

TPA3004D2EVM

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

User's Guide

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

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

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI 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 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. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

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

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265

EVM IMPORTANT NOTICE

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation kit being sold by TI is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not considered by TI to be fit for commercial use. As such, the goods being provided may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety measures typically found in the end product incorporating the goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may not meet the technical requirements of the directive.

Should this evaluation kit not meet the specifications indicated in the EVM User's Guide, the kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Please be aware that the products received may not be regulatory compliant or agency certified (FCC, UL, CE, etc.). Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive**.

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein**.

Please read the EVM User's Guide and, specifically, the EVM Warnings and Restrictions notice in the EVM User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact the TI application engineer.

Persons handling the product must have electronics training and observe good laboratory practice standards.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265

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 8.5 V to 18 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.

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265

Read This First

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

- TPA3004D2 data sheet (SLOS407)

Contents

1	Introduction	1-1
1.1	Description	1-2
1.2	TPA3004D2EVM Specifications	1-3
2	Operation	2-1
2.1	Quick Start List for Stand-Alone Operation	2-2
3	Reference	3-1
3.1	TPA3004D2 Schematic	3-2
3.2	EVM PCB Layers	3-4
3.3	TPA3004D2 Parts List	3-5
3.4	DC Volume Control for Class-D Outputs (OUT+ and OUT-)	3-6
3.5	DC Volume Control for Class-AB Outputs (VAROUTL and VAROUTR)	3-7

Figures

1-1	The TI TPA3004D2 Audio Power Amplifier EVM (Top View)	1-2
1-2	The TI TPA3004D2 Audio Power Amplifier EVM (Bottom View)	1-2
3-1	TPA3004D2EVM Schematic	3-2
3-2	TPA3004D2EVM With External Headphone Amplifier Schematic	3-3
3-3	TPA3004D2EVM (Top View)	3-4
3-4	TPA3004D2EVM (Bottom View)	3-4

Tables

3-1	TPA3004EVM Parts List	3-5
3-2	DC Volume Control for Class-D Outputs	3-6
3-3	DC Volume Control for Class-AB Outputs	3-7



Introduction

This chapter provides a brief description of the TPA3004D2EVM.

Topic	Page
1.1 Description	1-2
1.2 TPA3004D2EVM Specifications	1-3

1.1 Description

The TPA3004D2 audio power amplifier evaluation module is a 12-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 TPA3004D2 can be interfaced with the TPA6110A2 to provide additional headphone drive. The TPA3004D2 has an internal 5-V supply to power the TPA6110A2, and the variable outputs of the TPA3004D2 are used to drive the inputs of the TPA6110A2.

Figure 1–1. The TI TPA3004D2 Audio Power Amplifier EVM (Top View)

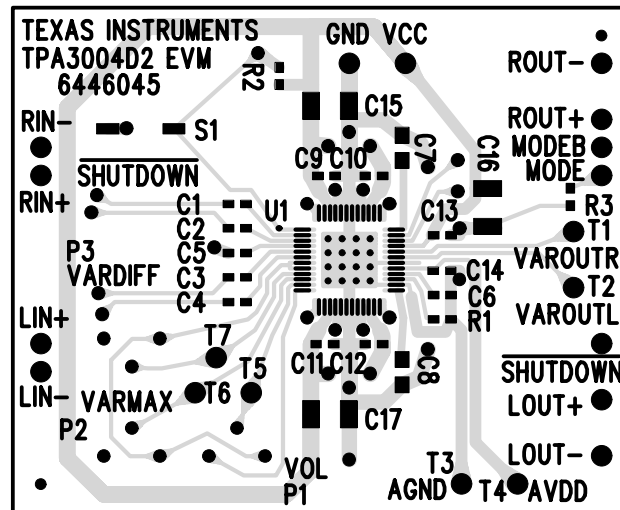
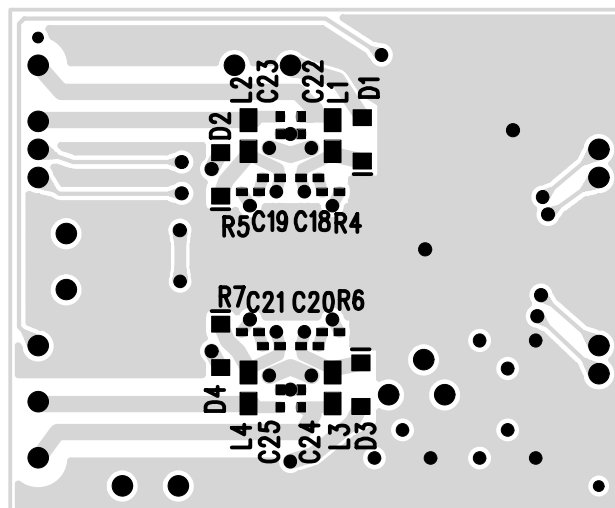


Figure 1–2. The TI TPA3004D2 Audio Power Amplifier EVM (Bottom View)



1.2 TPA3004D2EVM Specifications

Supply voltage range, V_{CC}	8.5 V to 18 V
Input voltage range, V_I (MODE, VREF, VARDIFF, VARMAX, VOLUME, \overline{FADE})	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 Ω , $V_{CC} = 14$ V, THD+N = 10%	12 W
Minimum load impedance, R_L	4 Ω



Operation

This chapter describes how to operate the TPA3004D2EVM.

Topic	Page
2.1 Quick Start List for Stand-Alone Operation	2-2

2.1 Quick Start List for Stand-Alone Operation

Follow these steps to use the TPA3004D2EVM 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, between 8.5 V and 18 V, to the module VCC and GND pins taking care to observe marked polarity.

Test points T3 (AGND) and T4 (AV_{DD}) are outputs of the TPA3004D2. Do not connect an external power supply to these test points.

WARNING

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-.

Note:

If RIN+ and LIN+ on the EVM are connected to ground, the RINP and LINP pins on the TPA3004D2 IC are ac-grounded through C2 and C3.

2.1.3 Evaluation Module Preparations

- 1) Adjust the signal source level as needed.

2.1.4 Control Inputs

Note:

Refer to the TPA3004D2 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.
- 3) **FADE:** This pin controls the stereo class-D and class-AB outputs of the amplifier (ROUT+, ROUT–, LOUT+, LOUT–, VAROUTL, and VAROUTR) during the four states of the device (power on, power off, coming out of shutdown, and going into shutdown). This pin is active low. A low on this pin causes the outputs (OUT+, OUT–, VAROUTL, and VAROUTR) to slowly ramp up to volume, when the device is powered on or when the device comes out of the shutdown state. A low also causes the outputs to slowly ramp down in volume when the device goes into shutdown. A high on this pin causes the outputs (OUT+, OUT–, VAROUTL, and VAROUTR) to instantaneously ramp up to volume when the device is powered on or when the device comes out of the shutdown state. A high also causes the outputs to instantaneously ramp down in volume when the device goes into shutdown. The absolute maximum voltage on this terminal is 5.5 V.

Note:

Do not leave the $\overline{\text{FADE}}$ pin floating. The TPA3004D2EVM connects the $\overline{\text{FADE}}$ pin to ground. If the fade function is to be disabled, unsolder the pin and lift it off the module circuit board. Solder a wire to the pin and apply the necessary voltage for the desired function.

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 to a higher volume. 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 TPA3004D2 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 Ω load on VAROUTR and VAROUTL to ground, if required. The 10-k Ω load resistor reduces feed-through audio when the amplifier is in the shutdown mode.

Reference

This chapter provides reference information for the TPA3004D2EVM.

Topic	Page
3.1 TPA3004D2EVM Schematic	3-2
3.2 EVM PCB Layers	3-4
3.3 TPA3004D2EVM Parts List	3-5
3.4 DC Volume Control for Class-D Outputs (OUT+ and OUT-)	3-6
3.5 DC Volume Control for Class-AB Outputs (VAROUTL and VAROUTR)	3-7

3.1 TPA3004D2EVM Schematic

Figure 3–1. TPA3004D2EVM Schematic

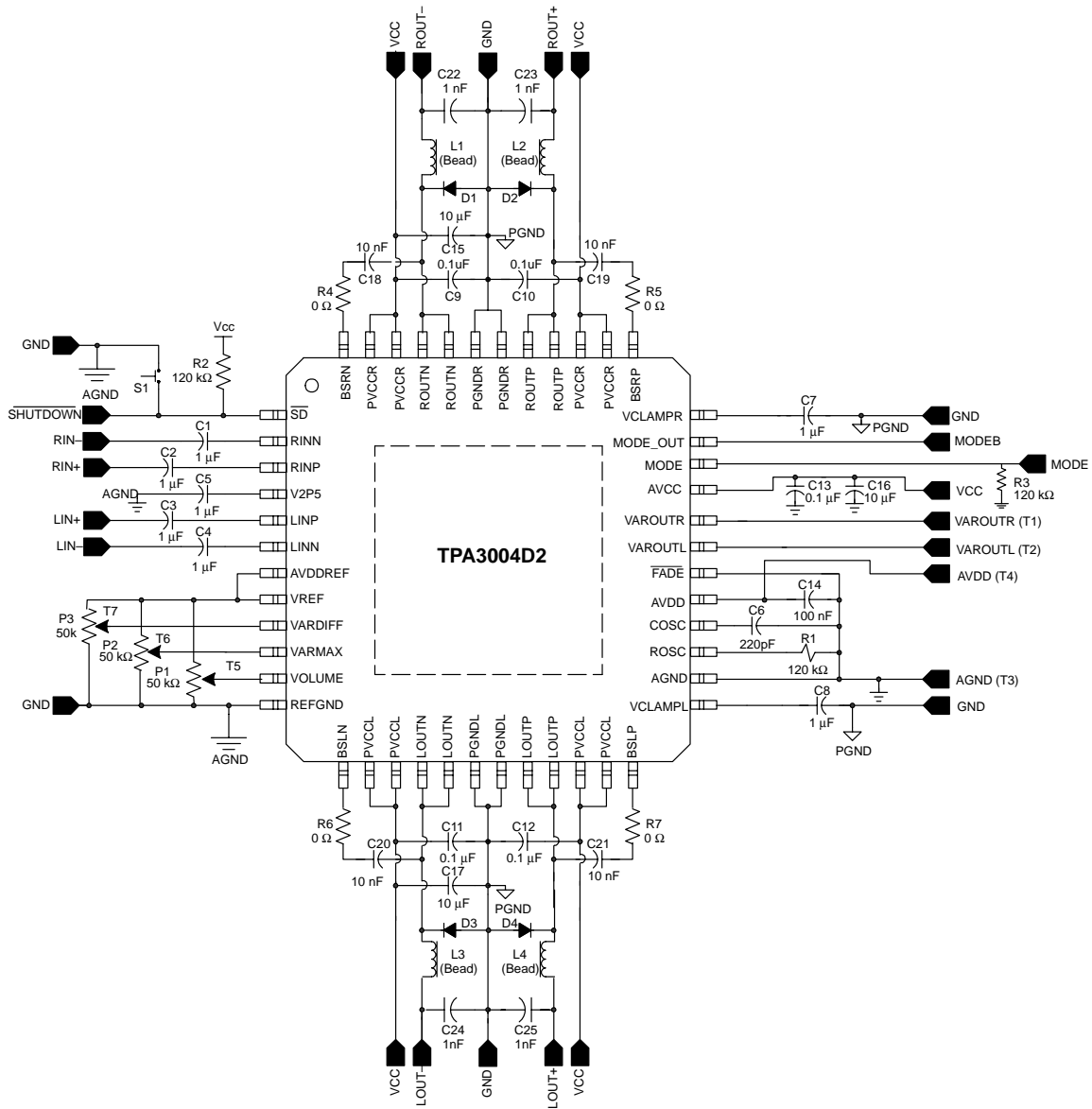
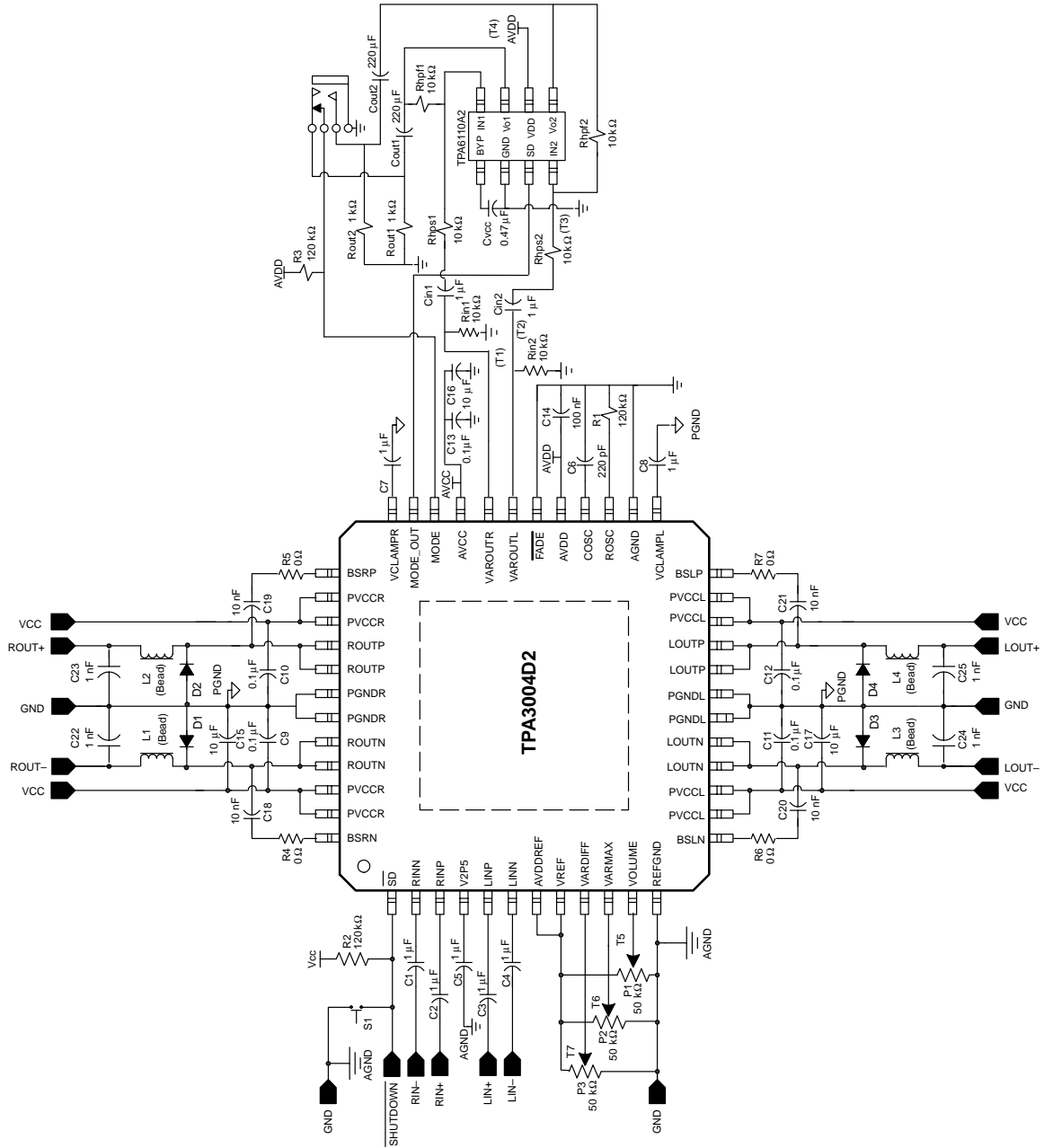


Figure 3–2. TPA3004D2 With External Headphone Amplifier Schematic



3.2 EVM PCB Layers

Figure 3–3. TPA3004D2EVM (Top Layer)

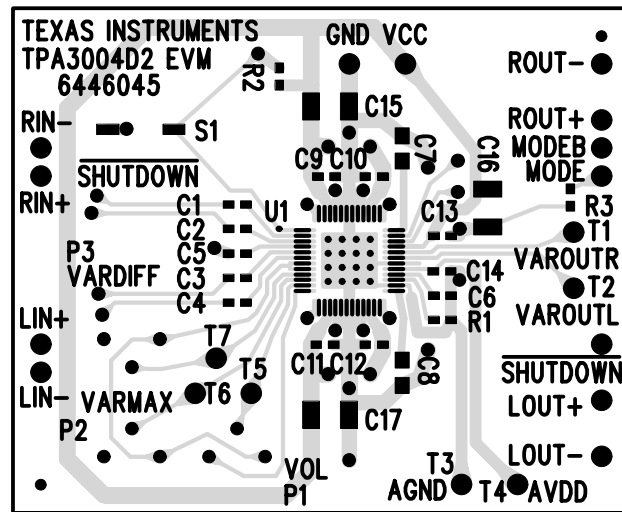
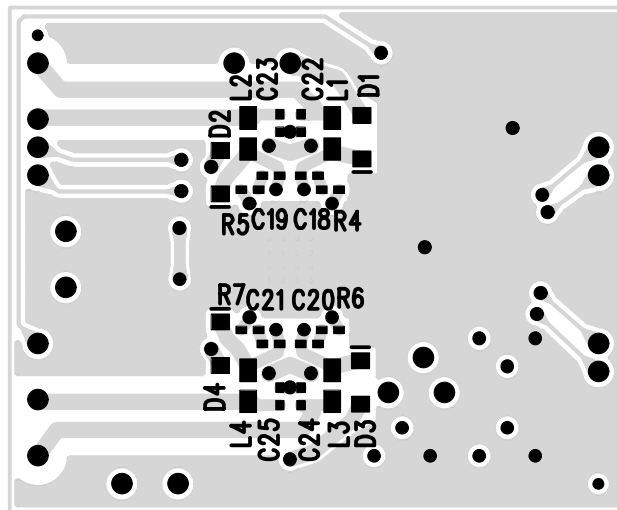


Figure 3–4. TPA3004D2EVM (Bottom Layer)



3.3 TPA3004D2EVM Parts List

Table 3–1. TPA3004D2EVM Parts List

Reference	Description	Size	Qty	Mfg.	Part #	Vendor Part #
C1–C5	Capacitor, ceramic, 1.0 μ F, +80%/–20%, Y5V, 10 V	0603	5	Panasonic	ECJ–1VF1A105Z	Digi-Key/PCC1787CT–ND
C6	Capacitor, ceramic, 220 pF, \pm 5%, 50 V	0603	1	Panasonic	ECJ–1VC1H221J	Digi-Key/PCC221ACVCT–ND
C7, C8	Capacitor, ceramic, 1.0 μ F, +80%/–20%, Y5V, 50 V	0805	2	Taiyo Yuden	UMK212F105ZG–T	TeCal/UMK212F105ZG–T
C9–C14	Capacitor, ceramic, 0.1 μ F, +80%/–20%, Y5V, 50 V	0603	5	Panasonic	ECJ–1VF1H104Z	Digi-Key/PCC2153CT–ND
C15–C17	Capacitor, ceramic, 10 μ F, +80%/–20%, Y5V, 25 V	1210	3	Panasonic	ECJ–4YF1E106Z	Digi-Key/PCC2171CT–ND
C18–C21	Capacitor, ceramic, 0.01 μ F, +80%/–20%, Y5V, 50 V	0603	4	Panasonic	ECJ–1VF1H103Z	Digi-Key/PCC1801CT–ND
C22–C25	Capacitor, ceramic, 1000 pF, \pm 10%, X7R, 50 V	0603	4	Panasonic	ECJ–1VB1H102K	Digi-Key/PCC1772TR–ND
D1–D4	Schottky diode, $V_{fm} = 0.5$ V at 1 A, $V_I = 30$ V	SMA	4	Diodes, Inc.	B130–13	Digi-Key/B130DITR–ND
L1–L4	Ferrite bead, 0.05 Ω DCR, 70 Ω at 100 MHz, 3A	1206	4	Fair–rite	2512067007Y3	
R1–R3	Resistor, chip, 120 k Ω , 1/16 W, 5%	0603	3	Panasonic	ERJ–3GEYJ124V	Digi-Key/P120KGTR–ND
R4–R7	Resistor, chip, 0 Ω , 1/16 W, 5%	0603	4	Panasonic	ERJ–3GEY0R00V	Digi-Key/P0.0GCT–ND
P1–P3	Potentiometer, 50 k Ω , thru hole		3	Bourns	3362P–1–503	Digi-Key/3362P–503–ND
S1	Switch, momentary, SMD, low profile		1	Panasonic	EVQ–PPBA25	Digi-Key/P8086SCT–ND
PnP pins	Headers, 0.1 in centers, 1/2 in long		13	Samtec	SW–19–8–G–S	
T1–T7	Test points, 0.040" mounting hole		7	Farnell	240–345	
U1	TPA3004D2PHP	48-pin QFP	1	TI	TPA3004D2PHP	

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
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
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

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

Note:

$$\text{VAROUT_VOLUME (V)} = \text{VOLUME (V)} - \text{VARDIFF (V)}$$

Please see the TPA3004D2 data sheet for more information.

