

***TPA6120A2***  
***Evaluation Module***

*User's Guide*

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## **EVM WARNINGS AND RESTRICTIONS**

It is important to operate this EVM within the supply voltage range of  $\pm 5$  V to  $\pm 15$  V.

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Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than  $125^{\circ}\text{C}$ . The EVM is designed to operate properly with certain components above  $125^{\circ}\text{C}$  as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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# Read This First

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### ***About This Manual***

This users guide describes the characteristics, operation, and use of the TPA6120A2 evaluation module (EVM). This users guide includes EVM description, performance specifications, board layout, bill of materials (BOM), and schematic diagram.

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

This document contains the following chapters:

- Chapter 1 – Introduction
- Chapter 2 – Getting Started
- Chapter 3 – Customizing the EVM
- Chapter 4 – EVM Circuit and Layout

### ***Related Documentation From Texas Instruments***

SLOS431 – TPA6120A2 data sheet

### ***If you need Assistance***

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# Introduction

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The TPA6120A2 is a high-fidelity audio amplifier. The amplifier can operate from a split power supply, and is designed for low noise, high dynamic range performance.

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## 1.1 Description

The TPA6120A2 EVM is designed to operate specifically with a split power supply, and is configured such that both left and right channels have a noninverting gain of 2 V/V. The output signal is routed into RCA jacks J1 and J2, as well as the 1/4 inch headphone jack, J10. The EVM is approximately 3 inches x 3 inches square, and comes complete with standoffs.

## 1.2 Performance Specifications

Table 1–1. TPA6120A2 EVM Specifications

	TPA6120A2
Supply voltage range, $V_{CC}$	$\pm 5$ V to $\pm 15$
Power supply current rating required	1 A
Continuous output power, $P_o$ : 32- $\Omega$ stereo, $V_{CC} = \pm 12$ V	2 W
Audio input voltage, $V_I$	$-V_{CC}$ to $V_{CC}$
Minimum load impedance, $Z_{(L)}$	8 $\Omega$

### CAUTION

- 1) Accidental swapping of supply polarities causes damage to the device and can cause damage to the other components on the board.
- 2) Do not short the outputs of the TPA6120A2 to either the positive or negative supply when operating with a split power supply. When operating with a single power supply, do not short the outputs to the positive supply. This damages the device.

# Getting Started

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Follow these steps to use the TPA6120A2 EVM in its original configuration. No soldering is necessary. Connection to the TPA6120A2 EVM can be made with banana plugs, RCA jacks, and a 1/4 inch headphone jack. See Figure 2-1 for an illustration of the top layer.

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## 2.1 Power Supply

- 1) Make sure all external power supplies are turned off.
- 2) Connect an external power supply with the positive voltage set between 5 V and 15 V to the terminal marked +12 V (J8) on the EVM.
- 3) Connect the negative voltage to the terminal marked –12 V (J9), making sure the negative voltage is set to the same magnitude as that of the positive (i.e.,  $\pm 5$  V,  $\pm 12$  V,  $\pm 15$  V).
- 4) Connect the ground of the external supply to the terminal marked GND (J7) on the EVM.

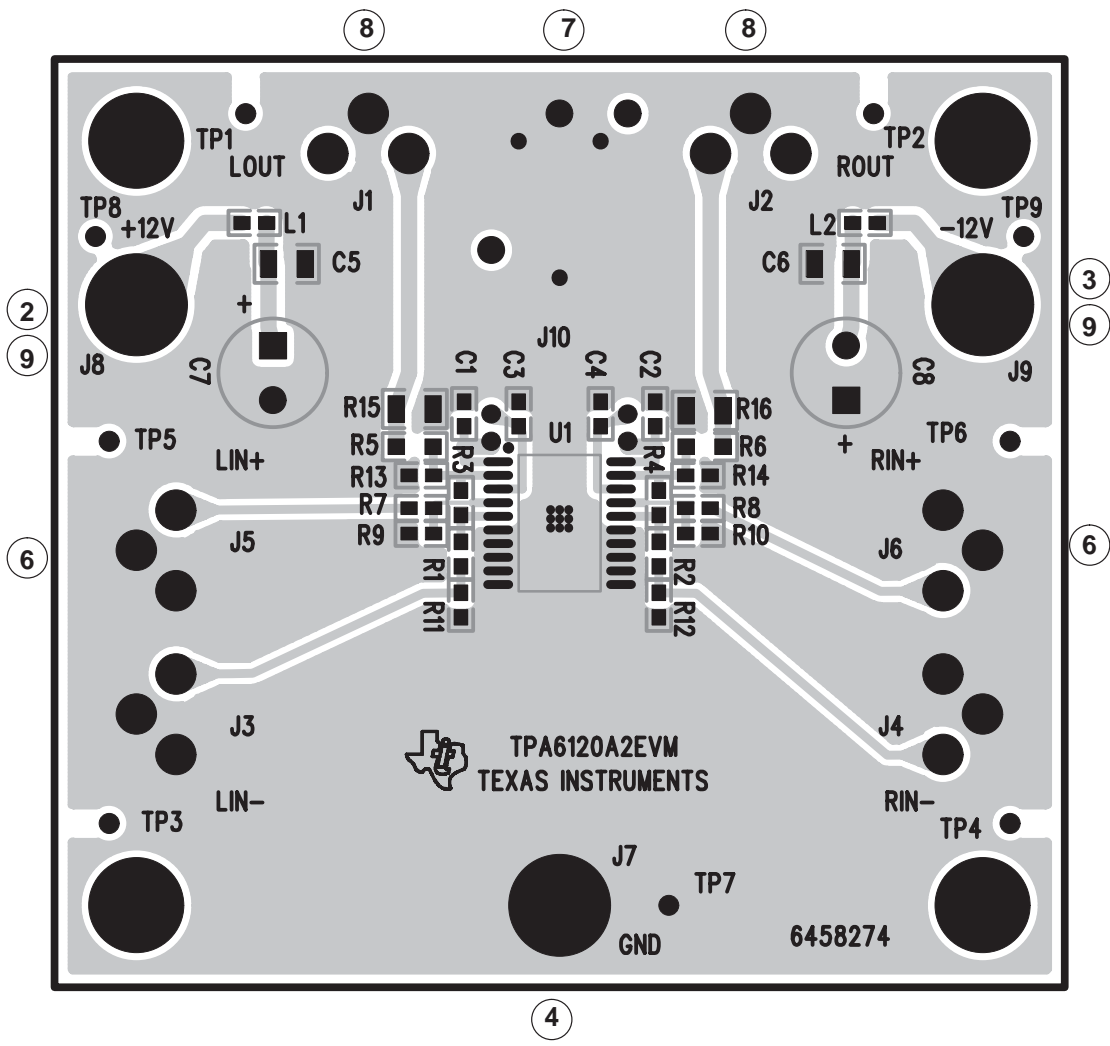
## 2.2 Inputs and Outputs

- 5) Ensure the signal source is turned off or set to a minimum.
- 6) Connect the left signal source to the RCA jack labeled LIN+ (J5), and the right signal source to the RCA jack labeled RIN+ (J6).
- 7) Insert headphones into 1/4 inch headphone jack, J10.
- 8) If desired, RCA Jacks J1 and J2 may be used instead of the headphone jack for load driving purposes. The RCA jacks and the headphone jack should not be used together when both are driving a load. One may be used to drive a load while the other is used for measurement purposes.

## 2.3 Power Up

- 9) Verify correct voltage polarity on the supplies.
- 10) Make sure the signal source is going into the *positive* inputs only. Do NOT connect anything to the negative inputs—this shorts the output of the signal source directly to ground (see schematic in *EVM Circuit and Layout* section)
- 11) Turn on the power supply.
- 12) Turn on the signal source.
- 13) Adjust signal source level as needed.

Figure 2-1. Top Layer With Numbered Callouts (From paragraphs 2.1 through 2.3)



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# Customizing The EVM

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The TPA6120A2 EVM comes in a noninverting configuration with a gain of 2 V/V. However, the EVM is designed to be flexible, and can be converted to operate in inverting and differential configurations. The TPA6120A2 EVM can also be operated in a single power supply configuration.

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### 3.1 Inverting Configuration

The TPA6120A2 EVM can be converted to operate in an inverting gain configuration. To do this, it is necessary to remove resistors R11 and R12, then connect the audio source to RCA jacks LIN– (J3) and RIN– (J4) instead of LIN+ (J5) and RIN+ (J6). With the feedback and input resistors already in place on the EVM, the gain is set to  $-1 V/V$  ( $R_F/R_I$ ).

### 3.2 Differential Configuration

The TPA6120A2 EVM can also be converted to operate in a differential input configuration. Remove resistors R11 and R12. Resistors R9 and R10 must be removed and replaced with resistors whose values match those of resistors R3 and R4, respectively. The  $49.9\text{-}\Omega$  input series resistors, R7 and R8 must likewise be removed and replaced with resistors whose values match those of input resistors R1 and R2, respectively. Both positive and negative input jacks should be used. Assuming the feedback resistors R9 and R3 are equal, and R10 and R4 are equal, and the input resistors R7 and R1 are equal, and R8 and R2 are equal, the gain is set by the following formula:

$$\text{Gain} = 2 \times \frac{R_F}{R_I}$$

### 3.3 Special Note on Gain and Input Configurations

The TPA6120A2 high-fidelity audio power amplifier has two separate channels, left and right. It is not necessary to operate each channel in the same configuration. For test purposes, it may be desirable to operate the left channel with a noninverting configuration, and the right channel with an inverting configuration. One channel may be configured to operate with differential inputs while the other channel with single-ended inputs. The TPA6120A2 EVM allows for this flexibility. From a listening standpoint, the best audio performance is achieved when both channels are operated with the same configuration. In this case, there is no sound difference between the left and right channels for the human ear to detect.

### 3.4 Single Power Supply Configuration

The TPA6120A2 EVM was not optimized for single power supply operation. To operate in this mode, the  $-12\text{-V}$  terminal must be connected to GND. DC-blocking capacitors must be used at the outputs to prevent large amounts of dc current from flowing through the headphones due to the high midrail bias. Likewise, dc-blocking capacitors must be used at the input. Resistors R11 and R12, and resistors R9 and R10 must be removed. The positive input nodes must be biased to midrail. Resistors R9 and R10 tie the positive node to ground.



# EVM Circuit and Layout

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The TPA6120A2 EVM layout was carefully planned to minimize the capacitance and inductance detected by the output and input pins of the amplifier. Test points are available, but intentionally left unpopulated to keep signal interference as low as possible.

This chapter includes the EVM layout, the TPA6120A2 EVM component selection, schematic, and bill of materials.

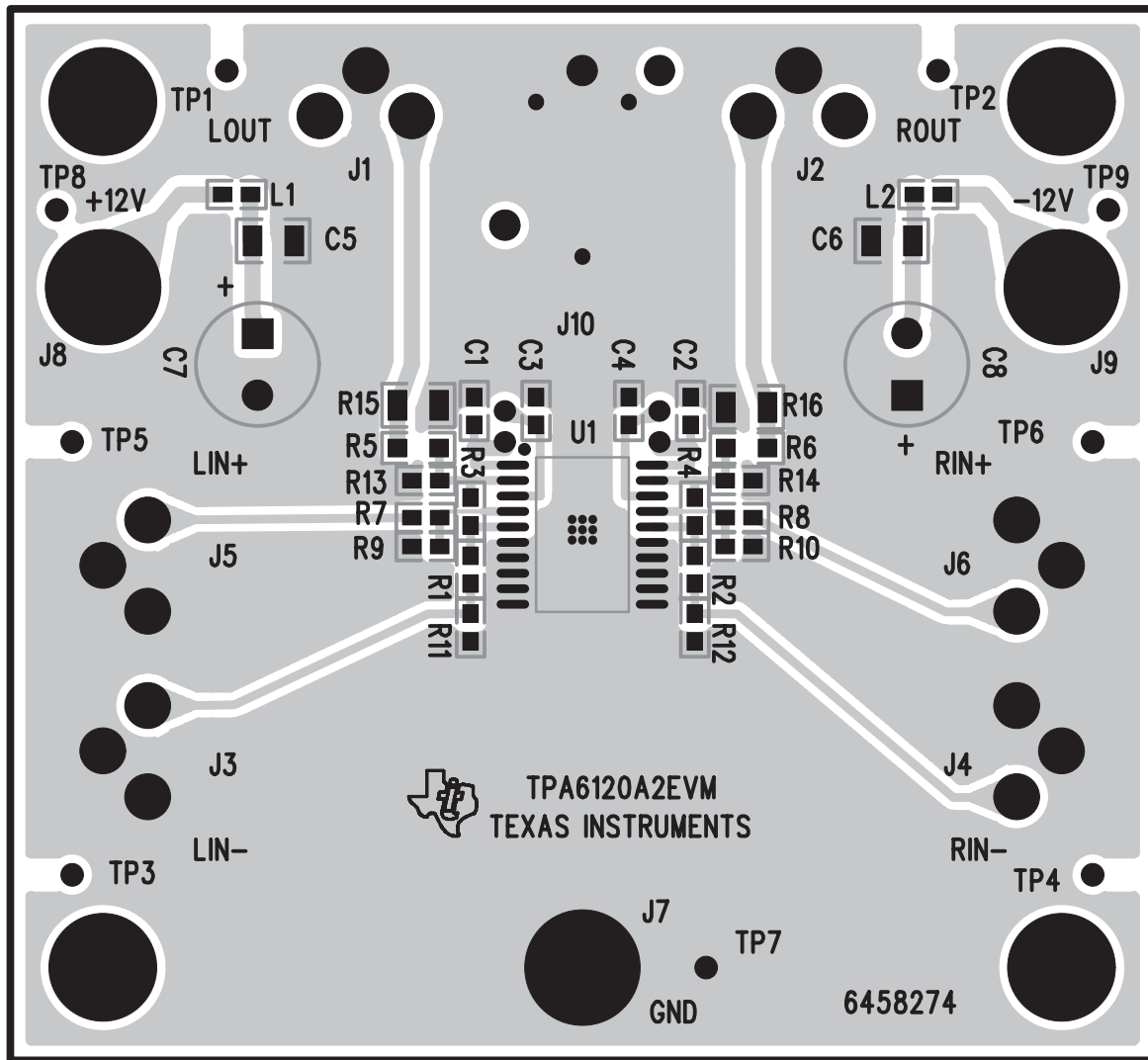
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### 4.1 TPA6120A2 EVM Top Layer

Figure 4–1 shows the top layer of the TPA6120A2 EVM. The RCA jacks at the inputs are configured to short to ground when no plug is inserted. The noninverting configuration of the EVM requires that RIN– and LIN– be at ground. Rather than have the signal go through the long signal trace to get to the input jacks, 0-Ω resistors R11 and R12 are used to provide a connection to ground much closer to the device.

A star point for ground should be chosen. For the TPA6120A2 EVM, the ground terminal of the board is (J7). Current paths to the star ground should be as direct as possible.

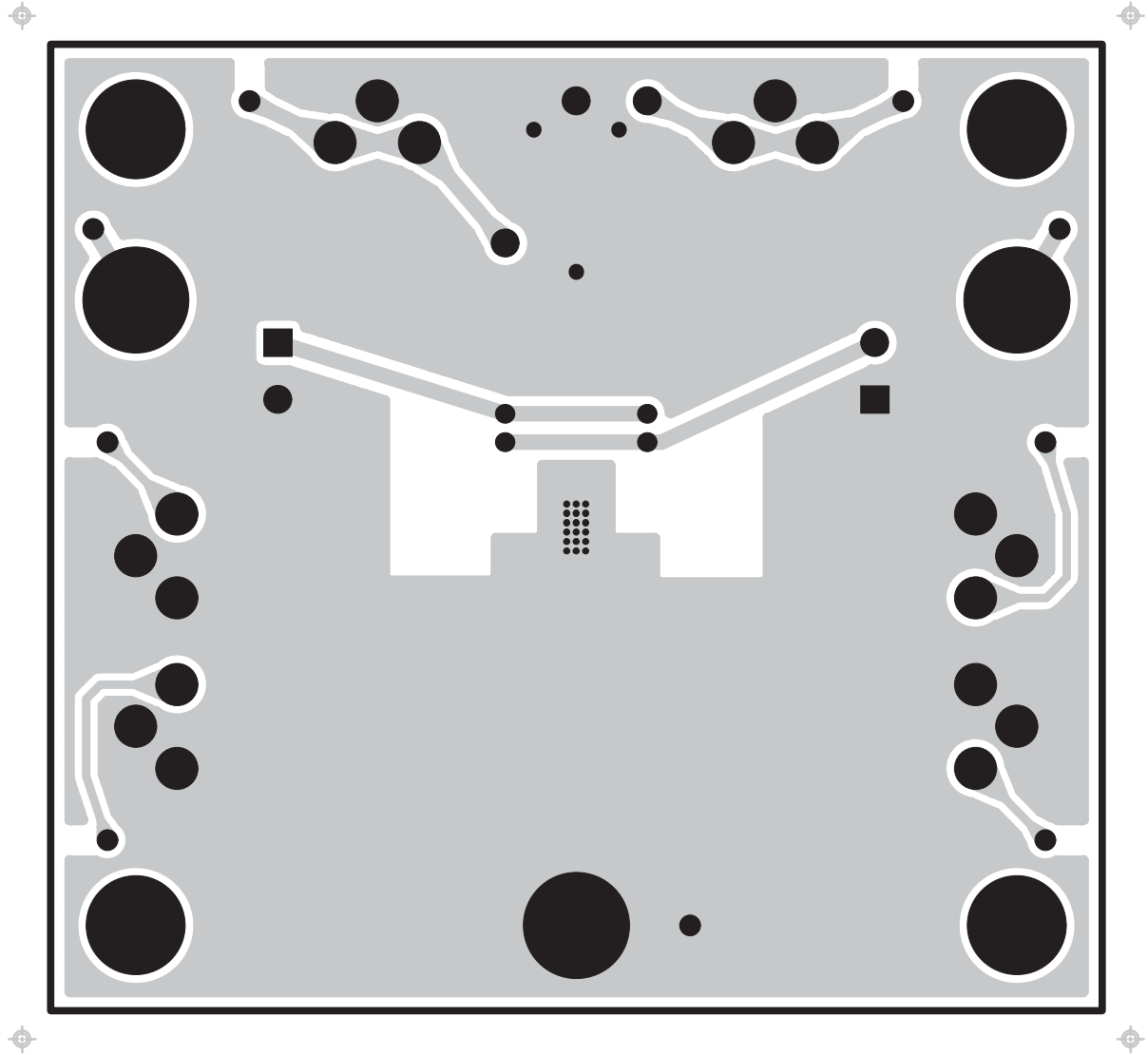
Figure 4–1. Top Layer of the TPA6120A2 EVM



## 4.2 TPA6120A2 EVM Bottom Layer

Figure 4–2 shows the bottom layer of the TPA6120A2 EVM. Note that the copper has been removed from around the capacitive sensitive nodes. It is important to remember that the thermal pad on the underside of the IC must be properly soldered to the board at all times.

Figure 4–2. Bottom Layer of the TPA6120A2 EVM



### 4.3 Component Selection

The TPA6120A2 is a high-fidelity audio amplifier. The composition of components is important when dealing with high fidelity. The best practice is to operate the device with a split power supply. This eliminates the need for capacitors in the signal path, which can introduce distortion. Capacitors can also fail after a certain period of time. The failure mode of many capacitors is to essentially turn into a short. If capacitors must be used in the signal path because the device is being used in a single power supply configuration, polystyrene and PPS film capacitors are good choices.

Thin film resistors have excellent noise and distortion performance.

### 4.4 Input Bias Voltage

The TPA6120A2 EVM is designed to keep a constant dc voltage on the positive input pins of the amplifier. This is done with resistors R9 and R10 which effectively tie the positive input pins to ground. This is necessary in most applications to protect the system and its components from unexpectedly high dc currents, and to prevent damage to headphones from both large continuous dc currents and a large *POP*.

When a source is not connected to the positive node, and the positive node is not tied to ground, it floats, typically up to the rail. A 12-V offset with a 32- $\Omega$  load can draw up to 375 mA of current, depending on the size of the output series resistor. When a source is then connected, or turned on and thus taken out of a high impedance state, the offset voltage quickly drops to near 0 V. This large, fast change can cause a loud, potentially headphone damaging *POP*. The solution is to keep the positive input pin of the amplifier at a constant voltage, regardless of the state of the audio source.

With headphones, permanent damage to the voice coil can begin to occur when the dc voltage across them exceeds 100 mV. The maximum input bias current of the TPA6120A2 is 12  $\mu$ A. Therefore, the maximum output offset with the audio source off is:

$$\left( (12 \mu\text{A} \times R_9) - (12 \mu\text{A} \times R_F \parallel R_I) \right) \times \text{Gain}$$

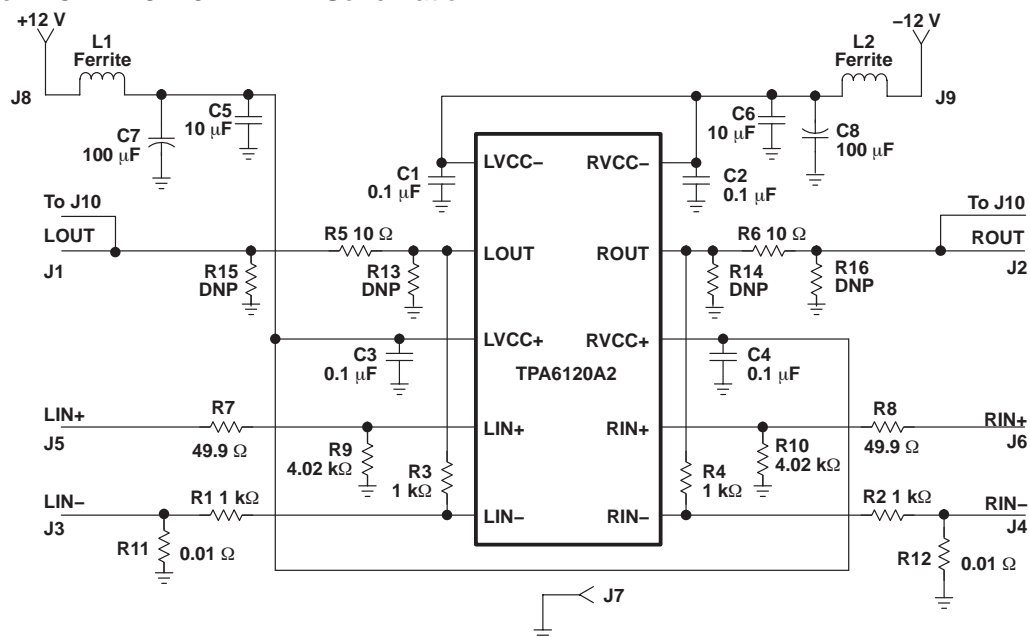
Once the audio source is turned on, the output offset voltage drops to just a few millivolts.

The value for R9 must be chosen carefully. The value has a direct impact on the output offset voltage and the loading of the audio source. In the configuration of the TPA6120A2EVM, where the input and feedback resistors (R1 and R3) are each 1-k $\Omega$ , a 500- $\Omega$  resistor would be the best choice for offset performance. However, a load of this size can degrade the performance of the audio source. The audio source should have no problems driving a large load such as a 100-k $\Omega$  resistor. However, a load of this size can cause as much as 2.4 V of output offset voltage (when the source is left floating).

The TPA6120A2 EVM uses 4.02-k $\Omega$  resistors to tie the positive terminals to ground. This value is a good compromise between the device's effect on the performance of the audio source and the output offset voltage. When the source is removed or is off (or high impedance), the maximum output offset value possible with a 4.02-k $\Omega$  resistor is about 85 mV. The loading effect on the audio source is minimal since for most sources, a 4.02-k $\Omega$  load is seen as high impedance. Going from 4.02 k $\Omega$  to 10 k $\Omega$  results in a minimal performance increase, but pushes the output offset voltage past the 100-mV threshold.

## 4.5 Schematic

Figure 4–3. TPA6120A2 EVM Schematic



## 4.6 Bill of Materials

Table 4–1. TPA6120A2 EVM Bill of Materials

Component	Qty	Value	Size	Manufacturer		Distributor	
				Name	Number	Name	Number
C5, C6	2	10 $\mu$ F, 50V, +80/–20%, F	1210	Panasonic	ECJ–4YF1H106Z	Digi–Key	PCC2308TR–ND
C1, C2, C3, C4	4	0.1 $\mu$ F, 50V, $\pm$ 10%, X7R	0805	Panasonic	ECJ–2YB1H104K	Digi–Key	PCC1840TR–ND
C7, C8	2	100 $\mu$ F, Aluminum Electrolytic, 63V, $\pm$ 20%	10 mm x 12.5 mm	Panasonic	EEU–FC1J101	Digi–Key	P10343–ND
L1, L2	2	Ferrite Bead, 330 $\Omega$ at 100 MHz, 2.5A	0805	TDK	MPZ2012S331A	Digi–Key	445–1569–2–ND
R1, R2, R3, R4	4	1 k $\Omega$ , $\pm$ 0.1%, 1/10W, TCR = $\pm$ 25 PPM/ $^{\circ}$ C	0805	Thin-Film Technology	RR1220P102B	Thin-Film Technology	RR1220P102B
R5, R6	2	10 $\Omega$ , $\pm$ 0.1%, 330 mW, TCR = $\pm$ 25 PPM/ $^{\circ}$ C	1206	Vishay	P1206E10R0BB		
R7, R8	2	49.9 $\Omega$ , $\pm$ 0.1%, 1/10W, TCR = $\pm$ 25 PPM/ $^{\circ}$ C	0805	Thin-Film Technology	RR1220P49R9B	Thin-Film Technology	RR1220P49R9B
R11, R12	2	10 m $\Omega$ , $\pm$ 2.0%	0805	Thin-Film Technology	RL1220TR010G	Thin-Film Technology	RL1220TR010G
R9, R10	2	4.02 k $\Omega$ , $\pm$ 0.1%, 1/10W, TCR = $\pm$ 25 PPM/ $^{\circ}$ C	0805	Thin-Film Technology	RR1220P4021B	Thin-Film Technology	RR1220P4021B
R13, R14	2	Do Not Populate	0805				
R15, R16	2	Do Not Populate	1210				
J1, J2, J3, J4, J5, J6	6	RCA Jacks, Black		Switch Craft	PJLAN1X1U01		
J7, J8, J9	3	Banana Jacks		USM EYELETS	SE–68–Hot Solder Dip	Bisco	SE–68–Hot Solder Dip
J10	1	Headphone Jack	1/4"	Switch Craft	RN112BPC	Digi–Key	SC1123–ND
	4	Aluminum Standoffs	1.00" Round 4–40	Keystone	3482	Digi–Key	3482K–ND
	4	Screws	1" #4				
U1	1	IC high-fidelity headphone driver	20 Pin DWP	Texas Instruments	TPA6120A2		
PCB	1	2 layer	3" x 3"				