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Evaluation Board for SSM2356 Filterless Class-D Audio Amplifier

PACKAGE CONTENTS

EVAL-SSM2356Z

OTHER SUPPORTING DOCUMENTATION

SSM2356 data sheet

GENERAL DESCRIPTION

The SSM2356 is a fully integrated, single-chip, stereo Class-D audio amplifier. It is designed to maximize performance for mobile phone applications. The application circuit requires a minimum of external components and operates from a single 2.5 V to 5.5 V supply. It is capable of delivering 2 × 2 W of continuous output power with less than 1% THD + N driving a 4 Ω load from a single 5.0 V supply.

The SSM2356 comes with a differential mode input port and a high efficiency, full H-bridge at the output that enables direct coupling of the audio power signal to the loudspeaker. The differential mode input stage allows for cancelling of common-mode noise.

The part also features a high efficiency, low noise output modulation scheme that does not require external LC output filters when attached to an inductive load. Filterless operation also helps to decrease distortion due to the nonlinearities of output LC filters.

This user guide describes how to configure and use the SSM2356 evaluation board to test the SSM2356. It is recommended that this user guide be read in conjunction with the SSM2356 data sheet, which provides more detailed information about the specifications, internal block diagrams, and application guidance for the amplifier IC.

EVALUATION BOARD DESCRIPTION

The SSM2356 evaluation board carries a complete application circuit for driving a loudspeaker. Figure 1 shows the top view of the evaluation board, and Figure 2 shows the bottom view.

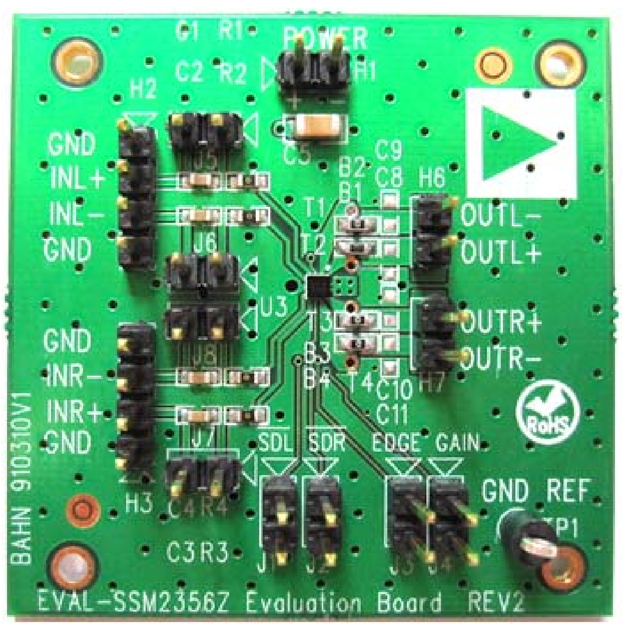

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Figure 1. SSM2356 Evaluation Board Top View

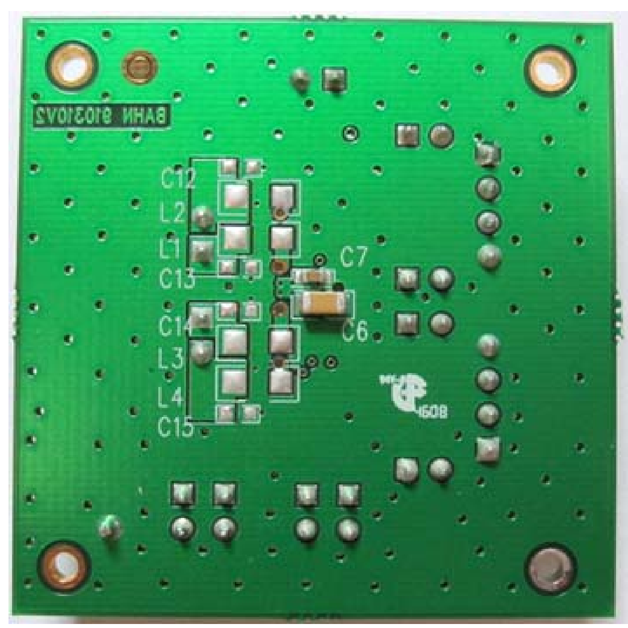

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Figure 2. SSM2356 Evaluation Board Bottom View

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REVISION HISTORY

10/10—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

INPUT CONFIGURATION

On the left side of the PCB are two 4-pin headers, H2 and H3 (see Figure 1). These are used to source the audio signal into the amplifier. If the input audio signal is differential use the two center pins of H2 (INL+ and INL−) for left channel audio and the two center pins of H3 (INR+ and INR−) for the right channel audio. In this case, either the top or bottom pin should be connected to the source/signal ground.

For a single-ended audio input, only two pins of H2 and H3 are used. One is for the ground and the other is for either IN+ or INL−. If INL+ is used, place a jumper between Pin 3 and Pin 4 of H2 and H3, shorting INL− to ground. If INL− is used as the single-ended audio source, place the jumper between Pin 1 and Pin 2 of H2 and H3, connecting INL+ to the ground.

The 2-pin headers, J1 and J2, are used to turn on/off the SSM2356 amplifier. Inserting a jumper across J1 pulls up the left-channel shutdown control to VDD level and activates the Class-D output. Removing the jumper from J1 shuts down the left channel of SSM2356 so that only a minimum current (about 20 nA) is drawn from the power supply. J2 applies the same functionality to the right-channel amplifier.

GAIN SELECTION

On the bottom-right side of the PCB is a 2-pin header, J3 (see Figure 1). This is used to select the gain of the amplifier. If the jumper is open, the gain of SSM2356 is 6 dB. Inserting a jumper across J3 sets the gain of SSM2356 to 18 dB.

OUTPUT CONFIGURATION

The output connectors, H6 and H7, are located on the right side of the board (see Figure 1). The output of SSM2356 drives a loudspeaker whose impedance should be no less than 4 Ω.

Although the SSM2356 does not require any external LC output filters due to a low noise modulation scheme, if the speaker length is >10 cm, it is recommended to put a ferrite bead (B1 to B4) near each output pin of the SSM2356 to reduce electromagnetic interference (EMI), as shown in the schematic in Figure 3. On the board, there are four inductors, L1 to L4, that are not loaded and not required for normal operation. Some users may want to replace the ferrite beads with these inductors to evaluate applications with specific EMI vs. audio performance constraints.

As an aid, a properly tuned ferrite bead-based EMI filter is assembled at the output terminals of the device. For optimal performance, as specified in the SSM2356 data sheet (in particular, for THD and SNR), remove the entire EMI filter, short across the ferrite bead terminals, and open the capacitor terminals.

EMISSIONS LIMITING CONFIGURATION

On the bottom-right side of the PCB is a 2-pin header, J3 (see Figure 1). This is used to select the emissions limiting mode of the amplifier. If the jumper is open, the SSM2356 is in normal emissions mode. While in normal emissions mode, the edge rate of the switching outputs is at maximum speed, with the most efficient operation. Inserting a jumper across J3 lowers the edge rate of the switching outputs. The benefit is that radiated emissions is suppressed, but at the cost of approximately 2% reduction in peak efficiency.

POWER SUPPLY CONFIGURATION

The 2-pin header (H1) must be used to power the board, which accepts a 2.5 V ~ 5.5 V dc power supply. Care must be taken to connect the dc power with the correct polarity and voltage.

Polarity and Voltage

The wrong power supply polarity or overvoltage may damage the board permanently. The maximum peak current is approximately 0.33 A when driving an 8 Ω load and when the input voltage is 5 V.

COMPONENT SELECTION

Selecting the proper components is the key to achieving the performance required at the budgeted cost.

Input Coupling Capacitor Selection—C1 to C4

The input coupling capacitors, C1 to C4, should be large enough to couple the low frequency signal components in the incoming signal and small enough to filter out unnecessary low frequency signals. For music signals, the cutoff frequency chosen is often between 20 Hz and 30 Hz. The value of the input capacitor is calculated by

$$C = 1/(2\pi R f_c)$$

where:

$R = 80\ k\Omega + R_{EXT}$ (the external resistor used to fine-tune the desired gain).

f_c is the cutoff frequency.

Output Ferrite Beads—B1 to B4

The output beads, B1 to B4, are suggested components for filtering out the EMI caused at the switching output nodes. The penalty for using ferrite beads for EMI filtering is slightly worse noise and distortion performance at the system level due to the nonlinearity of the beads. Ensure that these beads have enough current conducting capability while providing sufficient EMI attenuation. The current rating needed for an 8 Ω load is approximately 420 mA, and impedance at 100 MHz must be ≥120 Ω. In addition, the lower the dc resistance (DCR) of these beads, the better for minimizing their power consumption. Table 1 describes the recommended beads.

Table 1. Recommended Output Beads

Part No.	Manufacturer	Z (Ω)	I_{MAX} (mA)	DCR (Ω)	Size (mm)
BLM18PG121SN1D	Murata	120	2000	0.05	1.6 × 0.8 × 0.8
MPZ1608S101A	TDK	100	3000	0.03	1.6 × 0.8 × 0.8
MPZ1608S221A	TDK	220	2000	0.05	1.6 × 0.8 × 0.8
BLM18EG221SN1D	Murata	220	2000	0.05	1.6 × 0.8 × 0.8

Table 2. Recommended Output Inductors

Part No.	Manufacturer	L (µH)	I_{MAX} (mA)	DCR (Ω)	Size (mm)
LQM31PNR47M00	Murata	0.47	1400	0.07	3.2 × 1.6 × 0.85
LQM31PN1R0M00	Murata	1.0	1200	0.12	3.2 × 1.6 × 0.85
LQM21PNR47MC0	Murata	0.47	1100	0.12	2.0 × 1.25 × 0.5
LQM21PN1R0MC0	Murata	1.0	800	0.19	2.0 × 1.25 × 0.5
LQH32CN2R2M53	Murata	2.2	790	0.1	3.2 × 2.5 × 1.55
LBC2518T2R2M	Taiyo Yuden	2.2	630	0.13	2.5 × 1.8 × 2
1033AS-4R7M	Toko	4.7	680	0.31	3.8 × 3.8 × 1

Output Shunting Capacitors

There are four output shunting capacitors, C8 to C11, that work with the B1 to B4 ferrite beads or with the L1 to L4 inductors, if they are used. Use small size (0603 or 0402), multilayer ceramic capacitors that are made of X7R or COG (NPO) materials. Note that the capacitors can be used in pairs: a capacitor with small capacitance (up to 100 pF) plus a capacitor with a bigger capacitance (less than 1 nF). This configuration provides thorough EMI reduction for the entire frequency spectrum. For BOM cost reduction and capable performance, a single capacitor of approximately 470 pF can be used.

Output Inductors—L1 to L4

If using inductors for the purpose of EMI filtering at the output nodes, choose inductance that is <2.2 µH for these inductors. The higher the inductance, the lower the EMI is at the output. However, the cost and power consumption by the inductors are higher. Using 0.47 µH to 2.2 µH inductors is recommended, and the current rating needs >600 mA (saturation current) for an 8 Ω load. Table 2 shows the recommended inductors.

Note that these inductors are not populated on the evaluation board.

PCB LAYOUT GUIDELINES

To keep the EMI under the allowable limit and to ensure that the amplifier chip operates under the temperature limit, PCB layout is critical in application design. One particular focal point for radiated emissions reduction is minimizing ground loops whenever possible.

Layer Stacks and Grounding

The stack-up for the evaluation board is a 4-layer structure.

- Top layer—component layer with power and output copper land and ground copper pouring.
- Second layer—dedicated ground plane.
- Third layer—dedicated power plane.
- Bottom layer—bottom layer with ground copper pouring.

Component Placement and Clearance

Place all related components except decoupling capacitors on the same side as the SSM2356 and as close as possible to the chip to avoid vias (see Figure 4).

Place decoupling capacitors on the bottom side and close to the GND pin (see Figure 6).

Top Layer Copper Land and Ground Pouring

The output peak current of this amplifier is more than 1 A; therefore, PCB traces should be wide (>2 mm) to handle the high current. For the best performance, use symmetrical copper lands as large as space allows, instead of traces for the output pins.

Pour ground copper on the top side and use many vias to connect the top layer ground copper to the dedicated ground plane. The copper pouring on the top layer serves as both the EMI shielding ground plane and the heat sink for the SSM2356.

The SSM2356 works well only if these techniques are implemented in the PCB design to keep EMI and the amplifier temperature low.

GETTING STARTED

To ensure proper operation, carefully follow Step 1 through Step 6.

1. Configure the amplifier in the desired gain selection: insert a jumper across J3 to set 18 dB gain, or remove the jumper from J3 to set 6 dB gain.
2. Configure the amplifier in the desired emissions limiting mode: insert a jumper across J4 to activate the low emissions mode, or remove the jumper from J4 to place the amplifier in normal emissions mode.
3. Connect the load to the audio output connector, H6 and H7.
4. Connect the audio input to the board, in either differential mode or single-ended mode, depending on the application.
5. Connect the power supply with the proper polarity and voltage.
6. Insert a jumper across J1 and J2 to activate both right and left channels of the amplifier, or remove the corresponding jumper to disable the amplifier.

WHAT TO TEST

- Electromagnetic interference (EMI)—connect wires for the speakers, making sure they are the same length as the wires required for the actual application environment; then complete the EMI test.
- Signal-to-noise ratio.
- Output noise—make sure to use an A-weighted filter to filter the output before reading the measurement meter.
- Maximum output power.
- Distortion.
- Efficiency.

EVALUATION BOARD SCHEMATIC AND ARTWORK

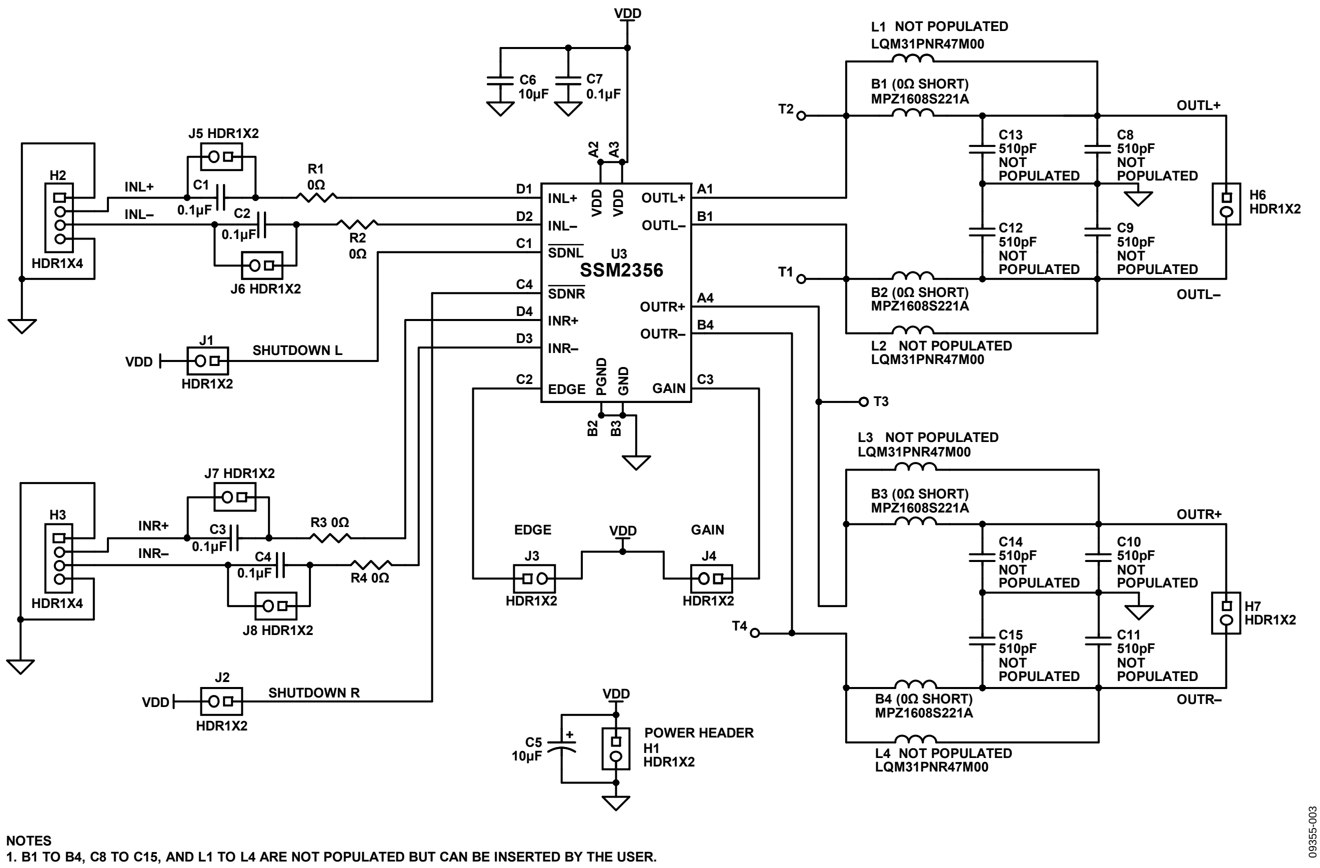

Figure 3. Schematic of the SSM2356 Evaluation Board

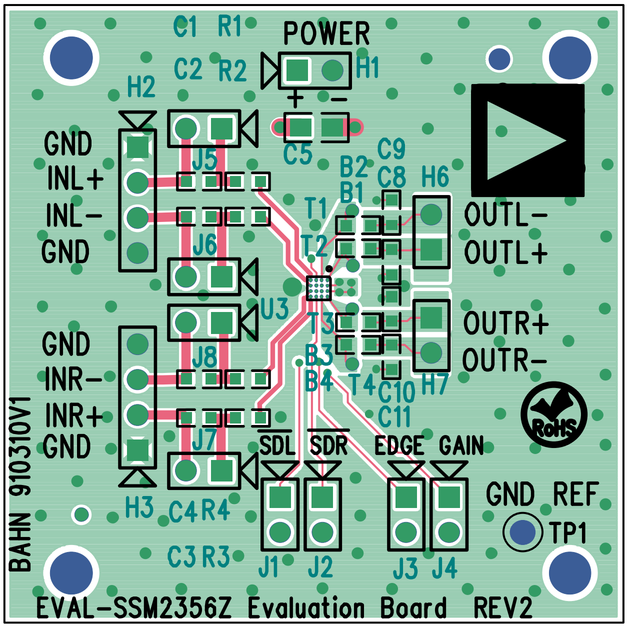

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Figure 4. Top Layer with Top Silkscreen

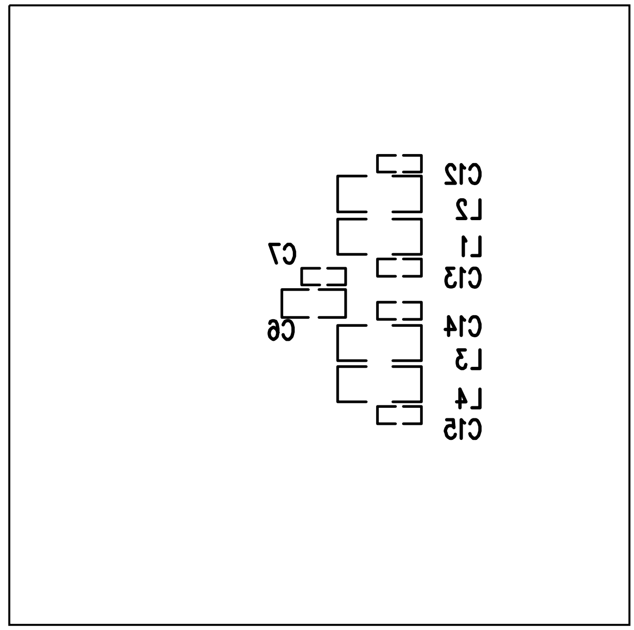

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Figure 6. Bottom Silkscreen

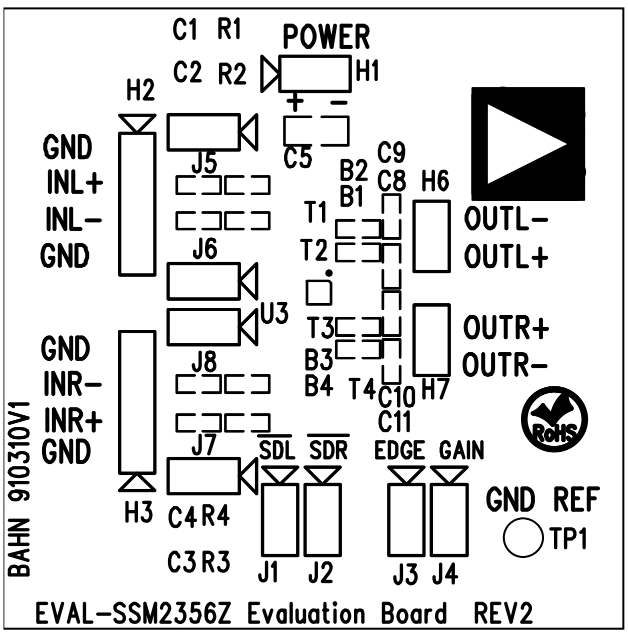

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Figure 5. Top Silkscreen

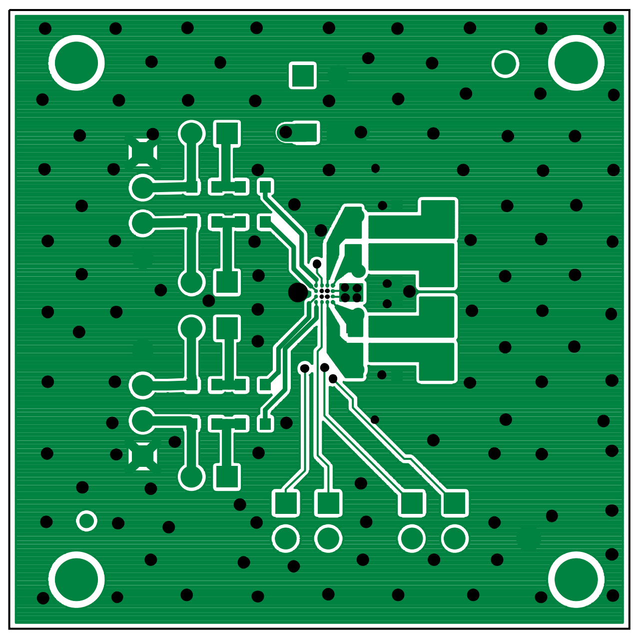
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Figure 7. Top Layer

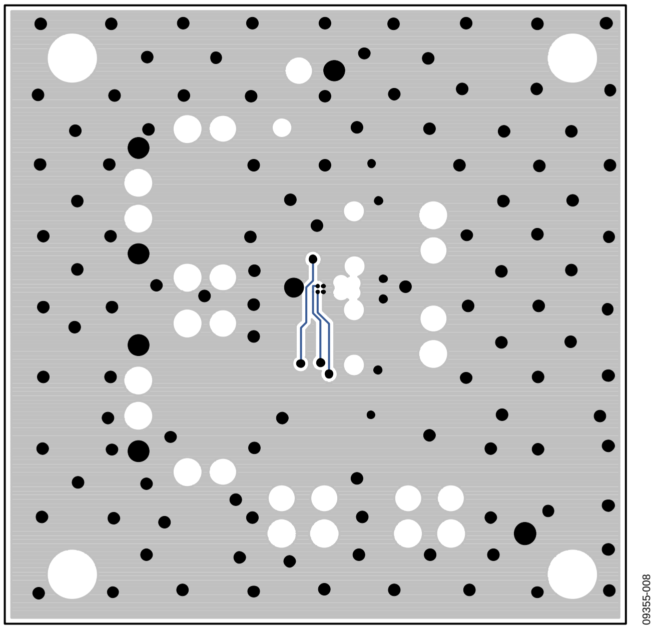

Figure 8. Layer 2 (Ground Plane)

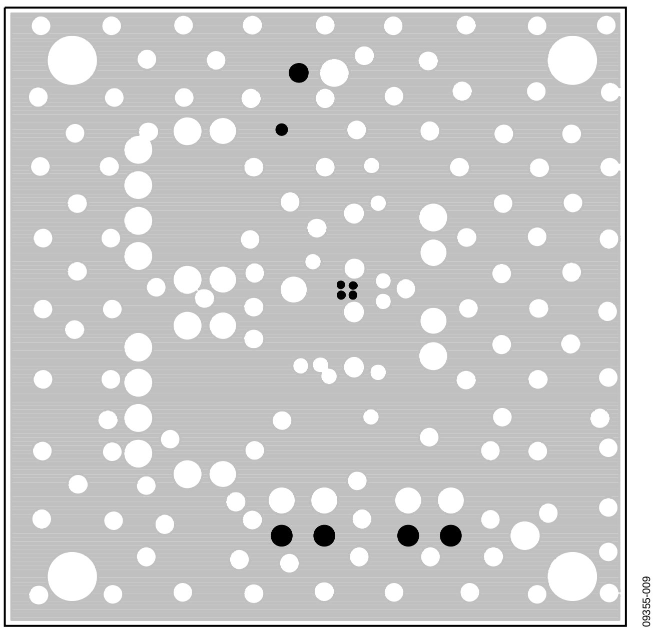

Figure 9. Layer 3 (Power Plane)

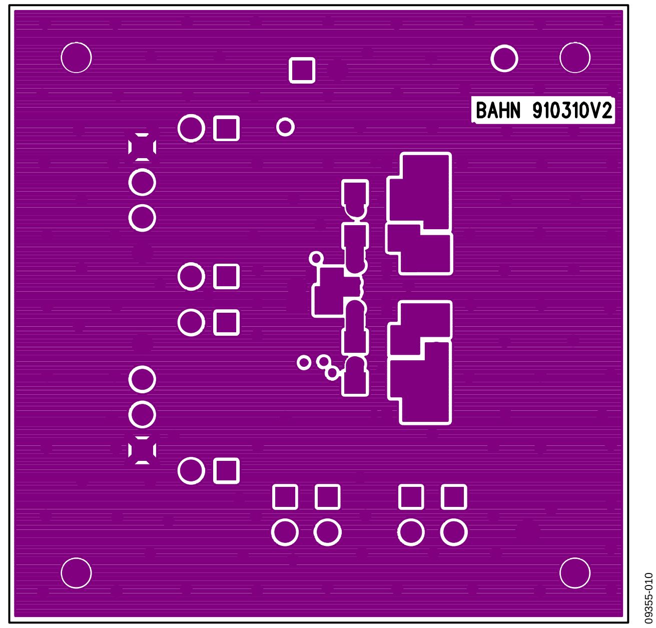

Figure 10. Bottom Layer

ORDERING INFORMATION

BILL OF MATERIALS

Table 3.

Qty	Reference Designator	Description	Supplier/Part No.
4	B1, B2, B3 ,B4	Ferrite bead, 220 Ω, 2 A, replaced with 0 Ω short	TDK, MPZ1608S221A
5	C1, C2, C3, C4, C7	Ceramic capacitor, 0.1 µF	Panasonic, ECJ-1VB1C104K
2	C5, C6	Ceramic capacitor, 10 µF	Murata, GRM21BR61A106KE19L
8	C8, C9, C10, C11, C12, C13, C14, C15	510 pF, not populated	Murata, GRM1885C2A511JA01D
11	J1, J2, J3, J4, J5, J6, J7, J8, H1, H6, H7	HDR1X2, two-position header	Tyco, 4-103747-0-02
2	H2, H3	HDR1X4, four-position header	Tyco, 4-103747-0-04
4	L1, L2, L3, L4	470 nH inductor, not populated	Murata, LQM31PNR47M00
4	R1, R2, R3, R4	Resistor, 0 Ω	Yageo, 9C06031A0R00JLHFT
4	T1, T2, T3, T4	Test pad	N/A
1	U3	SSM2356	Analog Devices, SSM2356Z
1	TP1	Test point, GND	Keystone Electronics, 5001

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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.

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