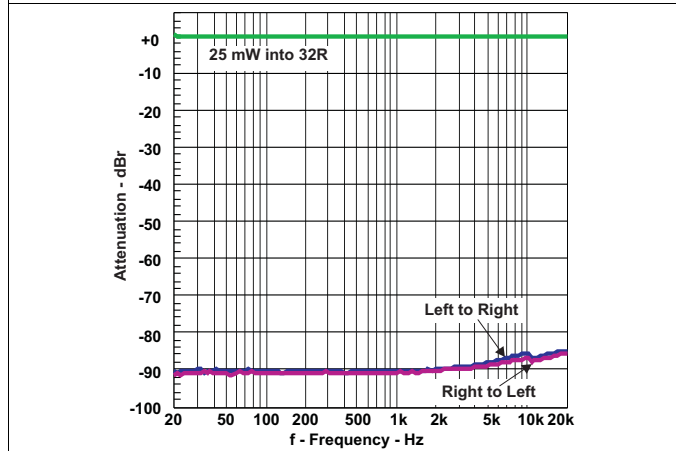
3.3 V, 100 k $\Omega$ , 1 kHz

Figure 1. THD+N vs Output Voltage



3.3 V, 600- $\Omega$  load, 1 kHz

Figure 2. THD+N vs Output Voltage



3.3 V, 5-k $\Omega$  load, 2 Vrms, Blue L to R, Red R to L

Figure 3. Channel Separation

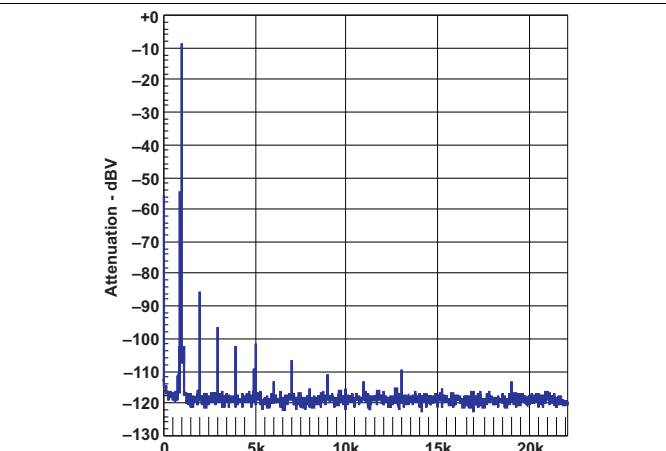


Figure 4. FFT

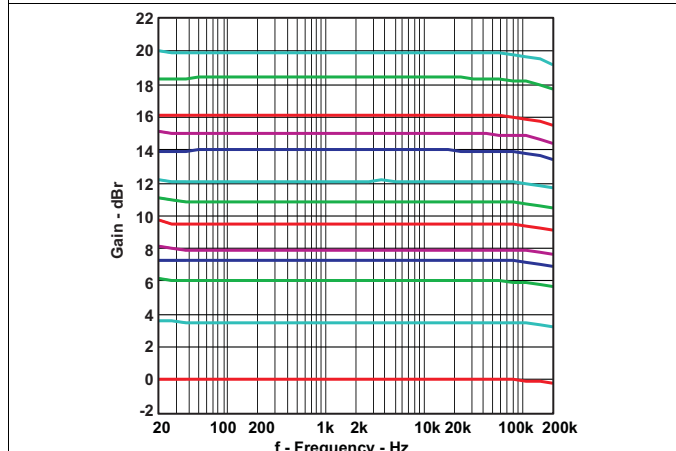


Figure 5. Gain vs Frequency

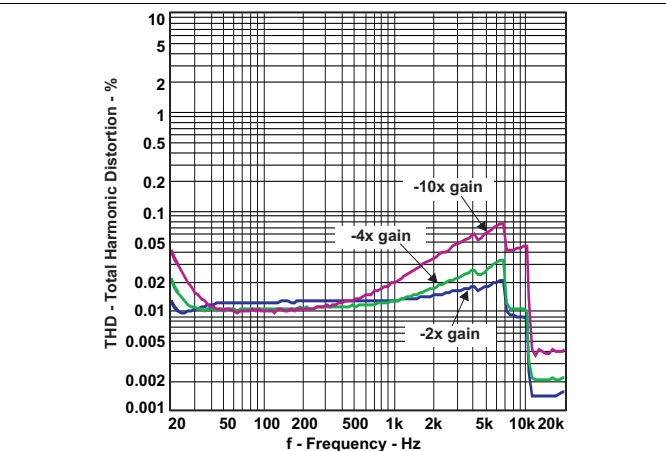
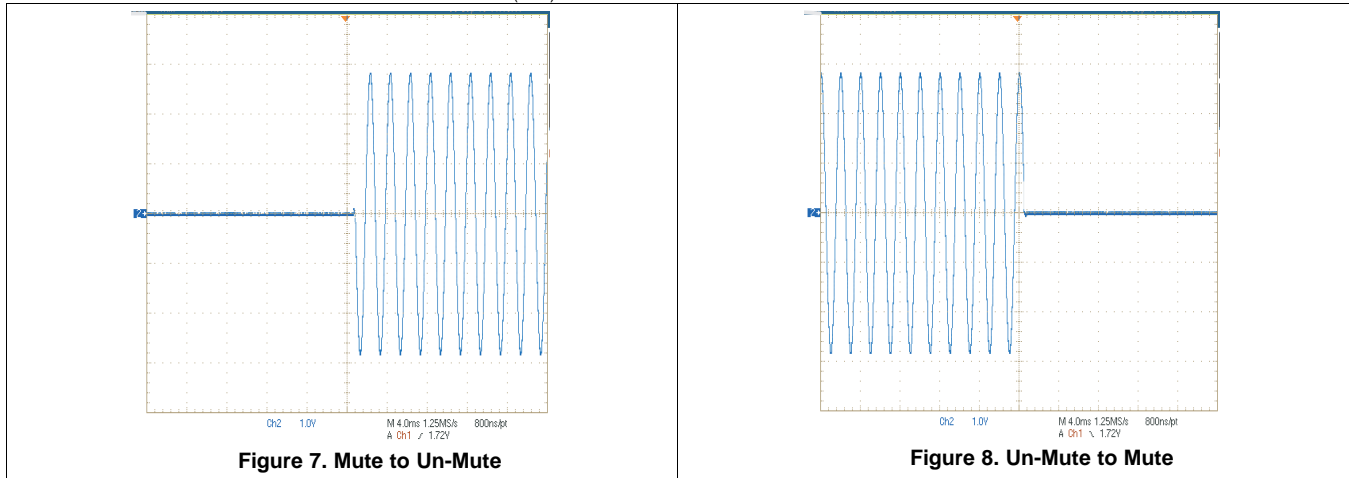


Figure 6. Total Harmonic Distortion vs Frequency

## Typical Characteristics, Line Driver (continued)

$V_{DD} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $R_L = 2.5\text{ k}\Omega$ ,  $C_{PUMP} = C_{(VSS)} = 10\text{ }\mu\text{F}$ , Gain Step =  $-2\text{ V/V}$  (unless otherwise noted)



## 8 Parameter Measurement Information

All parameters are measured according to the conditions described in the [Specifications](#) section.



## 9 Detailed Description

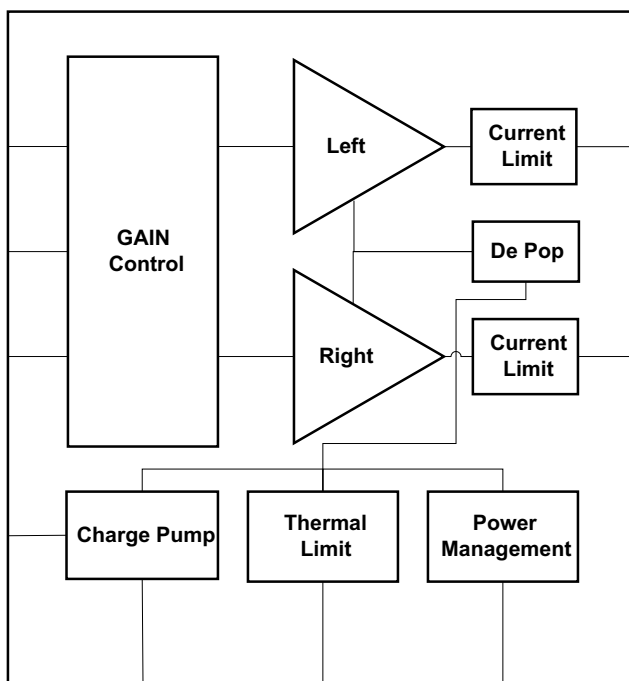
### 9.1 Overview

The TPA6139A2 is a DirectPath stereo headphone amplifier that requires no output DC-blocking capacitors and is capable of delivering 25 mW into a 32-Ω load. The device has built-in pop suppression circuitry to completely eliminate pop noise during turnon and turnoff. The amplifier outputs have short-circuit protection.

The TPA6139A2 gain is controlled by external resistors  $R_{in}$  and  $R_{fb}$ , see [Gain Setting](#) for recommended values.

The TPA6139A2 operates from a single 3-V to 3.6-V supply, as it uses a built-in charge pump to generate a negative voltage supply for the headphone amplifiers.

### 9.2 Functional Block Diagram



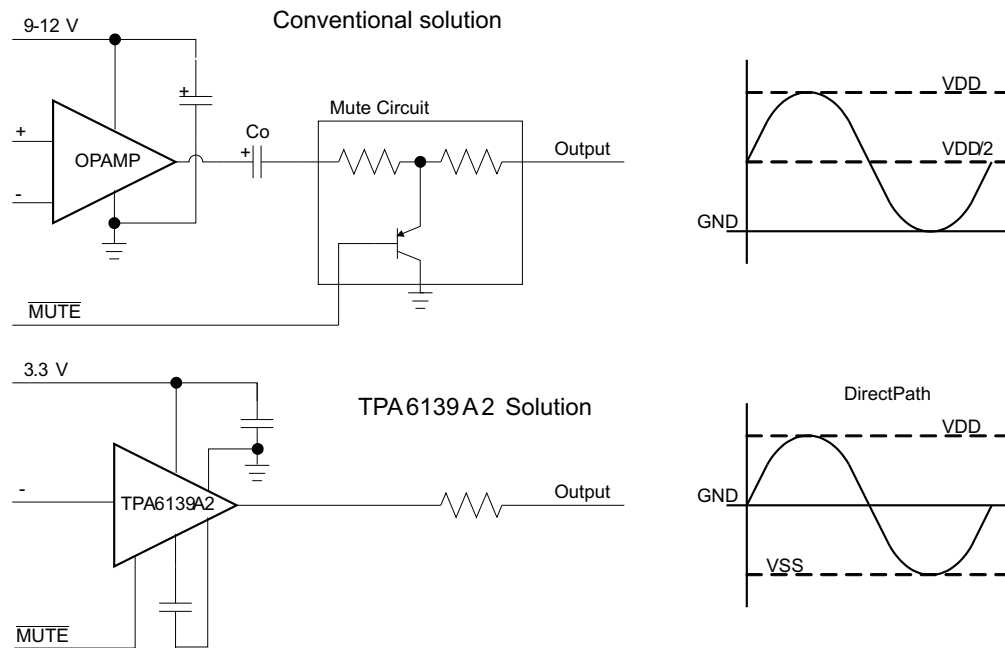
Copyright © 2016 Texas Instruments Incorporated

### 9.3 Feature Description

#### 9.3.1 DirectPath Headphone Driver

Single-supply line-driver amplifiers typically require DC-blocking capacitors. The top drawing in [Figure 9](#) illustrates the conventional line-driver amplifier connection to the load and output signal.

DC-blocking capacitors are often large in value, and a mute circuit is needed during power up to minimize click and pop. The output capacitor and mute circuit consume PCB area and increase cost of assembly, and can reduce the fidelity of the audio output signal.

**Feature Description (continued)**

**Figure 9. Conventional and DirectPath Line Driver**

The DirectPath amplifier architecture operates from a single supply but makes use of an internal charge pump to provide a negative voltage rail.

Combining the user-provided positive rail and the negative rail generated by the IC, the device operates in what is effectively a split supply mode.

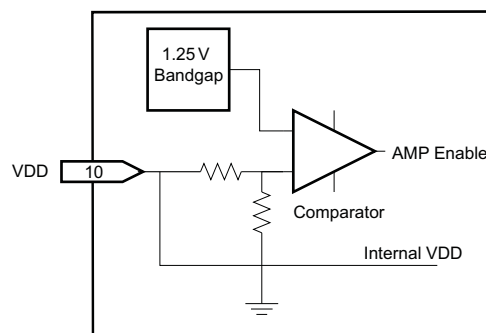
The output voltages are now centered at zero volts with the capability to swing to the positive rail or negative rail. Combining this with the built-in click and pop reduction circuit, the DirectPath amplifier requires no output DC-blocking capacitors.

The bottom block diagram and waveform of [Figure 9](#) illustrate the ground-referenced line-driver architecture.

## 9.4 Device Functional Modes

### 9.4.1 Internal Undervoltage Detection

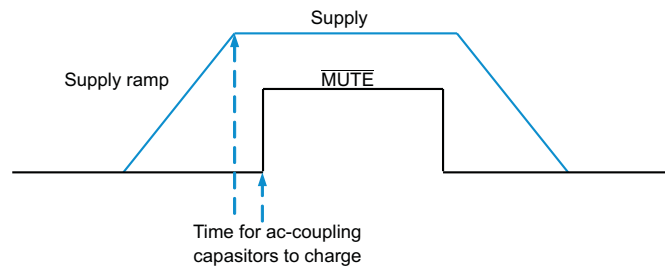
The TPA6139A2 contains an internal precision band-gap reference voltage and a comparator used to monitor the supply voltage, VDD. The internal VDD monitor is set at 2.8 V with 200-mV hysteresis.



## Device Functional Modes (continued)

### 9.4.2 Pop-Free Power Up

Pop-free power up is ensured by keeping the  $\overline{\text{MUTE}}$  low during power-supply ramp-up and ramp-down. The pin must be kept low until the input AC-coupling capacitors are fully charged before asserting the  $\overline{\text{MUTE}}$  pin high to precharge the AC-coupling; and, pop-less power up is achieved. Figure 10 illustrates the preferred sequence.



**Figure 10. Power-Up Sequence**

## 10 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.

---

### 10.1 Application Information

The TPA6139A2 device starts its operation by asserting the MUTE pin to logic 1. The device enters in mute mode when pulling the MUTE pin low. The charge pump generates a negative supply voltage. The charge pump flying capacitor connected between CP and CN transfers charge to generate the negative supply voltage. The output voltages are capable of positive and negative voltage swings and are centered close to 0 V, eliminating the need for output capacitors. Input coupling capacitors block any DC bias from the audio source and ensure maximum dynamic range.

This typical connection diagram highlights the required external components and system level connections for proper operation of the device in popular use case. Any design variation can be supported by TI through schematic and layout reviews. Visit <https://e2e.ti.com> for design assistance and join the audio amplifier discussion forum for additional information.

#### 10.1.1 Capacitive Load

The TPA6139A2 has the ability to drive a high capacitive load up to 220 pF directly. Higher capacitive loads can be accepted by adding a series resistor of 47  $\Omega$  or larger for the line driver output.

## 10.2 Typical Application

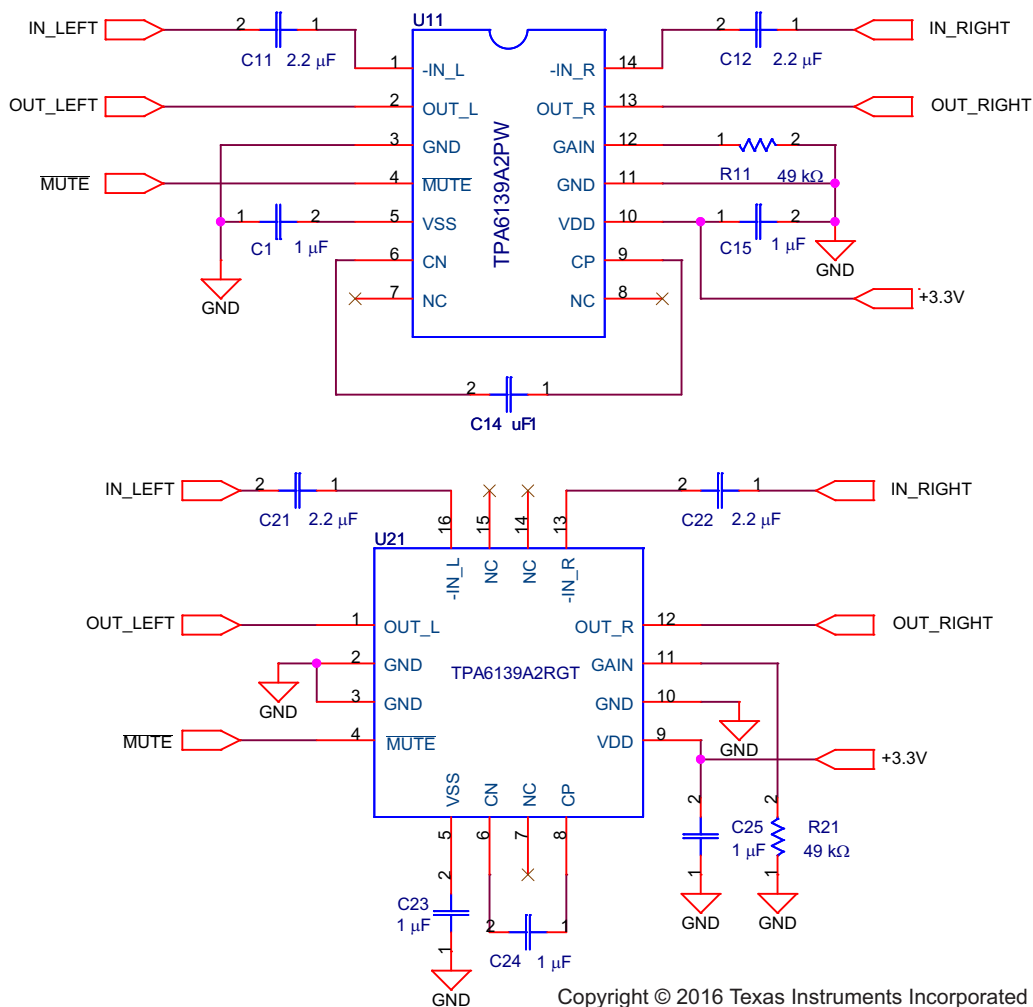


Figure 11. Single-Ended Input and Output, Gain Set to  $-1.5x$

### 10.2.1 Design Requirements

Table 1 lists the design parameters of this example.

Table 1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input voltage supply range	3 V to 3.6 V
Current	130 mA
Load impedance	32 Ω

### 10.2.2 Detailed Design Procedure

#### 10.2.2.1 Component Selection

##### 10.2.2.1.1 Charge Pump

The charge pump flying capacitor serves to transfer charge during the generation of the negative supply voltage. The VSS capacitor must be at least equal to the charge pump capacitor in order to allow maximum charge transfer. Low ESR capacitors are an ideal selection, and a value of 1 μF is typical. Capacitor values that are smaller than 1 μF cannot be recommended as it limits the negative voltage swing in low impedance loads.

### 10.2.2.1.2 Decoupling Capacitors

The TPA6139A2 is a DirectPath amplifier that requires adequate power-supply decoupling to ensure that the noise and total harmonic distortion (THD) are low. A good low equivalent-series-resistance (ESR) ceramic capacitor, typically 1  $\mu\text{F}$ , placed as close as possible to the device VDD leads works best. Placing this decoupling capacitor close to the TPA6139A2 is important for the performance of the amplifier. For filtering lower frequency noise signals, a 10- $\mu\text{F}$  or greater capacitor placed near the audio power amplifier also helps, but it is not required in most applications because of the high PSRR of this device.

### 10.2.2.1.3 Gain Setting

The gain setting is programmed with the GAIN pin individually for line driver and headphone section. Gain setting is latched when the MUTE pin is set high. Table 2 lists the gain settings. The default gain with the gain-set pin left open is  $-2x$ .

**Table 2. Gain Settings**

Gain_set RESISTOR	GAIN	GAIN (dB)	INPUT RESISTANCE
No connect	$-2x$	6	37k
82k0	$-1x$	0	55k
49k2	$-1.5x$	3.5	44k
35k1	$-2.3x$	7.2	33k
27k3	$-2.5x$	8	31k
20k5	$-3x$	9.5	28k
15k4	$-3.5x$	10.9	24k
11k5	$-4x$	12	22k
9k09	$-5x$	14	18k
7k50	$-5.6x$	15	17k
6k19	$-6.4x$	16.1	15k
5k11	$-8.3x$	18.4	12k
3k90	$-10x$	20	10k

### 10.2.2.1.4 Input-Blocking Capacitors

DC input-blocking capacitors are required to be added in series with the audio signal into the input pins of the TPA6139A2. These capacitors block the DC portion of the audio source and allow the TPA6139A2 inputs to be properly biased to provide maximum performance. The input blocking capacitors also limit the DC gain to 1, limiting the DC-offset voltage at the output.

These capacitors form a high-pass filter with the input resistor,  $R_{IN}$ . The cutoff frequency is calculated using Equation 1. For this calculation, the capacitance used is the input-blocking capacitor and the resistance is the input resistor chosen from Table 2. Then the frequency or capacitance can be determined when one of the two values is given, as shown in Equation 1.

$$f_{C_{IN}} = \frac{1}{2\pi R_{IN} C_{IN}} \text{ or } C_{IN} = \frac{1}{2\pi f_{C_{IN}} R_{IN}} \quad (1)$$

For a fixed cutoff frequency of 2 Hz, the size of the input capacitance is shown Table 3 with the capacitors rounded up to the nearest E6 values. For 20-Hz cutoff, simply divide the capacitor values with 10; for example, for  $1x$  gain, 150 nF is needed.

**Table 3. Input Capacitor for Different Gain and Cutoff**

Gain_set RESISTOR	GAIN	Gain (dB)	INPUT RESISTANCE	2-Hz CUTOFF
249k	$-2x$	6	37k	2.2 $\mu\text{F}$
82k0	$-1x$	0	55k	1.5 $\mu\text{F}$
49k2	$-1.5x$	3.5	44k	2.2 $\mu\text{F}$
35k1	$-2.3x$	7.2	33k	3.3 $\mu\text{F}$
27k3	$-2.5x$	8	31k	3.3 $\mu\text{F}$

**Table 3. Input Capacitor for Different Gain and Cutoff (continued)**

Gain_set RESISTOR	GAIN	Gain (dB)	INPUT RESISTANCE	2-Hz CUTOFF
20k5	–3x	9.5	28k	3.3 $\mu$ F
15k4	–3.5x	10.9	24k	3.3 $\mu$ F
11k5	–4x	12	22k	4.7 $\mu$ F
9k09	–5x	14	18k	4.7 $\mu$ F
7k50	–5.6x	15	17k	4.7 $\mu$ F
6k19	–6.4x	16.1	15k	6.8 $\mu$ F
5k11	–8.3x	18.4	12k	6.8 $\mu$ F
3k90	–10x	20	10k	10 $\mu$ F

### 10.2.3 Application Curves

The characteristics of this design are shown in [Typical Characteristics, Line Driver](#).

**Table 4. Table of Graphs**

	FIGURE
THD+N vs Output Voltage	<a href="#">Figure 2</a>
Total Harmonic Distortion vs Frequency	<a href="#">Figure 6</a>
Mute to Un-Mute	<a href="#">Figure 7</a>
Un-Mute to mute	<a href="#">Figure 8</a>

## 11 Power Supply Recommendations

The device is designed to operate from an input voltage supply from 3 V to 3.6 V. Therefore, the output voltage range of power supply should be within this range and well regulated. TI recommends placing decoupling capacitors in every voltage source pin. Place these decoupling capacitors as close as possible to the TPA6139A2.

## 12 Layout

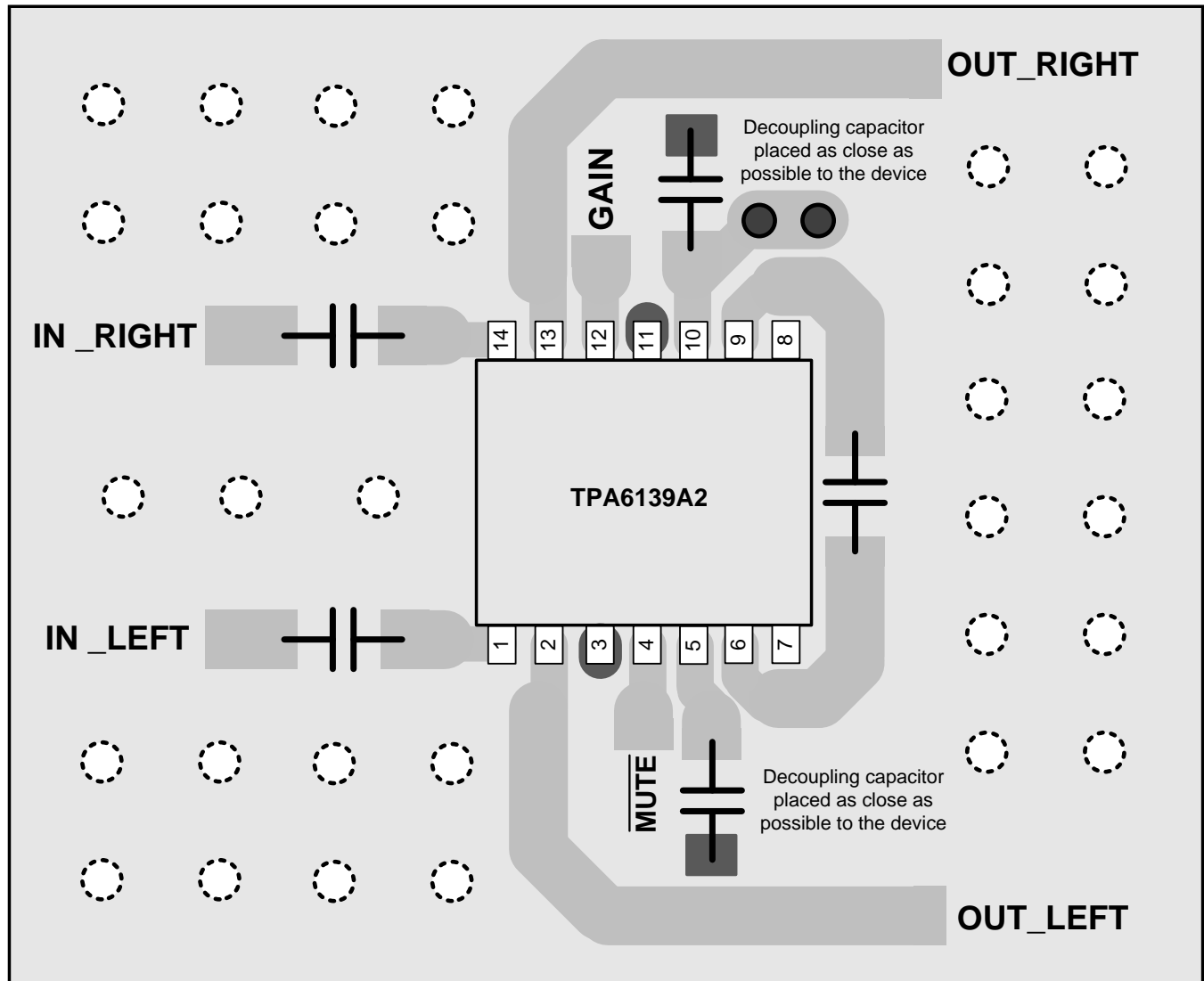
### 12.1 Layout Guidelines

A proposed layout for the TPA6139A2 can be seen in the TPA6139A2EVM User's Guide ([SLOU308](#)), and the Gerber files can be downloaded from <http://focus.ti.com/docs/toolsw/folders/print/TPA6139A2evm.html>. To access this information, open the TPA6139A2 product folder and look in the Tools and Software folder.

TI recommends routing the ground traces as a star ground to minimize hum interference. VDD, VSS decoupling capacitors, and the charge pump capacitors should be connected with short traces.

The TPA6139A2 stereo headphone amplifier is pin-compatible with the DRV612. A single PCB layout can therefore be used with stuffing options for different board configurations.

## 12.2 Layout Example








-  Top Layer Ground Plane
-  Top Layer Traces
-  Pad to Top Layer Ground Plane
-  Via to Power Supply
-  Via to Bottom Layer Ground Plane

Figure 12. Layout Example for the TSSOP Package



Layout Example (continued)

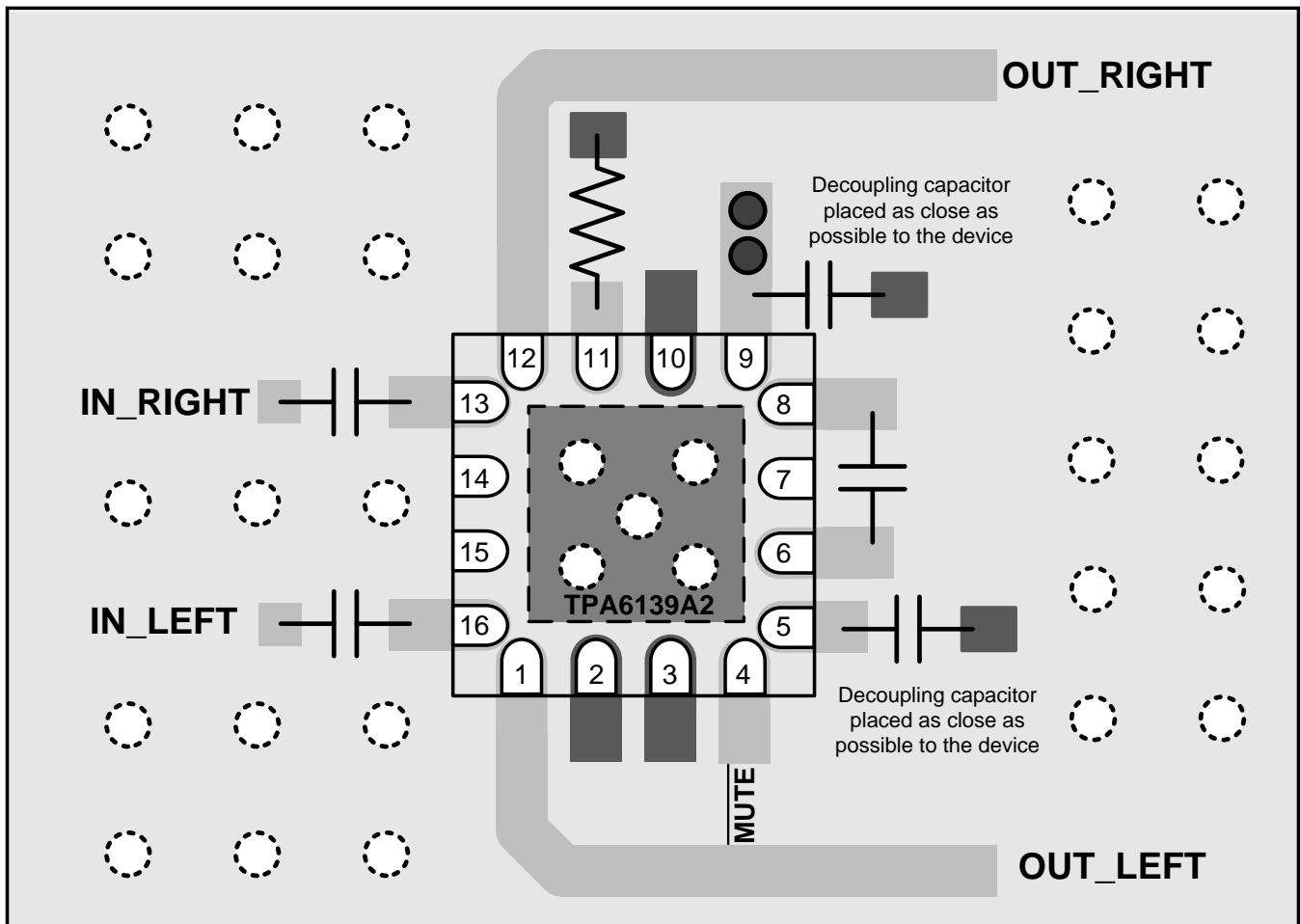


Figure 13. Layout Example for the VQFN Package

## 13 Device and Documentation Support

### 13.1 Device Support

For device support, see the following:

Gerber – <http://focus.ti.com/docs/toolsw/folders/print/TPA6139A2evm.html>

### 13.2 Documentation Support

For related documentation, see the following:

TPA6139A2EVM User's Guide (SLOU308)

### 13.3 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.

### 13.4 Trademarks

DirectPath, E2E are trademarks of Texas Instruments.  
 Blu-ray Discs is a trademark of Blu-ray Disc Association.  
 All other trademarks are the property of their respective owners.

### 13.5 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.

### 13.6 Glossary

[SLYZ022](#) — *TI Glossary*.

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

## 14 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.

**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
TPA6139A2PW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	TPA6139	<a href="#">Samples</a>
TPA6139A2PWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	TPA6139	<a href="#">Samples</a>
TPA6139A2RGTR	ACTIVE	QFN	RGT	16	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 150	T6139	<a href="#">Samples</a>
TPA6139A2RGTT	ACTIVE	QFN	RGT	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 150	T6139	<a href="#">Samples</a>

(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



### 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
TPA6139A2PWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TPA6139A2RGTR	QFN	RGT	16	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

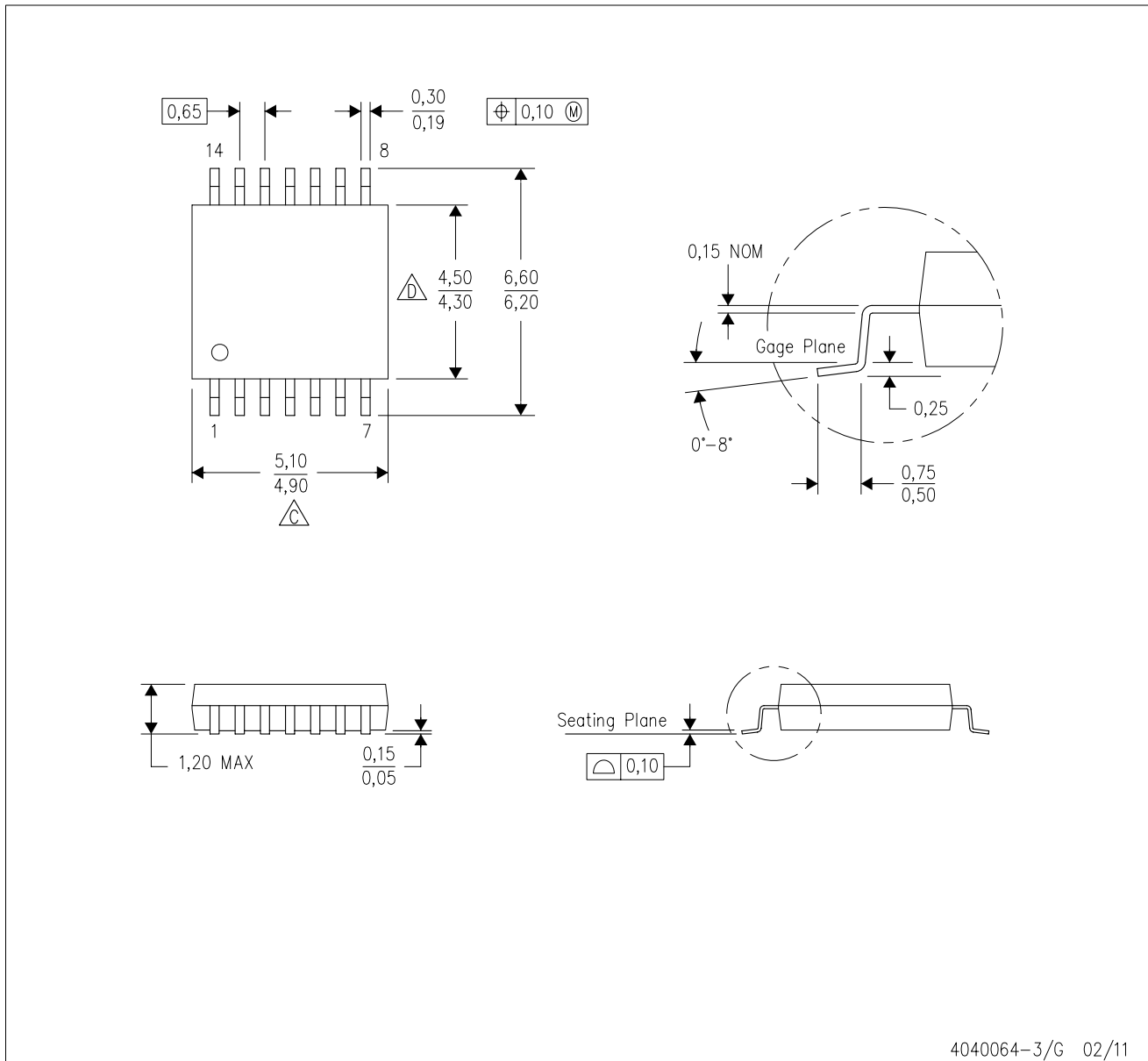
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPA6139A2PWR	TSSOP	PW	14	2000	367.0	367.0	38.0
TPA6139A2RGTR	QFN	RGT	16	3000	336.6	336.6	28.6

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4040064-3/G 02/11

- 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. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



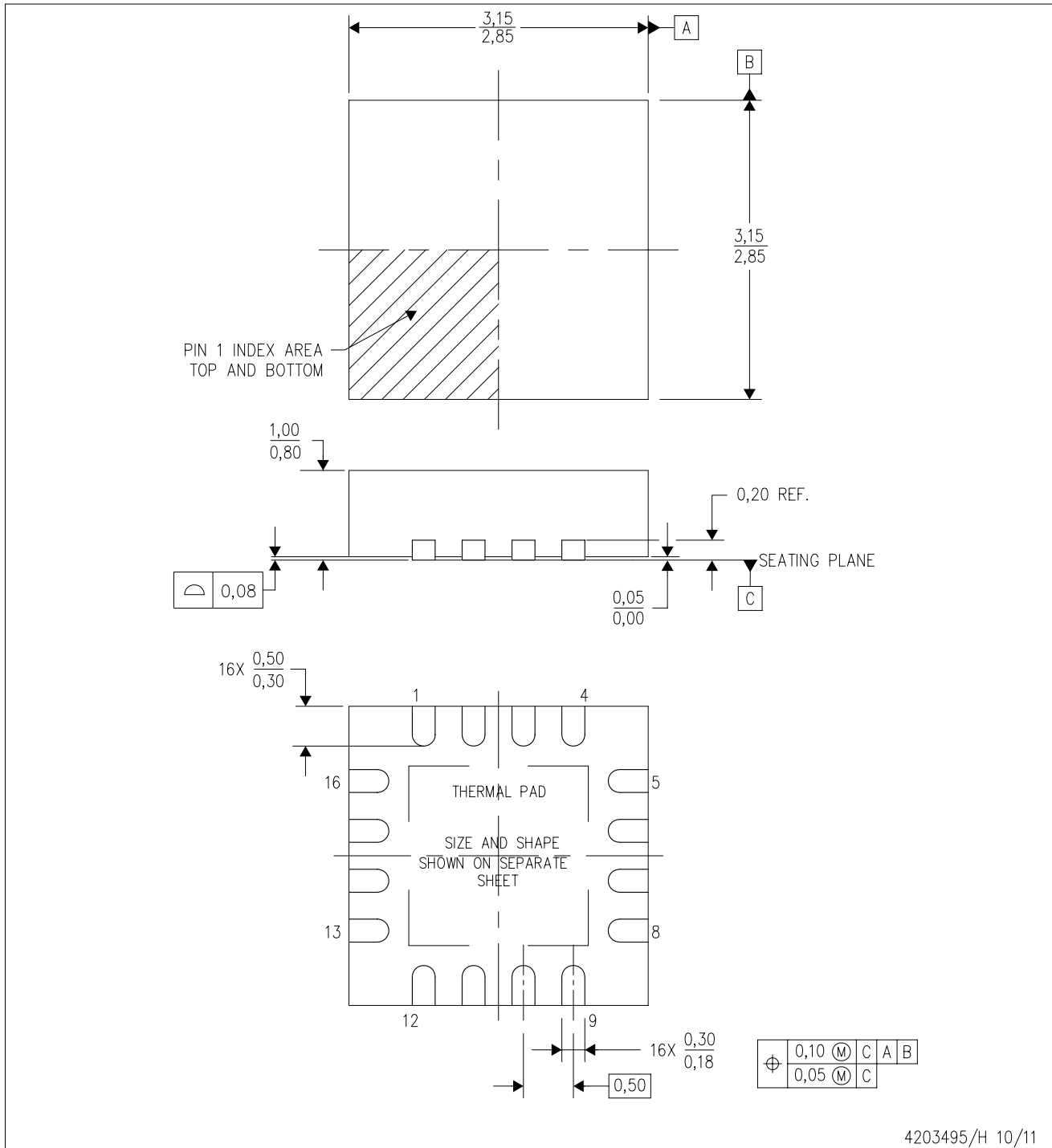
4211284-2/G 08/15

- 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. 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 other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.



RGT (S-PVQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



4203495/H 10/11

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - Quad Flatpack, No-leads (QFN) package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
  - Falls within JEDEC MO-220.

# THERMAL PAD MECHANICAL DATA

RGT (S-PVQFN-N16)

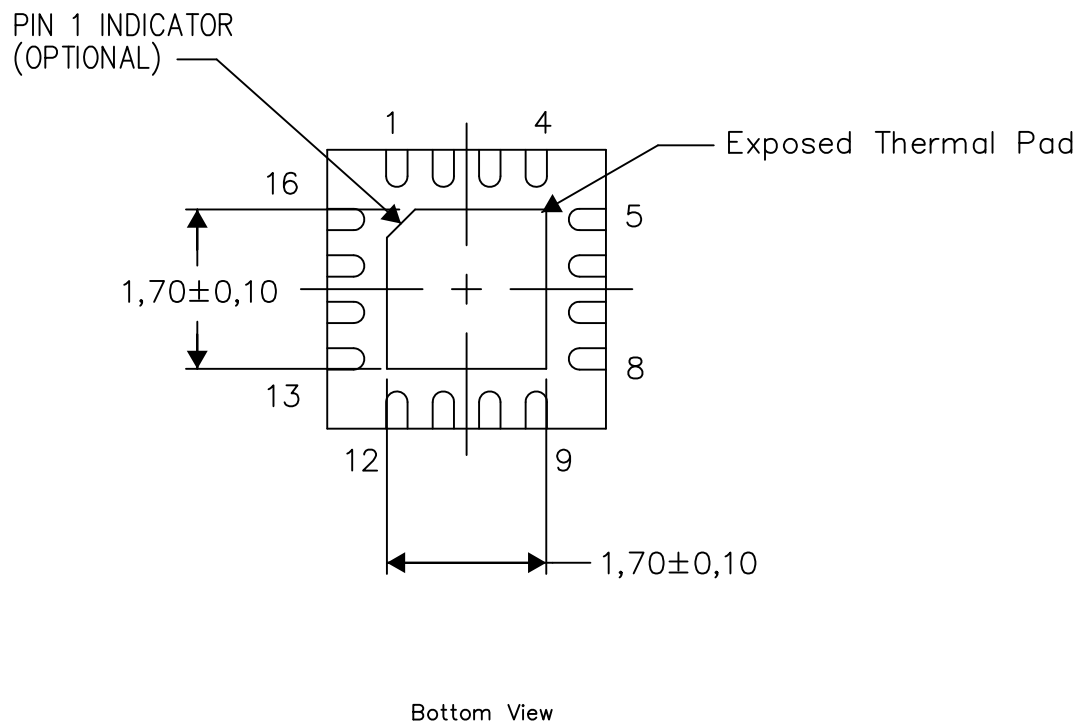
PLASTIC QUAD FLATPACK NO-LEAD

## 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](http://www.ti.com).

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



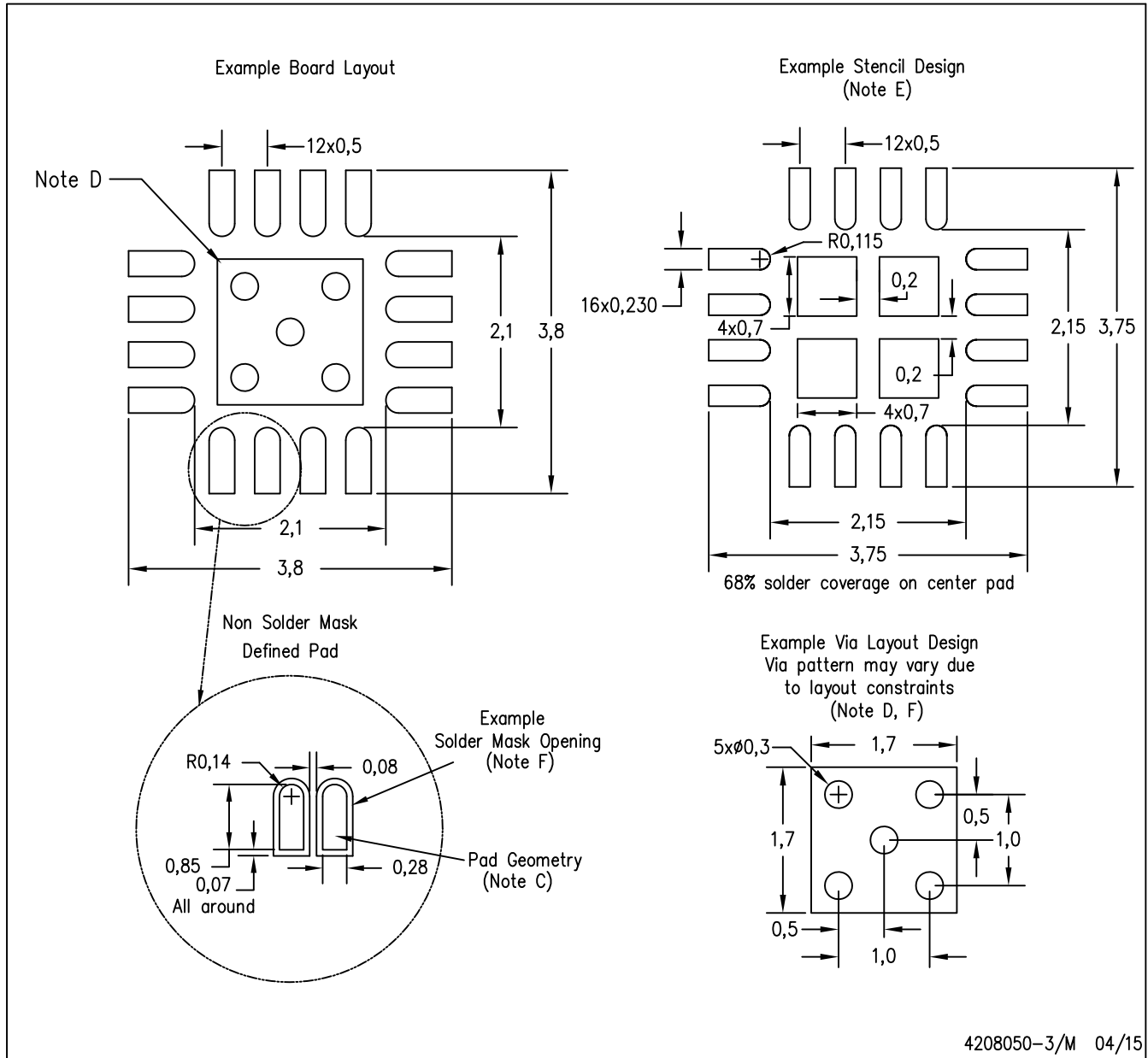
Exposed Thermal Pad Dimensions

4206349-4/Z 08/15

NOTE: All linear dimensions are in millimeters

RGT (S-PVQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



- 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/SON PCB Attachment, 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) <<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 minimum solder mask web tolerances between signal pads.

## 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

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)