

TPA721 MSOP Audio Power Amplifier Evaluation Module

User's Guide

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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.
- ***TPA721 700-mW Low-Voltage Audio Power Amplifier*** (literature number SLOS231) This is the data sheet for the TPA721 audio amplifier integrated circuit.

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Introduction

This chapter provides an overview of the Texas Instruments (TI™) TPA721 MSOP audio amplifier evaluation module (SLOP215). 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

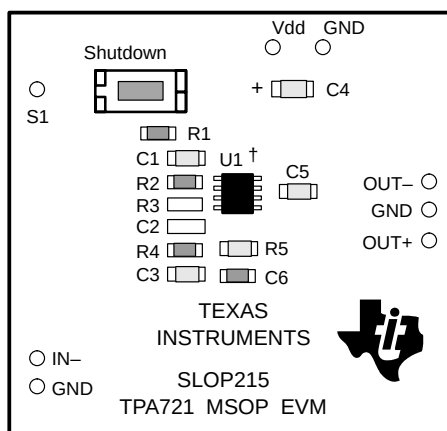
The TI TPA721 MSOP audio amplifier evaluation module and the TI plug-n-play audio amplifier evaluation platform include the following features:

- ❑ TPA721 Low-Voltage Audio Power Amplifier Evaluation Module
 - Single channel, bridge-tied load (BTL)
 - 3.3-V and 5-V operation
 - 700-mW output power into 8 Ω at 5 V, BTL
 - Internal depop circuitry
 - Internal thermal and short-circuit protection
 - Module gain is set at -4 V/V in BTL mode, -2 V/V in SE mode
- ❑ 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/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 TPA721 MSOP audio power amplifier evaluation module is a complete, low-power single-channel audio power amplifier. It consists of the TI TPA721 700-mW low-voltage 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 TPA721 Audio Amplifier Evaluation Module



† Due to the very small size of the MSOP IC package, the standard part number TPA721 is replaced with the code TIABC.

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, with room for a pair of TPA721 MSOP evaluation modules, 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 TPA721 EVM Specifications

Supply voltage range, V_{DD}	2.5 V to 5.5 V
Supply current, I_{DD}	450 mA, max
Continuous output power, P_O : 8- Ω BTL, $V_{DD} = 5$ V	700 mW
Audio input voltage, V_I	2 V _{pp} , max
Minimum load impedance, R_L	8 Ω

Quick Start

Follow the steps in this chapter to quickly prepare the TPA721 MSOP audio amplifier EVM for use. Using the TPA721 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 TPA721 MSOP EVM. They will cause the TPA721 amplifier IC on the EVM 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 TPA721 MSOP EVM

EVM	JP6	JP7	JP8	S2	S3
TPA721	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

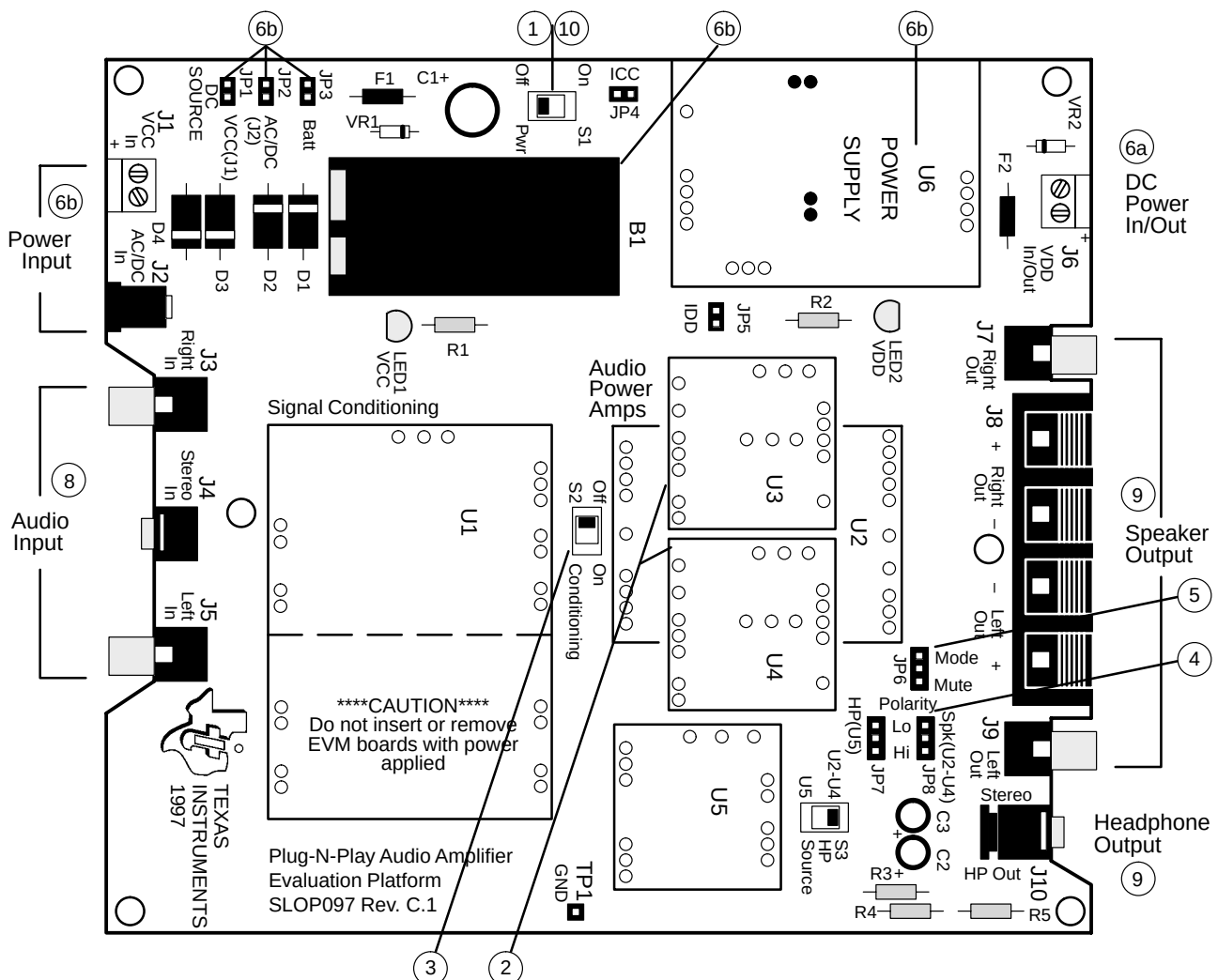
Power Supply Input Polarity and Maximum Voltage

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

Follow these steps when using the TPA721 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 TPA721 MSOP 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 TPA721 to shut down if a plug is inserted into platform headphone jack **J10**).

Table 2–2. Platform Jumper and Switch Settings for the TPA721 MSOP EVM

EVM	JP6	JP7	JP8	S2	S3
TPA721	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 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 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 on-board regulator EVM are used to provide V_{DD} , set platform power switch **S1** to **ON**.

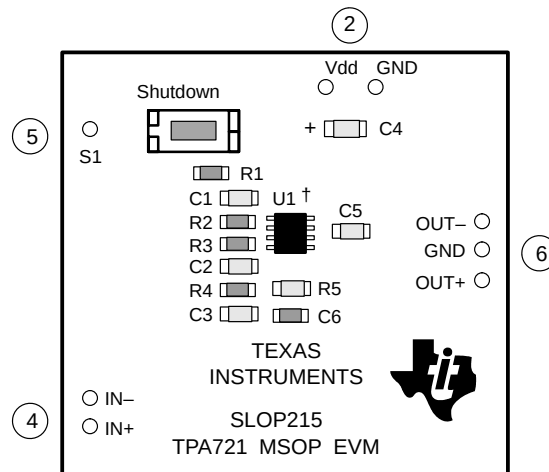
Platform LED2 should light indicating the presence of V_{DD} , and the evaluation modules installed on the platform should begin operation.

- 11) Adjust the signal source level as needed.

2.3 Quick Start List for Stand-Alone

Follow these steps to use the TPA721 MSOP EVM stand-alone or when connecting it into existing circuits or equipment. Connections to the TPA721 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 TPA721 is replaced with the code TIABC

☐ 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 positive lead from the audio source to the module **IN-** pin and the negative lead to the **In+** pin.
- 5) Connect the **S1** pin to V_{DD} through a normally open switch.
- 6) Connect an 8- Ω – 32- Ω speaker to the module **OUT+** and **OUT-** pins.

☐ Power Up

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

The EVM should begin operation.

- 8) Adjust the signal source level as needed.

Details

This chapter provides details on the TPA721 IC, the evaluation module, the steps in the Quick-Start List, additional application information, and a parts list for the TPA721 MSOP evaluation module.

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3.1 Precautions

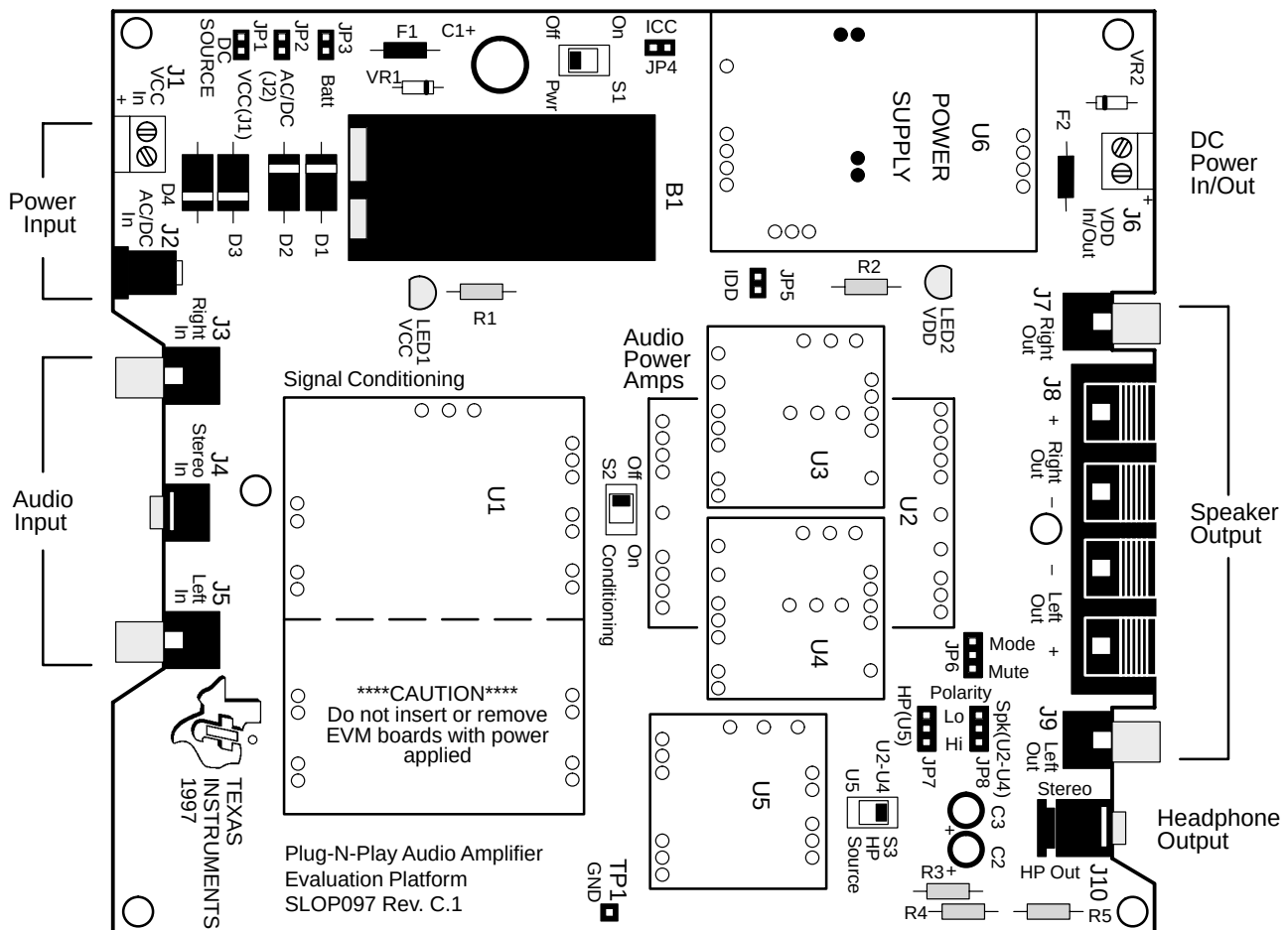
Power Supply Input Polarity and Maximum Voltage

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 TPA721 MSOP Audio Power Amplifier Evaluation Module

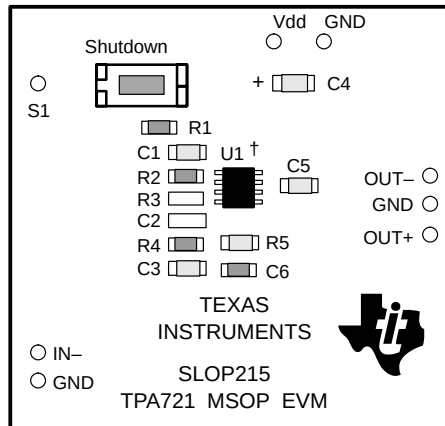
The TPA721 MSOP audio power amplifier evaluation module is powered by a TPA721 700-mW low-power audio amplifier IC. The EVM includes a shutdown control signal input with an onboard switch for manual shutdown.

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, the EVM can be wired directly into existing circuits and equipment when used stand-alone.

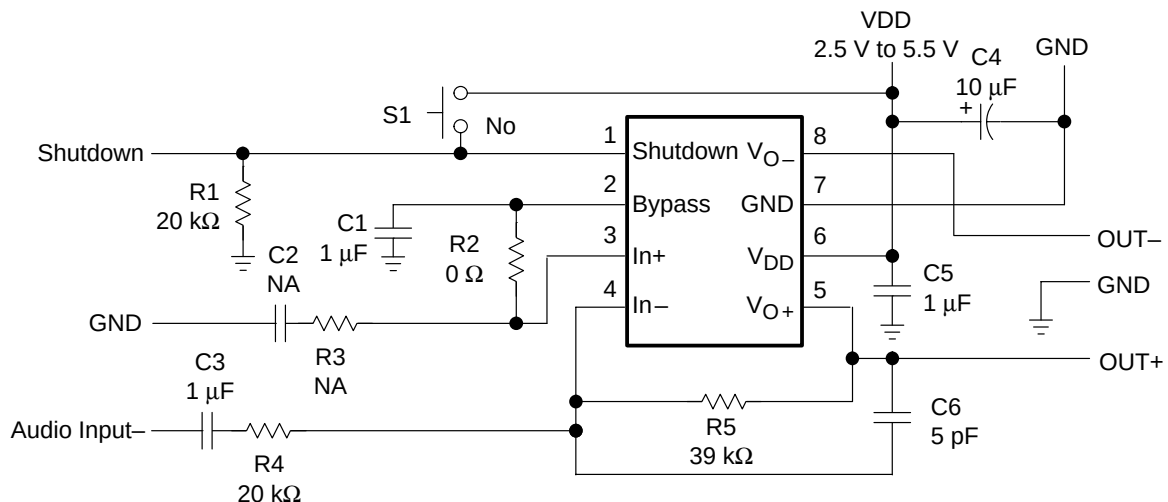
The module appears in Figure 3–2 and its schematic is shown in Figure 3–3.

Figure 3–2. TPA721 MSOP EVM



† Due to the very small size of the MSOP IC package, the standard part number TPA721 is replaced with the code TIABC

Figure 3–3. TPA721 MSOP EVM Schematic Diagram

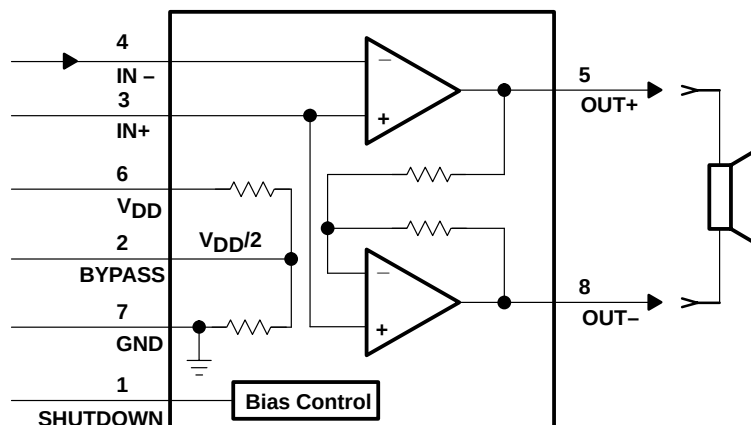


Note: NA is not assembled on PCB.

3.2.1 TPA721 Audio Amplifier IC

The TPA721 audio amplifier IC is a CMOS device intended for bridge-tied load (BTL) operation in battery-powered applications. Supplied in a very small surface-mount package, the TPA721 has been designed to operate from low supply voltages (between approximately 2.5 V and 5.5 V) and to deliver up to approximately 700 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. TPA721 Amplifier IC



The IC includes two separate internal amplifiers, depop circuitry, and a shutdown control. The two amplifiers operate as mirror images of each other in the bridge-tied load (BTL) configuration for increased power. BTL operation provides many benefits, including quadruple the output power of single-ended operation and no need for bulky output coupling capacitors. For more information, see the TPA721 amplifier IC data sheet, TI literature number SLOS231.

3.2.2 BTL Operation

The TPA721 amplifier IC operates in the BTL mode, which means that the 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 amplifier EVM sockets directly to separate left and right speaker connectors.

3.2.3 Module Gain

The TPA721 MSOP evaluation module has a set gain of 2. However, the gain can be adjusted to a maximum of 22 by changing the value of resistor R5 (Figure 3–3). Use the following equation to determine value of R4:

$$\text{Gain} = \frac{-R5}{R4} \times 2 \quad \text{for BTL}$$

The TPA721 amplifier IC, like most other amplifiers, exhibits its best distortion and noise performance at lower gain levels (see the TPA721 data sheet). Even so, the TPA721 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 TPA721 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 TPA721 input, and the TPA721 gain should be kept as low as possible.

3.2.4 Shutdown

When the shutdown terminal of the TPA721 amplifier IC is taken high, the IC ceases operation and enters a low-power state. This is accomplished by applying a control signal to the module shutdown pin (S1) or by pressing the shutdown switch 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 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).

3.2.5 Internal Depop Circuitry

Internal depop circuitry reduces or eliminates the various turn-on transients that might appear at the output during the transition from power off or shutdown mode to normal operation. These output transients are often heard as a pop from the speaker and occur when the two amplifiers in the IC turn on or off at different rates, causing a voltage spike to appear across the output. The depop circuitry adds a delay with an RC network at the amplifier IC bypass pin to help ensure that the amplifiers turn on and off at the same rate, thus eliminating the pop. For best results, bypass capacitor C1 should have a value between 0.1 μF and 2.2 μF . A 1 μF unit was selected for the EVM.

3.3 Using The TPA721 MSOP EVM With the Plug-N-Play Evaluation Platform

The TPA721 MSOP 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 TPA721 MSOP 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.

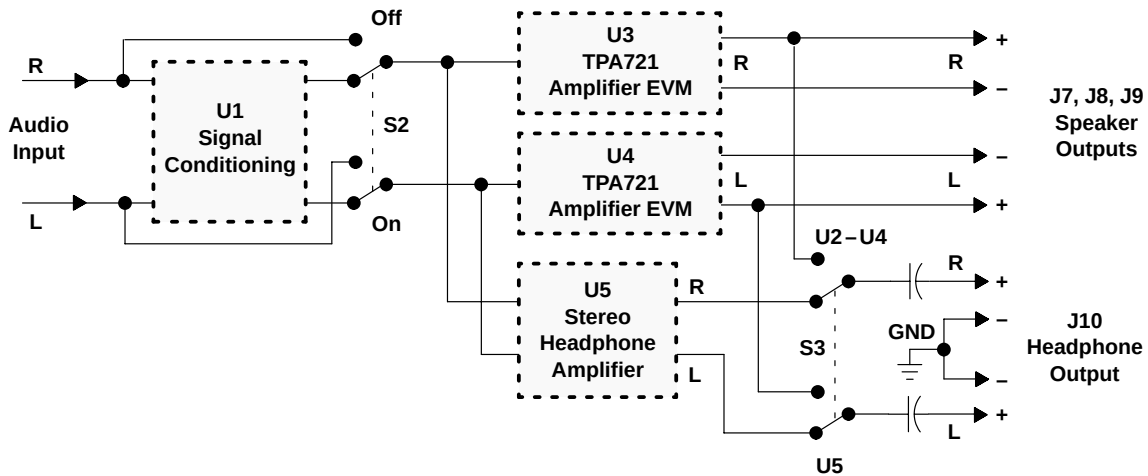
3.3.1.2 EVM Removal

- 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 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 TPA721 power amplifiers.

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

3.3.3 Mute/Mode

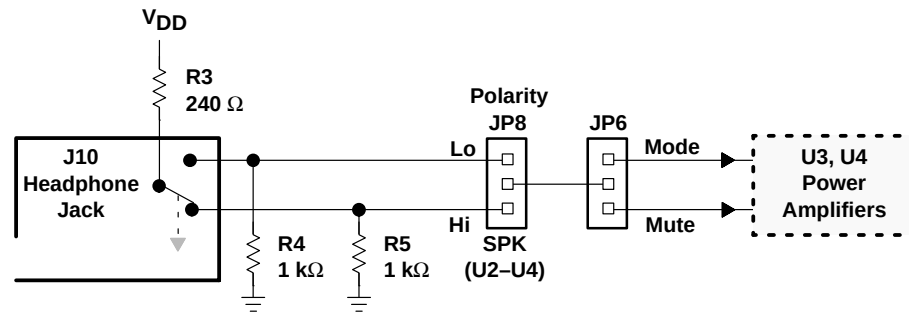
The TPA721 MSOP EVM is equipped with a shutdown (mute) control input pin. When this input is tied to V_{DD} , the TPA721 amplifier IC on the module shuts down and assumes a low-power mode. When the EVM control input is tied to GND or allowed to float, amplifier operation resumes.

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 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 (Figure 3–6). Each control line is pulled down by a 1-k Ω 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 or not a plug is inserted in J10.

Figure 3–6. Mute/Mode and Polarity Control



3.3.3.2 Mute/Mode Select (JP6)

A 3-pin jumper header (JP6) on the platform, functioning as a SPDT switch, routes the control signal from the headphone jack to either the mute control input pin or the mode control input pin of the evaluation module.

- To mute the TPA721 MSOP amplifier module using the control signal from the platform headphone jack, jumper **JP6** to **MUTE**.
- To not affect the TPA721 amplifier when a plug is inserted into the headphone jack, jumper **JP6** to **Mode** or leave **JP6** unjumped.

3.3.3.3 Mute/Mode Polarity Select (JP8)

A second 3-pin jumper header (JP8) on the platform selects the control signal polarity by connecting either the active-high or the active-low line from the headphone jack to jumper JP6.

- ☐ When JP6 is set to mute, use the following JP8 settings for the TPA721:
 - To mute the TPA721 MSOP amplifier module *when* a plug is inserted into the headphone jack, jumper **JP8** to **Hi** (this is the typical setting).
 - To mute the TPA721 MSOP amplifier module *until* a plug is inserted into the headphone jack, jumper **JP8** to **Lo**.
- ☐ When JP6 is set to mode, the TPA721 amplifier is unaffected by the insertion of the headphone plug.

3.3.4 Power Requirements

The TPA721 MSOP audio power amplifier evaluation module can operate from any voltage between approximately 2.5 V and 5.5 V; however, the TPA721 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 TPA721 MSOP 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 TPA721 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 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.

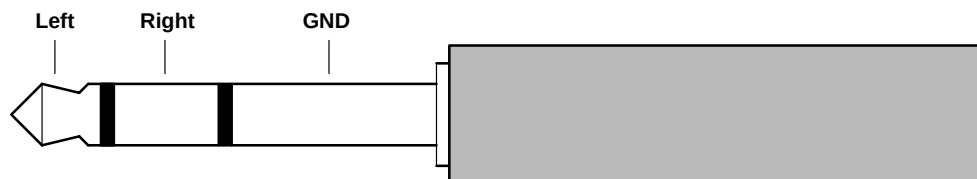
The platform audio signal input jacks (J3, J4, and J5) are of the closed-circuit type, grounding the signal input lines when no plugs are inserted.

3.3.5.2 Outputs

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).

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 TPA721 power amplifier EVMs to operate in the highly-efficient bridge-tied load configuration.

Figure 3–7. Typical Headphone Plug



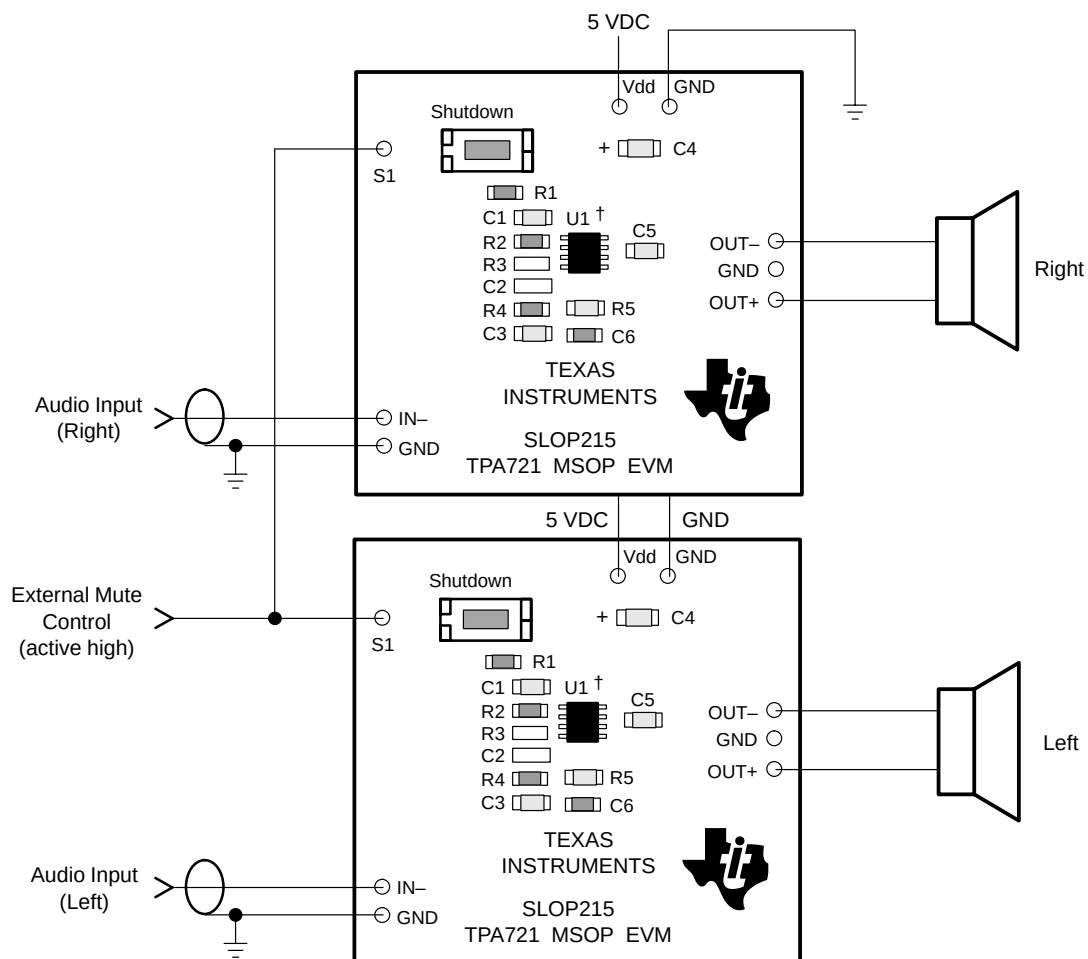
3.4 Using The TPA721 MSOP EVM Stand-Alone

Using the TPA721 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 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 ($20\text{ k}\Omega \parallel 20\text{ k}\Omega$ for two EVMs).

3.4.1 TPA721 MSOP EVM Connected for BTL Output

Figure 3–8. TPA721 MSOP EVM Connected for Stereo BTL Output



† Due to the very small size of the MSOP IC package, the standard part number TPA721 is replaced with the code TIABC.

3.5 TPA721 MSOP Audio Power Amplifier Evaluation Module Parts List

Table 3–1. TPA721 MSOP EVM Parts List

Reference	Description	Size	EVM Qty.	Manufacturer/ Part Number	Vendor Number
C4	Capacitor, 10 μ F, 6.3 V	A	1	Panasonic ECS-TOJY106R	Digi-Key PCS1106CT-ND
C1, C3, C5	Capacitor, 1 μ F, 80%/–20%, nonpolarized	0603	3	Murata GRM39-Y5V105Z10PT	Newark
C2, C6	Capacitor, pad only	0603	0		
R1, R4	Resistor, 20 k Ω , 1/16 W, 5%	0603	2	Panasonic ERJ-3GSYJ203	Digi-Key P20KGCT-ND
R5	Resistor, 39 k Ω , 1/16 W, 5%	0603	1	Panasonic ERJ-3GSYJ393	Digi-Key P39KGCT-ND
R2	Resistor, 0 Ω , 1/16 W	0603	1	Panasonic ERJ-3GSY0R00V	Digi-Key P0.0GCT-ND
R3	Resistor, pad only	0603	1		
S1	Switch, momentary		1	Panasonic P8048SCT-ND	Digi-Key P8048SCT-ND
	Terminal Post Headers		9	Sullins PTC36SABN	Digi-Key S1022-36-ND
U1	IC, TPA721DGN [†] , audio amplifier, 700 mW, mono	MSOP-8	1	TI TPA721DGN	
PCB1	PCB, TPA721 MSOP EVM		1		

[†] Due to the very small size of the MSOP IC package, the standard part number TPA721 is replaced with the code TIABC.

Note: All items are SMD except as noted.