TEXAS INSTRUMENTS

TPA301
Audio Power Amplifier Evaluation Module

User's Guide

2001

Mixed-Signal Products

SLOU014A

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Preface

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.
- ***TPA301 350-mW Low-Voltage Audio Power Amplifier*** (literature number SLOS208) This is the data sheet for the TPA301 audio amplifier integrated circuit.

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Chapter 1

Introduction

This chapter provides an overview of the Texas Instruments (TI™) TPA301 audio amplifier evaluation module (SLOP115). 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 Feature Highlights

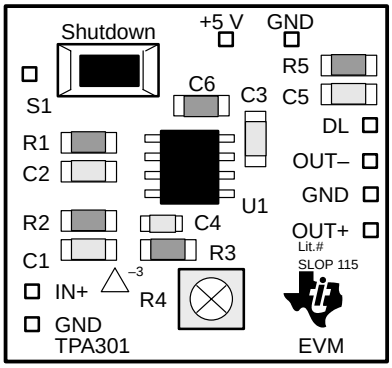
The TI TPA301 audio amplifier evaluation module and the TI plug-n-play audio amplifier evaluation platform include the following features:

- TPA301 Low-Voltage Audio Power Amplifier Evaluation Module
  - Single channel, bridge-tied load (BTL) or single-ended operation
  - 3.3-V and 5-V operation
  - 350 mW output power into 8 Ω at 5 V, BTL
  - Ultra-low current consumption in shutdown/mute mode
  - Internal thermal and short-circuit protection
  - Module gain adjustable between approximately 2 and 22
- 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 DC V_{CC} supply inputs
  - External regulated V_{DD} supply input
  - Socket for on-board 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 TPA301 audio power amplifier evaluation module is a complete, low-power single-channel audio power amplifier. It consists of the TI TPA301 350-mW low-voltage audio power amplifier IC 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 TPA301 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 pair of TPA301 evaluation modules 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 TPA301 EVM Specifications

Supply voltage range, V_{DD}	2.5 V to 5.5 V
Supply current, I_{DD}	250 mA, max
Continuous output power, P_O: 8-Ω BTL, V_{DD}=5 V:	350 mW
32-Ω BTL, V_{DD}=5 V:	75 mW
Audio input voltage, V_I	2 Vpp, max
Minimum load impedance, R_L	8 Ω

Chapter 2

Quick Start

The steps in this chapter can be followed to quickly prepare the TPA301 audio amplifier EVM for use. While using the TPA301 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, 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 TPA301 EVM and will cause the TPA301 to mute 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 TPA301

EVM	JP6	JP7	JP8	S2	S3
TPA301	Mute	X	Hi	Note 2	X

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

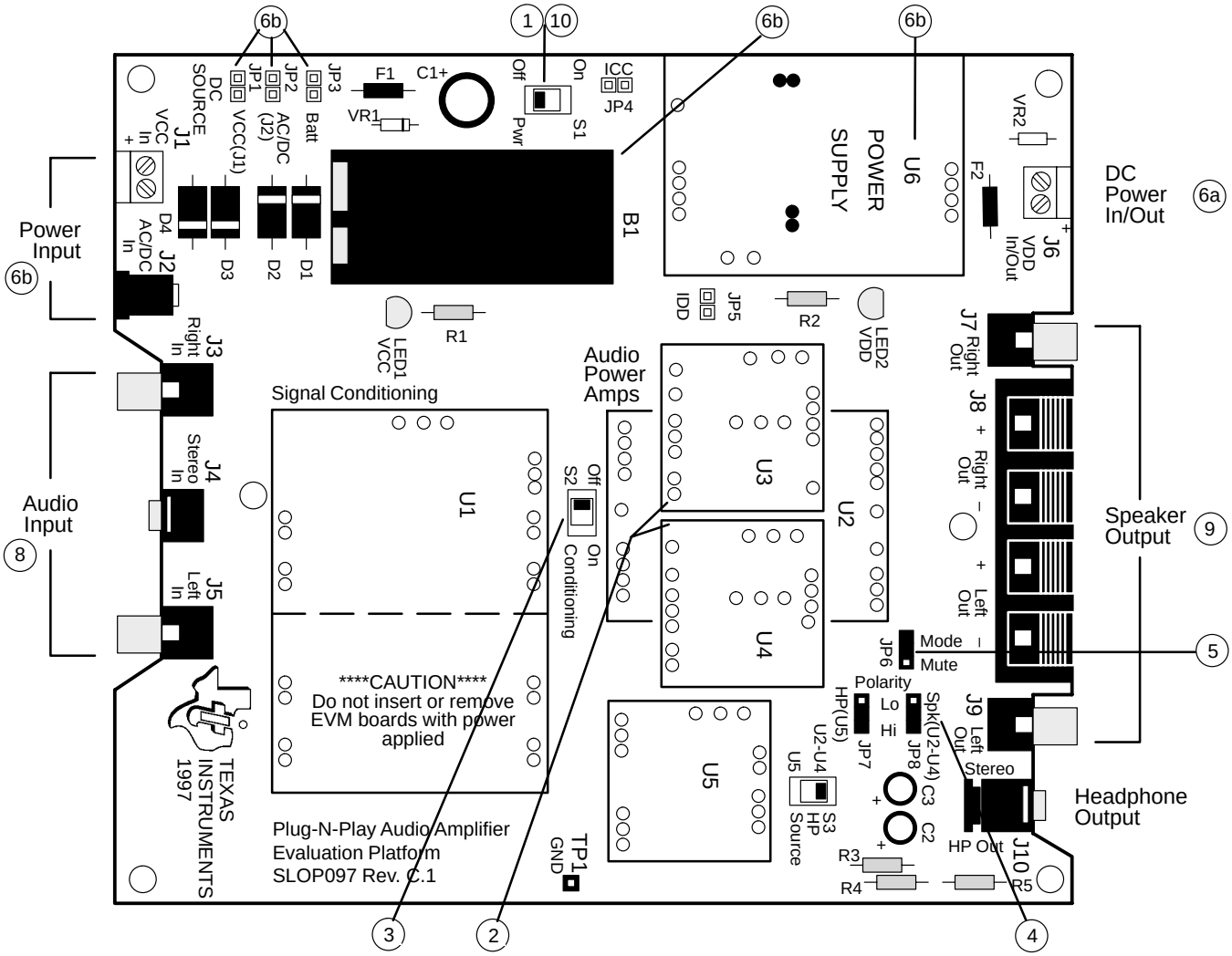
Power Supply Input Polarity and Maximum Voltage

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 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

Use the following steps when using the TPA301 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 TPA301 module in platform sockets **U3** and **U4** for stereo operation (or a module in either **U3** *or* **U4** for single channel operation)**,** 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 ***Hi***
5) Set jumper **JP6** to select the ***Mute*** control input (causes the TPA301 to mute if a plug is inserted into platform headphone jack **J10**)

Table 2–2. Platform Jumper and Switch Settings for the TPA301

EVM	JP6	JP7	JP8	S2	S3
TPA301	Mute	X	Hi	Note 2	X

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 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 adjustments and EVM gain, **R4**, are 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 8-Ω – 32-Ω speakers to left and right RCA jacks **J7** and **J9** or to stripped wire connectors **J8**

❑ **Power-up**

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

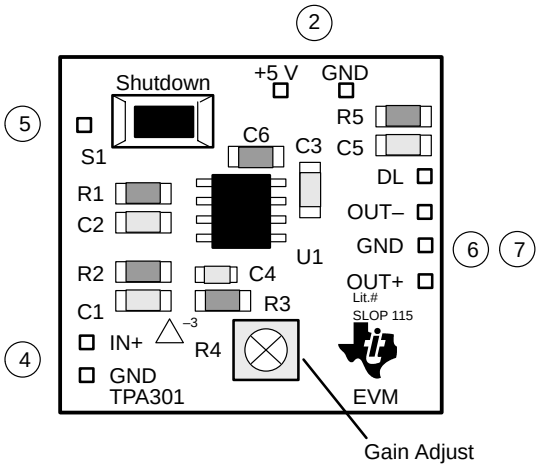
Platform LED2 should light indicating the presence of V_{DD}, and the evaluation modules installed on the platform should begin operation.

11) Adjust the signal source level and EVM gain level (**R4**) as needed

2.3 Quick Start List for Stand-Alone

Use the following steps to use the TPA301 EVM stand-alone or when connecting it into existing circuits or equipment. Connections to the TPA301 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 **+5V** and **GND** pins taking care to observe marked polarity

❑ **Inputs and outputs**

3) Ensure that signal source level adjustments and EVM gain (**R4**) are set to minimum

4) Connect the audio source to the module **IN+** and **GND** pins taking care to observe marked polarity

5) Connect the **Shutdown** pin to V_{DD} through a normally open switch

6) For BTL output, connect an 8-Ω – 32-Ω speaker to the module **OUT+** and **OUT–** pins, or

7) For single-ended output, connect a headphone or an 8-Ω – 32-Ω speaker to the module **OUT+** and **GND** pins through a 33 μF to 1000 μF output-coupling capacitor (figure 3–9)

❑ **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 and EVM gain level (**R4**) as needed

Chapter 3

Details

This chapter provides details on the TPA301 IC, the evaluation module, and the steps in the Quick-Start List, additional application information, and a parts list for the TPA301 evaluation module.

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3.1 Precautions

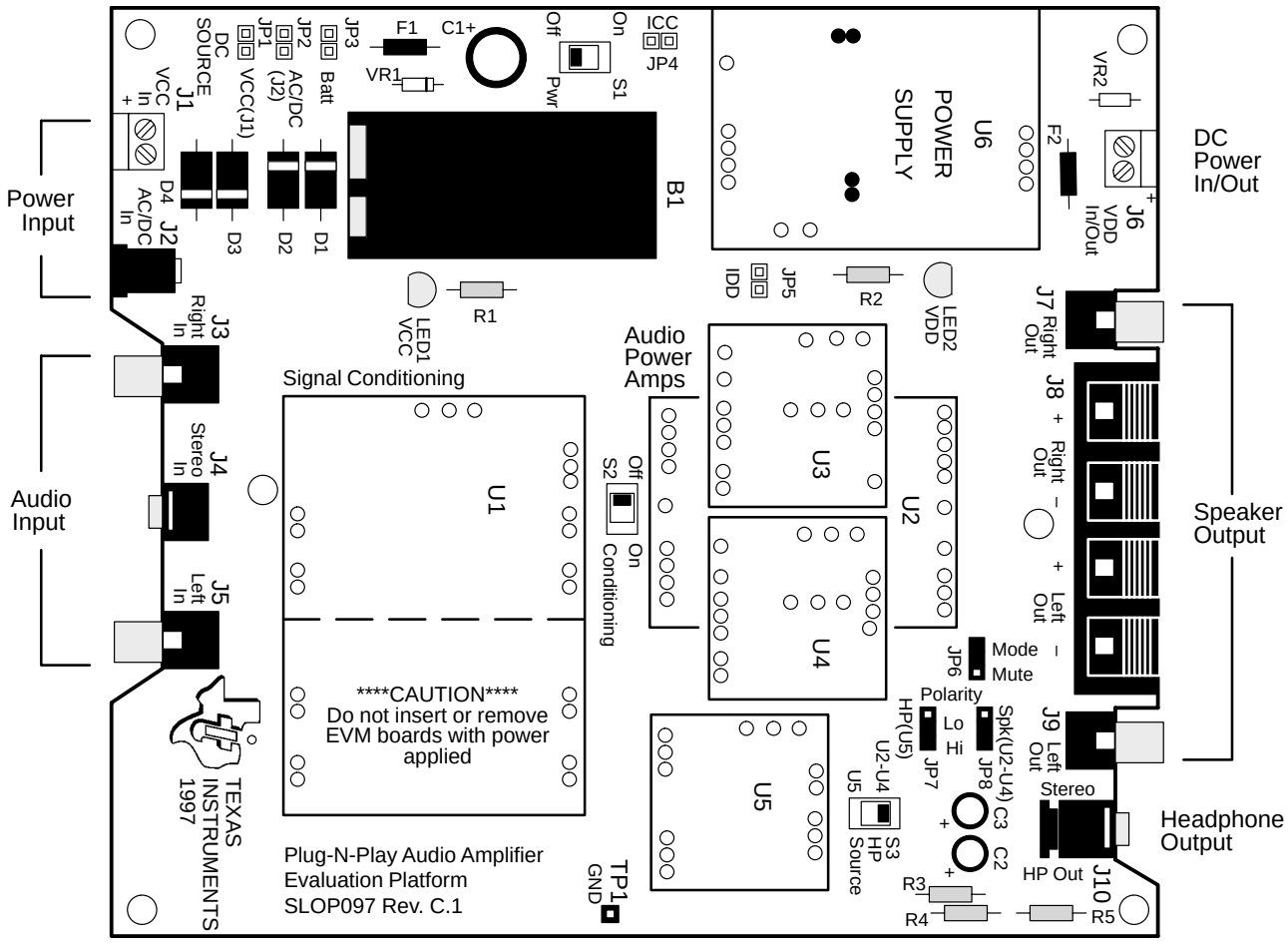
Power Supply Input Polarity and Maximum Voltage

Always ensure that the polarity and voltage of the external power connected to V_{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 TPA301 Audio Power Amplifier Evaluation Module

The TPA301 audio power amplifier evaluation module is powered by a TPA301 350-mW low-power audio amplifier IC and includes onboard gain adjustment, a shutdown control signal input with onboard switch, and can be operated in either the BTL or single-ended output mode.

The 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 to 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. TPA301 EVM

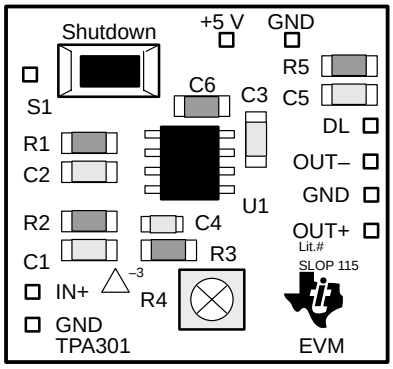
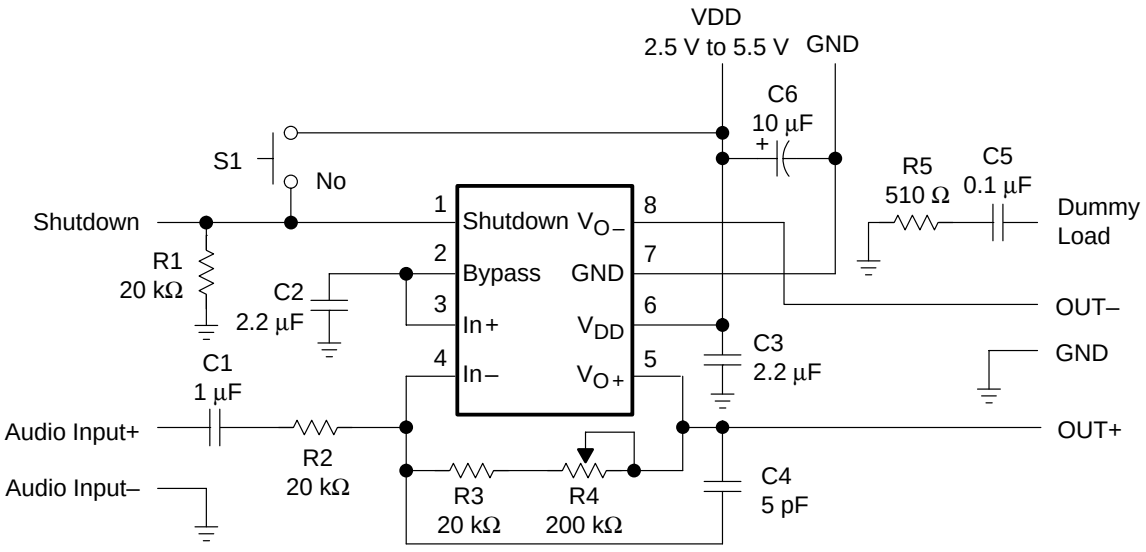


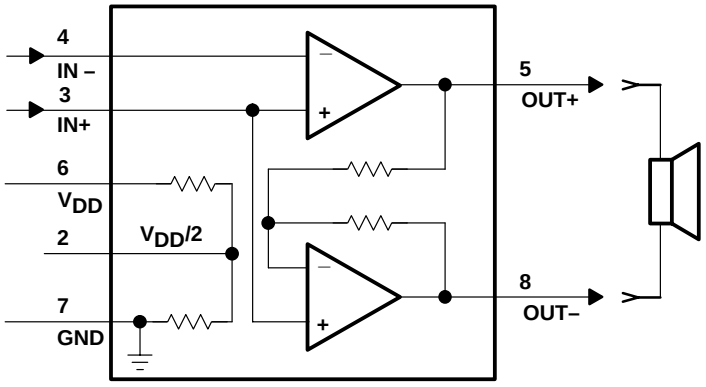
Figure 3–3. TPA301 EVM Schematic Diagram



3.2.1 TPA301 Audio Amplifier IC

The TPA301 audio amplifier IC is a CMOS device intended primarily for bridge-tied load (BTL) operation in battery-powered applications. It is supplied in a very small surface-mount package and has been designed to operate from low supply voltages (between approximately 2.5 V and 5.5 V) and deliver up to approximately 350 mW into an 8-Ω, BTL (Figure 3–4). Typical applications include portable phones, toys, games, and similar hand-held audio applications.

Figure 3–4. TPA301 Amplifier IC



The amplifier IC includes two separate amplifiers that operate 180° out-of-phase with each other for increased power (BTL). The speaker load is connected directly across OUT+ and OUT–, and neither line is connected to ground. Although the amplifier can operate in the single-ended mode, there are many benefits to the BTL output configuration including no bulky output coupling capacitors and quadruple the output power. For more information, see the TPA301 amplifier IC data sheet, TI Literature Number SLOS208.

3.2.2 BTL Operation

To operate in the bridge-tied load output configuration, the module output signal from OUT+ must go through the speaker load and be returned directly to OUT–, and *not* to system ground. This requires that the OUT– line be isolated not only from system ground, but also from the OUT– lines of any other amplifiers in the system. The platform provides such isolated output lines from the EVM sockets directly to separate left and right speaker connectors.

3.2.3 SIngle-Ended Operation

For single-ended operation, the speaker (or headphone) load is connected to the module OUT+ output pin through a coupling capacitor, and to platform/system ground. The module OUT– pin can be connected to the module DL pin, a dummy-load circuit on the module, for improved amplifier stability (however, this is not required). A 470-µF electrolytic coupling capacitor is provided on the platform in the signal path to the headphone output jack.

In the single-ended mode, the amplifier inside the TPA301 IC that drives the OUT– line still operates and dissipates power even though it is not being used to help drive the load. A better choice for low-power applications that operate in the single-ended mode from time to time might be the TPA311 (SLOP116), which shuts down the unused internal amplifier for reduced power consumption when operating in the single-ended mode.

3.2.4 Module Gain

The TPA301 evaluation module can be set for an overall gain of between 2 and 22 by adjustment of the the onboard gain control, R4. The TPA301 amplifier IC, as most other amplifiers, exhibits its best distortion and noise performance at lower gain levels (see the TPA301 data sheet). Even so, the TPA301 at its highest gain setting has significantly less distortion than most low-cost speakers.

Gain versus total harmonic distortion (THD) should be considered in each application. Both the module input signal level and the TPA301 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 TPA301 input, and the TPA301 gain kept as low as possible.

3.2.5 Shutdown

When the shutdown terminal of the TPA301 amplifier IC is taken high, the IC ceases operation and enters an ultralow-power state. This is accomplished by applying a control signal to the module shutdown 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 P-N-P platform can generate the shutdown (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 (JP8).

3.3 Using The TPA301 EVM With the Plug-N-Play Evaluation Platform

The TPA301 audio amplifier evaluation module was designed to be used with the TI plug-n-play audio amplifier evaluation platform. It simply plugs into socket U3 or U4.

The following paragraphs provide additional details for using the TPA301 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 U3 or U4 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

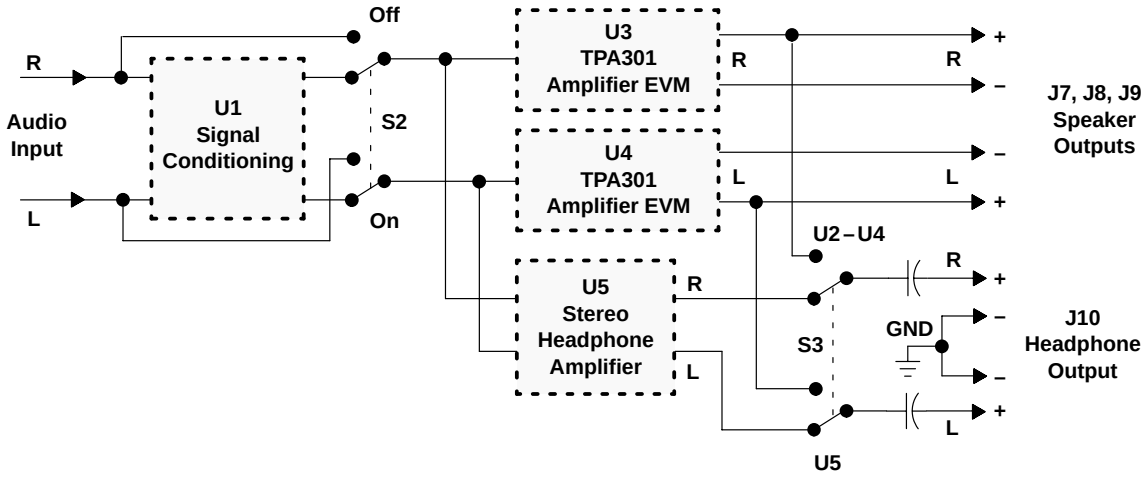
3.3.1.2 EVM Removal

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 small amount
3) Change to the opposite side of the module and use the tool to pry that side up a small amount
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 of 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 TPA301 power amplifiers.

❑ Switch **S2** selects signal conditioning or bypasses it

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 µF electrolytics) and can output either the signal from the headphone amplifier in socket U5, or the signal from the TPA301 power amplifiers installed in sockets U3 and U4, as determined by the setting of headphone source select switch S3.

When S3 is set to the power amplifier position (U2 – U4), the headphone jack is connected to the TP301 power amplifier OUT+ output lines. When a plug is inserted into the jack, signals output through J10 are returned to platform ground, requiring single-ended power amplifier operation. A switch inside the headphone jack produces a control signal that can be routed to the power amplifier sockets to shut down the TPA301 EVMs when a plug is inserted.

Source select switch S3 connects the headphone jack to the output lines of either the headphone amplifier socket U5, or the power amplifier sockets (U2 – U4).

- To keep the TPA301 amplifier outputs separated, set switch **S3** to the headphone amplifier position (***U5***) and use the speaker outputs (**J7**, **J8**, and **J9**)
- To route the TPA301 amplifier outputs to the headphone output jack (**J10**), set switch **S3** to the power amplifier position (***U2 – U4***) and reverse the jumper on **JP8** to prevent muting of the TPA301 module when a plug is inserted into **J10** — use this setting *only* if the TPA301 EVMs are to drive single-ended loads connected to **J10**

3.3.3 Muting

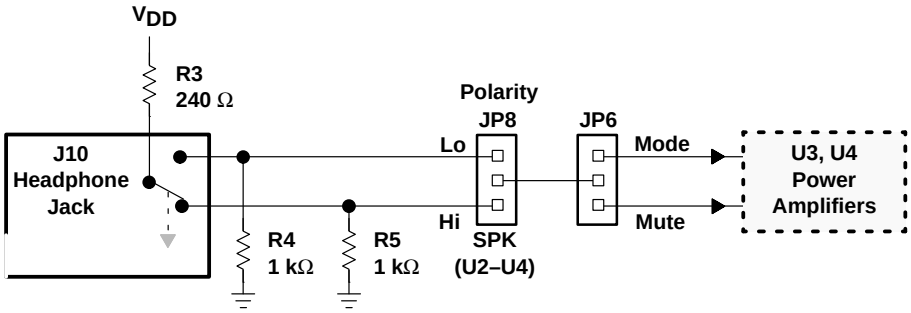
The TPA301 EVM is equipped with a mute (shutdown) control input pin. When this input is tied to V_{DD}, the TPA301 amplifier IC on the module shuts down and assumes an ultra-low power mode. When the control input is tied to GND or allowed to float, amplifier operation resumes.

The typical application, as often found in notebook computers, portable audio products, and such, would have the internal speakers mute when headphones are plugged into the headphone jack, or have internal speakers mute when external speakers are connected. In applications using separate speaker and headphone amplifiers, the one not being used can be shut down (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. Each control line is pulled down by a 1-kΩ 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 Ω resistor (R3) depending on whether a plug is inserted in J10 or not (Figure 3–6).

Figure 3–6. Mute/Mode and Polarity Control



3.3.3.2 Mute Polarity Select (JP8)

A three-pin jumper header (JP8), functioning as a SPDT switch, selects the control signal polarity by connecting either the active-low or the active-high line from the headphone jack to jumper JP6.

- To mute the TPA301 amplifier module *when* a plug is inserted into the headphone jack, jumper **JP8** to ***Hi***.
- To mute the TPA301 amplifier module *until* a plug is inserted into the headphone jack, jumper **JP8** to ***Lo***.

3.3.3.3 Mute Select (JP6)

A second three-pin jumper header (JP6) routes the control signal from the headphone jack to either the mute or the mode pin of the evaluation module.

- To mute the TPA301 amplifier module when a plug is inserted into the headphone jack, jumper **JP6** to ***MUTE***.
- To not affect the TPA301 amplifier when a plug is inserted into the headphone jack, jumper **JP6** to ***MODE*** or leave **JP6** unjumpered.

3.3.4 Power Requirements

The TPA301 audio evaluation module can operate from any voltage between approximately 2.5 V and 5.5 V, however, the TPA301 amplifier IC on the module is characterized for operation at 3.3 V and 5 V. For best performance (highest output power with lowest distortion), the module should be operated at approximately 5 V unless there is a specific reason for operating it from a lower voltage.

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 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 TPA301 evaluation modules 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 TPA301 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.

3.3.5 Inputs and Outputs

The TI plug-n-play audio amplifier evaluation platform is equipped with several standard conectors 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.

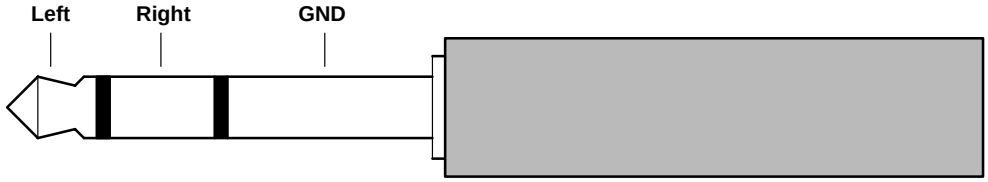
3.3.5.2 Outputs

Amplified audio output signals 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 a miniature (1/8″) stereo phone jack (J10), for headphones.

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 TPA301 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 TPA301 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), requiring single-ended operation of the power amplifiers.

Figure 3–7. Typical Headphone Plug



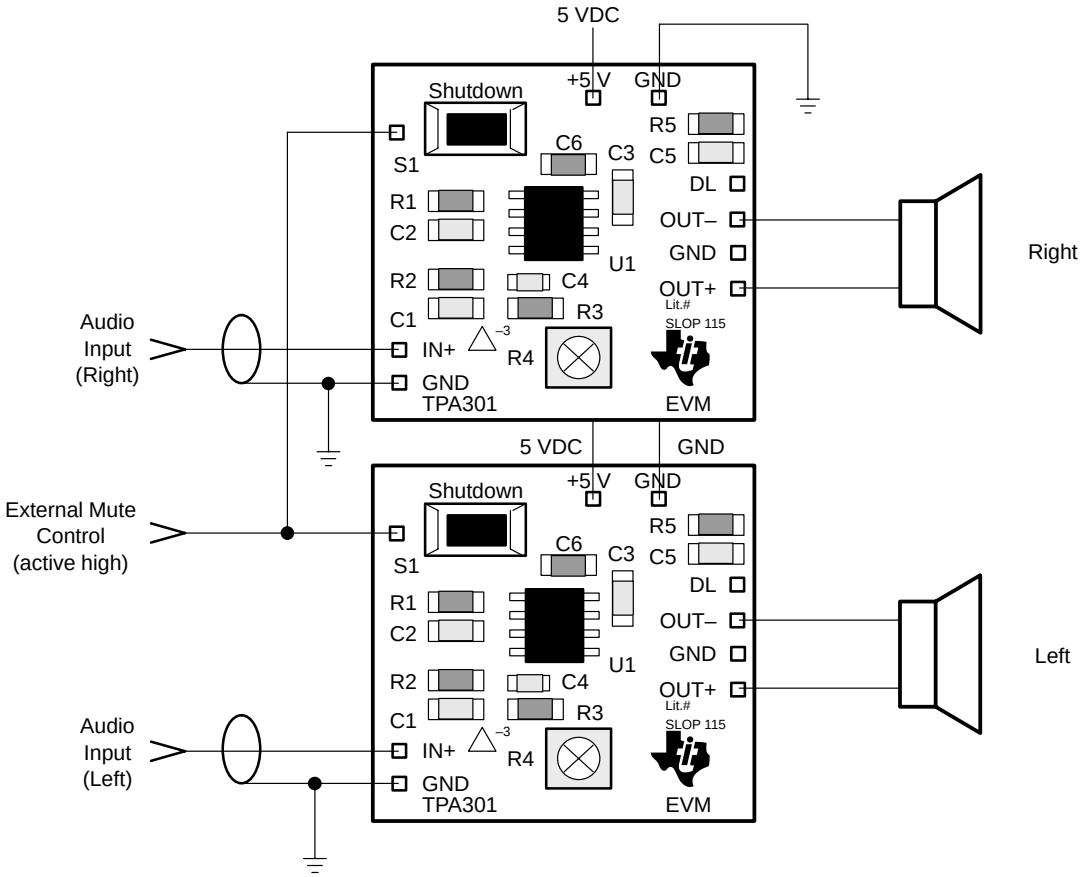
3.4 Using The TPA301 EVM Stand-Alone

Using the TPA301 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 range and the isolated OUT+ and OUT– lines for BTL operation requirement exists.

Note that the mute signal applied to the EVM shutdown pins must be able to supply enough current to overcome the pulldown resistors on the modules (20 kΩ || 20 kΩ for two EVMs).

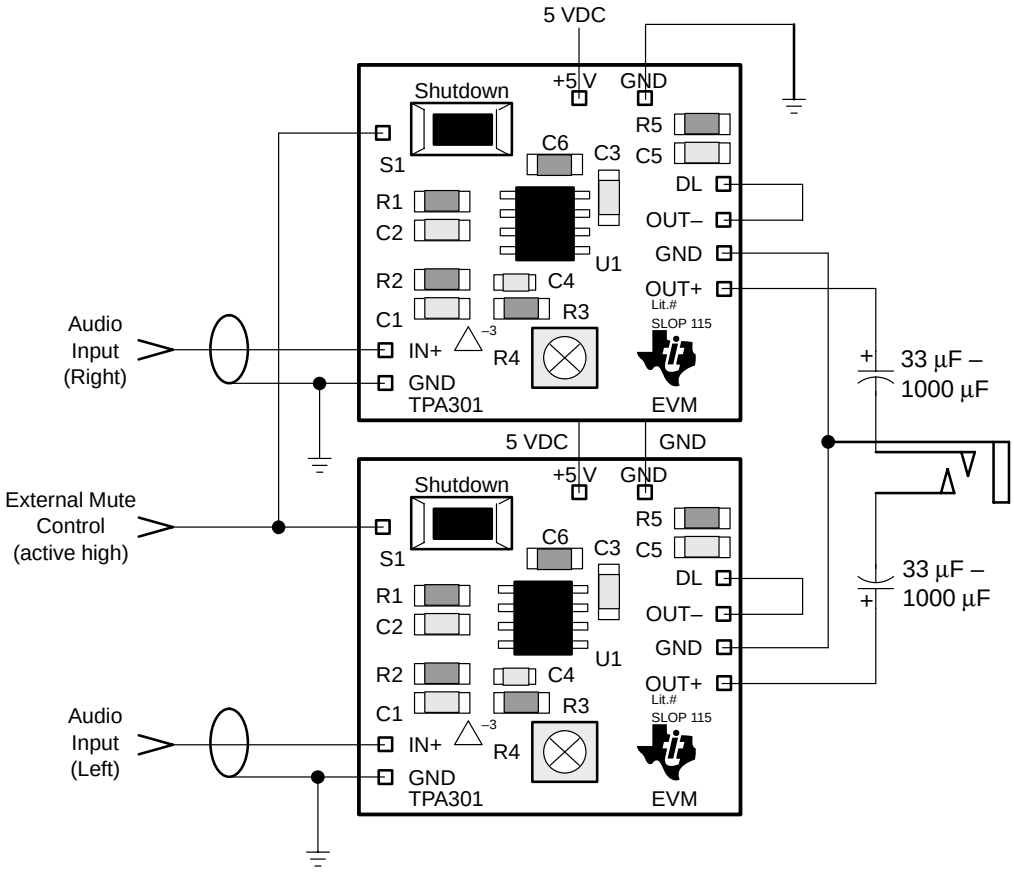
3.4.1 TPA301 EVM Connected for BTL Output

Figure 3–8. TPA301 EVM Connected for Stereo BTL Output



3.4.2 TPA301 EVM Connected for Single-Ended Output

Figure 3–9. TPA301 EVM Connected for Stereo Single-Ended Output



3.5 TPA301 Audio Power Amplifier Evaluation Module Parts List

Table 3–1. TPA301 EVM Parts List

Ref.	Description	Size	EVM Qty.	Manufacturer/ Part Number	Vendor Number
R4	Trim Pot, 200 kΩ Cermet ST SL, (through hole)		1	Bourns 3323P-1-204	Digi-Key 3323P-204-ND
C6	Capacitor, 10 μF, 6.3 V	A	1	Panasonic ECS-TOJY106R	Digi-Key PCS1106CT-ND
C1	Capacitor, 1 μF, +80%/–20%, nonpolarized	1206	1	Murata GRM42-6Y5V105Z16BL	Newark 93F2254
C2, C3	Capacitor, 2.2 μF, 20%, nonpolarized	1206	2	TDK C3216X5R1A225	
C5	Capacitor, 0.1 μF, 16 V	1206	1	Panasonic ECS-H1CY105R	Digi-Key PCT104BCT-ND
C4	Capacitor, 5 pF	0805	1	Panasonic ECU-V1H050CCN	Digi-Key PCC050CNCT-ND
R1, R2, R3	Resistor, 20 kΩ, 1/8 W, 5%	1206	3	Panasonic ERJ-8GEYJ203	Digi-Key P20KECT-ND
R5	Resistor, 510 Ω, 1/8W	1206	1	Panasonic ERJ-8GEYJ511	Digi-Key P510ECT-ND
S1	Switch, momentary		1	Panasonic P8048SCT-ND	Digi-Key P8048SCT-ND
U1	IC, TPA301, audio amplifier, 350 mW, mono	SOIC-8	1	TI TPA301	
PCB1	PCB, TPA301 sample EVM		1		

Note: All items are SMD except as noted.