

# **TPA152**

## **Audio Power Amplifier**

### **Evaluation Module**

*User's Guide*

***TPA152***  
***Audio Power Amplifier***  
***Evaluation Module***

***User's Guide***

***SLOU019***  
***June 1998***



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# Preface

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## ***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.
- ***TPA152 75-mW STEREO AUDIO POWER AMPLIFIER*** (literature number SLOS210) This is the data sheet for the TPA152 audio amplifier integrated circuit.

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# Introduction

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This chapter provides an overview of the Texas Instruments (TI™) TPA152 Audio Amplifier Evaluation Module (SLOP123). It includes a list of EVM features, a brief description of the module illustrated with a pictorial diagram, and a list of EVM specifications.

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## 1.1 Features

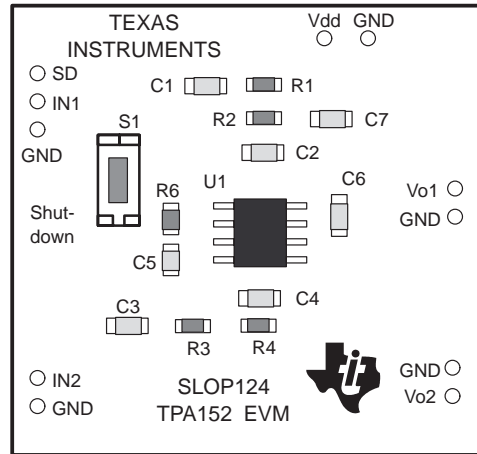
The TI TPA152 Audio Amplifier Evaluation Module and the TI Plug-N-Play Audio Amplifier Evaluation Platform include the following features:

- TPA152 Stereo Audio Power Amplifier Evaluation Module
  - Dual channel, single-ended operation
  - 75 mW output power into 32  $\Omega$  at 5 V
  - 4.5-V to 5.5-V operation
  - Very low distortion — THD+N is less than 0.005% into 10-k $\Omega$  loads at 1 kHz, and less than 0.01% from 20 Hz to 20 kHz
  - Low current consumption in shutdown/mute mode
  - Internal thermal and short-circuit protection
  - Internal pop reduction circuitry
  
- 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
  - On-board 9-V battery
  - External 5-V – 15-V ( $V_{CC}$ ) supply inputs
  - External regulated  $V_{DD}$  supply input
  - Socket for on-board 5-V  $V_{DD}$  voltage regulator EVM
  - On-board 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 TPA152 Audio Power Amplifier Evaluation Module is a complete, low-power stereo audio power amplifier for high-fidelity line-level output and headphone applications. It consists of the TI TPA152 75-mW Stereo Audio Power Amplifier IC in a very small package, along with a small number of other parts mounted on a circuit board that is approximately one and a quarter inches square (Figure 1–1).

Figure 1–1. The TI TPA152 Audio Amplifier Evaluation Module



Single in-line header pins are mounted to 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 TPA152 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 TPA152 EVM Specifications

Supply voltage range, $V_{DD}$ .....	4.5 V to 5.5 V
Supply current, $I_{DD}$ .....	80 mA, max
Continuous output power, $P_O$ : 32- $\Omega$ , $V_{DD}=5$ V: .....	75 mW
Audio input voltage, $V_I$ .....	$V_{DD} + 3$ Vpp, max
Minimum load impedance, $R_L$ .....	32 $\Omega$

## Quick Start

The steps in this chapter can be followed to quickly prepare the TPA152 audio amplifier EVM for use. Using the TPA152 EVM 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 TPA152 EVM and will cause the TPA152 IC to mute when a plug is removed from platform headphone jack J10.

*Table 2–1. Typical TI Plug-N-Play Platform Jumper and Switch Settings for the TPA152 EVM*

EVM	JP6	JP7	JP8	S2	S3
TPA152	X	Lo	X	Note 2	U5

**Notes:** 1) 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.

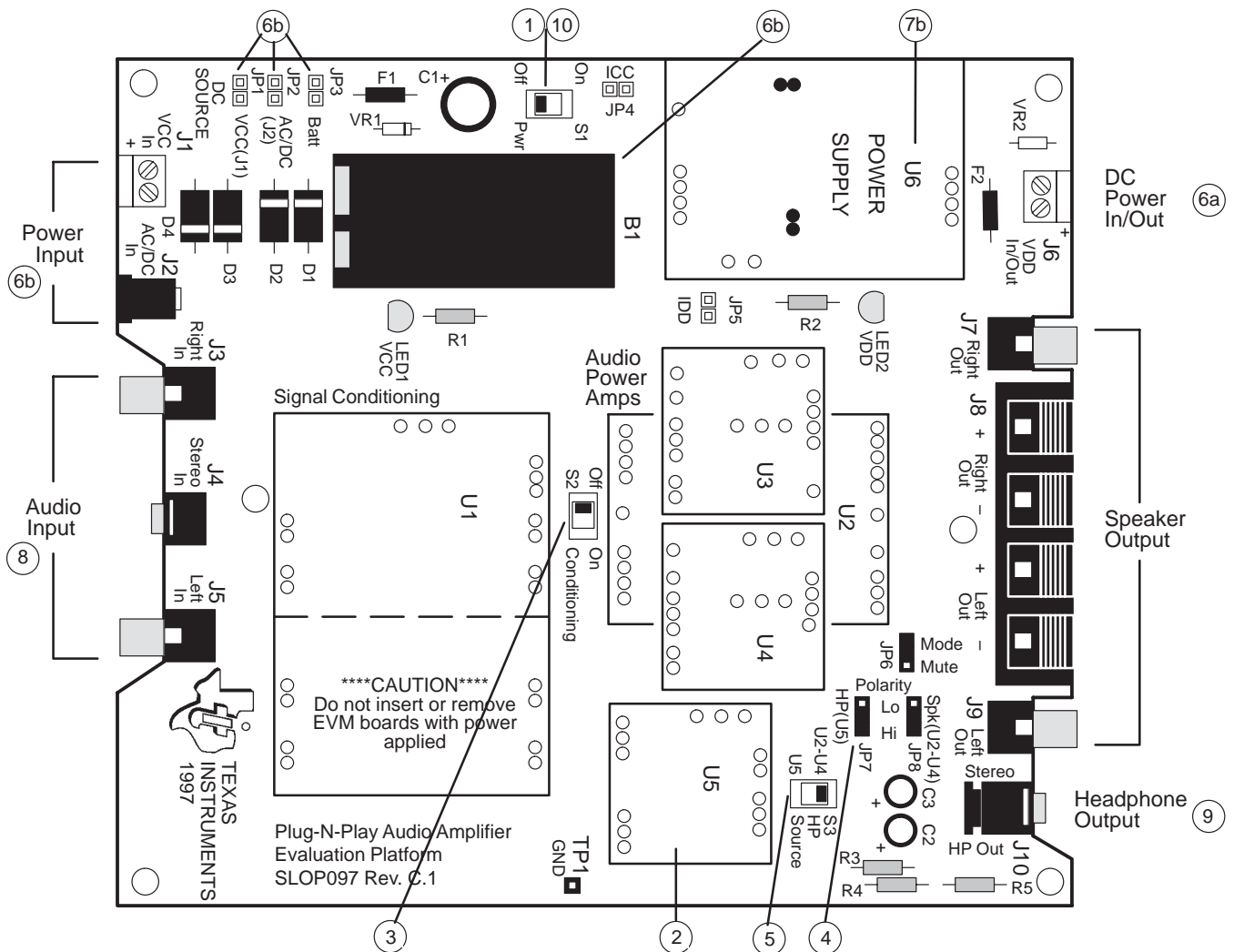
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## 2.1 Precautions

**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 on-board 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 TPA152 EVM with the TI Plug-N-Play Audio Amplifier Evaluation Platform (see the platform user's guide, SLOU011, for additional details). Numbered callouts for selected steps are shown in Figure 2–1 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 TPA152 module in platform socket **U5**, 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 **JP7** to **Lo**.
- 5) Set Hp source switch **S3** to **U5** to route the output signal to the headphone Jack (**J10**).

Table 2–2. Platform Jumper and Switch Settings for the TPA152 EVM

EVM	JP6	JP7	JP8	S2	S3
TPA152	X	Lo	X	Note 2	U5

**Notes:** 1) 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

- 6) Select and connect the power supply:
  - a) Connect an external regulated power supply set to a voltage between 4.5 V and 5.5 V to platform  $V_{DD}$  power input connector **J6** taking care to observe marked polarity, or
  - b) Install a 5-V voltage regulator EVM (SLVP097 or equiv.) in platform socket **U6**. Install a 9-V battery in **B1** or 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).

### □ Inputs and outputs

- 7) Ensure that signal source level is set to minimum.
- 8) Connect the audio source to left and right RCA phono jacks **J3** and **J5** or stereo miniature phone jack **J4**.
- 9) Connect 32- $\Omega$  headphones to headphone jack **J10**.

### □ Power-up

- 10) 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**.

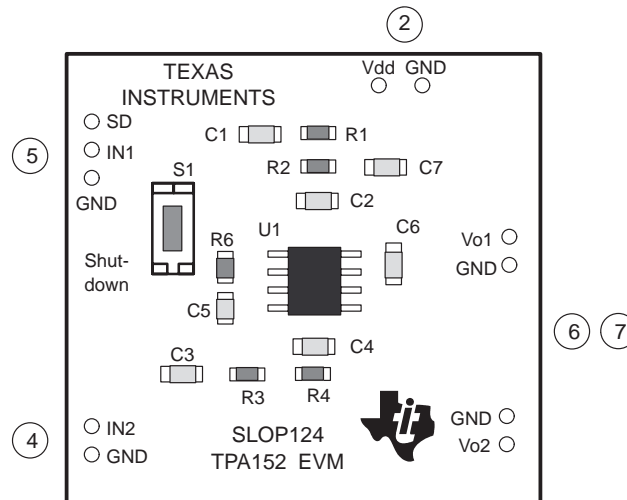
Platform LED2 should light indicating the presence of  $V_{DD}$ , and the evaluation modules installed on the platform should begin operation.

- 11) Adjust the signal source level as needed.

## 2.3 Quick Start List for Stand-Alone

Follow these steps to use the TPA152 EVM stand-alone or when connecting it into existing circuits or equipment. Connections to the TPA152 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 2–2 and details appear in Chapter 3.

Figure 2–2. Quick Start Module Map



### ❑ 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 the signal source level is set to minimum.
- 4) Connect the audio source to the module **IN1**, **IN2**, and **GND** pins taking care to observe marked polarity.
- 5) Connect the **Shutdown** pin to  $V_{DD}$  through a Normally Open switch.
- 6) Connect 32- $\Omega$  headphones to the module **Vo1**, **Vo2** pins through 33  $\mu\text{F}$  to 1000  $\mu\text{F}$  output-coupling capacitors (figure 3–8) and return to the **GND** pin, or
- 7) For line output, connections to the **Vo1** and **Vo2** pins must be made through 33  $\mu\text{F}$  to 1000  $\mu\text{F}$  output-coupling capacitors and returned to GND.

### ❑ Power-up

- 8) Verify correct voltage and input polarity and set the external power supply to **ON**.

The EVM should begin operation.

- 9) Adjust the signal source level as needed.

# Details

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This chapter provides details on the TPA152 IC, the evaluation module, the steps in the Quick-Start List, additional application information, and a parts list for the TPA152 evaluation module.

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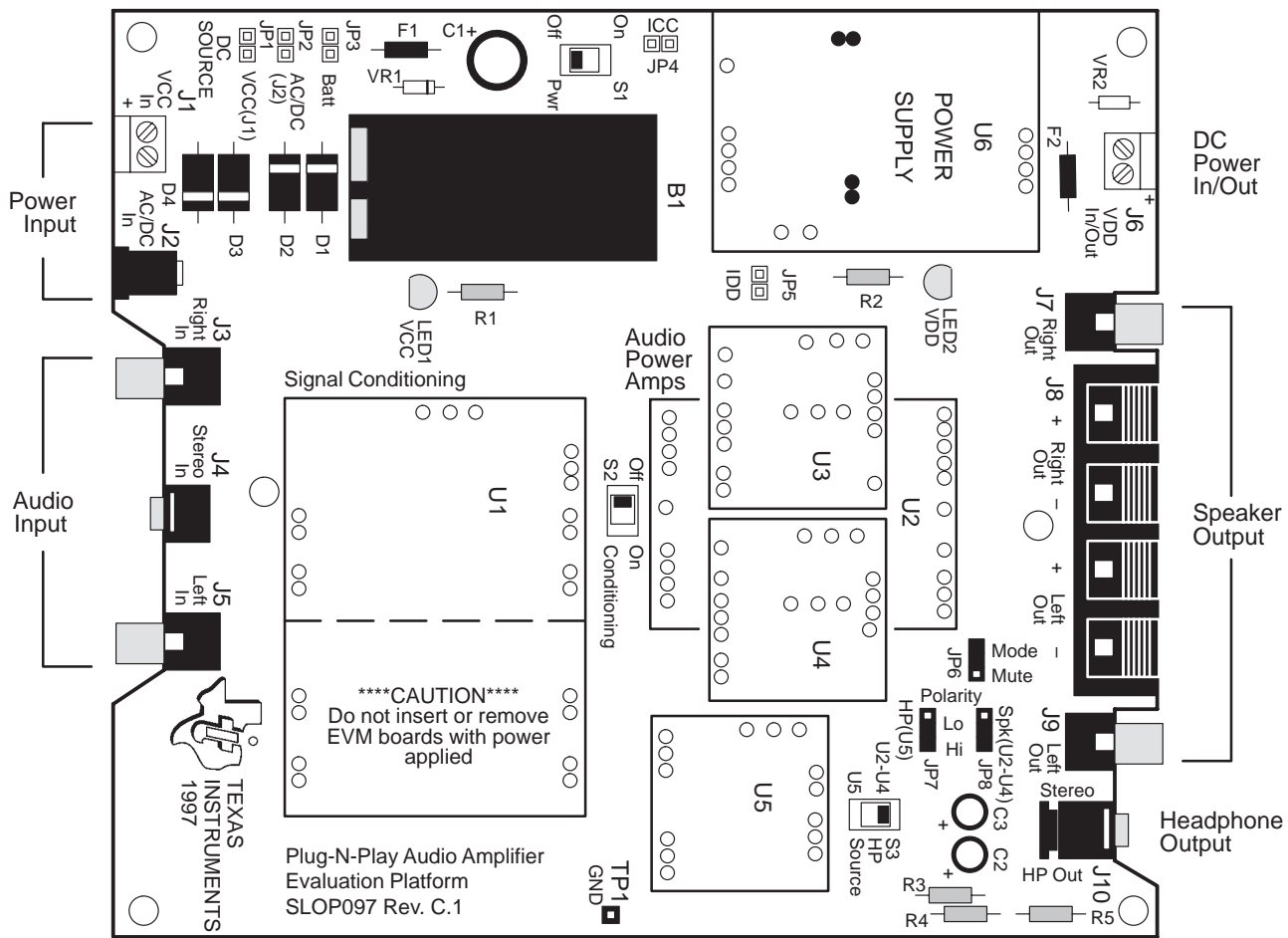


### 3.1 Precautions

**Power Supply Input Polarity and Maximum Voltage**  
 Always ensure that the polarity and voltage of the external power connected to V<sub>CC</sub> power input connector J1, J2, and/or V<sub>DD</sub> power input connector J6 are correct. Overvoltage or reverse-polarity power applied to these terminals can open on-board 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 3–1. The TI Plug-N-Play Audio Amplifier Evaluation Platform



### 3.2 The TPA152 Audio Power Amplifier Evaluation Module

The TPA152 Audio Power Amplifier Evaluation Module is powered by a TPA152 75-mW Stereo Audio Amplifier IC, includes a mute control signal input with on-board switch, and can drive either 32-Ω headphones or line-level outputs.

The evaluation module can be used with the TI Plug-N-Play Audio Amplifier Evaluation Platform (Figure 3–1) or wired directly into circuits or equipment. The module has single in-line header connector pins mounted to the under side of the board. These pins allow the module to be plugged into the TI platform, which automatically makes all the signal input and output, power, and control connections to the module.

The module connection pins are on 0.1-inch centers to allow easy use with standard perf board and plug board-based prototyping systems. Or, the EVM can be wired directly into existing circuits and equipment when used stand-alone.

The module appears in Figure 3–2 and its schematic is shown in Figure 3–3.

Figure 3–2. TPA152 EVM

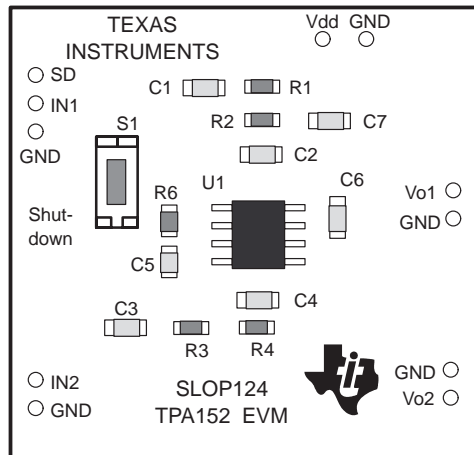
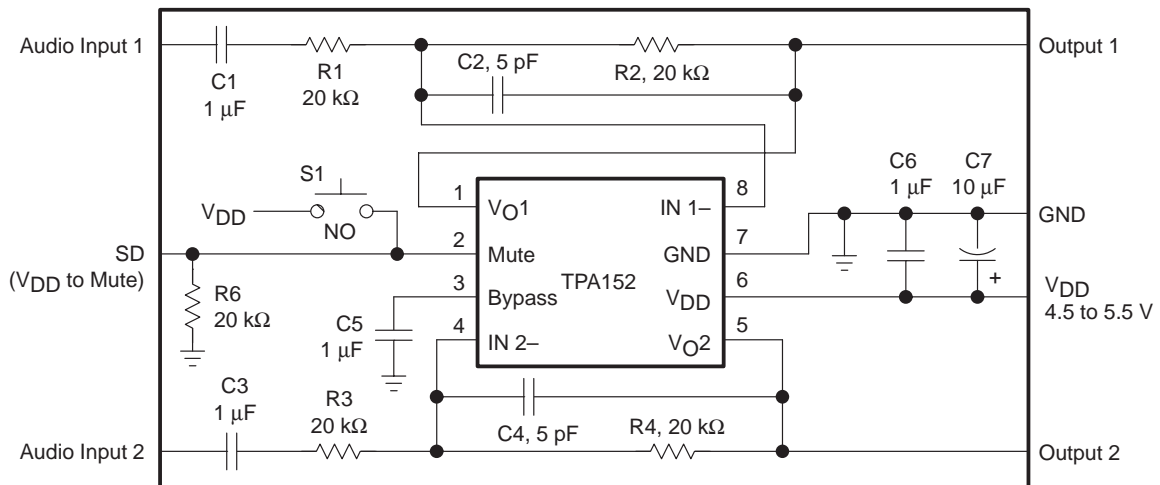


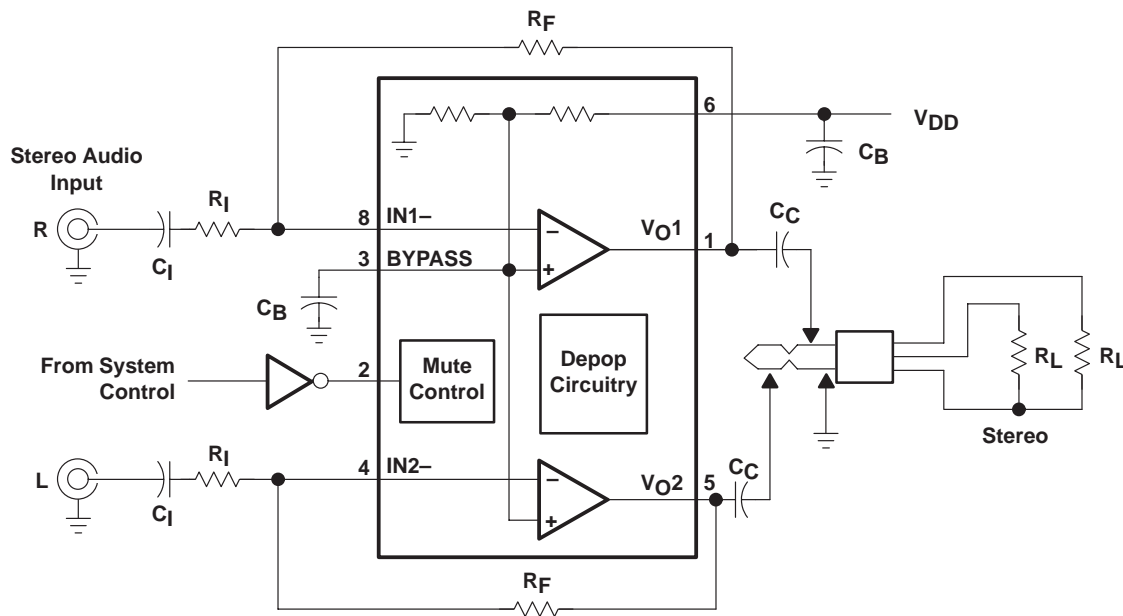
Figure 3–3. TPA152 EVM Schematic Diagram



### 3.2.1 TPA152 Audio Amplifier IC

The TPA152 audio amplifier IC is a CMOS device intended primarily for high-performance line-level output and headphone driver applications. It is supplied in a very small surface-mount package and has been designed to operate from low supply voltages (between approximately 4.5 V and 5.5 V) and deliver up to approximately 75 mW into 32- $\Omega$  headphones with low distortion. As a line-level driver, distortion levels (THD+N) are below 0.01% into 10-k $\Omega$  loads across the audio band (20 Hz to 20 kHz) (Figure 3–4). Typical applications include portable computers, desktop computers, personal audio, toys, games, and similar audio applications.

Figure 3–4. TPA152 Amplifier IC



The IC includes two separate internal amplifiers, depop circuitry, and a common mute control. The load for each channel is connected between the  $V_O$  pin and GND through a coupling capacitor. For more information, see the TPA152 amplifier IC data sheet, TI Literature Number SLOS210.

### 3.2.2 Module Gain

The TPA152 evaluation module has a set gain of 1 (inverting) for each channel. However, the gain can be adjusted to a maximum of approximately 10 (inverting) by changing the value of feedback resistors (R2 and R4, Figure 3-3). Use the following equation to determine the value of  $R_F$ :

$$\text{Gain} = \frac{-R_F}{R_I}$$

The TPA152 amplifier IC, as most other amplifiers, exhibits its best distortion and noise performance at lower gain levels. In addition, higher gain levels require a small compensation capacitor to ensure stability (see the TPA152 data sheet).

Gain versus total harmonic distortion (THD) and gain versus signal-to-noise ratio (SNR) should be considered in each application. Both the module input signal level and the TPA152 module gain should be adjusted to obtain the lowest overall distortion level for a particular overall gain. A quick rule of thumb (everything else being equal): the module input signal level should be as high as possible without clipping or overloading the TPA152 input, and the TPA152 gain should be kept as low as possible.

### 3.2.3 Mute

When the mute terminal of the TPA152 amplifier IC is taken high, the IC ceases operation. This is accomplished by applying a control signal to the module SD pin or by pressing the Shutdown switch, S1, on the module. When the control signal goes low or is removed (or the switch is released), amplifier operation resumes.

The Plug-N-Play platform can generate the mute signal for the module either when a plug is *inserted* into the platform headphone output jack or when the plug is *removed*, as selected by a platform jumper (JP7).

### 3.3 Using The TPA152 EVM With the Plug-N-Play Evaluation Platform

The TPA152 Audio Amplifier Evaluation Module was designed to be used with the TI Plug-N-Play Audio Amplifier Evaluation Platform. It simply plugs into socket U5.

The following paragraphs provide additional details for using the TPA152 EVM with the platform.

#### 3.3.1 Installing and Removing EVM Boards

TI Plug-N-Play evaluation modules use single-in-line header pins installed on the underside of the module circuit board to plug into sockets on the platform. The EVM pins and the platform sockets are keyed such that only the correct type of EVM can be installed in a particular socket, and then only with the proper orientation.

Evaluation modules are easily removed from the platform by simply prying them up and lifting them out of their sockets. Care must be taken, however, to prevent bending the pins.

##### 3.3.1.1 EVM Insertion

- 1) Remove all power from the evaluation platform
- 2) Locate socket U5 on the platform
- 3) Orient the module correctly
- 4) Carefully align the pins of the module with the socket pin receptacles
- 5) Gently press the module into place
- 6) Check to be sure that all pins are seated properly and that none are bent over

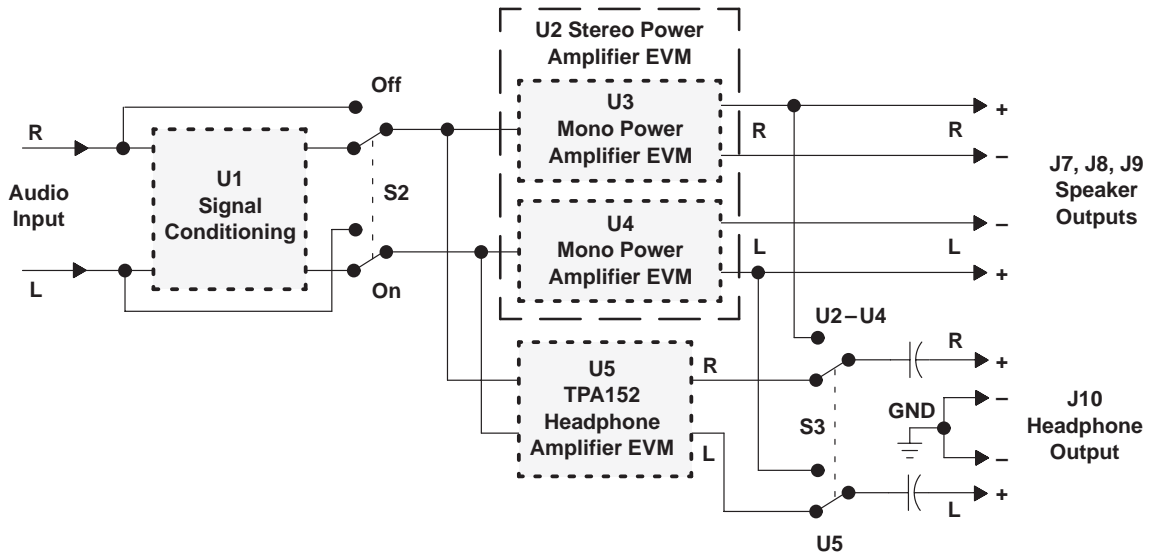
##### 3.3.1.2 EVM Removal

- 1) Remove all power from the evaluation platform
- 2) Using an appropriate tool as a lever, gently pry up one side of the module a short distance
- 3) Change to the opposite side of the module and use the tool to pry that side up a short distance
- 4) Alternate between sides, prying the module up a little more each time to avoid bending the pins, until it comes loose from the socket
- 5) Lift the EVM off the platform

### 3.3.2 Signal Routing

Signal flow on the platform is controlled by two signal routing switches, as shown in Figure 3–5.

Figure 3–5. Platform Signal Routing and Outputs



#### 3.3.2.1 Signal Conditioning

The audio signal from the input jacks can be applied to the signal conditioning socket (U1) if an EVM is installed there, or socket U1 can be bypassed and the audio input signal applied directly to the inputs of the TPA152 power amplifiers.

- Switch **S2** selects or bypasses signal conditioning.

#### 3.3.2.2 Headphone Output Jack

Switch S3 is the source select for the stereo headphone output jack, J10. The headphone jack is capacitively coupled (via 470  $\mu$ F electrolytics) and can output either the signal from the the TPA152 headphone amplifier in socket U5, or the signal from power amplifiers installed in socket U2 or in sockets U3 and U4, as determined by the setting of headphone source select switch S3.

When S3 is set to the headphone amplifier position (U5), the headphone jack is connected to the headphone amplifier EVM output lines. When a plug is inserted into the jack, signals output through J10 are returned to platform ground. A switch inside the headphone jack produces a control signal that can be routed to the headphone amplifier socket to mute the TPA152 EVM when the headphone plug is removed.

- Switch **S3** connects the headphone jack to either the headphone amplifier platform socket (**U5**) or to the platform power amplifier sockets (**U2 – U4**).

### 3.3.3 Mute

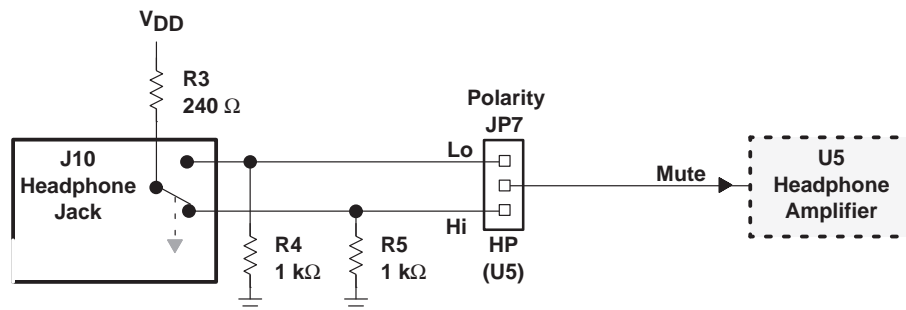
The TPA152 EVM is equipped with a mute control input pin. When this input is tied to  $V_{DD}$ , the TPA152 amplifier IC on the module ceases operation. When the EVM control input is tied to GND or allowed to float, amplifier operation resumes.

In typical applications, as often found in notebook computers, portable audio products, and such, the internal speakers mute when headphones are plugged into the headphone jack, or internal speakers mute when external speakers are connected. In applications using separate speaker and headphone amplifiers, the one not being used can be muted to conserve power.

#### 3.3.3.1 Headphone Jack Control Signals

The platform headphone output jack (J10) contains an internal switch that changes the state of a pair of control lines when a plug is inserted or removed (Figure 3–6). Each control line is pulled down by a 1-k $\Omega$  resistor to ground (R4 and R5). The switch in the headphone jack pulls one line or the other up to  $V_{DD}$  through a 240  $\Omega$  resistor (R3) depending on whether or not a plug is inserted in J10.

Figure 3–6. Mute Polarity Control



#### 3.3.3.2 Mute Polarity Select (JP7)

A 3-pin jumper header (JP7) on the platform selects the mute control signal polarity by connecting either the active-high or the active-low line from the headphone jack to platform socket U5. The TPA152 EVM mutes when  $V_{DD}$  is applied to the module SD pin

- To mute the TPA152 amplifier module *when* a plug is inserted into the headphone jack, jumper **JP7** to **Hi**.
- To mute the TPA152 amplifier module *until* a plug is inserted into the headphone jack, jumper **JP7** to **Lo** (this is the typical setting).

### 3.3.4 Power Requirements

The TPA152 Audio Power Amplifier Evaluation Module can operate from a  $V_{DD}$  voltage between approximately 4.5 V and 5.5 V.

The TI Plug-N-Play Audio Amplifier Evaluation Platform with a voltage regulator EVM installed on it can provide a regulated 5-V  $V_{DD}$  supply from a wide variety of unregulated  $V_{CC}$  voltage inputs between approximately 5.5 V and 12 V, including an on-board 9-V battery. Or, an external regulated power source can be used to supply  $V_{DD}$  voltage to the platform and the TPA152 evaluation module installed on it.

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 TPA152 amplifier IC installed on the evaluation module (5.5 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.



### 3.3.5 Inputs and Outputs

The TI Plug-N-Play Audio Amplifier Evaluation Platform is equipped with several standard connectors for audio inputs and outputs.

#### 3.3.5.1 Inputs

In most cases, audio signals enter the platform through either a pair of RCA phono jacks (J3 and J5) or a miniature (1/8") stereo phone jack (J4). Certain signal conditioning and amplifier EVMs, however, may have additional signal input connectors mounted on the module circuit board.

The platform audio signal input jacks (J3, J4, and J5) are of the closed-circuit type, grounding the signal input lines when no plugs are inserted.

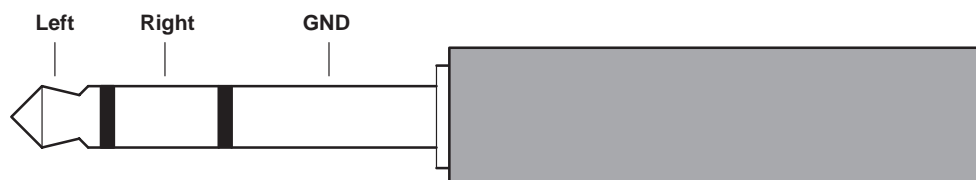
#### 3.3.5.2 Outputs

Output signals from the headphone amplifier (U5) leave the platform through a miniature (1/8") stereo headphone jack (J10). Amplified audio output signals from the power amplifiers (U2 – U4) leave the platform through left and right RCA phono jacks (J7 and J9), left and right pairs of compression connectors for stripped speaker wires (J8), and optionally, through the headphone jack.

The audio output lines from the power amplifiers are separate all the way to the edge of the platform (output jacks J7, J8, and J9) — the OUT– lines from the power amplifier sockets are not tied to each other or to platform ground. This allows the power amplifier EVMs to operate in the highly-efficient bridge-tied load configuration.

The headphone jack (J10) is capacitively coupled to source select switch S3, which connects J10 to the output lines of either the headphone amplifier socket or the power amplifier sockets (Figure 3–5). When the TPA152 output signal is routed to J10 by S3, signals output via J10 are returned to platform ground when a plug is inserted (Figure 3–7).

Figure 3–7. Typical Headphone Plug



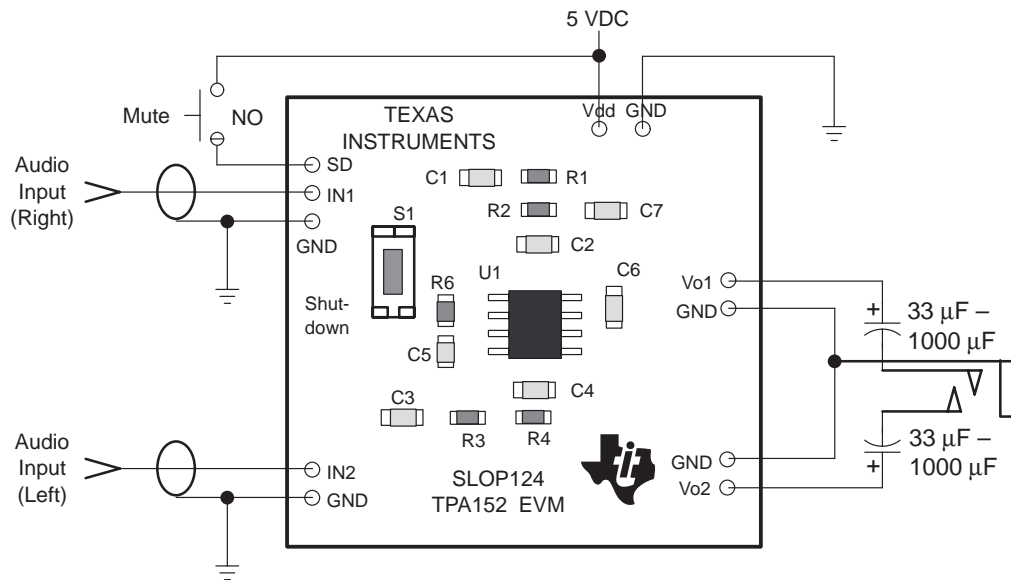
### 3.4 Using The TPA152 EVM Stand-Alone

Using the TPA152 Audio Power Amplifier Evaluation Module stand-alone is much the same as using it with the platform. The same 4.5-V to 5.5-V power supply requirement exists.

Note that the mute signal applied to the EVM SD pin must be able to supply enough current to overcome the pulldown resistor on the module (20 k $\Omega$ ).

#### 3.4.1 TPA152 EVM Connected as a Stereo Headphone Amplifier

Figure 3–8. TPA152 EVM Connected as a Stereo Headphone Amplifier



### 3.5 TPA152 Audio Power Amplifier Evaluation Module Parts List

Table 3–1. TPA152 EVM Parts List

Ref.	Description	Size	EVM Qty.	Manufacturer/ Part Number	Vendor/Number
C1, C3, C5, C6	Capacitor, 1 $\mu$ F, 6.3 V	1206	4	Murata GRM42-6Y5V105Z16BL	Newark 93F2254
C7	Capacitor, 10 $\mu$ F, 6.3 V	A	1	Panasonic ECS-TOJY106R	Digi-Key PCS1106CT-ND
C2, C4	Capacitor, 5 pF, 6.3 V	0805	2	Panasonic ECU-V1H050CCN	Digi-Key PCC050CNCT-ND
R1 – R6	Resistor, 20 k $\Omega$ , 1/8 W, 5%	1206	6	Panasonic ERJ-8GEYJ203	Digi-Key P20KECT-ND
S1	Switch, momentary		1	Panasonic P8048SCT-ND	Digi-Key P8048SCT-ND
U1	IC, TPA152, audio amplifier, 75 mW,	SOIC-8	1	TI TPA152	
PCB1	PCB, TPA152 EVM		1		

NOTE: All items are SMD.

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