

# ***TPA102 MSOP Audio Power Amplifier Evaluation Module***

## *User's Guide*

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# Preface

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## ***How to Use This Manual***

This document contains the following chapters:

- Chapter 1—Introduction
- Chapter 2—Quick Start
- Chapter 3—Details

## ***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.
- TPA102 150-mW Stereo Audio Power Amplifier*** (literature number SLOS213) This is the data sheet for the TPA102 audio amplifier integrated circuit.

This book may contain cautions and warnings.

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

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# Contents

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---

<b>1</b>	<b>Introduction</b>	<b>1-1</b>
1.1	Features	1-2
1.2	Description	1-3
1.3	TPA102 MSOP EVM Specifications	1-3
<b>2</b>	<b>Quick Start</b>	<b>2-1</b>
2.1	Precautions	2-2
2.2	Quick Start List for Platform	2-3
2.3	Quick Start List for Stand-Alone	2-4
<b>3</b>	<b>Details</b>	<b>3-1</b>
3.1	Precautions	3-2
3.2	The TPA102 MSOP Audio Amplifier Evaluation Module	3-3
3.2.1	TPA102 Audio Amplifier IC	3-4
3.2.2	Module Gain	3-5
3.2.3	Shutdown	3-5
3.3	Using the TPA102 MSOP EVM With the Plug-N-Play Evaluation Platform	3-6
3.3.1	Installing and Removing EVM Boards	3-6
3.3.2	Signal Routing	3-7
3.3.3	Shutdown	3-8
3.3.4	Power Requirements	3-9
3.3.5	Inputs and Outputs	3-10
3.4	Using the TPA102 MSOP EVM Stand-Alone	3-11
3.4.1	TPA102 MSOP EVM Connected as a Stereo Headphone Amplifier	3-11
3.5	TPA102 MSOP Audio Power Amplifier Evaluation Module Parts List	3-12

# Figures

---

---

---

1-1	The TI TPA102 MSOP Audio Amplifier Evaluation Module .....	1-4
2-1	Quick Start Platform Map .....	2-2
2-2	Quick Start Module Map .....	2-4
3-1	The TI Plug-N-Play Audio Amplifier Evaluation Platform .....	3-2
3-2	TPA102 MSOP EVM .....	3-3
3-3	TPA102 MSOP EVM Schematic Diagram .....	3-3
3-4	TPA102 Audio Amplifier IC .....	3-4
3-5	Platform Signal Routing and Outputs .....	3-7
3-6	Mute Polarity Control .....	3-8
3-7	Typical Headphone Plug .....	3-10
3-8	TPA102 MSOP EVM Connected as a Stereo Headphone Amplifier .....	3-11

# Tables

---

---

---

2-1	Typical TI Plug-N-Play Platform Jumper and Switch Settings for the TPA102 MSOP EVM .....	2-1
2-2	Platform Jumper and Switch Settings for the TPA102 MSOP EVM .....	2-3
3-1	TPA102 MSOP EVM Parts List .....	3-12

# Introduction

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---

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This chapter provides an overview of the Texas Instruments (TI) TPA102 MSOP audio amplifier evaluation module (SLOP125). It includes a list of EVM features, a brief illustrated description of the module, and a list of EVM specifications.

<b>Topic</b>	<b>Page</b>
<b>1.1 Features</b> .....	<b>1-2</b>
<b>1.2 Description</b> .....	<b>1-3</b>
<b>1.3 TPA102 MSOP EVM Specifications</b> .....	<b>1-3</b>

## 1.1 Features

The TI TPA102 MSOP audio amplifier evaluation module and the TI plug-n-play audio amplifier evaluation platform include the following features:

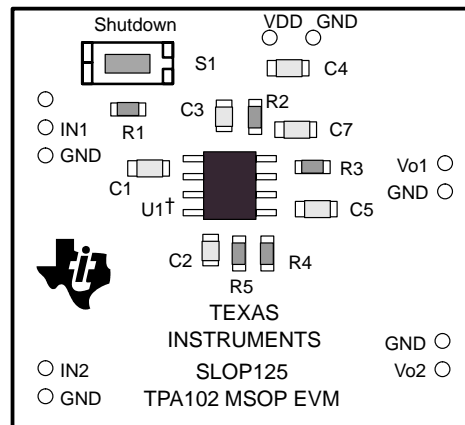
- TPA102 MSOP stereo audio power amplifier evaluation module
  - Dual channel, single-ended operation
  - 150 mW output power into 8  $\Omega$  at 5 V
  - 2.5-V to 5.5-V operation
  - Very low distortion — THD+N is less than 0.01% at 1 kHz and less than 0.03% from 20 Hz to 20 kHz into 10-k $\Omega$  loads, less than 0.02% at 1 kHz and less than 0.4% from 20 Hz to 20 kHz into 32- $\Omega$  loads, and less than 0.05% at 1 kHz and less than 0.8% from 20 Hz to 20 kHz into 8- $\Omega$  loads
  - Extremely low current consumption in shutdown 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
  - Onboard 9-V battery
  - External 5-V – 15-V ( $V_{CC}$ ) supply inputs
  - External regulated  $V_{DD}$  supply input
  - Socket for onboard 5-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 TPA102 MSOP audio power amplifier evaluation module is a complete, low-power stereo audio power amplifier for high-fidelity line-level output, headphone, and small speaker applications. It consists of the TI TPA102 150-mW stereo audio power amplifier IC in a very small MSOP 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 TPA102 MSOP Audio Amplifier Evaluation Module



† Due to the very small size of the MSOP IC package, the standard part number TPA102 is replaced with the code TIAAC

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 TPA102 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 TPA102 MSOP EVM Specifications

Supply voltage range, $V_{DD}$	2.5 V to 5.5 V
Supply current, $I_{DD}$	160 mA, max
Continuous output power, $P_O$ : 8 $\Omega$ , $V_{DD}=5$ V	150 mW
Audio input voltage, $V_I$	$V_{DD} + 0.3$ V <sub>pp</sub> , max
Minimum load impedance, $R_L$	8 $\Omega$



## Quick Start

The steps in this chapter can be followed to quickly prepare the TPA102 MSOP audio amplifier EVM for use. Using the TPA102 MSOP 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 TPA102 MSOP EVM and will cause the TPA102 IC to shutdown/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 TPA102 MSOP EVM*

EVM	JP6	JP7	JP8	S2	S3
TPA102	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.

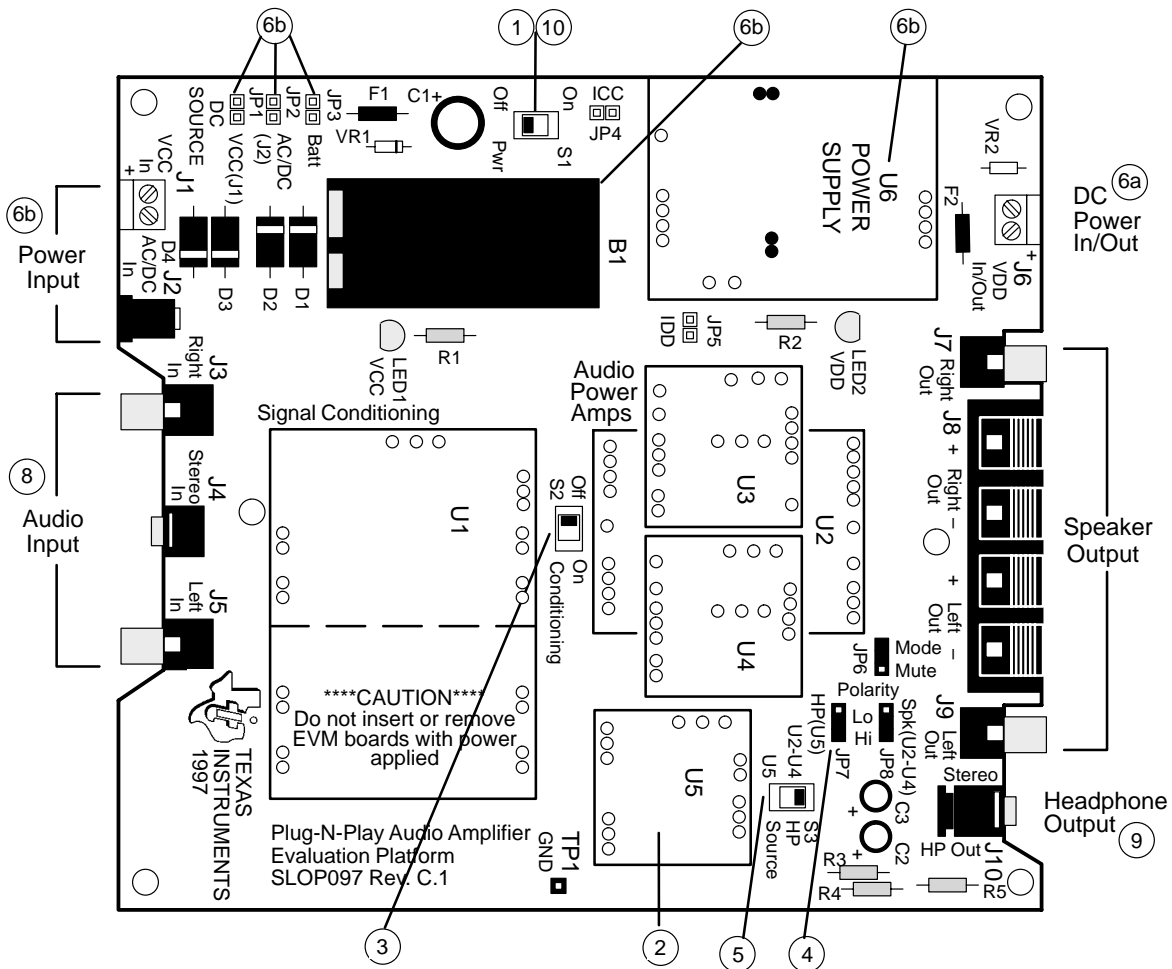
Topic	Page
2.1 Precautions .....	2–2
2.2 Quick Start List for Platform .....	2–3
2.3 Quick Start List for Stand-Alone .....	2–4

## 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. Overtoltage 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 TPA102 MSOP 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 TPA102 MSOP 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 TPA102 MSOP EVM

EVM	JP6	JP7	JP8	S2	S3
TPA102	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 2.5 V and 5.5 V to platform  $V_{DD}$  power input connector J6, taking care to observe marked polarity, or
  - b) Install a 3-V to 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*.

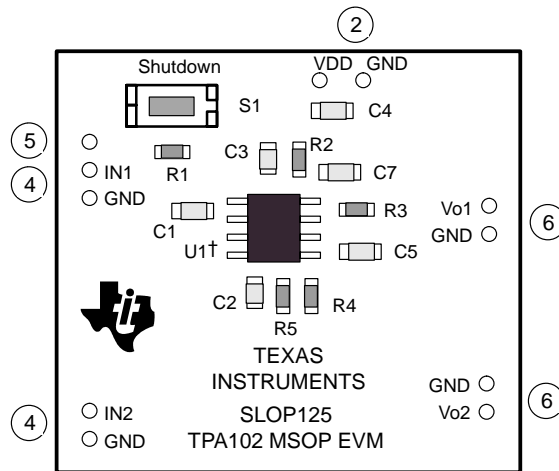
Platform LED2 should light indicating the presence of  $V_{DD}$ , and the evaluation modules installed on the platform should begin operation.

- 11) Adjust the signal source level as needed.

## 2.3 Quick Start List for Stand-Alone

Follow these steps to use the TPA102 MSOP EVM stand-alone or when connecting it into existing circuits or equipment. Connections to the TPA102 MSOP 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



† Due to the very small size of the MSOP IC package, the standard part number TPA102 is replaced with the code TIAAC

### ❑ 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<sub>DD</sub> through a normally open switch.
- 6) Connect 32-Ω headphones to the module V<sub>O1</sub>, V<sub>O2</sub> pins through 33 μF to 1000 μF output-coupling capacitors (figure 3–8) and return to the GND pin, or
- 7) For line output, connections to the V<sub>O1</sub> and V<sub>O2</sub> pins must be made through 33 μF to 1000 μF 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 TPA102 IC, the evaluation module, the steps in the Quick-Start List, additional application information, and a parts list for the TPA102 MSOP evaluation module.

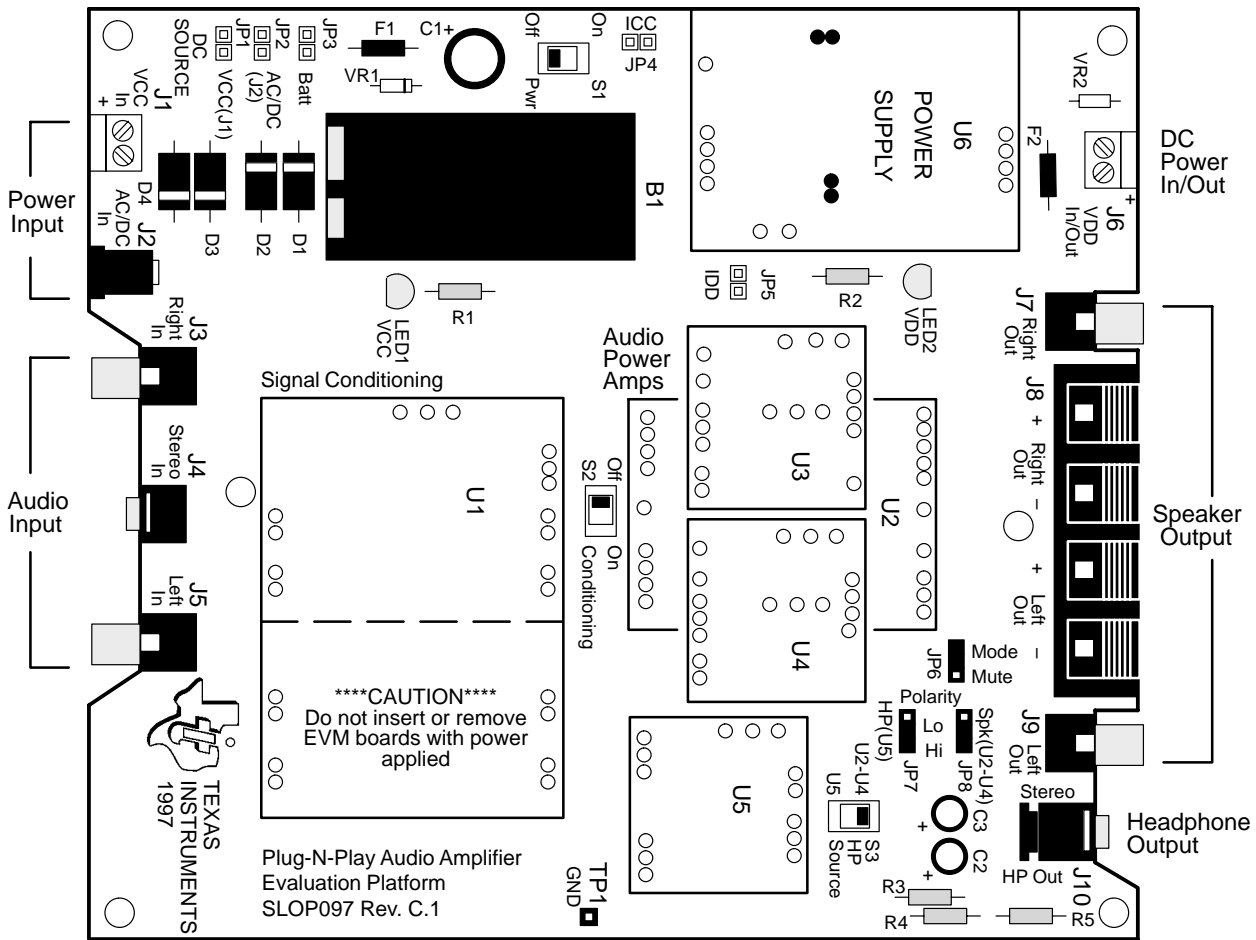
<b>Topic</b>	<b>Page</b>
<b>3.1 Precautions</b> .....	<b>3-2</b>
<b>3.2 The TPA102 MSOP Audio Power Amplifier Evaluation Module</b> ....	<b>3-3</b>
<b>3.3 Using The TPA102 MSOP EVM With the Plug-N-Play Evaluation Platform</b> .....	<b>3-6</b>
<b>3.4 Using the TPA102 MSOP EVM Stand-Alone</b> .....	<b>3-11</b>
<b>3.5 TPA102 MSOP Audio Power Amplifier EVM Parts List</b> .....	<b>3-12</b>

### 3.1 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 3–1. The TI Plug-N-Play Audio Amplifier Evaluation Platform





### 3.2 The TPA102 MSOP Audio Power Amplifier Evaluation Module

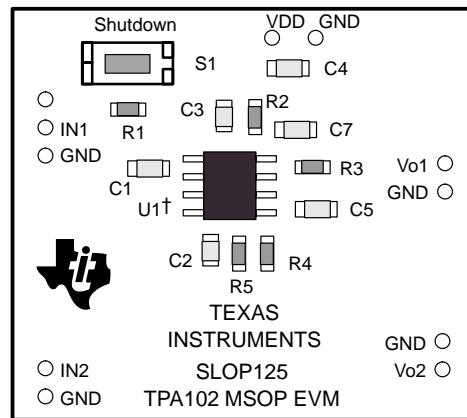
The TPA102 MSOP audio power amplifier evaluation module is powered by a TPA102 150-mW stereo audio amplifier IC. It includes a shutdown control signal input with onboard switch and can drive either line-level outputs, 32-Ω headphones, or 8-Ω speakers.

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.

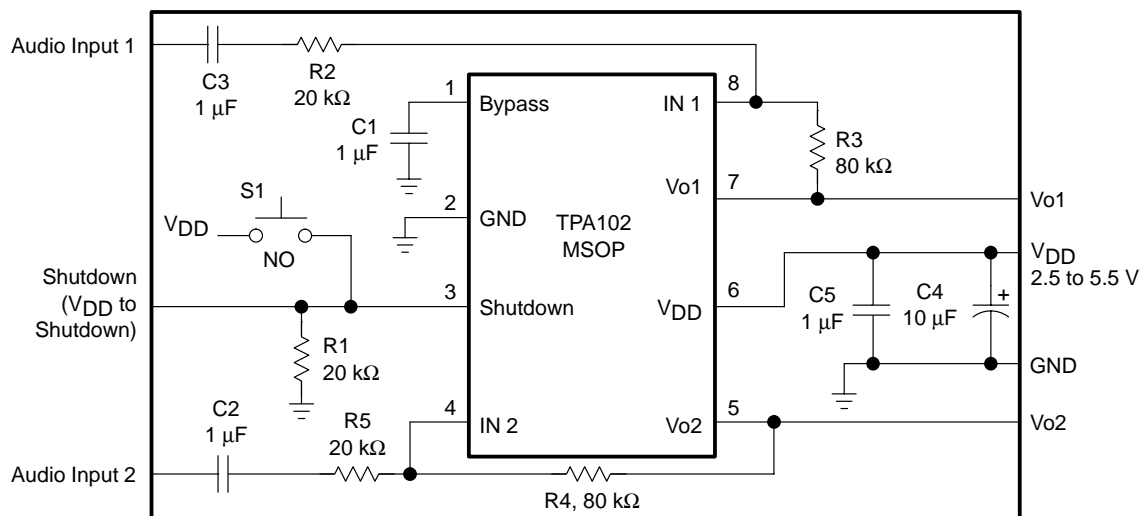
The module appears in Figure 3–2 and its schematic is shown in Figure 3–3.

Figure 3–2. TPA102 MSOP EVM



† Due to the very small size of the MSOP IC package, the standard part number TPA102 is replaced with the code TIAAC

Figure 3–3. TPA102 MSOP EVM Schematic Diagram

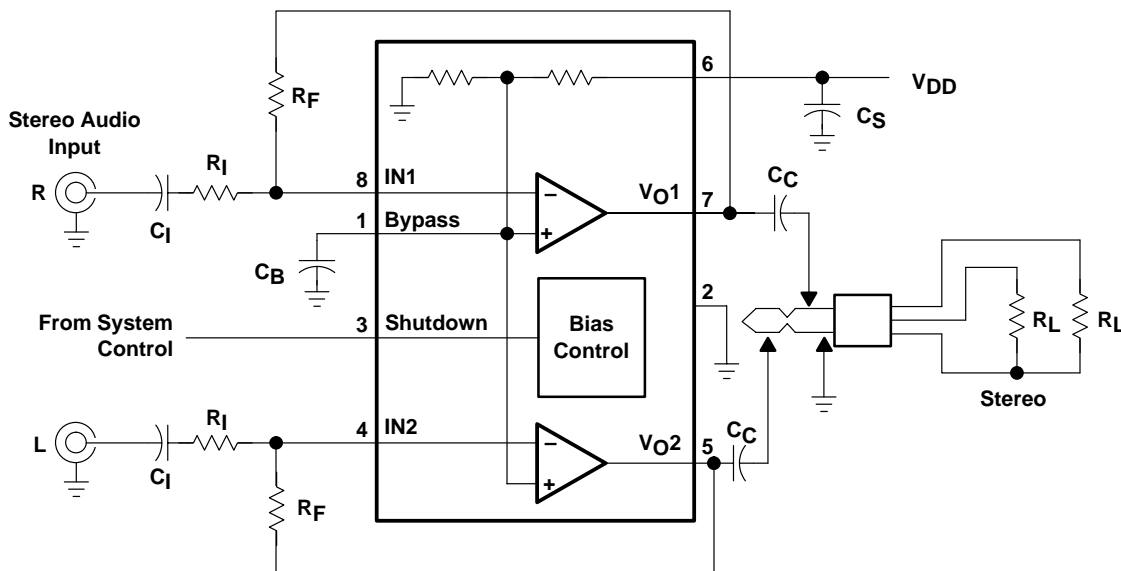


### 3.2.1 TPA102 Audio Amplifier IC

The TPA102 audio amplifier IC is a CMOS device intended primarily for high-performance line-level output, headphone driver, and small speaker applications. It is supplied in a very small surface-mount MSOP package designed to operate from low supply voltages (between approximately 2.5 V and 5.5 V) and deliver up to approximately 150 mW into 8-Ω speakers with low distortion. As a line-level driver, distortion levels (THD+N) are below 0.03% into 10-kΩ loads across the audio band (20 Hz to 20 kHz). As a headphone driver, distortion levels are below 0.4% into 32-Ω loads across the audio band. And as a speaker driver, distortion levels are below 0.8% into 8-Ω loads across the audio band. Typical applications include portable computers, desktop computers, personal audio, toys, games, and similar audio applications.

The IC includes two separate internal amplifiers, depop circuitry, and a common shutdown control (Figure 3–4). The load for each channel is connected between the  $V_O$  pin and GND through a coupling capacitor. For more information, see the TPA102 amplifier IC data sheet, TI literature number SLOS213.

Figure 3–4. TPA102 Amplifier IC



### 3.2.2 Module Gain

The TPA102 MSOP evaluation module has a set gain of 4 (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 TPA102 amplifier IC, like 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 TPA102 amplifier IC data sheet, TI literature number SLOS213).

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 TPA102 MSOP 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 TPA102 input, and the TPA102 gain should be kept as low as possible.

### 3.2.3 Shutdown

When the shutdown terminal of the TPA102 amplifier IC is taken high, the IC ceases operation and enters a very low power state (65  $\mu\text{A}$ , Typ). 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 TPA102 MSOP EVM With the Plug-N-Play Evaluation Platform

The TPA102 MSOP audio amplifier evaluation module is designed for use 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 TPA102 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.

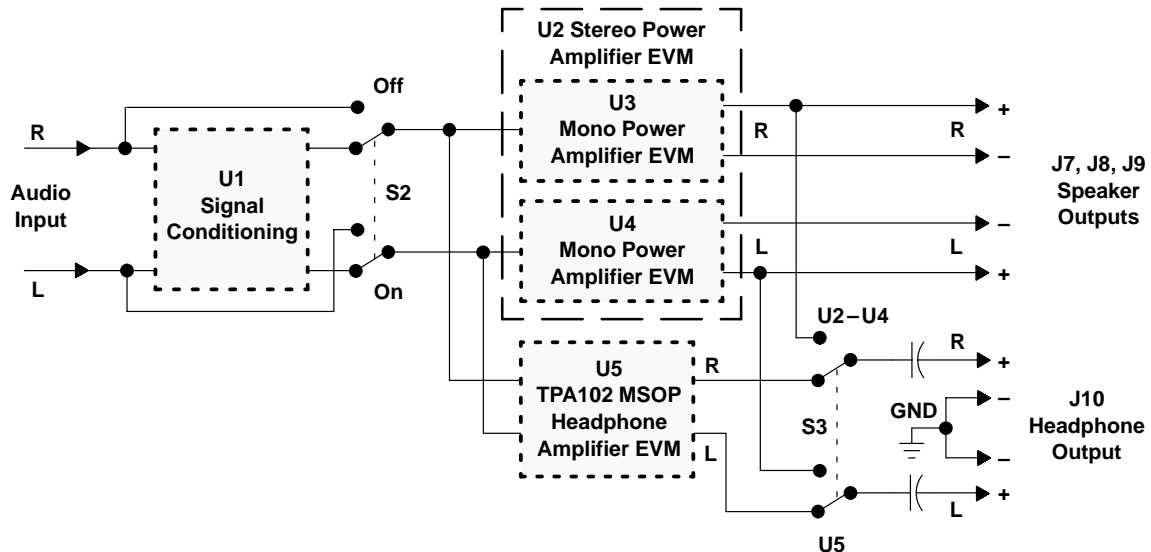
##### 3.3.1.2 EVM Removal

- 1) Remove all power from the evaluation platform.
- 2) Gently pry up one side of the module a short distance.
- 3) Change to the opposite side of the module and 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 TPA102 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). It can output either the signal from the the TPA102 MSOP 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 shutdown the TPA102 MSOP 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 Shutdown

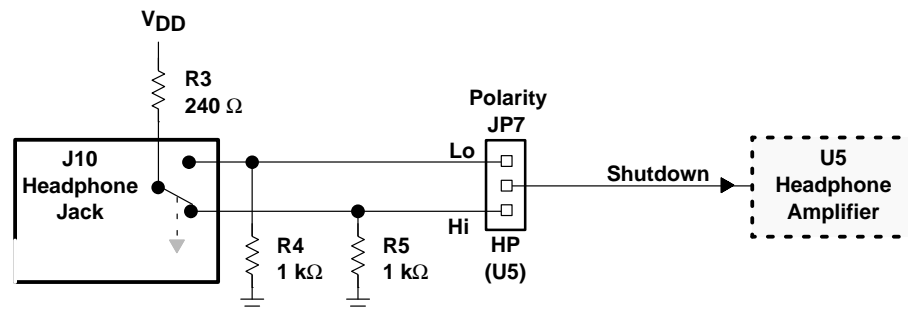
The TPA102 MSOP EVM is equipped with a shutdown control input pin. When this input is tied to  $V_{DD}$ , the TPA102 amplifier IC on the module ceases operation and enters an ultralow-power state. When the EVM shutdown control input is tied to GND or allowed to float, amplifier operation resumes.

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. Shutdown Polarity Control



#### 3.3.3.2 Shutdown Polarity Select (JP7)

A 3-pin jumper header (JP7) on the platform selects the shutdown control signal polarity by connecting either the active-high or the active-low line from the headphone jack to platform socket U5. The TPA102 MSOP EVM shuts down when  $V_{DD}$  is applied to the module SD pin.

- To shutdown the TPA102 MSOP amplifier module *when* a plug is inserted into the headphone jack, jumper JP7 to *Hi*.
- To shutdown the TPA102 MSOP 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 TPA102 MSOP audio power amplifier evaluation module can operate from a  $V_{DD}$  voltage between approximately 2.5 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 3.3-V or 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 onboard 9-V battery. Or, an external regulated power source can be used to supply  $V_{DD}$  voltage to the platform and the TPA102 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 TPA102 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.

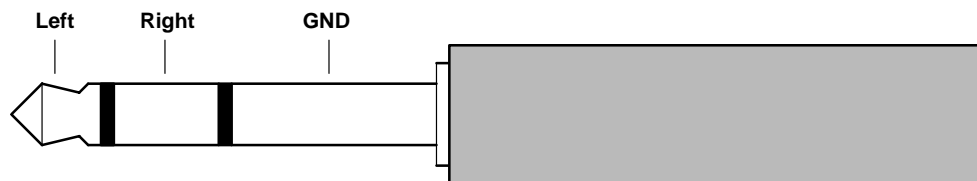
#### 3.3.5.2 Outputs

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 TPA102 MSOP EVM 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





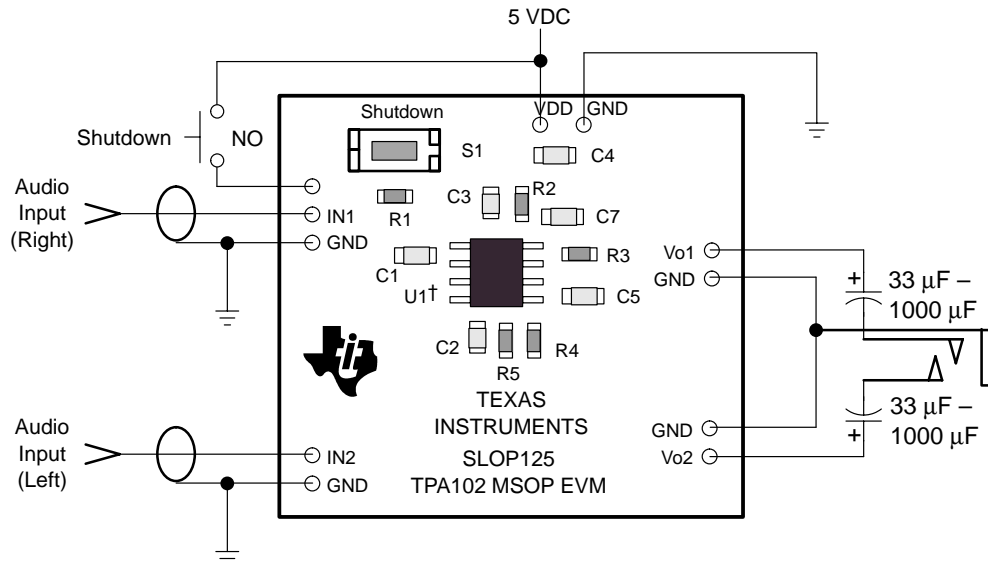
### 3.4 Using the TPA102 MSOP EVM Stand-Alone

Using the TPA102 MSOP audio power amplifier evaluation module stand-alone is much the same as using it with the platform. The same 2.5-V to 5.5-V power supply requirement exists.

Note that the shutdown 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 TPA102 MSOP EVM Connected as a Stereo Headphone Amplifier

Figure 3–8. TPA102 MSOP EVM Connected as a Stereo Headphone Amplifier



† Due to the very small size of the MSOP IC package, the standard part number TPA102 is replaced with the code TIAAC

### 3.5 TPA102 MSOP Audio Power Amplifier Evaluation Module Parts List

Table 3–1. TPA102 MSOP EVM Parts List

Ref.	Description	Size	EVM Qty.	Manufacturer/ Part Number	Vendor/Number
C1, C2, C3, C5	Capacitor, 1 $\mu$ F, 80%/–20%, Non-polarized, SMD	0603	4	Murata GRM39-Y5V105Z10PT	Newark
C4	Capacitor, 10 $\mu$ F, 6.3 V, SMD	A	1	Panasonic ECS-TOJY106R	Digi-Key PCS1106CT-ND
R1, R2, R5	Resistor, 20 k $\Omega$ , 1/16 W, 5%, SMD	0603	3	Panasonic ERJ-3GSYJ203	Digi-Key
R3, R4	Resistor, 80 k $\Omega$ , 1/16 W, 5%, SMD	0603	2	Panasonic ERJ-3GSYJ803	Digi-Key
S1	Switch, momentary	SMD	1	Panasonic P8048SCT-ND	Digi-Key P8048SCT-ND
U1	IC, TPA102, audio amplifier, 150 mW, 2 channel, SMD	MSOP-8	1	TI TPA102DGN†	
	Terminal post headers		11	Sullins	Digi-Key S1022-36-ND
PCB1	PCB, TPA102 MSOP EVM		1		

† Due to the very small size of the MSOP IC package, the standard part number TPA102 is replaced with the code TIAAC

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