

# ***TPA3002D2EVM***

***9-W Stereo Class-D Audio Power Amplifier  
With DC Volume Control***

## *User's Guide*

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## **EVM WARNINGS AND RESTRICTIONS**

It is important to operate this EVM within the supply voltage range specified in this user's guide. The supply voltage range should be 8 V to 14 V, and supply current ( $I_{CC}$ ) should be no greater than 3 A maximum.

Operating outside the specified supply voltage range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the supply voltage and current range, please contact a TI field representative prior to applying power to the device.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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# Read This First

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### *Information About Cautions and Warnings*

This book may contain cautions and warnings.

**This is an example of a caution statement.**

**A caution statement describes a situation that could potentially damage your software or equipment.**

**This is an example of a warning statement.**

**A warning statement describes a situation that could potentially cause harm to you.**

The information in a caution or a warning is provided for your protection. Please read each caution and warning carefully.

### *FCC Warning*

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

## **Electrostatic Sensitive Devices**



**This EVM contains components that can potentially be damaged by electrostatic discharge. Always transport and store the EVM in its supplied ESD bag when not in use. Handle using an antistatic wristband. Operate on an antistatic work surface. For more information on proper handling, refer to SSYA008.**

## **Related Documentation From Texas Instruments**

- TPA3002D2 data sheet (SLOS402)

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# Introduction

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This chapter provides a brief description of the TPA3002D2EVM.

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## 1.1 Description

The TPA3002D2 audio power amplifier evaluation module is a 9-watt per channel class-D stereo audio power amplifier complete with a small number of external components mounted on a circuit board that measures approximately 2-1/4 inches by 1-3/4 inches (Figure 1–1 and Figure 1–2).

The TPA3002D2 can be interfaced with the TPA6110A2 to provide additional headphone drive. The TPA3002D2 has an internal +5 V supply to power the TPA6110A2, and the variable outputs of the TPA3002D2 are used to drive the inputs of the TPA6110A2.

Figure 1–1. The TI TPA3002D2 Audio Power Amplifier EVM (Top View)

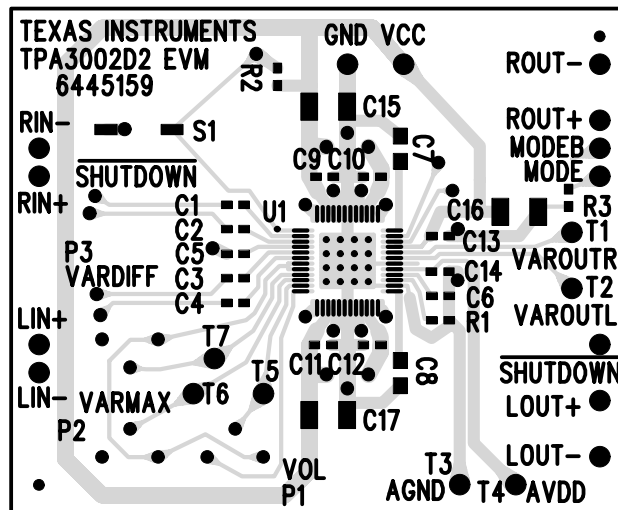
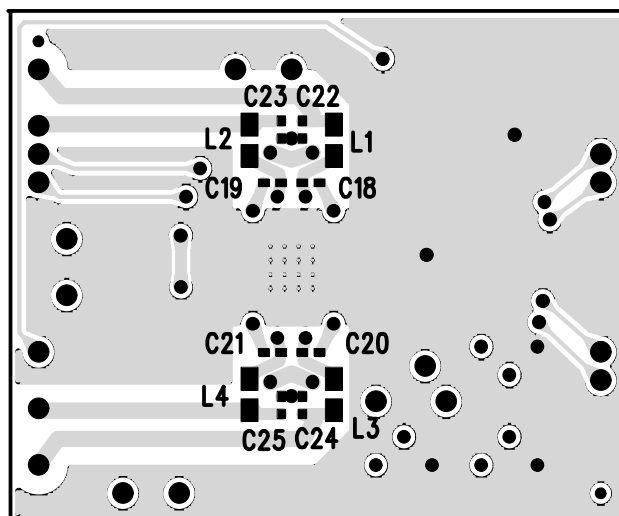


Figure 1–2. The TI TPA3002D2 Audio Power Amplifier EVM (Bottom View)



## 1.2 TPA3002D2EVM Specifications

Supply voltage range, $V_{CC}$ .....	8 V to 14 V
Input voltage range, $V_I$ (MODE, VREF, VARDIFF, VARMAX, VOLUME) .....	0 V to 5.5 V
$V_I$ (SHUTDOWN) .....	0 V to $V_{CC} + 0.3$ V
$V_I$ (RINN, RINP, LINN, LINP) .....	0 V to 7 V
Supply current, $I_{CC}$ .....	3 A Max
Continuous output power per channel, $P_O$ : 8 $\Omega$ , $V_{CC} = 12$ V, THD+N = 10% .....	9 W
Minimum load impedance, $R_L$ .....	8 $\Omega$



# Operation

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This chapter describes how to operate the TPA3002D2EVM.

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## 2.1 Quick Start List for Stand-Alone Operation

Follow these steps to use the TPA3002D2 EVM stand-alone or when connecting it into existing circuits or equipment. Connections to the EVM module header pins can be made via individual sockets, wire-wrapping, or soldering to the pins, either on the top or the bottom of the module circuit board.

### 2.1.1 Power Supply

- 1) Ensure that all external power sources are set to OFF.
- 2) Connect an external regulated power supply, set to 12 V, to the module VCC and GND pins taking care to observe marked polarity.

### 2.1.2 Inputs and Outputs

- 1) Ensure that the audio signal source level adjustments are set to minimum.
- 2) Connect the right and left positive audio source to the module RIN+ and LIN+ pins, respectively. Connect the right and left negative audio source to the module RIN- and LIN- pins, respectively.
- 3) If using single ended inputs, ground the LIN+ and RIN+ pins and connect the signal source to RIN- and LIN-.

### 2.1.3 Evaluation Module Preparations

- 1) Adjust the signal source level as needed.

### 2.1.4 Control Inputs

**Note:**

Refer to the TPA3002D2 data sheet for logic threshold voltage ratings.

- 1) **SHUTDOWN:** This pin is active low. A low on this pin shuts down the amplifier; a high on this pin places the amplifier in the active state. Leaving this pin floating also allows normal amplifier operation. Holding down switch S1 places the amplifier in the shutdown state. Releasing S1 returns the amplifier to the active state. The absolute maximum voltage on this terminal is  $V_{CC} + 0.3$  V.
- 2) **MODE:** This pin controls the stereo class-D outputs of the amplifier (ROUT+, ROUT-, LOUT+, and LOUT-). A low on this pin allows the amplifier to drive stereo speakers in a bridged configuration across OUT+ and OUT-. A HIGH on this pin disables the class-D outputs and the stereo speakers connected across OUT+ and OUT- are muted. The class-AB outputs, VAROUTL and VAROUTR, are active regardless of the voltage on the MODE pin. The absolute maximum voltage on this terminal is 5.5 V.

### 2.1.5 Control Outputs

- 1) **MODEB:** This pin is a TTL-compatible output for controlling the shutdown pin of an external headphone amplifier. The MODEB pin drives low when

the MODE pin is high. When the MODE pin is low, the MODEB pin drives high. If the MODEB pin is connected to the shutdown pin on an external TPA6110A2, the TPA6110A2 mutes when the class-D outputs are active.

## 2.1.6 Power Up

- 1) Verify correct voltage and input polarity and set the external power supply to ON. The EVM should begin operation.
- 2) Adjust the signal source level as needed.

### Adjusting the Speaker Volume

- 3) Adjust the speaker (connected across OUT+ and OUT-) volume as needed by turning the P1 potentiometer in the clockwise direction to increase the volume. Conversely, turn P1 in the counterclockwise direction to decrease the volume. Refer to Table 3-2 in the Reference section for volume control settings.

### Setting Maximum Headphone Volume

- 4) Set the maximum possible VAROUT volume by adjusting P2. Turning P2 in the clockwise direction sets the limit higher. Turning P2 in the counterclockwise direction lowers the VAROUT volume limit. Refer to Table 3-3 in the Reference section for volume control settings.

### Adjusting the Headphone Volume

- 5) Adjust the VAROUTL and VAROUTR (headphone) volume by adjusting potentiometer P3. The headphone volume (VAROUT) is set by the difference between VOLUME speaker voltage and VARDIFF voltage. Turning P3 in the clockwise direction decreases the voltage on the VARDIFF terminal and the VAROUT (headphone) volume increases. Conversely, turning P3 in the counterclockwise direction increases the VARDIFF voltage and decreases the VAROUT volume. Refer to Table 3-3 in the Reference section for volume control settings.

### Test Pins for External HP Driver, Regulated Output, Speaker Volume, and Headphone Volume

- T1 – VAROUTR
- T2 – VAROUTL
- T3 – AGND
- T4 – AVDD – 5 V regulated voltage capable of 120 mA output
- T5 – VOLUME – Speaker volume
- T6 – VARMAX – Max headphone volume
- T7 – VARDIFF – Headphone volume

## 2.1.7 External Headphone Amplifier Special Considerations

- 1) Refer to the TPA3002D2 data sheet or Figure 3-2 for proper pin connections.
- 2) Noise may occur if proper grounding is not applied.
- 3) Additional load may be needed on outputs VAROUTR and VAROUTL to obtain the full range of volume control. Apply a 10-k $\Omega$  load on VAROUTR

and VAROUTL to ground, if required. The 10-k $\Omega$  load resistor reduces feed-through audio when the amplifier is in the shutdown mode.



# Reference

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This chapter provides reference information for the TPA3002D2EVM.

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### 3.1 TPA3002D2EVM Schematic

Figure 3–1. TPA3002D2EVM Schematic

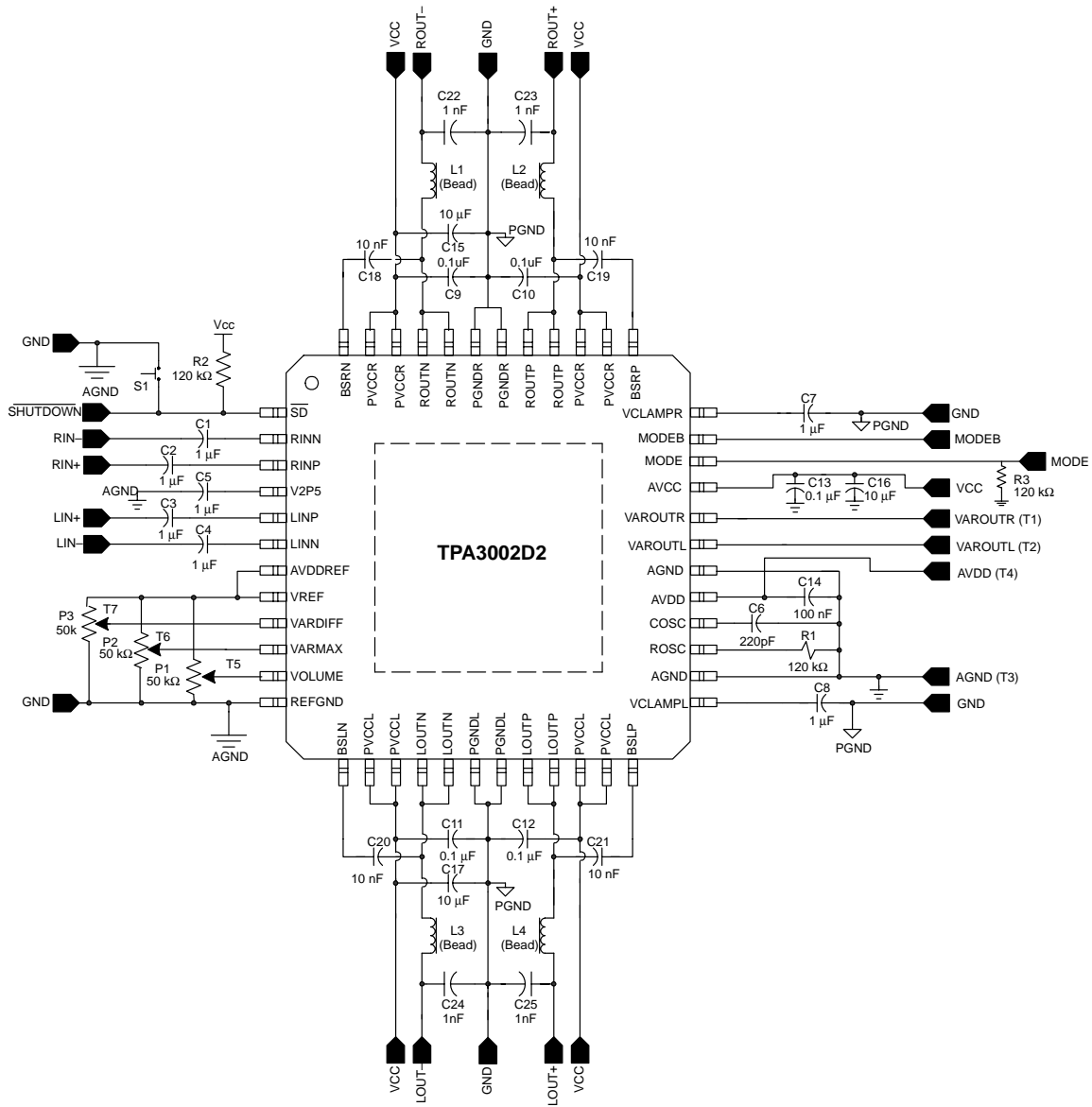
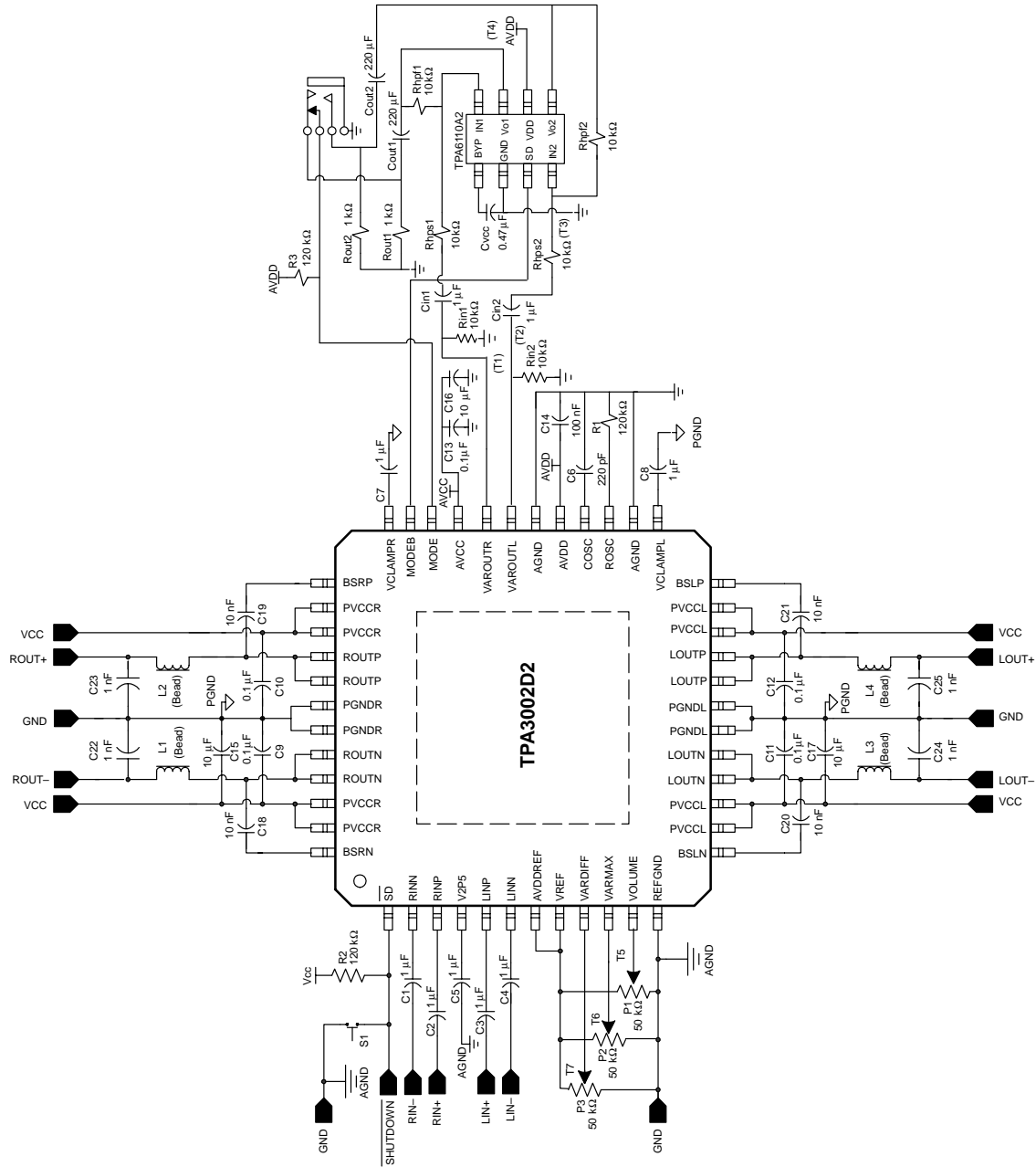


Figure 3–2. TPA3002D2 with External Headphone Amplifier Schematic



### 3.2 EVM PCB Layers

Figure 3–3. TPA3002D2EVM (Top Layer)

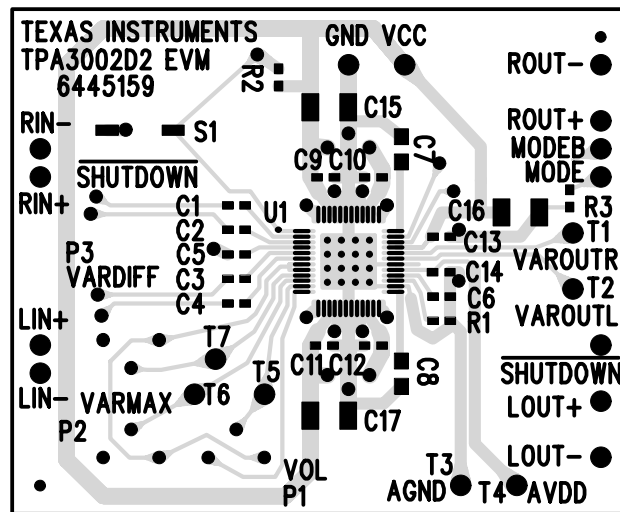
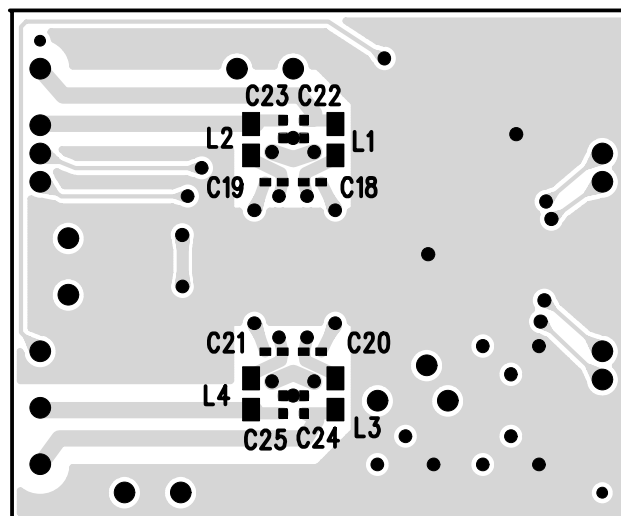


Figure 3–4. TPA3002D2EVM (Bottom Layer)



### 3.3 TPA3002D2EVM Parts List

Table 3–1. TPA3002D2EVM Parts List

Reference	Description	Size	Qty	Mfg.	Part #
C1–C5	Capacitor, ceramic, 1.0 $\mu$ F, +80%/–20%, Y5V, 10 V	0603	4	Panasonic	ECJ–1VF1A105Z
C6	Capacitor, ceramic, 220 pF, $\pm$ 5%, 50 V	0603	2	Panasonic	ECJ–1VC1H221J
C7, C8	Capacitor, ceramic, 1.0 $\mu$ F, +80%/–20%, Y5V, 50 V	0805	2	Tayio Yuden	UMK212F105ZG–T
C9–C14	Capacitor, ceramic, 0.1 $\mu$ F, +80%/–20%, Y5V, 50 V	0603	5	Panasonic	ECJ–1VF1H104Z
C15, C16, C17	Capacitor, ceramic, 10 $\mu$ F, +80%/–20%, Y5V, 25 V	1210	3	Panasonic	ECJ–4YF1E106Z
C18–C21	Capacitor, ceramic, 0.01 $\mu$ F, +80%/–20%, Y5V, 50 V	0603	4	Panasonic	ECJ–1VF1H103Z
C22–C25	Capacitor, ceramic, 1000 pF, $\pm$ 10%, X7R, 50 V	0603	4	Panasonic	ECJ–1VB1H102K
L1–L4	Ferrite bead, 0.05 $\Omega$ DCR, 70 $\Omega$ at 100 MHz, 3A	1206	4	Fair–rite	2512067007Y3
R1–R3	Resistor, chip, 120 k $\Omega$ , 1/16 W, 5%	0603	3	Panasonic	ERJ–3GEYJ124V
P1–P3	Potentiometer, 50 k $\Omega$ , thru hole		3	Bourns	3362P–1–503
S1	Switch, momentary, SMD, low profile		1	Panasonic	EVQ–PPBA25
PnP pins	Headers, 0.1 in centers, 1/2 in long		13	Sullins	PZC36SABN
T1–T7	Test points, 0.040" mounting hole		7	Farnell	240–345
U1	TPA3002D2PHP	48-pin QFP	1	TI	TPA3002D2PHP

### 3.4 DC Volume Control for Class-D Outputs (OUT+ and OUT-)

Table 3–2. DC Volume Control for Class-D Outputs

VOLTAGE ON THE VOLUME PIN AS A PERCENTAGE OF VREF (INCREASING VOLUME OR FIXED GAIN)	VOLTAGE ON THE VOLUME PIN AS A PERCENTAGE OF VREF (DECREASING VOLUME)	GAIN OF CLASS-D AMPLIFIER
%	%	dB
0 – 4.5	0 – 2.9	-75 <sup>†</sup>
4.5 – 6.7	2.9 – 5.1	-40.0
6.7 – 8.91	5.1 – 7.2	-37.5
8.9 – 11.1	7.2 – 9.4	-35.0
11.1 – 13.3	9.4 – 11.6	-32.4
13.3 – 15.5	11.6 – 13.8	-29.9
15.5 – 17.7	13.8 – 16.0	-27.4
17.7 – 19.9	16.0 – 18.2	-24.8
19.9 – 22.1	18.2 – 20.4	-22.3
22.1 – 24.3	20.4 – 22.6	-19.8
24.3 – 26.5	22.6 – 24.8	-17.2
26.5 – 28.7	24.8 – 27.0	-14.7
28.7 – 30.9	27.0 – 29.1	-12.2
30.9 – 33.1	29.1 – 31.3	-9.6
33.1 – 35.3	31.3 – 33.5	-7.1
35.3 – 37.5	33.5 – 35.7	-4.6
37.5 – 39.7	35.7 – 37.9	-2.0
39.7 – 41.9	37.9 – 40.1	0.5 <sup>†</sup>
41.9 – 44.1	40.1 – 42.3	3.1
44.1 – 46.4	42.3 – 44.5	5.6
46.4 – 48.6	44.5 – 46.7	8.1
48.6 – 50.8	46.7 – 48.9	10.7
50.8 – 53.0	48.9 – 51.0	13.2
53.0 – 55.2	51.0 – 53.2	15.7
55.2 – 57.4	53.2 – 55.4	18.3
57.4 – 59.6	55.4 – 57.6	20.8
59.6 – 61.8	57.6 – 59.8	23.3
61.8 – 64.0	59.8 – 62.0	25.9
64.0 – 66.2	62.0 – 64.2	28.4
66.2 – 68.4	64.2 – 66.4	30.9
68.4 – 70.6	66.4 – 68.6	33.5
> 70.6	>68.6	36.0 <sup>†</sup>

<sup>†</sup> Tested in production. Remaining steps are specified by design.

NOTE: For other values of VREF, scale the voltage values in the first two columns by a factor of VREF/5.

### 3.5 DC Volume Control for Class-AB Outputs (VAROUTL and VAROUTR)

Table 3–3. DC Volume Control for Class-AB Outputs

VAROUT_VOLUME (V) AS A PERCENTAGE OF VREF (INCREASING VOLUME OR FIXED GAIN)	VAROUT_VOLUME (V) AS A PERCENTAGE OF VREF (DECREASING VOLUME)	GAIN OF VAROUT AMPLIFIER
%	%	dB
0 – 4.5	0 – 2.9	–66†
4.5 – 6.7	2.9 – 5.1	–56.0
6.7 – 8.91	5.1 – 7.2	–53.5
8.9 – 11.1	7.2 – 9.4	–50.9
11.1 – 13.3	9.4 – 11.6	–48.4
13.3 – 15.5	11.6 – 13.8	–45.9
15.5 – 17.7	13.8 – 16.0	–43.3
17.7 – 19.9	16.0 – 18.2	–40.8
19.9 – 22.1	18.2 – 20.4	–38.3
22.1 – 24.3	20.4 – 22.6	–35.7
24.3 – 26.5	22.6 – 24.8	–33.2
26.5 – 28.7	24.8 – 27.0	–30.7
28.7 – 30.9	27.0 – 29.1	–28.1
30.9 – 33.1	29.1 – 31.3	–25.6
33.1 – 35.3	31.3 – 33.5	–23.1
35.3 – 37.5	33.5 – 35.7	–20.5
37.5 – 39.7	35.7 – 37.9	–18.0
39.7 – 41.9	37.9 – 40.1	–15.5
41.9 – 44.1	40.1 – 42.3	–13.0†
44.1 – 46.4	42.3 – 44.5	–10.4
46.4 – 48.6	44.5 – 46.7	–7.9
48.6 – 50.8	46.7 – 48.9	–5.3
50.8 – 53.0	48.9 – 51.0	–2.8
53.0 – 55.2	51.0 – 53.2	–0.3
55.2 – 57.4	53.2 – 55.4	2.3
57.4 – 59.6	55.4 – 57.6	4.8
59.6 – 61.8	57.6 – 59.8	7.3
61.8 – 64.0	59.8 – 62.0	9.9
64.0 – 66.2	62.0 – 64.2	12.4
66.2 – 68.4	64.2 – 66.4	14.9
68.4 – 70.6	66.4 – 68.6	17.5
> 70.6	>68.6	20.0†

† Tested in production. Remaining steps are specified by design.  
 NOTE: For other values of VREF, scale the voltage values in the first two columns by a factor of VREF/5.

