TEXAS INSTRUMENTS

TPA2008D2 Stereo Filter-Free Class-D Audio Power Amplifier Evaluation Module

User's Guide

May 2004

Mixed-Signal Products

SLOU116A

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the supply voltage range specified in the user's guide. The supply voltage range should be 4.5 V to 5.5 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

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 85°C. The EVM is designed to operate properly with certain components above 85°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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Preface

How to Use This Manual

This document contains the following chapters:

- ❏ Chapter 1—Introduction
- ❏ Chapter 2—Operation
- ❏ Chapter 3—Reference

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.

Related Documentation From Texas Instruments

- ***TI Plug-N-Play Audio Amplifier Evaluation Platform*** (literature number SLOU011) provides detailed information on the evaluation platform and its use with TI audio evaluation modules.

- ***TPA2008D2 3-W STEREO CLASS-D AUDIO POWER AMPLIFIER*** (literature number SLOS413) This is the data sheet for the TPA2008D2 audio amplifier integrated circuit.

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.

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Chapter 1

Introduction

This chapter provides an overview of the Texas Instruments (TI) TPA2008D2 stereo filter-free class-D audio amplifier evaluation module (SLOP392). It includes a list of EVM features, a brief illustrated description of the module, and a list of EVM specifications.

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1.1 Feature Highlights

The TI TPA2008D2 audio amplifier evaluation module and the TI plug-n-play audio amplifier evaluation platform include the following features:

- TPA2008D2 Stereo 3-W Filter-Free Class-D Audio Power Amplifier Evaluation Module
  - Class-D without output filter
  - Internal depop circuitry to minimize transients in outputs
  - High efficiency
  - Low distortion
  - Low supply current (7 mA)
  - 3 W per channel output power into 3 Ω at 5 V
  - Low current consumption in shutdown mode
  - DC volume control from −38 dB to 20 dB
  - Differential stereo inputs
  - 24-pin TSSOP PWP package
- Quick and Easy Configuration With the TI Plug-N-Play Audio Amplifier Evaluation Platform
  - Evaluation module is designed to simply plug into the platform, automatically making all signal, control, and power connections
  - Platform provides flexible power options
  - Jumpers on the platform select power and module control options
  - Switches on the platform route signals
  - Platform provides quick and easy audio input and output connections
- Platform Power Options
  - External 5-V − 15-V dc V_{CC} supply inputs
  - External regulated V_{DD} supply input
  - Socket for onboard 5 V/3.3 V V_{DD} voltage regulator EVM
  - Onboard overvoltage and reverse polarity power protection
- Platform Audio Input and Output Connections
  - Left and right RCA phono jack inputs
  - Miniature stereo phone jack input
  - Left and right RCA phono jack outputs
  - Left and right compression speaker terminal outputs
  - Miniature stereo headphone jack output

1.2 Description

The TPA2008D2 filter-free class-D stereo audio power amplifier evaluation module is a complete, 3-W per channel class-D stereo audio power amplifier that can operate without an output filter. It consists of the TI TPA2008D2 class-D stereo 3-W audio power amplifier IC along with a small number of other parts mounted on a circuit board that measures approximately 2-1/4 inches by 1-1/2 inches.

Figure 1−1. TPA2008D2 Audio Power Amplifier EVM Without Output Filter—Top View

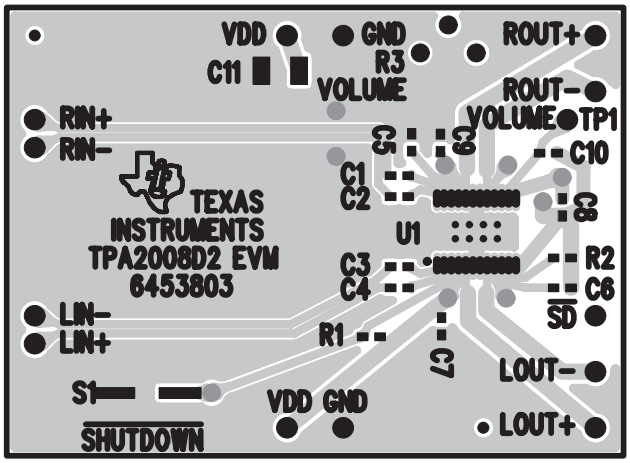
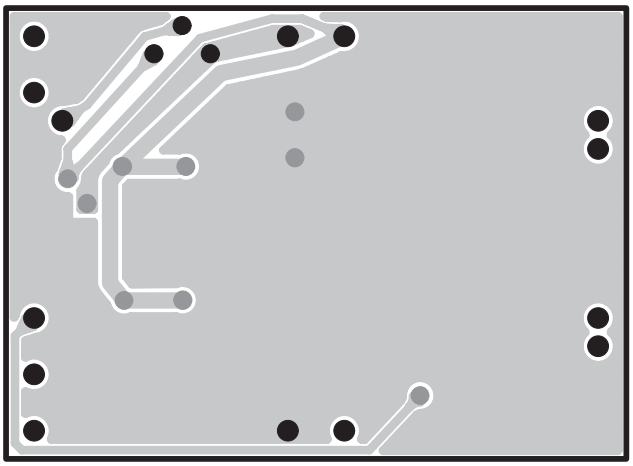


Figure 1−2. TPA2008D2 Audio Power Amplifier EVM Without Output Filter—Bottom View



Single in-line header pins extend from the underside of the module circuit board to allow the EVM to be plugged into the TI plug-n-play audio amplifier evaluation platform, or to be wired directly into existing circuits and equipment when used stand-alone.

The platform has room for a single TPA2008D2 evaluation module and is a convenient vehicle for demonstrating TI's audio power amplifier and related evaluation modules. The EVMs simply plug into the platform, which automatically provides power to the modules, interconnects them correctly, and connects them to a versatile array of standard audio input and output jacks and connectors. Easy-to-use configuration controls allow the platform and EVMs to quickly model many possible end-equipment configurations.

There is nothing to build, nothing to solder, and nothing but the speakers included with the platform to *hook up*.

1.3 TPA2008D2 EVM Specifications

Supply voltage range, V_{DD} . . . . . 4.5 V to 5.5 V
Supply current, I_{DD} . . . . . 2 A max
Continuous output power per channel, P_O: 3 Ω, V_{DD} = 5 V . . . . . 3 W
Minimum load impedance, R_L . . . . . 3 Ω

Chapter 2

Operation

The steps in this chapter can be followed to quickly prepare the TPA2008D2 stereo filter-free class-D audio amplifier EVM for use. Using the TPA2008D2 with the TI plug-n-play audio amplifier evaluation platform is a quick and easy way to connect power, signal and control inputs, and signal outputs to the EVM using standard connectors. However, the audio amplifier evaluation module can be used stand-alone by making connections directly to the module pins, and can be wired directly into existing circuits or equipment.

The platform switch and jumper settings shown in Table 2−1 are typical for the TPA2008D2 EVM and causes the TPA2008D2 to shut down when a plug is inserted into platform headphone jack J10.

Table 2−1. Typical TI Plug-N-Play Platform Jumper and Switch Settings for the TPA2008D2

EVM	JP4	JP5	JP6	JP7	JP8	S2	S3
P-N-P Platform	X	ON	Mute	X	Lo	Note 2	U5

Notes: 1) ON = Jumper installed, OFF = Jumper ***NOT*** Installed, X = Don't care

2) Set S2 to ON when signal conditioning board is installed in U1; set S2 to OFF when no signal conditioning board is installed.

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2.3 Quick Start List for Stand-Alone . . . . . 2−4

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2.1 Precautions

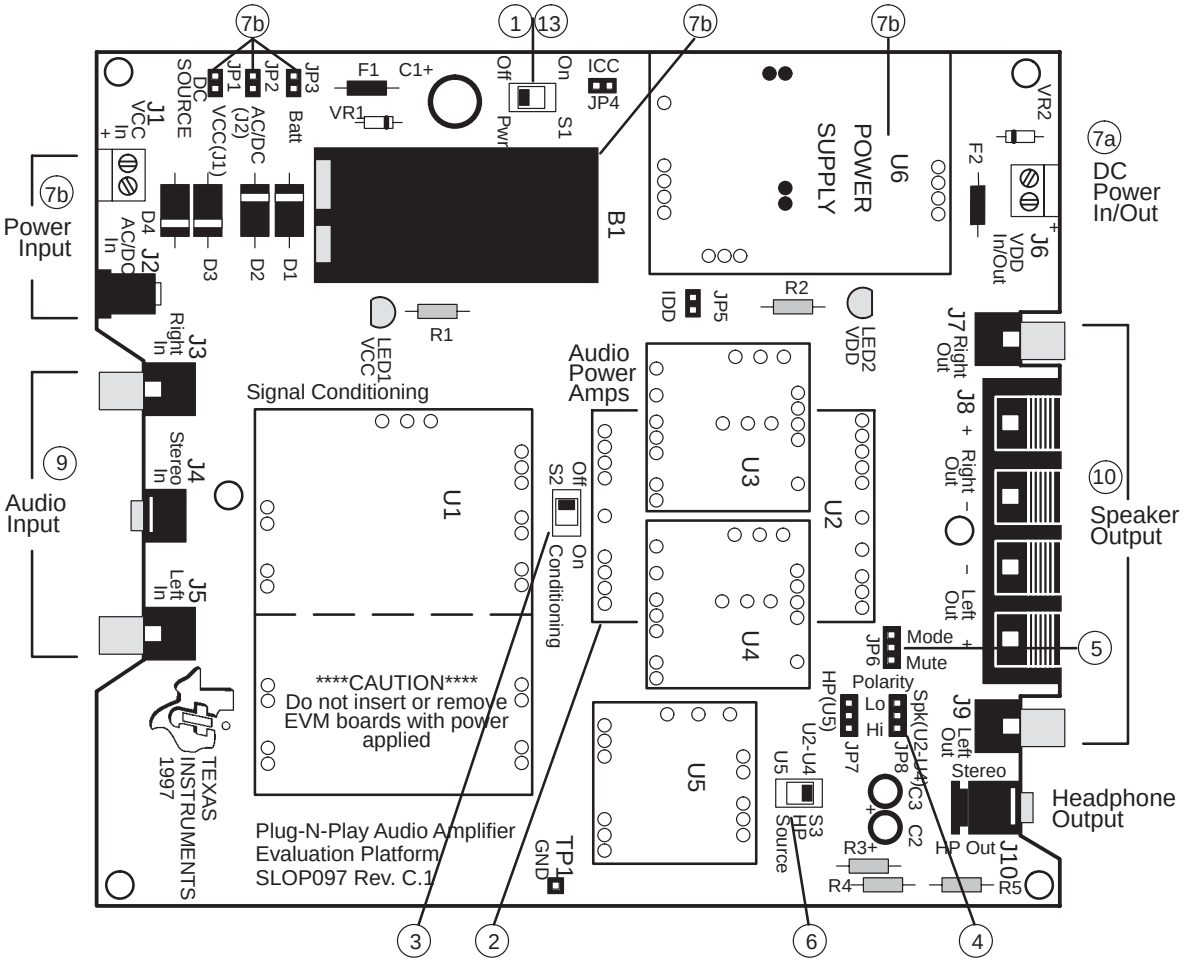
Power Supply Input Polarity and Maximum Voltage

Always ensure that the polarity and voltage of the external power connected to V_{CC} power input connector J1, J2, and/or V_{DD} power input connector J6 are correct. Overvoltage or reverse-polarity power applied to these terminals can open onboard soldered-in fuses and cause other damage to the platform, installed evaluation modules, and/or the power source.

Inserting or Removing EVM Boards

Do not insert or remove EVM boards with power applied—damage to the EVM board, the platform, or both may result.

Figure 2−1. Quick Start Platform Map



2.2 Quick Start List for Platform

Follow these steps when using the TPA2008D2 EVM with the TI plug-n-play audio amplifier evaluation platform (see the platform user's guide, literature number SLOU011, for additional details). Numbered callouts for selected steps are shown in Figure 2−2, and details appear in Chapter 3.

❑ **Platform preparations**

1) Ensure that all external power sources are set to OFF and that the platform power switch S1 is set to OFF.

2) Install a TPA2008D2 module in platform socket U2, taking care to align the module pins correctly.

3) Use switch S2 to select or bypass the signal conditioning EVM (U1).

4) Set control signal Polarity jumper JP8 to Lo.

5) Set jumper JP6 to select the Mute control input (causes the TPA2008D2 to shut down if a plug is inserted into platform headphone jack J10).

6) If a headphone amplifier will be installed in U5, set the headphone source switch S3 to U5.

Table 2−2. Platform Jumper and Switch Settings for the TPA2008D2

EVM	JP4	JP5	JP6	JP7	JP8	S2	S3
P-N-P Platform	X	ON	Mute	X	Lo	Note 2	U5

Notes: 1) ON = Jumper installed, OFF = Jumper NOT Installed, X = Don't care

2) Set S2 to ON when signal conditioning board is installed in U1; set S2 to OFF when no signal conditioning board is installed.

❑ **Power supply**

7) Select and connect the power supply (ensure power supply is set to OFF):

   a) Connect an external regulated power supply set to 5 V to platform V_{DD} power input connector J6 taking care to observe marked polarity, or

   b) Install a voltage regulator EVM (SLVP097 or equiv.) in platform socket U6. Connect a 7-V − 12-V power source to a platform V_{CC} power input J1 or J2 and jumper the appropriate power input (see platform user's guide). If using J1, J2, or B1, set S1 to ON to supply power to the EVM.

❑ **Inputs and outputs**

8) Ensure that the audio signal source level is set to minimum.

9) Connect the audio source to left and right RCA phono jacks J3 and J5 or stereo miniature phone jack J4.

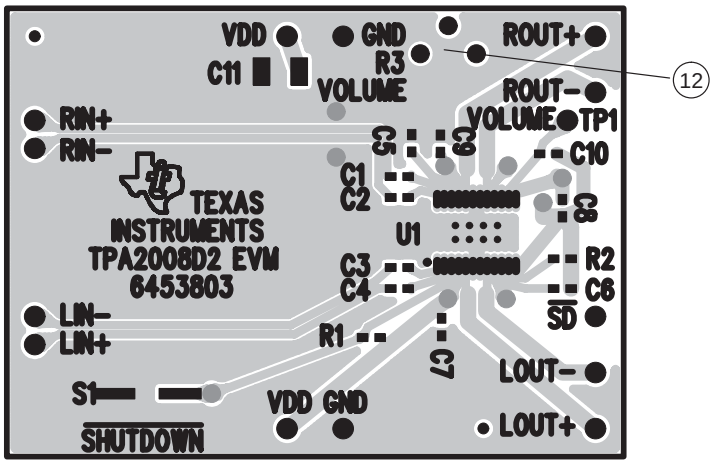
10) Connect speakers to left and right RCA jacks J7 and J9 or to stripped wire speaker connectors J8.

❑ **Evaluation Module Preparations**

11) Use potentiometer R3 to set the volume. Turning R3 in the clockwise direction will increase the volume. See Table 3−1 for voltage levels on the VOLUME pin and corresponding gain settings.

12) If using an external DAC, adjust R3 to the center position by placing a DMM across the VOLUME pin and ground and adjusting the potentiometer until 25 kΩ is measured across the leads. Apply the external source to the VOLUME pin. Be sure to use the board VDD as a reference for the DAC. Also connect the reference GND of the DAC to the GND terminal of the EVM.

Figure 2−2. Module Preparation



❑ **Power Up**

13) Verify correct voltage and input polarity and set the external power supply to ON. If V_{CC} and an on-board regulator EVM are used to provide V_{DD}, set platform power switch S1 to ON.

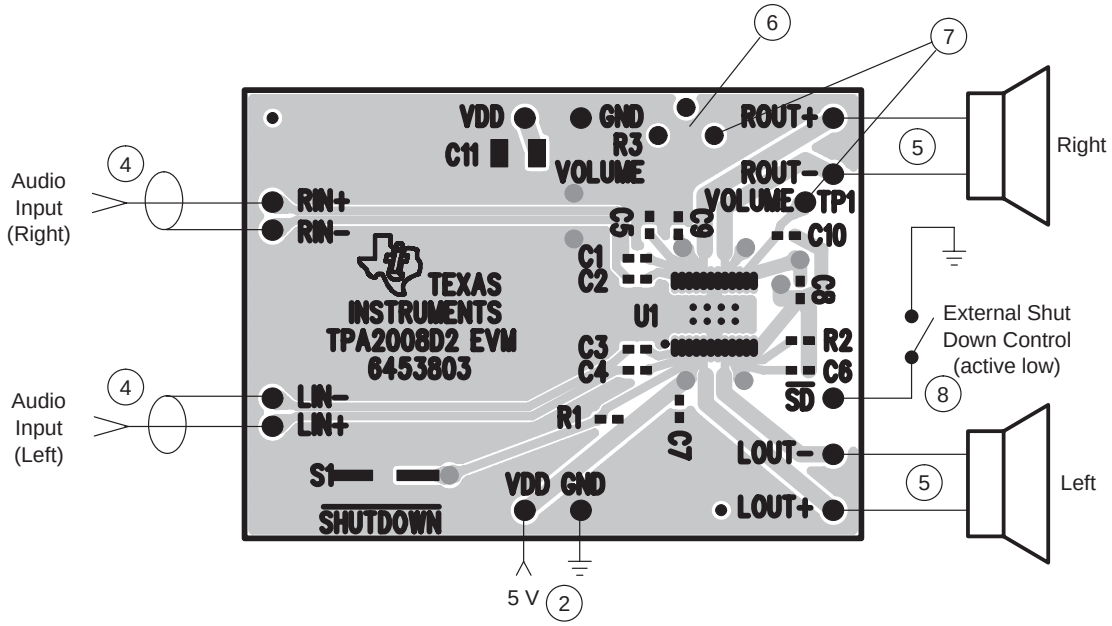
Platform LED2 should light indicating the presence of V_{DD}, and the evaluation modules installed on the platform should begin operation.

14) Adjust the signal source level and potentiometer R3 as needed.

2.3 Quick Start List for Stand-Alone

Follow these steps to use the TPA2008D2 EVM stand-alone or when connecting it into existing circuits or equipment. Connections to the TPA2008D2 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. Numbered callouts for selected steps are shown in Figure 2−3.

Figure 2−3. Quick Start for Stand-Alone



❑ **Power supply**

1) Ensure that all external power sources are set to OFF.

2) Connect an external regulated power supply set to 5 V to the module VDD and GND pins taking care to observe marked polarity.

❑ **Inputs and outputs**

3) Ensure that audio signal source level adjustments are set to minimum.

4) Connect the right (left) positive lead of the audio source to the module RIN+ (LIN+) pins and the negative lead to the RIN− (LIN−) pins.

5) Connect speakers to the left and right outputs.

❑ **Evaluation module preparations**

6) Use potentiometer R3 to set the volume. Turning R3 in the clockwise direction will increase the volume. See Table 3−1 for voltage levels on the VOLUME pin and corresponding gain settings.

7) If using an external DAC, adjust R3 to the center position by placing a DMM across the VOLUME pin and ground and adjusting the potentiometer until 25 kΩ is measured across the leads. Apply the external source to the VOLUME pin. Be sure to use the board VDD as a reference for the DAC. Also connect the reference GND of the DAC to the GND terminal of the EVM.

❑ **Control inputs**

8) **$\overline{\text{SHUTDOWN}}$**: A low shuts down the amplifier IC on the module; a high or float allows normal operation.

❑ **Power up**

9) Verify correct voltage and input polarity and set the external power supply to ON.

The EVM should begin operation.

10) Adjust the signal source level and potentiometer R3 as needed.

2.4 Power Requirements

The TPA2008D2 audio power amplifier evaluation module can operate from any voltage between approximately 4.5 V and 5.5 V; however, the TPA2008D2 amplifier IC on the module is characterized for operation at 5 V. For best performance (highest output power with lowest distortion), the module should be operated at 5 V.

The TI plug-n-play audio amplifier evaluation platform with a voltage regulator EVM installed on it can provide a regulated V_{DD} supply from a wide variety of unregulated V_{CC} voltage inputs between 5.5 V and 12 V, including an onboard 9-V battery. Alternatively, an external regulated power source can be used to supply V_{DD} voltage to the platform and the TPA2008D2 evaluation module installed on it.

Although the TPA2008D2 amplifier IC draws approximately 1 A from the power supply during continuous full power output, peak current draw can be as high as 2 A. Any power supply connected to the platform should be capable of providing 2 A of current to avoid clipping of the output signal during peaks. Current consumption driving speakers at normal listening levels is typically 0.1 A or less.

The platform is equipped with overvoltage and reverse-polarity supply voltage input protection in the form of fused crowbar circuits.

- V_{DD} voltage applied to platform screw terminals J6 *MUST NOT* exceed the absolute maximum rating for the TPA2008D2 amplifier IC installed on the evaluation module (6 V) or damage to the IC may result. In no case should V_{DD} voltage of the incorrect polarity or in excess of 6.1 V be applied to screw terminals J6 of the platform, or the power protection circuit on the V_{DD} line will trip.
- V_{CC} voltage applied to the platform *MUST NOT* exceed the maximum voltage input specified for the voltage regulator module installed in socket U6 (12 V for the SLVP097), or damage to the voltage regulator module may result. In no case should V_{CC} voltage applied to the platform exceed 15 V, or the overvoltage protection circuit on the V_{CC} bus will trip.

Chapter 3

Reference

This chapter contains the EVM schematic, PCB layers, parts list, and dc volume control table.

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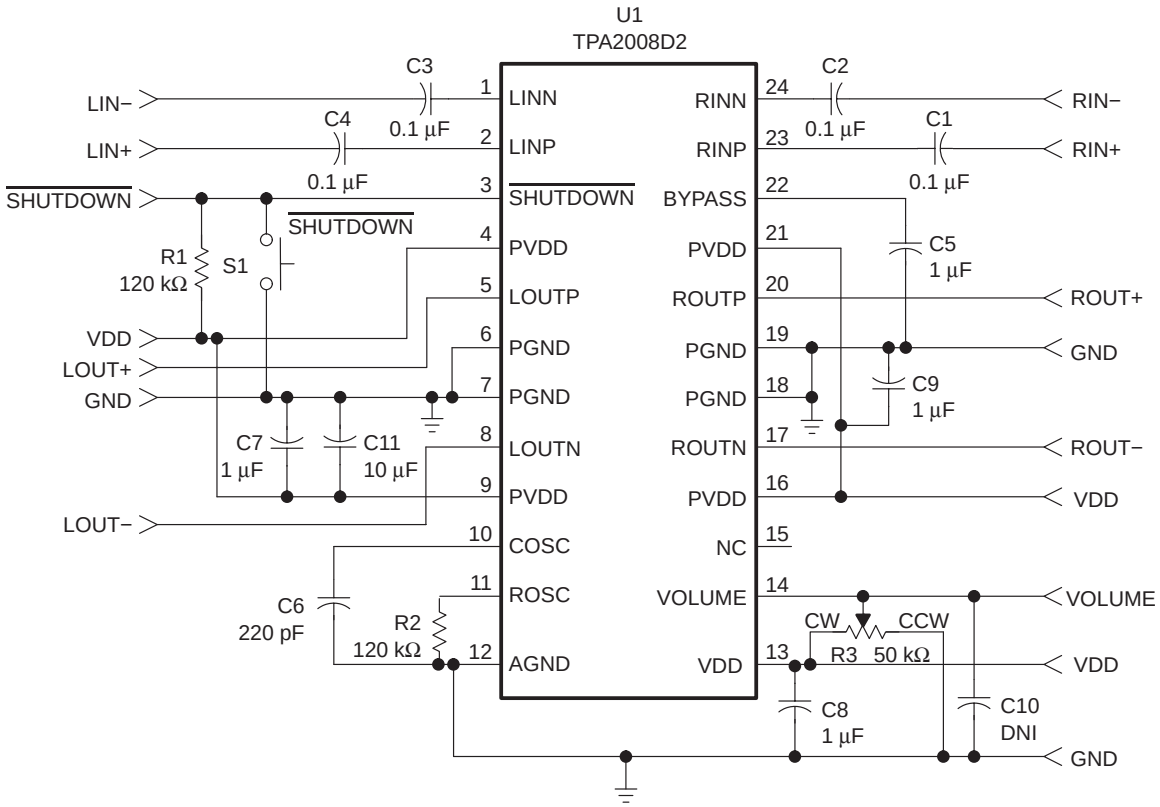
3.1 TPA2008D2 EVM Schematic

Figure 3−1. TPA2008D2 Filter-Free Class-D EVM Schematic Diagram



3.2 TPA2008D2 EVM PCB Layers

Figure 3−2 and Figure 3−3 depict the TPA2008D2 EVM PCB layers. These drawings are not to scale. Gerber plots can be obtained from any TI sales office.

Figure 3−2. TPA2008D2 EVM Top Assembly

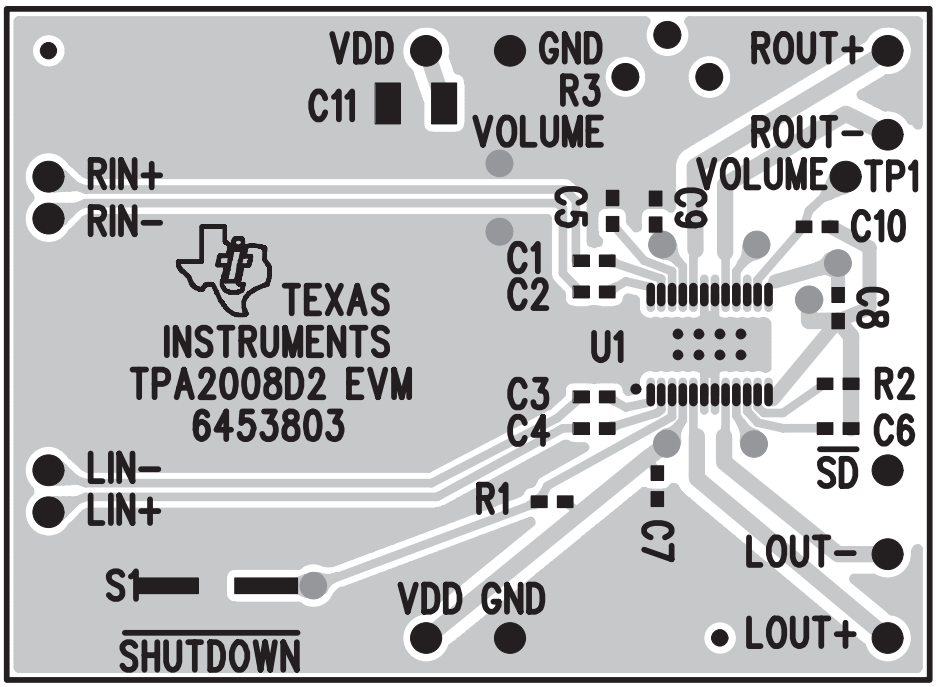
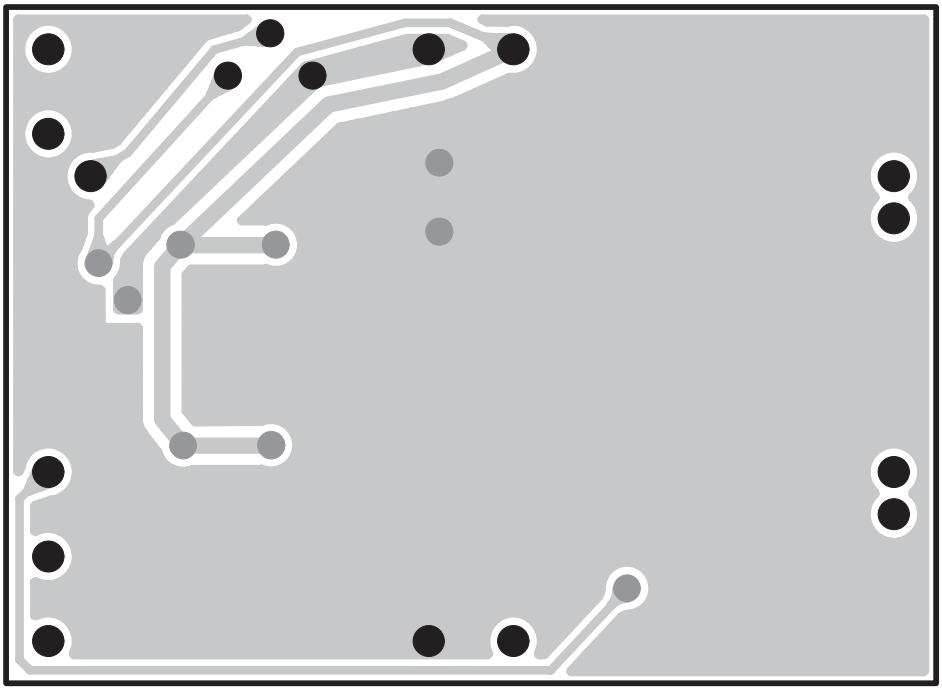


Figure 3−3. TPA2008D2 EVM Bottom Assembly



3.3 TPA2008D2 EVM Parts List

Table 3−1. TPA2008D2 EVM Parts List

Reference	Description	Size	EVM Qty.	Manufacturer/ Part Number	Vendor/ Part Number
C1, C2, C3, C4	Capacitor, 0.1 μF, ±5%, X7R, 16 V	603	4	Panasonic ECJ−1VB1C104K	Digi-Key PCC1762CT−ND
C5, C7, C8, C9	Capacitor, 1 μF, 80%/−20%, Y5V, 10 V	603	4	Panasonic ECJ−1VF1A105Z	Digi-Key PCC1787CT−ND
C10	No not install				
C6	Capacitor, 220 pF, ±5%, X7R, 50 V	603	1	Panasonic ECJ−1VC1h221J	Digi-Key PCC221ACVCT−ND
C11	Capacitor, 10 μF, 80%/−20%, Y5V, 16 V	1210	1	Murata GRM23SY5V106Z016AK	Arrow GJ232NF51C106ZD 01
R1, R2	Resistor, 120 kΩ, 1/16 W, 5%	603	2	Panasonic ERJ−3GEYJ124V	Digi-Key P120K6CT−ND
R3	Potentiometer, 50 kΩ, Cermet ST SL, thru hole		1	Bourns 3362P−1−503	Digi-Key 3362P−503−ND
S1	Switch, momentary pushbutton, 12 V, 50 mA	SMD	1	Panasonic EVQ−PPBA25	Digi-Key P8086SCT−ND
	Headers, 0.1 in centers, 1/2 in long	0.5 X 0.25 X 0.1”	13	Sullin PTC36SABN	Digi-Key S1022−36−ND
TP1	Test point, 0.040” mounting hole		1	Farrell 240−345	
U1	IC, 3-W, stereo class-D audio power amplifer	24-pin TSSOP	1	TI TPA2008D2PWP	
PCB	PCB, 2 layer, fits U2 on PnP	2.25” X 1.25”	1	TI TPA2008D2EVM	

3.4 DC Volume Table

Table 3−2. DC Volume Control

Voltage on VOLUME Pin (V) (Increasing or Fixed Gain)	Voltage on VOLUME Pin (V) (Decreasing Gain)	Gain of Amplifier (dB)(1)
0−0.33	0.31−0	−38(2)
0.34−0.42	0.43−0.32	−37
0.43−0.52	0.54−0.44	−35
0.53−0.63	0.64−0.55	−33
0.64−0.75	0.75−0.65	−31
0.76−0.86	0.86−0.76	−29
0.87−0.97	0.97−0.87	−27
0.98−1.07	1.08−0.98	−25
1.08−1.18	1.19−1.09	−23
1.19−1.30	1.32−1.20	−21
1.31−1.41	1.42−1.33	−19
1.42−1.52	1.53−1.43	−17
1.53−1.63	1.63−1.54	−15
1.64−1.75	1.75−1.64	−13
1.76−1.85	1.84−1.76	−12
1.86−1.96	1.96−1.85	−10
1.97−2.07	2.09−1.97	−8
2.08−2.18	2.19−2.10	−6
2.19−2.30	2.33−2.20	−4
2.31−2.40	2.43−2.34	−2
2.41−2.52	2.49−2.44	0(2)
2.53−2.63	2.62−2.50	2
2.64−2.75	2.75−2.63	4
2.76−2.87	2.85−2.76	6
2.88−2.98	2.99−2.86	8
2.99−3.10	3.12−3.00	10
3.11−3.22	3.25−3.13	12
3.23−3.33	3.36−3.26	14
3.34−3.47	3.48−3.37	16
3.48−3.69	3.64−3.49	18
3.70−V_{DD}	V_{DD}−3.65	20(2)

1) The Typiocal part-to-part variation can be as large as ±2dB (one gain step)
2) Tested in production