Evaluation Board for Filterless Class-D Audio Amplifier

EVAL-SSM2301

FEATURES

Highly configurable DIP switch settings: gain adjustment, input configuration, and shutdown control
Optional dc power supply jack (accepts 2.5 V to 5 V)
Single-ended and differential input capability
Multiple output interface connection terminals

GENERAL DESCRIPTION

The SSM2301 is a single-chip, single-channel, Class-D audio amplifier. It is a fully integrated chip, which means that the application circuit requires a minimum of external components. It comes with a differential mode input port and a high efficiency H-bridge at the output. When compared to a half-bridge output stage, a full H-bridge enables direct coupling of the audio power signal to the loudspeaker, doubling the output voltage swing and eliminating the need for a large output coupling capacitor. Another benefit of a full H-bridge is an increase of the maximum output power by 4× when compared to a half bridge under the same load impedance. These benefits are particularly useful for low voltage, battery-powered portable electronics where energy and space are limited. The differential mode input stage allows for cancelling of common-mode noise leading to a superior CMRR.

Moreover, the part features a high efficiency, low noise output modulation scheme that does not require external LC output filters when attached to an inductive load. The modulation provides high efficiency even at low output power. Filterless operation also helps to decrease distortion due to nonlinearities of output LC filters, thereby having a better sound quality and leading to savings in board space and overall cost.

This data sheet describes how to configure and use the SSM2301 evaluation board. It is recommended that this data sheet be read in conjunction with the SSM2301 data sheet, which provides more detailed information about the specifications, internal block diagrams, and application guidance for the amplifier IC.

EVALUATION BOARD DESCRIPTION

The SSM2301 evaluation board carries a complete application circuit for driving one loudspeaker. Figure 1 shows the top view of the PCB and Figure 2 shows the typical setup of the evaluation board while in operation. Figure 8 shows its layout. The bottom layer of the evaluation board is shown in Figure 9, and its mirrored version is shown in Figure 10. The schematic is shown in Figure 7. The bill of materials is given in Table 1.

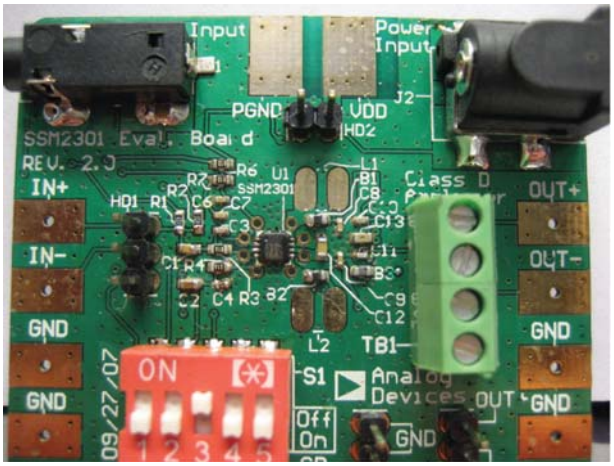

Figure 1. SSM2301 Evaluation Board

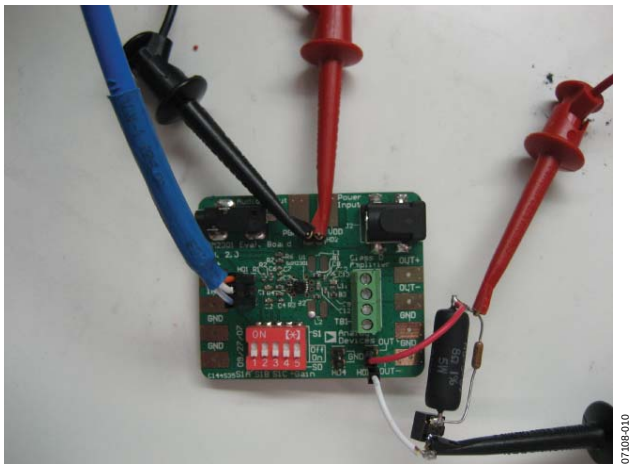

Figure 2. SSM2301 Evaluation Board Typical Setup

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REVISION HISTORY

5/08—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

Note that the SSM2301 evaluation board and layout guidelines were developed by Gang Liu of Analog Technologies, Inc., Sunnyvale, CA.

SWITCHES

On the upper left corner of the evaluation board is an audio stereo jack connector (3.5 mm), J1. It accepts standard stereo audio signals by using a conventional audio stereo signal connector/cable to receive audio signals from common appliances such as DVD players, personal computers, and TVs. Note that the two output signals from the J1 connector are combined by a resistor network, R1 and R2, into a single signal. When this input connector is utilized, turn the switch, S1C, to the upper position to short circuit the negative input node to ground, essentially creating a single-ended input signal. S1C, in the upper position, blocks any interference shown on this floating node. This signal path is shown in the schematic in Figure 7. Some appliances may have strong ground noise. In the event that the audio source has strong ground noise, do not use the J1 connector as the input connection point. A single-ended input signal with strong ground noise generates an audible hissing sound at the output. When this happens, differential mode connection is needed and the ground noise interference can be cancelled.

The input signal can be connected in a differential mode using the HD1 (Header 1) connector or the solder pads on the left side of the board. Note that the S1C switch should be turned off (placed in the lower position) for differential input mode. See Figure 7 and Figure 8. The solder pads on the left edge of the board can conveniently be connected by using alligator clips. Figure 3 shows such a connection: the ground on the signal source appliance is sensed by a dedicated cable wire in addition to the ground connection wire.

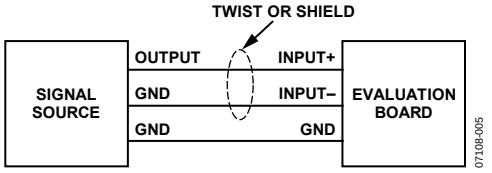

Figure 3. Cancelling Ground Noise by Differential Input Mode

The SSM2301 evaluation board has two ground soldering pads on the lower left corner. They can be used for connection to the ground of the signal source, as indicated in Figure 3.

The lower side of the board has a switch bank with the following functions:

- S1A
  Upper position: short circuits the input coupling capacitor for positive input port.
  Lower position: open circuits the input coupling capacitor for positive input port.
- S1B
  The same functions as the S1A switch but for the coupling capacitor connected to the negative input port.
- S1C
  Upper position: short circuits the ac signal on the negative input port to ground. This function is only needed when driving the input port in single-ended mode, such as by using the audio jack.
  Lower position: differential input.
- S1D (marked with GAIN)
  Upper position: For controlling the gain, short circuits the GAIN pin to ground, setting the amplifier to a lower gain, 6 dB.
  Lower position: sets the amplifier to a higher gain, 12 dB.
- S1E (marked with SD)
  Upper position: shuts down the amplifier for the shutdown functions.
  Lower position: activates the amplifier.

The upper right corner of the SSM2301 evaluation board has a dc power jack connector. The center pin is for the positive terminal. The SSM2301 can operate from 2.5 V to 5 V supply voltage. The maximum peak current is approximately 0.6 A when driving an 8 Ω load with a 5 V supply. The SSM2301 evaluation board also has two solder pads in the upper center edge area for connecting the power supply voltages by clipping with alligator clips or soldering wires.

The output ports are located on the right side of the board. There are three options to connect the output ports to a load: screw terminal (TB1), header (HD3), or the soldering pads on the right edge of the board. Header HD4, which is also on the right side of the board, is solely a ground connection point and not associated with load connection to the output (see Figure 7 and Figure 8).

GETTING STARTED

To ensure proper operation, follow these steps carefully.

1. Verify that the control switches are set at the proper positions.
   - Shutdown control: S1E down. This activates the amplifier.
   - Gain setting: S1D. Select the position based on the gain needed.
   - Audio source: S1C. For single-ended mode (audio jack), be sure to put S1C in the upper position.
   - Input coupling: S1A/S1B. For most applications, ac couple the inputs by setting these switches in the lower position.
2. Connect load across output ports.
3. Connect the power supply with the correct polarity and proper voltage.

LAYOUT GUIDELINES

1. Place at least nine vias on the solder pad for the thermal pad of the amplifier for proper conduction of heat to the opposite side of the board. The outer diameter of the vias should be 0.5 mm and the inner diameter should be 0.25 mm to 0.3 mm. Use a PCB area of at least 2 cm^2 equivalent area on the opposite side of the layer of the amplifier chip as a heat sink. Also, extend the ground pad (for the thermal pad) as much as possible on the amplifier side of the PCB as a heat sink (see Figure 4). If internal layers are available, allocate a certain area as a heat sink; make sure to connect the vias conducting the heat to the internal layers.

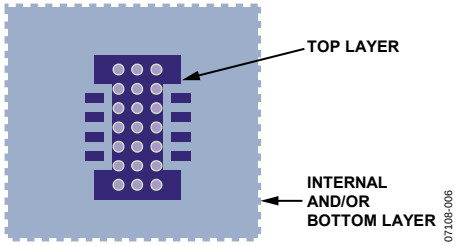

Figure 4. Heat Sink Layout

2. Place the EMI filtering beads, B1, B2 and B3, as close to the amplifier chip as possible.
3. Place the decoupling capacitors for the beads, C8, C9, and C12, as close to the amplifier chip as possible, and connect all their ground terminals together as close as possible. Ideally, solder their ground terminals together, as shown in Figure 5; do not rely on PCB tracks or ground planes for connecting their ground terminals together.

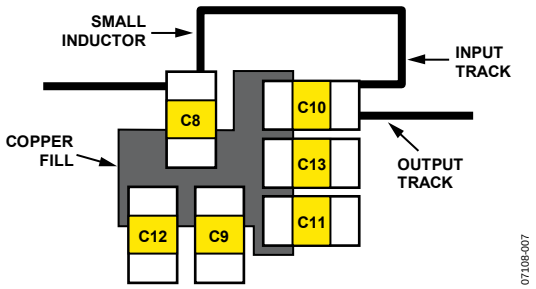

Figure 5. Placement and Routing for Decoupling Capacitors

4. The 1 nF capacitor and the ferrite bead can block the EMI for up to 250 MHz. To eliminate EMI higher than 250 MHz, place a low value small size capacitor, such as a 100 pF, 0402 size capacitor, in parallel with the 1 nF decoupling capacitor. Place this small capacitor a short distance away from the 1 nF capacitor and use the PCB connection track as an inductor to form a PI shape low-pass filter, as shown in Figure 5.
5. If implementing a PCB track PI filter, the arriving input PCB track and the leaving output PCB track connection to the decoupling capacitor should not be connected. The correct layout example is shown in Figure 5. The incorrect layout is shown in Figure 6.
6. Decouple the input port nodes with small capacitors, such as a 100 pF C3 and a 100 pF C4. They are not necessary but can lower the input EMI.

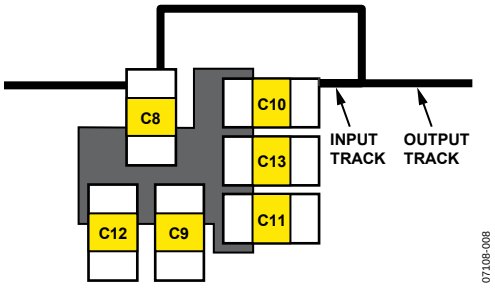

Figure 6. Wrong Routing for the Inductive Track Output Decoupling Capacitor

EVALUATION BOARD SCHEMATIC AND ARTWORK

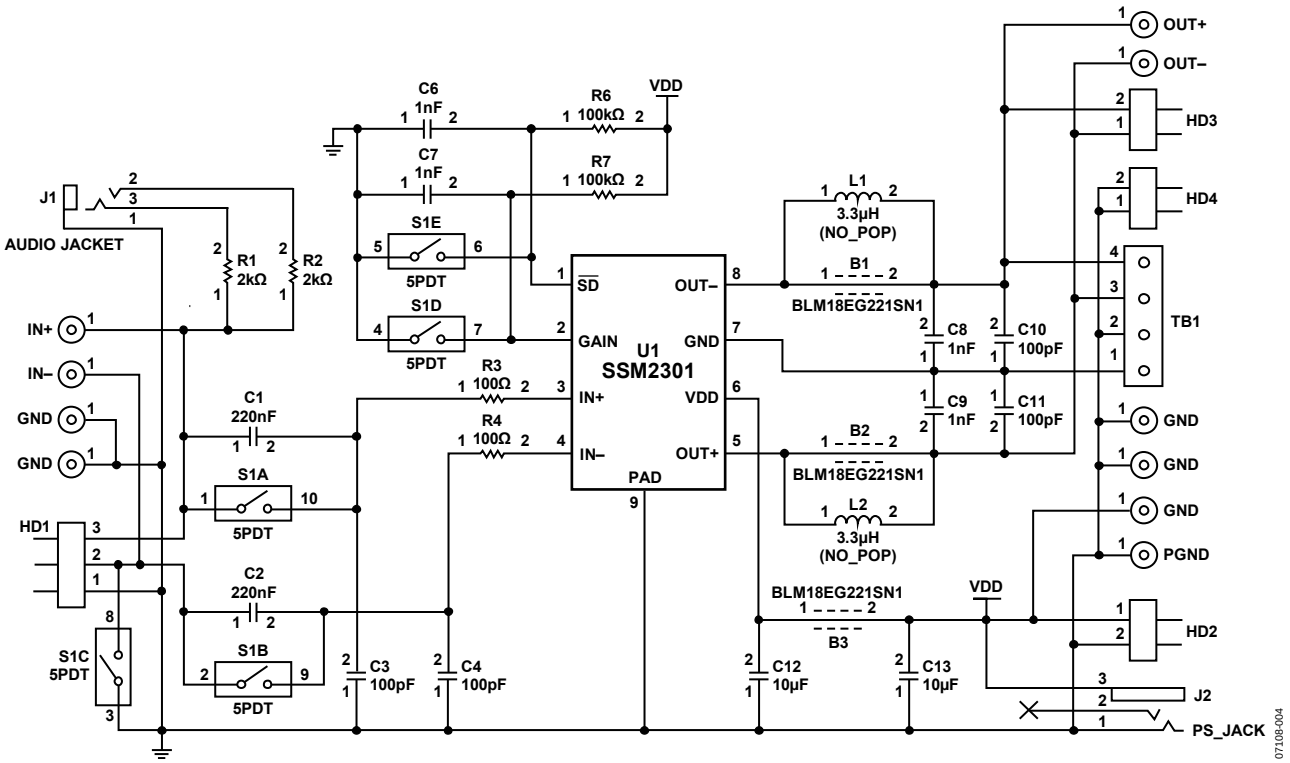

Figure 7. Schematic of SSM2301 Evaluation Board (Rev. 2.0)

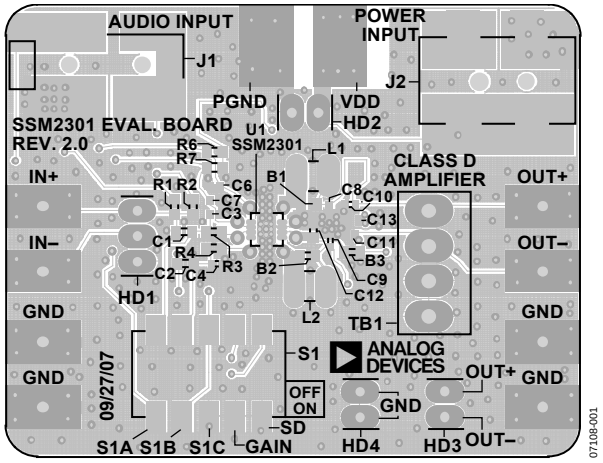

Figure 8. SSM2301 Evaluation Board (Rev. 2.0) Layout

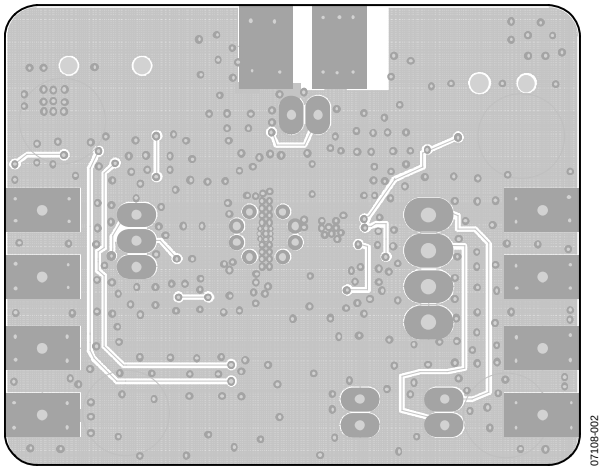

Figure 9. Bottom Layer of the Evaluation Board

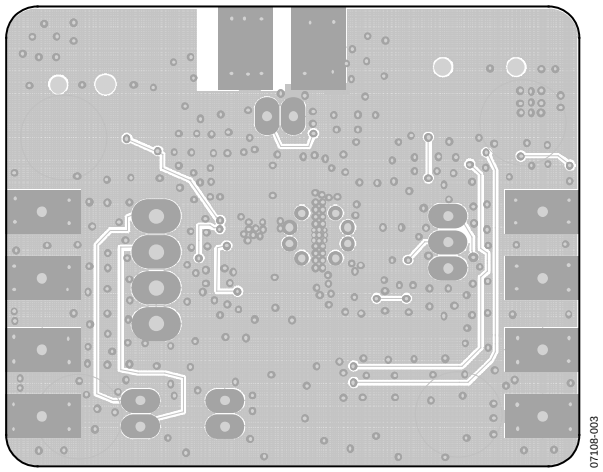

Figure 10. Mirrored Bottom Layer of the Evaluation Board

ORDERING INFORMATION

BILL OF MATERIALS

Table 1.

Qty	Designator	Description	Supplier	Supplier Part No.
2	R1, R2	Resistor, 2.00 kΩ, 1/10 W, 1%, 0603, SMD	Digi-Key	RHM2.00KHTR-ND
2	R3, R4	Resistor, 100 Ω, 1/10 W, 1%, 0603, SMD	Digi-Key	RHM100HTR-ND
2	R6, R7	Resistor, 100 kΩ, 1/10 W, 1%, 0603, SMD	Digi-Key	RHM100KHTR-ND
2	C1, C2	Capacitor, ceramic, 220 nF, 50 V, Y5V, 0603	Digi-Key	490-1569-2-ND
4	C3, C4 , C10, C11	Capacitor, ceramic, 100 pF, 6.3 V, X7R, 0402	Digi-Key	04026C101KAT2A-ND
4	C6, C7, C8, C9	Capacitor, ceramic, 1 nF, 5%, 50 V, X7R, 0402	Digi-Key	478-3661-2-ND
2	C12, C13	Capacitor, ceramic, 10 µF, 6.3 V, X5R, 0603	Digi-Key	PCC2395TR-ND
2	L1, L2	Inductor, 3.3 µH, type D62LCB SMD	Digi-Key	A918CY-3R3M
3	B1, B2, B3	Filter chip, 220 Ω, 2 A, 0603	Digi-Key	490-3992-2-ND
5	S1 (S1A, S1B, S1C, S1D, S1E)	Switch, DIP, top slide, 5-position, SMD	Digi-Key	CKN6074-ND
1	J1	Audio connectors, 3.5 mm, SMT	Mouser	806-STX-3500-3N
1	J2	DC power connectors, 2 mm, SMT power jack	Mouser	806-KLDX-SMT20202A
1	U1	Filterless high efficiency, mono 1.4 W, Class-D audio amplifier	Analog Devices	SSM2301CPZ-REEL7
3	HD2, HD3, HD4	Connector header 2-position, 0.100" SGL gold	Digi-Key	SAM1029-02-ND
1	HD1	Connector header 3-position, 0.100" SGL gold	Digi-Key	SAM1029-03-ND
1	TB1	Terminal block, 3.5 mm, 4-position PCB	Digi-Key	ED1516-ND

ORDERING GUIDE

Model	Description
SSM2301-EVALZ[1]	Evaluation Board

[1] Z = RoHS Compliant Part.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

NOTES

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