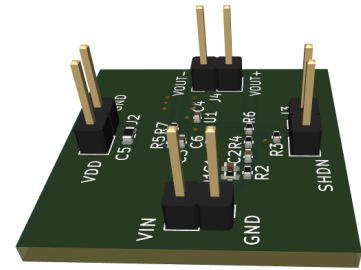




PUIaudio



Data Sheet

AMP1X1 Audio Amplifier Board

PUI Audio's AMP1X1 audio amplifier board features an Analog Device's MAX98309 Class AB mono amplifier circuit for maximum signal fidelity. This amplifier delivers 1.4W per channel into 8Ω loads and 2.1W per channel into 4Ω loads, both at 1% THD+N while using a 5V DC supply.

The board features a small size of 25.4mm x 25.4mm and preinstalled header pins for easy design prototype development.

Features:

- 1.4W per channel into 8Ω loads
- 2.1W per channel into 4Ω loads
- Enhances System Performance that includes
 - Differential input that improves noise immunity
 - Transient suppression when the supply voltage is applied
 - High 90dB PSRR ($f_{IN} = 217\text{Hz}$)
- Low quiescent current
 - Extends battery life for portable applications
- Thermal overload protection
- Short-circuit protection
- Power supply range: $2.5\text{V} \leq V_{DD} \leq 5.5\text{V}$
- 1.2mA supply current ($V_{DD} = 3.7\text{V}$)
- $P_{OUT} = 750\text{mW}$ into 8Ω (THD= 1%, $V_{DD} = 3.7\text{V}$)
- $P_{OUT} = 1.4\text{W}$ into 8Ω (THD= 1%, $V_{DD} = 5.0\text{V}$)
- $P_{OUT} = 2.1\text{W}$ into 4Ω (THD= 1%, $V_{DD} = 5.0\text{V}$)
- External resistors adjust the amplifier gain
- 1.8V Logic-Compatible SHDN Input
- 100mil spaced header pins for input, output, shutdown, power supply, and ground connections

Absolute Maximum Rating

V_{DD} with respect to GND	$-0.3V \leq V_{DD} \leq 6V$
\overline{SHDN} with respect to GND	$-0.3V \leq V_{DD} \leq 6V$
All other pins with respect to GND	$-0.3V \leq (V_{DD} + 0.3V)$
Continuous Current	
V_{DD} , GND, OUT	$\pm 750mA$
IN_, \overline{SHDN} , BIAS, TON	$\pm 20mA$
OUT_ Short-Circuit with respect to GND or V_{DD} Duration	Continuous
OUT+ with respect to OUT- Short-Circuit Duration	Continuous
Operating Temperature Range	$-40^{\circ}C \leq T_A \leq 85^{\circ}C$
Storage Temperature Range	$-65^{\circ}C \leq T_A \leq 150^{\circ}C$

Electrical Characteristics

($V_{DD} = 3.7V$, $V_{GND} = 0V$, $\overline{SHDN} = V_{DD}$, GAIN = V_{DD} (0dB), $C_{BIAS} = 0.1\mu F$, $C_{IN} = 0.47\mu F$, no load: $R_{IN} = R_F = 10k\Omega$, $T_A = t_{MIN} \leq t \leq t_{MAX}$.
Typical values are given at $T_A = 25^{\circ}C$, unless otherwise noted.)

Parameter	Conditions		Minimum	Typical	Maximum	Unit
Power Supply Voltage Range	Guaranteed by the PSRR test		2.5		5.5	V
Output Power	$V_{DD} = 3.7V$, 1% THD+N	$R_L = 8\Omega + 68\mu H$		0.750		W
		$R_L = 4\Omega + 33\mu H$		1.2		
	$V_{DD} = 3.7V$, 10% THD+N	$R_L = 8\Omega + 68\mu H$		0.9		
		$R_L = 4\Omega + 33\mu H$		1.5		
	$V_{DD} = 5.0V$, 1% THD+N (Note 1)	$R_L = 8\Omega + 68\mu H$		1.4		
		$R_L = 4\Omega + 33\mu H$, thermally limited		2.1		
$V_{DD} = 5.0V$, 10% THD+N (Note 1)	$R_L = 8\Omega + 68\mu H$		1.7			
	$R_L = 4\Omega + 33\mu H$, thermally limited		2.7			
Total Harmonic Distortion + Noise	$f_{IN} = 1kHz$, BW = $22Hz \leq f \leq 22kHz$	$R_L = 8\Omega + 68mH$, $P_{OUT} = 375mW$		0.008		%
		$R_L = 4\Omega + 33mH$, $P_{OUT} = 750mW$		0.02	0.06	
	$f_{IN} = 6kHz$, BW = $22Hz \leq f \leq 22kHz$	$R_L = 8\Omega + 68mH$, $P_{OUT} = 375mW$		0.01		
Signal-to-Noise Ratio				110		dB
Output Noise Voltage				9		mV
Over-Current Protection Threshold				2		A
Thermal Protection Threshold	A-weighted, $V_{DD} = 5V$, $P_{OUT} = 1.4W$, $R_L = 8\Omega + 33mH$			160		$^{\circ}C$
Thermal Protection Hysteresis				15		$^{\circ}C$
Maximum Capacitive Load Drive				500		pF
Under-Voltage Lockout	V_{DD} decreasing			1.8	2.3	V
Quiescent Power Supply Current	$V_{DD} = 3.7V$			1.2		mA
	$V_{DD} = 5.0V$			1.8	1.9	
Shutdown Active Power Supply Current	$\overline{SHDN} = 0V$			2	3	μA
Turn-On Time	Shutdown to full operation, logic-low applied to TON pin			10	22.8	ms
Input Bias Current					± 1	μA
Output Offset Voltage	Inputs AC-coupled to GND			± 0.2	± 1	
Output Turn-On Transient Magnitude	$R_L = 8\Omega$, 32 samples per second, A-weighted, $T_A = +25^{\circ}C$ (Notes 2, 3)	Into Shutdown		-66		dBV
		Out of Shutdown		-66		

Electrical Characteristics (continued)

($V_{DD} = 3.7V$, $V_{GND} = 0V$, $\overline{SHDN} = V_{DD}$, GAIN = V_{DD} (0dB), $C_{BIAS} = 0.1\mu F$, $C_{IN} = 0.47\mu F$, no load: $R_{IN} = R_F = 10k\Omega$, $T_A = t_{MIN} \leq t \leq t_{MAX}$.
 Typical values are given at $T_A = 25^\circ C$, unless otherwise noted.)

Common-Mode Bias Voltage	Voltage at BIAS pin	0.475(V_{DD})	0.5(V_{DD})	0.525(V_{DD})	V
Input Common-Mode Voltage Range	Inferred from CMRR test	0.5		$V_{DD} - 0.6$	V
Power-Supply Rejection Ratio	DC = $2.5V \leq V_{DC} \leq 5.5V$	73	92		dB
	$V_{RIPPLE} = 200mV_{P-P}$ (Note 2)	$f_{IN} = 217Hz$		90	
		$f_{IN} = 1kHz$		90	
		$f_{IN} = 10kHz$		72	

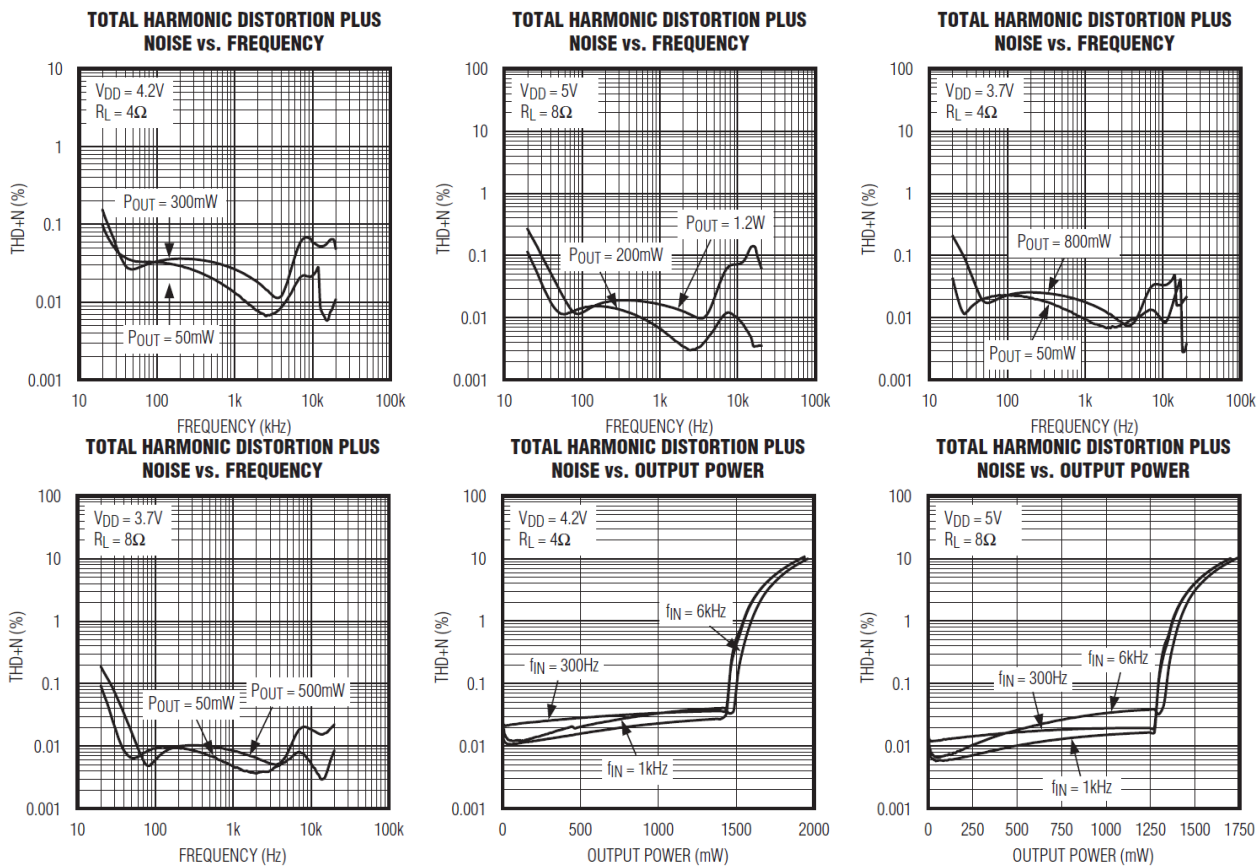
Note 1: Thermally limited by package.

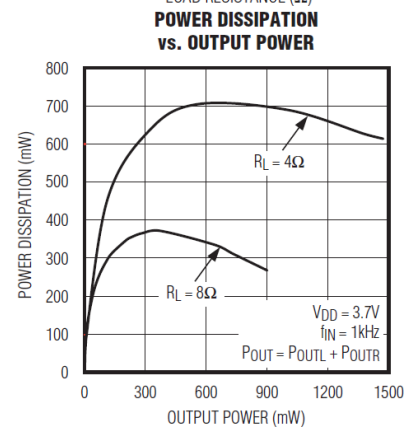
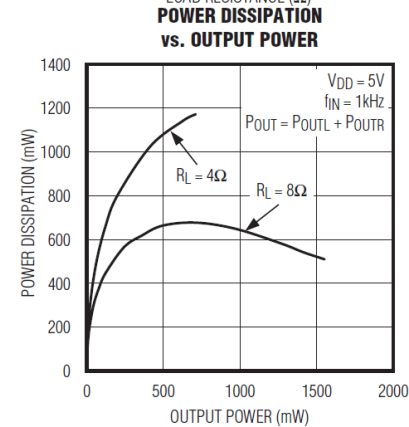
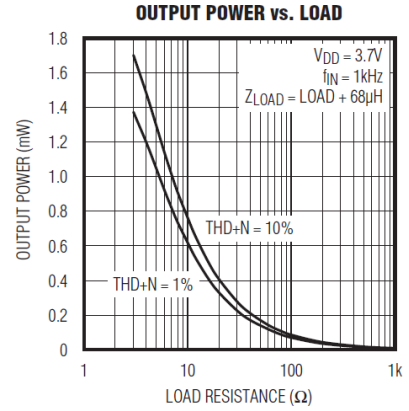
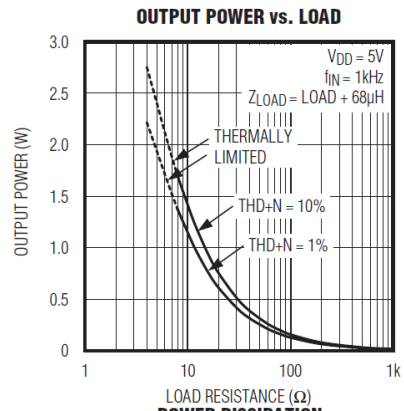
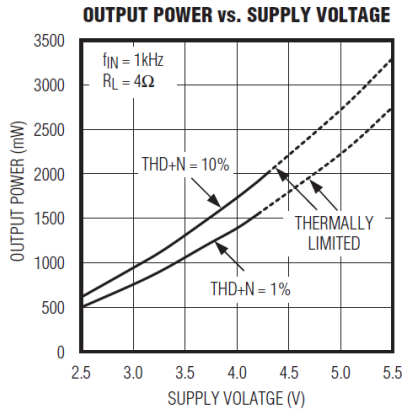
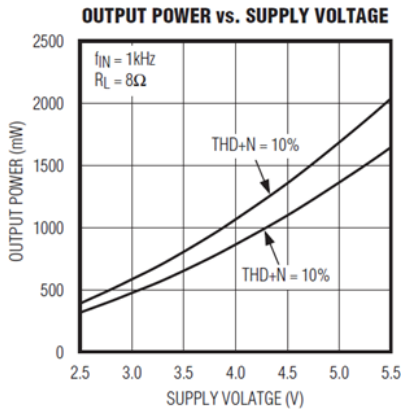
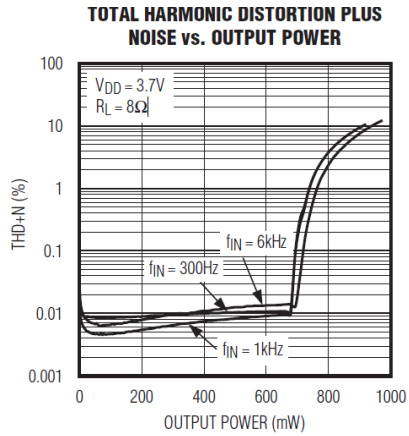
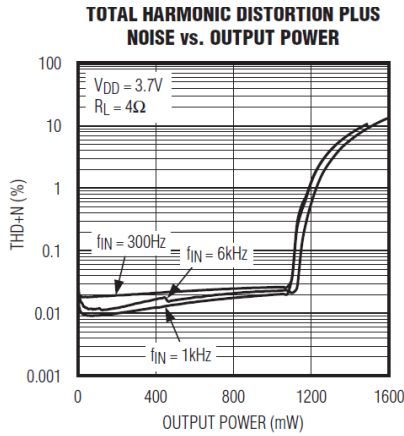
Note 2: Inputs are AC-coupled to GND.

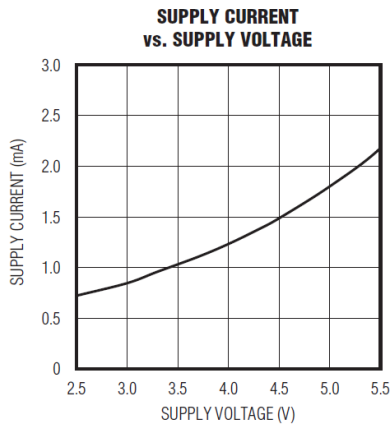
Note 3: Mode transitions controlled by \overline{SHDN} .

Typical Performance Characteristics

($V_{DD} = 3.7V$, $V_{GND} = 0V$, $\overline{SHDN} = V_{DD}$, GAIN = GND ($R_F = R_{IN} = 10k\Omega$), $C_{BIAS} = 0.1\mu F$, $C_{IN} = 1\mu F$, no load, unless otherwise noted.)







MAX98309 Amplifier Pin Descriptions

MAX98309 Pin	Name	Function
A1	OUT+	Positive amplifier output.
A2	SHDN	Active-low shutdown input. Connecting to GND places the amplifier in shutdown. Connecting to V _{DD} places the amplifier in normal operation.
A3	IN-	Inverting audio input.
B1	GND	Ground
B2	TON	Turn-on time selection. By default, this is connected to GND, which selects 10ms turn-on. Connecting to V _{DD} selects 100ms turn-on time.
B3	VDD	Power supply voltage input.
C1	OUT-	Negative amplifier output.
C2	BIAS	Common-mode DC bias bypass connection. Typical bypass capacitor value, connected between the BIAS pin and GND, is 0.1mF or higher.
C3	IN+	Noninverting audio input.

Detailed Description

The AMP1X1 audio amplifier board uses the MAX98309 mono 1.4W Class AB audio amplifier. This amplifier offers low, 1.8mA (typical, V_{DD} = 5V_{DC}), an excellent 110dB (typical) SNR, and high linearity expressed in its 0.008% THD+N. The amplifier features circuitry that produces high suppression of output transients when the power supply voltage is applied. Additionally, the amplifier's power supply rejection ratio (PSRR) is an outstanding 90dB.

The AMP1X1's amplifier's closed-loop gain is set by the value of external resistors.

The AMP1X1's amplifier features a pin-selectable 10ms or 100ms turn-on time.

The board is set to a default 10ms turn-on time.

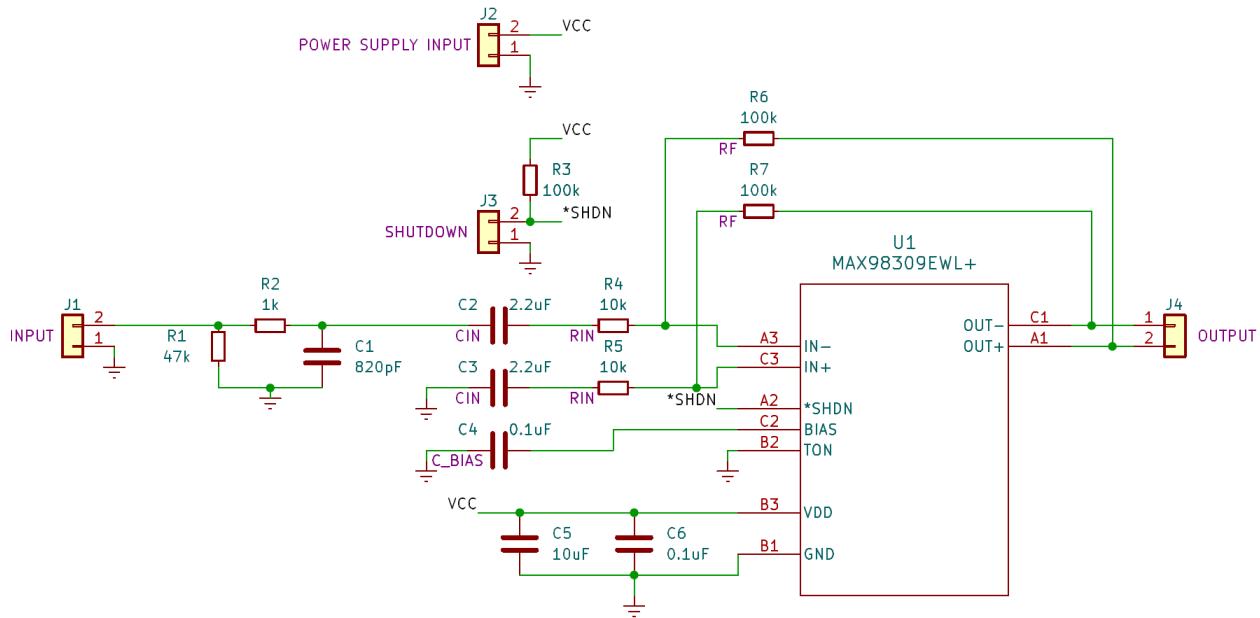


Figure 1. AMP1X1 schematic.

Bias

The AMP1X1's amplifier operates with a single 2.5V to 5.5V power supply voltage. It uses internal circuitry to generate the $V_{DD}/2$, ground-referenced common-mode bias voltage. This circuitry suppresses the output transients during supply voltage application while it sets the amplifier outputs' DC-bias level. The BIAS circuitry's output is available on the BIAS pin so that an external capacitor can be connected between this pin and GND, allowing for the connection of a decoupling capacitor. The value of this capacitor is chosen based on the recommendations detailed in the BIAS Capacitor section below. To ensure proper amplifier operations, do not connect any load to the BIAS pin. Doing so will compromise the amplifier's overall operation.

Turn-On Time

The AMP1X1's amplifier features two pin-programmable turn-on times, 10ms and 100ms. By default, with the TON pin connected to GND, the amplifier's turn-on time is 10ms. If the longer 100ms turn-on time is desired, connect the TON pin to V_{DD} .

Shutdown Mode

The AMP1X1 features a low-power shutdown mode that, when activated, reduces power supply current to a nominal $1.8\mu\text{A}$. When shutdown mode is active, the internal bias circuitry is disabled, the amplifier's outputs change to a high impedance state, and the BIAS pin output is equal to GND.

Suppressing Amplifier Output Transients

The AMP1X1's MAX98309 features a leading-edge transient suppression circuit that ensures that output transients' magnitude the occur when the power supply voltage is applied to the amplifier are minimized. This is a result of controlling the slew rate of the bias circuitry's output voltage's magnitude changes to $V_{DD}/2$. Conversely, when shutdown is activated, the impedance of amplifier's outputs is set to a high impedance. Both functions work together to ensure that transient energy in the audio bandwidth is suppressed and minimized.

BTL Amplifier Output

The AMP1X1's amplifier is designed to differentially drive loads connected between the OUT+ and OUT- pins. This is a bridge-tied-load (BTL). This configuration has advantages over a single-ended, ground referenced load. Differential output drive doubles the output voltage across the load when compared by the drive voltage across a single-ended load.

Doubling the voltage applied across a load quadruples the power dissipated by the load. The power dissipated by a single-ended load is expressed by Eq. 1.

$$V_{RMS} = \frac{V_{OUTp-p}}{2\sqrt{2}} \quad \text{Eq. 1}$$

$$P_{OUT} = \frac{V_{RMS}^2}{R_L} \quad \text{Eq. 2}$$

Substituting

$$2xV_{OUT p-p}$$

For

$$V_{OUT p-p}$$

Results in

$$V_{RMS} = \frac{V_{OUTp-p}}{\sqrt{2}} \quad \text{Eq. 3}$$

And

$$P_{OUT} = \frac{\frac{(V_{POUTp-p})^2}{2}}{R_L} \quad \text{Eq. 4}$$

When the results of Eq. 3 are applied to Eq. 1, it is observed that P_{OUT} is quadrupled. This is verified by Eq. 4.

Even though each amplifier is biased to one-half of the power supply voltage, since the voltage with respect to ground is the same on each output, there is no net differential DC voltage applied across the load. There is, therefore, no need to use any DC-blocking capacitors in series between the amplifier's outputs and the load. This is unlike a single-ended amplifier, which must have a DC-blocking capacitor when the single-ended output and the ground terminated load. DC-blocking capacitors used with single-ended amplifiers and very low resistances will typically have high values, large size, and can degrade low-frequency response and performance.

Amplifier Gain

The AMP1X1's amplifier uses external resistors to set the desired closed loop gain. The MAX98309's gain is set using Eq. 3.

$$A_V = \frac{R_F}{R_{IN}} \quad \text{Eq. 3}$$

Referring to Figure 1 with $R_{IN} = 10\text{k}\Omega$ and $R_F = 100\text{k}\Omega$, the gain is 10V/V or 20dB.

Input Filter

The AMP1X1 uses AC-coupling capacitors, C_{IN} , in series with both differential inputs. These capacitors allow the MAX98309's inputs to bias to the optimum DC level. Assuming a zero-source impedance, the combination of the input resistor, R_{IN} , and coupling capacitor C_{IN} , forms a high-pass filter that has a cutoff frequency as defined by Eq. 4.

$$f_{-3dB} = \frac{1}{2\pi R_{IN} C_{IN}} \quad \text{Eq. 4}$$

Setting the f_{-3dB} frequency is set too high can compromise the low frequency performance. This frequency is dependent on the frequency bandwidth design targets for the system in which the AMP1X1 is used.

Capacitor chemistry recommendations include selecting devices with low voltage coefficients such as film capacitors or NPO or X7R ceramic devices. It is best to use high voltage ratings beyond 20V.

BIAS Capacitor

The BIAS pin is internally connected to the circuitry that generates the $V_{DD}/2$ bias voltage. This connection allows connecting a capacitor between the internal bias voltage generator and ground. This capacitor reduces power supply and other source noise present at the common-mode node, maximizing the PSRR and THD+N performance. This capacitor is also used by the bias generator circuitry to produce a controlled slew rate bias voltage waveform that ensures

transient suppression at the amplifier outputs. This capacitor's minimum value is 0.1 μ F and can use higher values up to 1 μ F to maximize PSRR.

Power Supply Bypassing

The AMP1X1 uses proper supply capacitive bypassing to ensure low-noise, low-distortion audio performance. Whereas the suggested bypass device is a 1 μ F ceramic capacitor connected between the V_{DD} pin and GND. The AMP1X1 uses an additional 10 μ F bulk capacitance in parallel with a 0.1 μ F capacitor. The bypass capacitance is placed as close as possible to the V_{DD} pin.

AMP1X1 Controls, Input, Outputs, and Settings

The AMP1X1 features the following controls, input, output, and settings.

Jumper J1 provides the connection node for the single-ended audio signal input. The audio signal is applied to V_{IN} pin (pin 2) and the input signal's ground reference is applied to GND (pin 1).

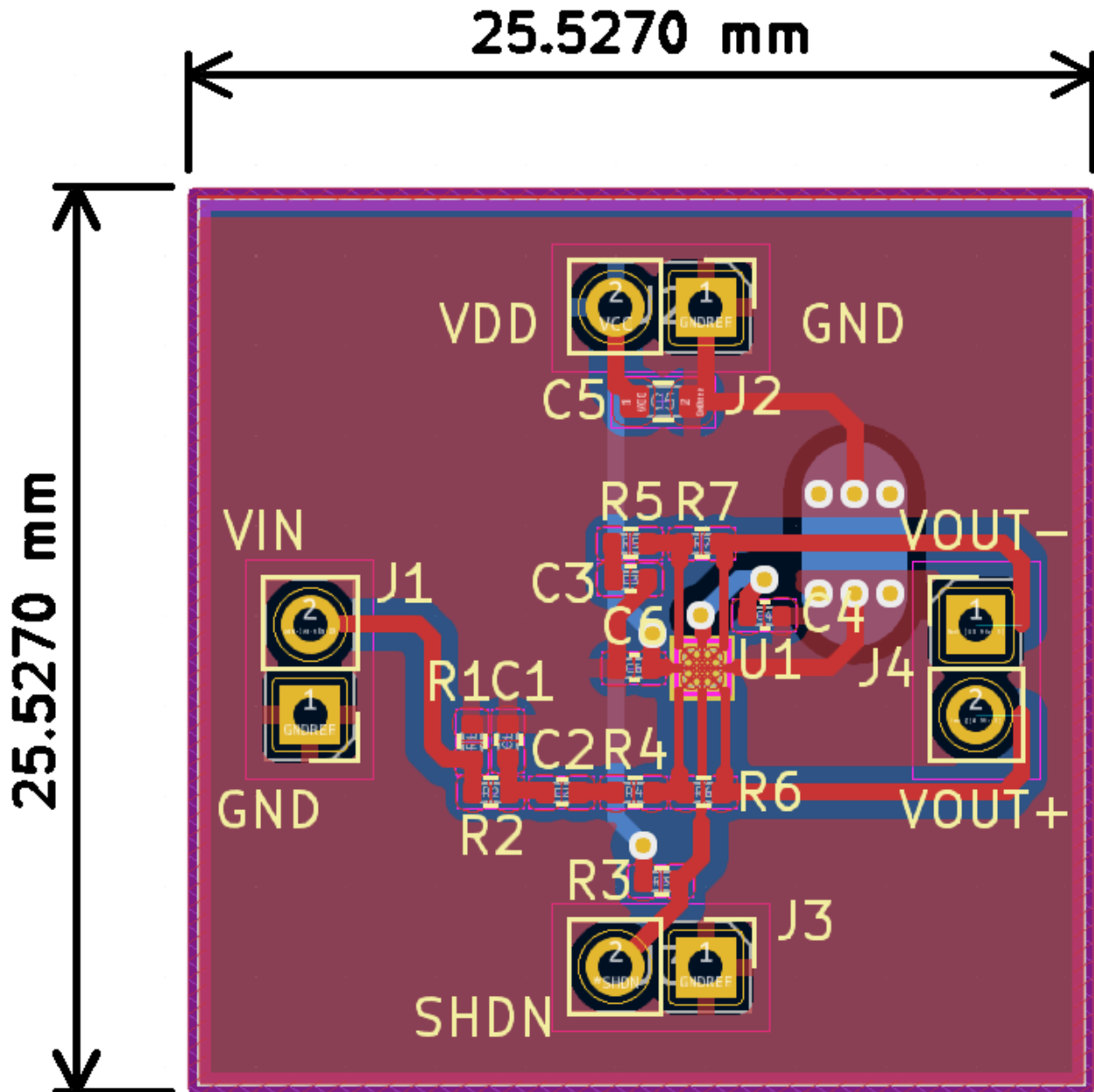
The input signal's voltage magnitude is predicated on the power supply voltage and the closed-loop gain set by resistors R4/R5 and R6/R7. As configured, the AMP1X1 has a 10x (20dB) closed-loop gain. For example, when using a 5V power supply voltage, the output voltage is nominally 3.35V_{RMS} when driving an 8 Ω loads and 2.9V_{rms} when driving 4 Ω loads. These voltages translate into 4.74V_{PEAK} and 4.1V_{PEAK}, respectively. With the AMP1X1's nominal gain, the peak input voltage levels are, respectively, 0.474V_{PEAK} and 0.41V_{PEAK} or 0.335V_{RMS} and 0.29V_{RMS}. At these levels, the THD will typically not exceed 1%.

Jumper J2 is the AMP1X1's power supply voltage input. Apply a DC voltage in the range of 2.5V_{DC} to 5.5V_{DC}. Apply the positive voltage to the V_{DD} pin (pin 2) and apply ground to the GND pin (pin 1).

Jumper J3 controls the amplifier's shutdown function. The default setting is the jumper is open, pulling the active-low $\overline{\text{SHDN}}$ input to a logic high, allowing full operation. When shutdown is desired, place a short between pin 1 and pin 2. When shutdown is active, the amplifier output's change to a high-impedance state, and the power supply current drops to a nominal 2 μ A.

Jumper 4 is the MAX98309's BTL amplifier output. Connect a load across the jumper's pin 1 and pin 2. Pin 1 is the inverting output, whereas pin 2 is the non-inverting output.

Dimensions



Packaging

One box that contains one single-channel, 1W amplifier board and through-hole headers contained within an ESD-protective bag.

Specifications Revisions

Revision	Description	Date	Approved
A	Datasheet released from Engineering	08/08/2024	KH

Note:

- Unless otherwise specified:
 - All dimensions are in millimeters.
 - Default tolerances are $\pm 0.5\text{mm}$ and angles are $\pm 3^\circ$, unless otherwise specified.
- Specifications subject to change or withdrawal without notice.