Evaluation Board for Class-D Audio Amplifiers

EVAL-ADAU1513/ADAU1590/ADAU1592

FEATURES

For the evaluation of ADAU1513, ADAU1590, and ADAU1592 2x15W audio amplifiers
THD + N better than 85 dB @ 1 W for ADAU1590, and ADAU1592
SNR better than 100 dB for ADAU1590, and ADAU1592
Pop-and-click noise suppression
Built in output short-circuit protection, thermal protection, undervoltage protection

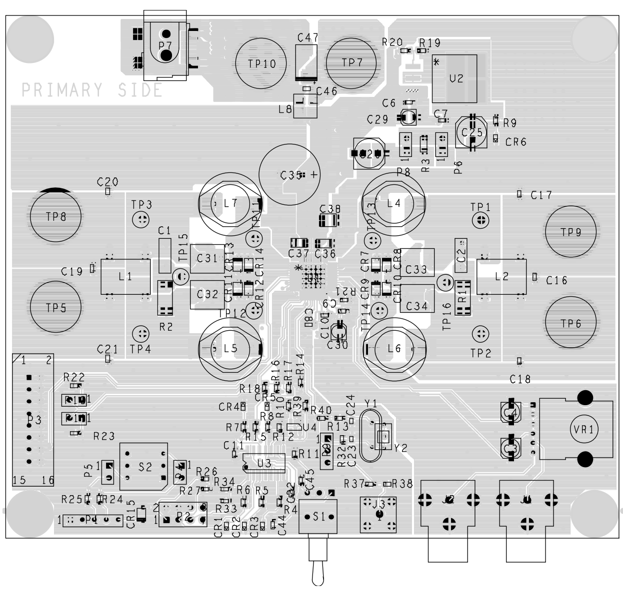
APPLICATIONS

LCD/plasma TVs
Home Theaters
Mini/micro systems
Powered speakers
iPod™ docking stations

GENERAL DESCRIPTION

The EVAL-ADAU1513/ADAU1590/ADAU1592 is simple and user friendly for quick evaluation of the ADAU1513, ADAU1590, and ADAU1592 Class-D amplifiers. The board can deliver up to 15 W of output power. The power supply operating range is 9 V to 18 V. The typical load impedance is 6 Ω, but it is possible to configure for 4 Ω or 8 Ω with few component changes.

EVALUATION BOARD PICTURE



06916-001

Figure 1. Evaluation Board Top View

Rev. 0

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 **www.analog.com**
Fax: 781.461.3113

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REVISION HISTORY

10/07—Revision 0: Initial Version

OVERVIEW OF THE ADAU1513, ADAU1590, AND ADAU1592

The EVAL-ADAU1513/ADAU1590/ADAU1592 can be used for quick evaluation of ADAU1513, ADAU1590, and ADAU1592 Class-D amplifiers. The ADAU1590 and ADAU1592 consist of stereo Class-D amplifiers based on sigma-delta (Σ-Δ) architecture. The ADAU1513 is a stereo integrated power stage part.

The ADAU1590 and ADAU1592 offer excellent audio performance. The closed-loop architecture reduces THD + N to about 85 dB. The LFCSP with a bottom exposed pad allows heat dissipation through PCB copper. A highly efficient output stage requires no extra heat sink for 2x15W applications in 6 Ω. The ADAU1590 and ADAU1592 use 512 × f_S clock generated using an external crystal or ceramic resonator. Internally, the clock is divided by 2 to derive 256 × f_S master clock. The modulator works at 256 × f_S clock. The closed-loop Σ-Δ architecture improves the THD + N and PSRR. The selectable PGA gain setting allows part to be configured at 4 different gain settings from 0 dB, 6 dB, 12 dB, or 18 dB. The parts also allow two modes of operation either stereo or mono (for high output current driving in low impedances). The parts have pop-and-click suppression during turn-on and turn-off.

The ADAU1513 is a power stage only part, which accepts 3.3 V logic level digital differential pulse-width modulated (PWM), inputs from external modulator. The inputs to the power stage can be fed from an external PWM controller such as the ADAV4201.

The ADAU1513, ADAU1590, and ADAU1592 have built-in output short-circuit protection, overcurrent protection, and thermal protection.

EVALUATION BOARD HARDWARE

The board allows single-supply operation ranging from 9 V to 18 V and consists of one footprint for ADAU1513, ADAU1590, ADAU1592, which provides up to 2x15W output. The footprint on the PCB is optimized for both LFCSP (CP-48-1) and TQFP (SV-48-5) packages. The typical load impedance is 6 Ω, but 4 Ω or 8 Ω operation is possible with minor component changes to an output LC filter. The board is designed as 4-layer PCB. The top and bottom layers are for signals, whereas Layer 2 and Layer 3 are used as GND and a power plane. The board is designed for typical stereo or 2-channel audio amplifier application. The PCB layout is important to achieve good audio performance and EMI performance. The following sections offer useful guidelines for designing the board.

SUPPLY DECOUPLING

Power supply decoupling is the most critical element in the design of switching amplifier boards. For the evaluation board to work properly, it is very important to pay attention to the selection and placement of the supply decoupling capacitors. The typical 0.1 μF multilayer ceramic chip (MLCC) in either a 0805 or 1206 package is most suitable for a high frequency decoupling capacitor and must be placed as close as possible to the ADAU1513, ADAU1590, or ADAU1592. The X7R or X5R dielectric should be given preference over Y5V or Z5U. The placement of these components is also important. The 0.1 μF high frequency decoupling capacitors must be placed as close to the part as possible. In addition, take care that the supply and GND connection to the PVDD and PGND pins of ADAU1513, ADAU1590, and ADAU1592 is direct. Avoid placing vias in the traces connecting decoupling capacitors to PVDD and PGND pins. Higher value MLCC or 1 μF tantalum capacitors may also be used.

SCHOTTKY DIODE

The Schottky diodes limit the voltages at the bridge output from exceeding damaging levels, due to the presence of inductors. Hence, the diodes must be placed very close to the ADAU1513, ADAU1590, or ADAU1592 to provide a low inductive current return path.

LC FILTER

The EVAL-ADAU1513/ADAU1590/ADAU1592 uses a 2-pole Butterworth filter for reconstruction of the output signal. The inductor forms an important element as it can limit the THD + N performance as well as EMI performance. The EVAL-ADAU1513/ADAU1590/ADAU1592 uses a shielded drum core inductor. The current saturation limit must be greater than 5 A for preventing the saturation of the inductor at high output powers. Though the unshielded drum cores saturation current rating is higher than the shielded current rating, the shielded ones are preferred and aid in reducing the EMI radiation. The typical polyester or film capacitors are used for the output filter. See Table 1 for typical LC filter component values for commonly used loads.

Table 1. Output LC Filter Component Value

Load Impedance (Ω)	Inductors L4, L5, L6, L7 (μH)	Capacitors C31, C32, C33, C34 (μF)
4	10	1.5
6	15	1
8	22	0.68

INPUT/OUTPUT CONNECTORS

The EVAL-ADAU1513/ADAU1590/ADAU1592 has two RCA jack connectors for analog input and three pairs of binding posts for amplifier outputs and power supply connections. The RCA jacks, J2 and J1, are left- and right-channel analog inputs.

Binding Post TP5 (red) and Binding Post TP8 (black) are positive and negative left-channel speaker outputs, whereas Binding Post TP6 (red) and Binding Post TP9 (black) are positive and negative right-channel speaker outputs. Binding Post TP7 (red) and Binding Post TP10 (black) are positive PVDD and PGND power supply inputs to the board.

The 5-pin male header, P1, is the test input port for internal use only and should not be connected to the evaluation board.

The dual row, 8-pin male header, P2, is a control I/O port useful for accessing the error flag outputs, mute inputs, and reset inputs.

The dual row, 16-pin male header, P3, is a PWM input port used for logic level PWM inputs to the ADAU1513 only.

The 2-pin male headers, P6 and P8, are used to provide the AVDD and DVDD supply. These must be installed to provide 3.3 V, AVDD, and DVDD to all the circuits on board.

An SMA type connector, J3, is used for external clock input

JUMPERS AND SWITCHES

The 3-way toggle switch, S1, is used for reset, as well as to mute or turn on the amplifier. S1 has three positions that are used as reset/mute/on. The reset position is momentary (see Figure 2).

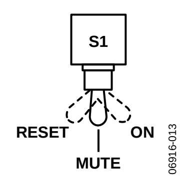

Figure 2. Reset/Mute/On Switch

The 4-way rotary switch, S2, is used for setting PGA gain and the 2-pin jumpers, P4 and P5, must be installed for S2 to be effective. See Figure 3 for switch settings. The switch has four positions, which can be used to set either 0 dB, 6 dB, 12 dB, or 18 dB of PGA gain. Switch S2 is effective only for ADAU1590 or ADAU1592.

The PGA switch settings are as follows:

- Position 0 = 0 dB PGA gain (approximately 1 V rms input for a clipped output)
- Position 1 = 6 dB PGA gain (approximately 0.5 V rms input for a clipped output)
- Position 2 = 12 dB PGA gain (approximately 0.25 V rms input for a clipped output)
- Position 3 = 18 dB PGA gain (approximately 0.125 V rms input for a clipped output)

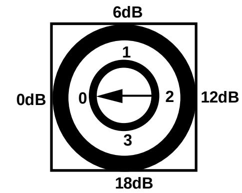

Figure 3. PGA Setting Switch S2

The 3-pin jumper, P9, is for using either the external or the internal clock for the board. When P9 is set for external, the external clock is fed at J3. When P9 is set for internal, the internal clock is generated using the quartz crystal or ceramic resonator on the board. This is used to provide the master clock for ADAU1590, or ADAU1592.

The volume can be controlled using a potentiometer, VR1, and is effective for ADAU1590 or ADAU1592 only.

BOARD CONNECTIONS SETUP

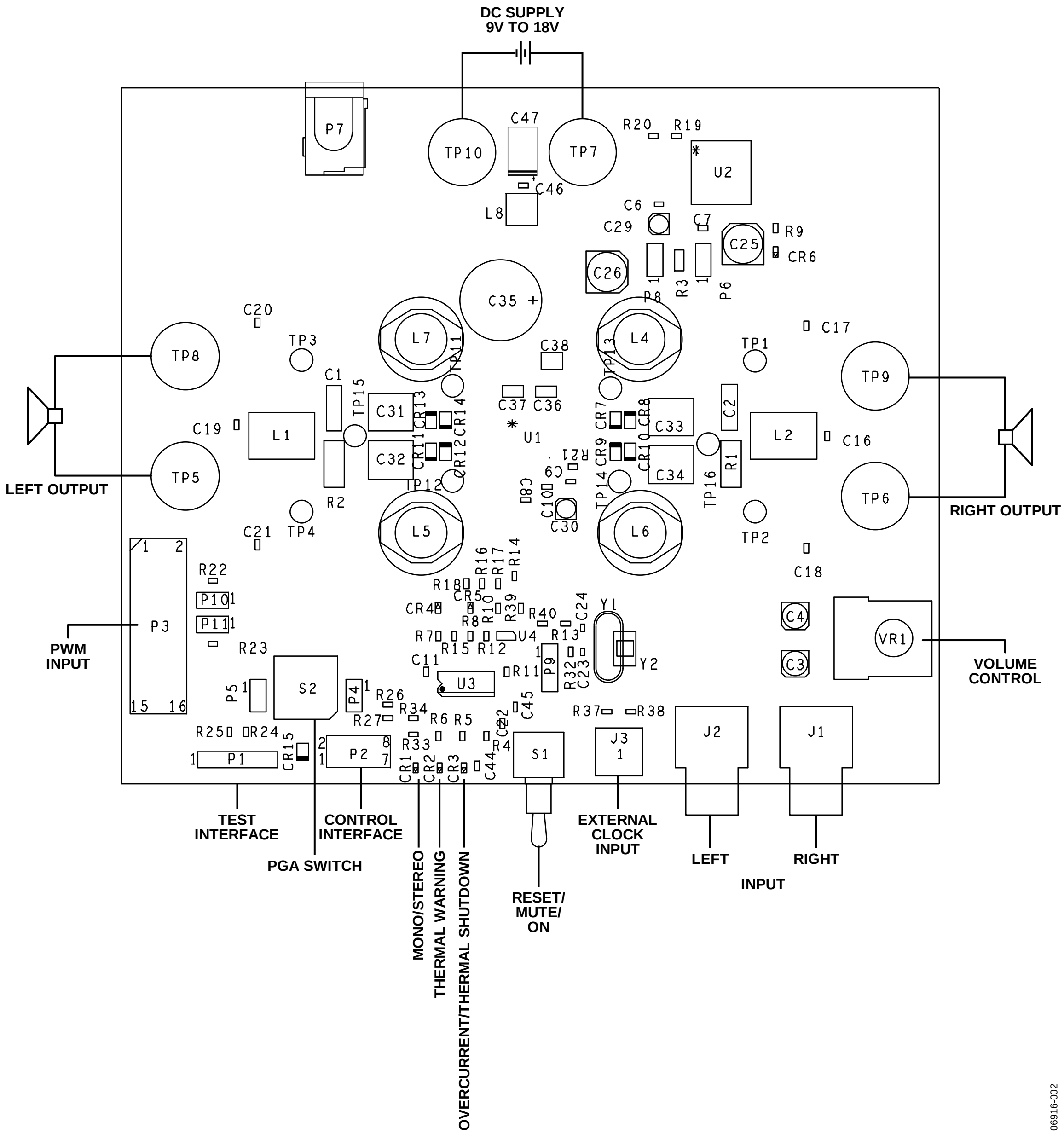

Figure 4.

BOARD SETTING UP INSTRUCTION

Setting up the EVAL-ADAU1513/ADAU1590/ADAU1592 is simple; the user needs a power supply, input source, and load for quick evaluation of the board. Use a single 9 V to 18 V, either variable or fixed, 3 A to 5 A current rating for power supply.

Use a sine wave signal generator 0 V to 2 V rms variable output or suitable audio source (stereo) for the ADAU1590, ADAU1592. Use a suitable PWM input source 3.3 V logic, differential type for the ADAU1513.

Use two 6 Ω or 8 Ω/20 W resistive loads or suitable speakers for load.

ADAU1590, ADAU1592

See Figure 4 for the connection board setup of the ADAU1590, or ADAU1592.

1. Connect the power supply positive lead to TP7 and 0 V lead to TP10 of the board. Do not turn on the power supply at this time.
2. Connect the suitable load across TP5 and TP8 for the left channel; connect the suitable load across TP6 and TP9 for the right channel.
3. Connect the input signal source to J2 for the left channel and J1 for the right channel. Ensure that Switch S1 is at the center position (mute). Place the PGA switch (S2) in the 0 dB position (arrow at 0 position).
4. Turn VR1 fully counterclockwise (minimum volume) and turn on the power supply to the desired voltage, in the range of 9 V to18 V. Make sure the red LED CR4 (mute) and green LED CR6 (power) are on.
5. Move S1 to the on position. The mute LED should turn off. Slowly turn the VR1 clockwise and adjust the volume control to the desired output level. If the speakers are connected, the audio output should be heard on the speakers or be available at the load resistors.

Note that the red LED, CR2, is a thermal warning. It lights up when the junction temperature reaches ~135°C.

The red LED, CR3, is an error indicator. It turns on when the junction temperature reaches 150°C thermal shutdown or in overcurrent condition (when the amplifier detects the overcurrent condition or short circuit on the outputs). The amplifier shuts itself down and mute needs to be asserted and then deasserted to restore the amplifier to normal operation.

The red LED CR1 is a mono mode indicator and turns on when the part is configured for mono mode operation.

Use S1 to reset/mute the amplifier.

ADAU1513

See Figure 4 for the connection board setup of the ADAU1513.

1. Connect the power supply positive lead to TP7 and the 0 V lead to TP10 of the board. Do not turn on the power supply at this time.
2. Connect the suitable load across TP5 and TP8 for the left channel, across TP6 and TP9 for the right channel.
3. Connect the pulse-width modulated signal source to P3, Pin 13, and Pin 15 for the left channel and Pin 9 and Pin 11 for the right channel. See Table 2 for pinout details.

Table 2. PWM Input Header Pin

P3 Pin Number	Signal Name
9	PWM input right negative polarity
11	PWM input right positive polarity
13	PWM input left negative polarity
15	PWM input left positive polarity
2, 4, 6, 8, 10, 12, 14	GND

4. Ensure that Switch S1 is at the center position (mute). Place the PGA switch, S2, to the 0 dB position (arrow at the 0 position), and the PWM source is in mute condition.
5. Turn on the power supply to the desired supply voltage in the range of 9 V to 18 V. Make sure only the red LED CR4 (mute) and green LED CR6 (power) are on.
6. Move Switch S1 to the on position. The mute LED should turn off. Unmute the PWM source. If speakers are connected, the audio output can be heard.

Note that the on board volume control is ineffective when using the ADAU1513. The digital modulator is expected to have volume control in this application.

The PGA switch, S2, is inactive when using the ADAU1513.

The red LED, CR2, is the thermal warning and lights up when the junction temperature reaches ~135°C.

The red LED, CR3, is an error indicator. It turns on when the junction temperature reaches 150°C thermal shutdown or in overcurrent (when the amplifier detects the overcurrent condition or short circuit on outputs). The amplifier shuts down and mute needs to be asserted and deasserted to restore the amplifier in normal operation.

Use Switch S1 to reset the amplifier.

SCHEMATICS AND ARTWORK

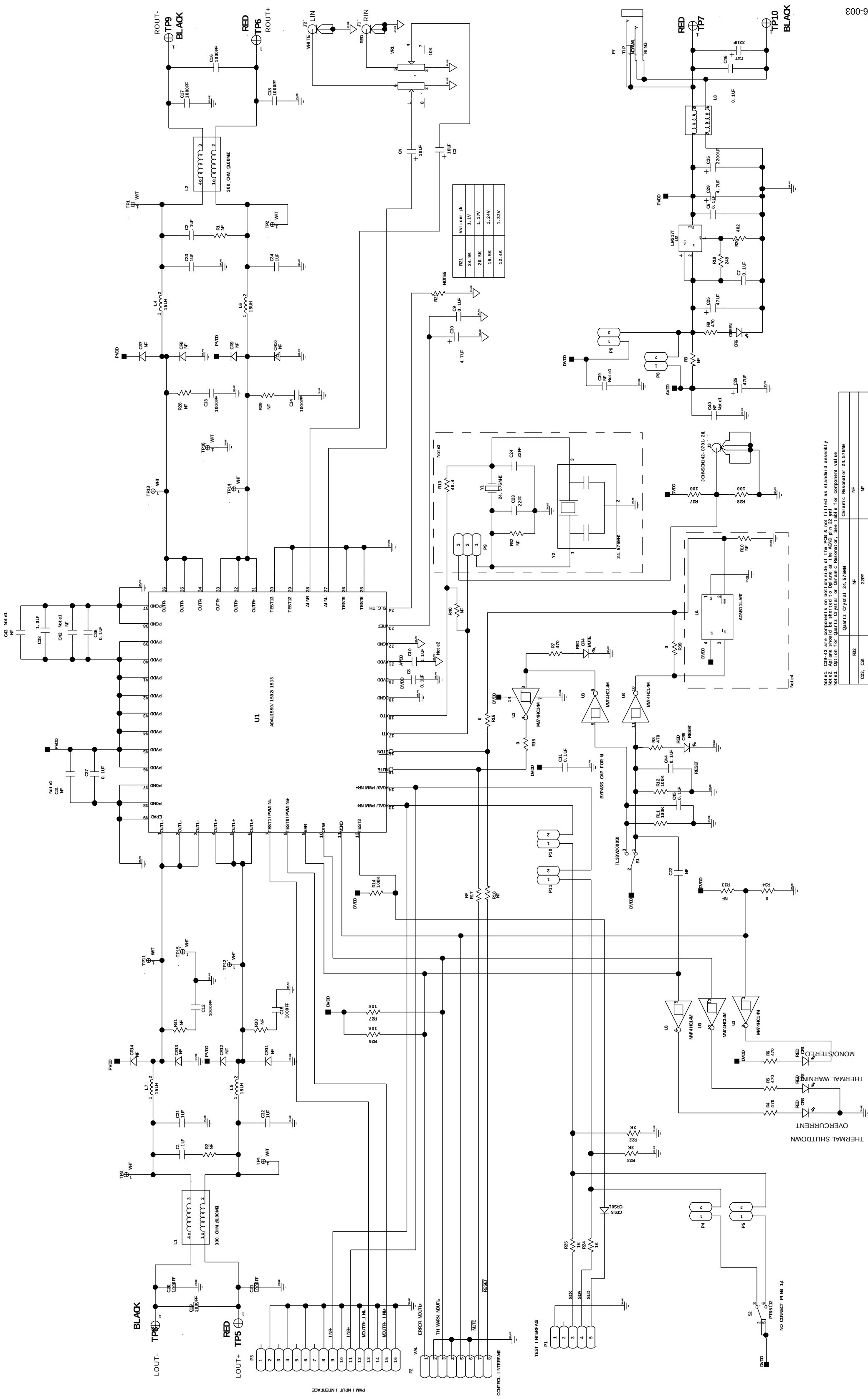

Figure 5. Schematic

BOARD LAYOUT

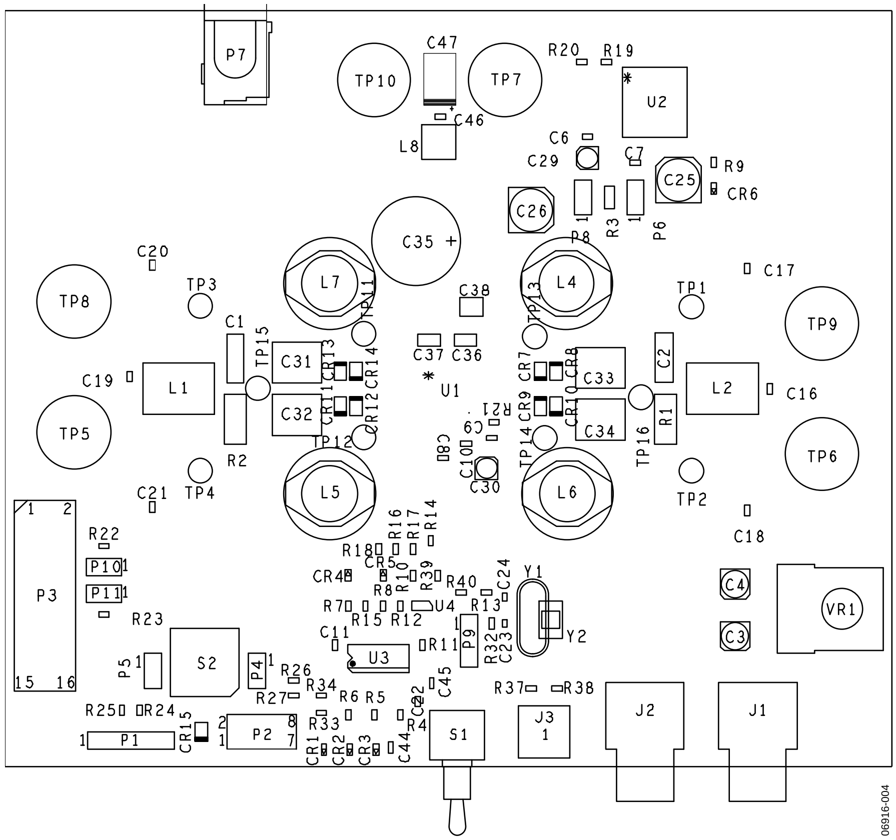

Figure 6. Top Assembly

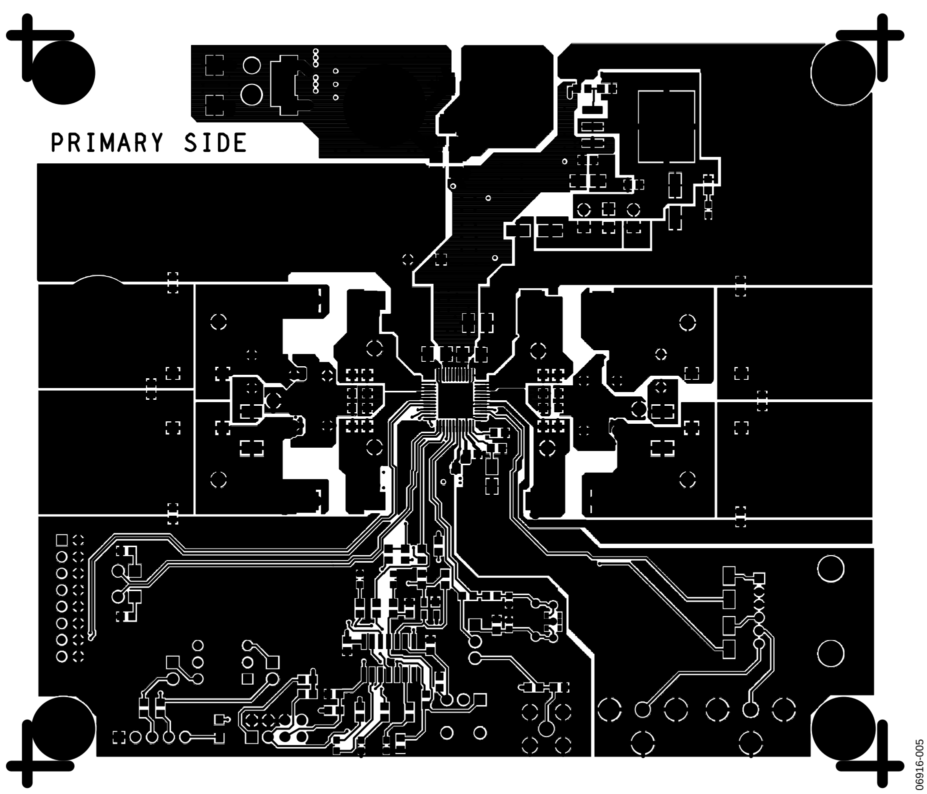

Figure 7. Top Layer

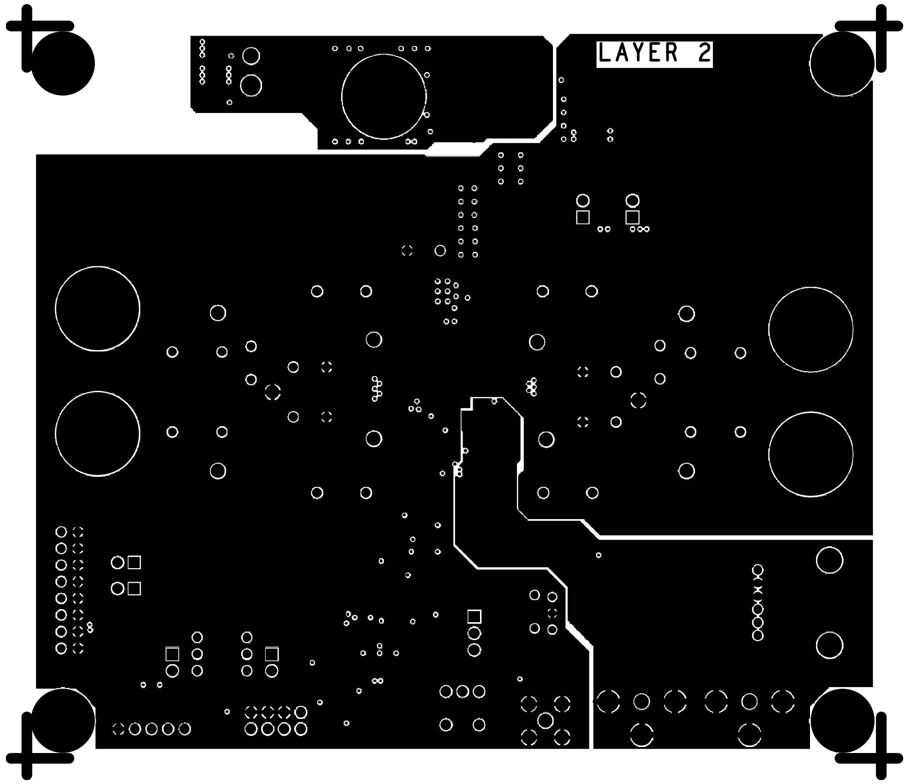

Figure 8. Layer 2

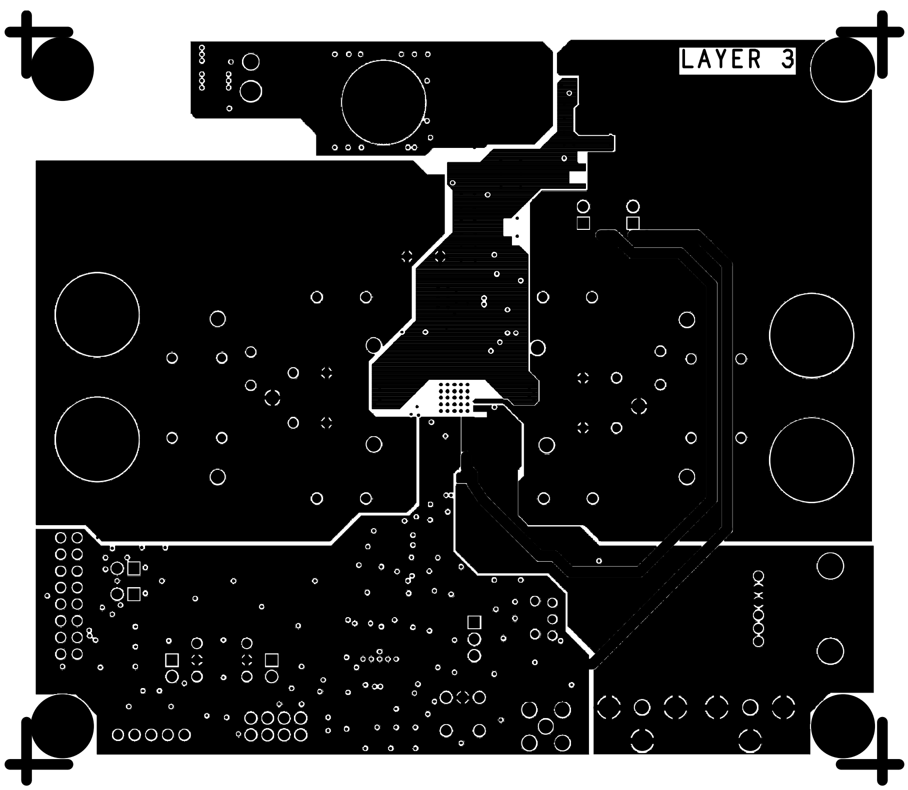

Figure 9. Layer 3

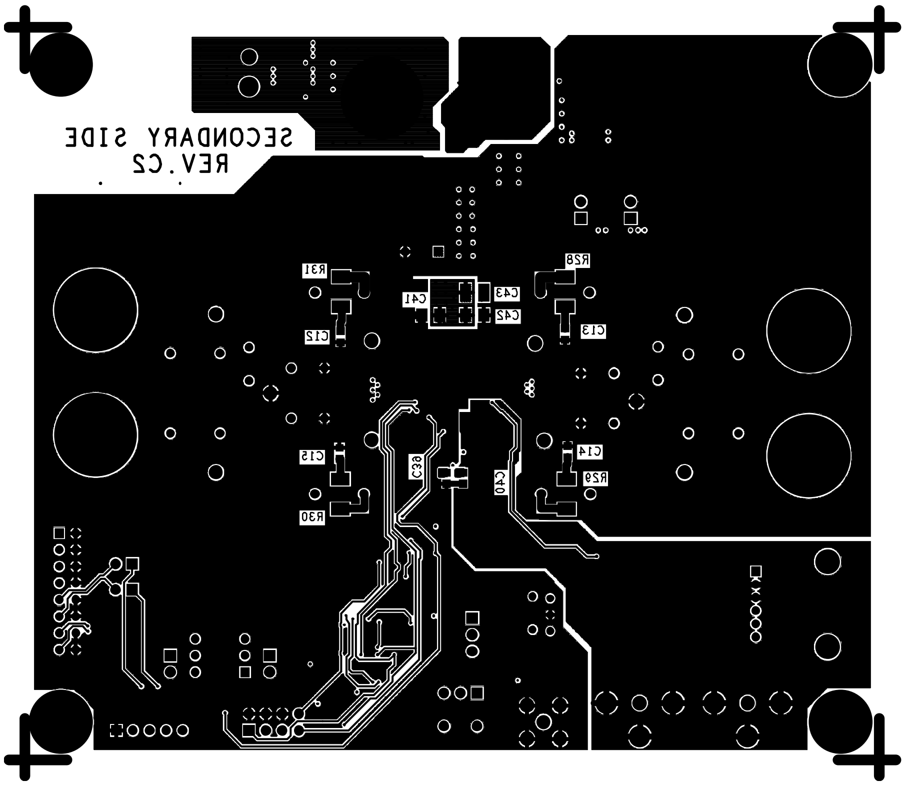

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Figure 10. Bottom Layer

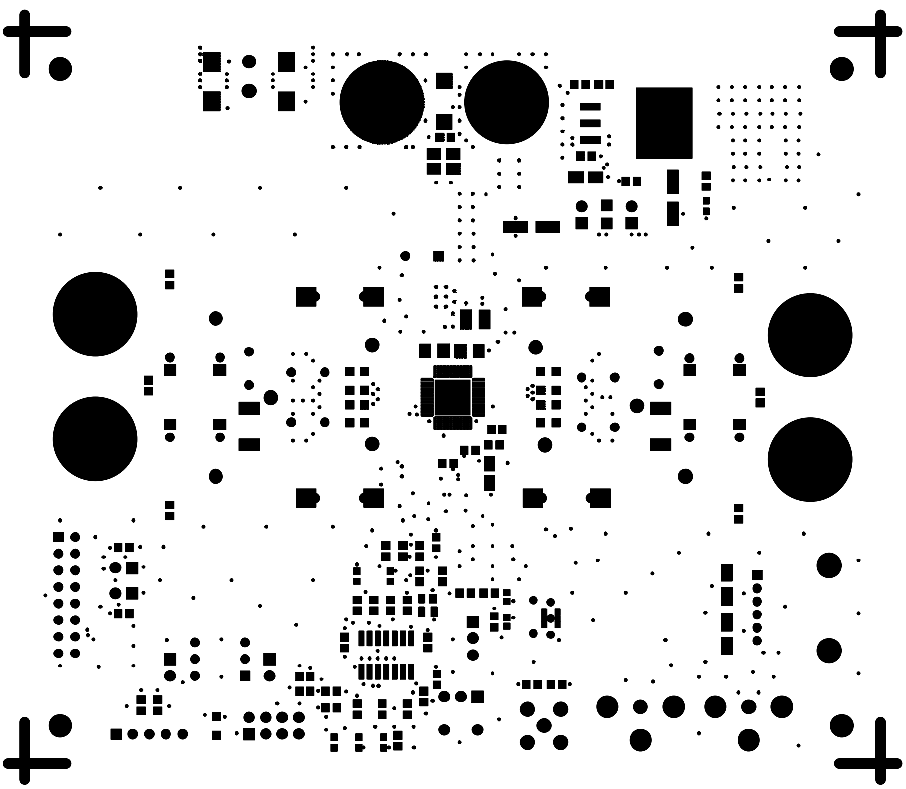

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Figure 11. Top Solder Mask

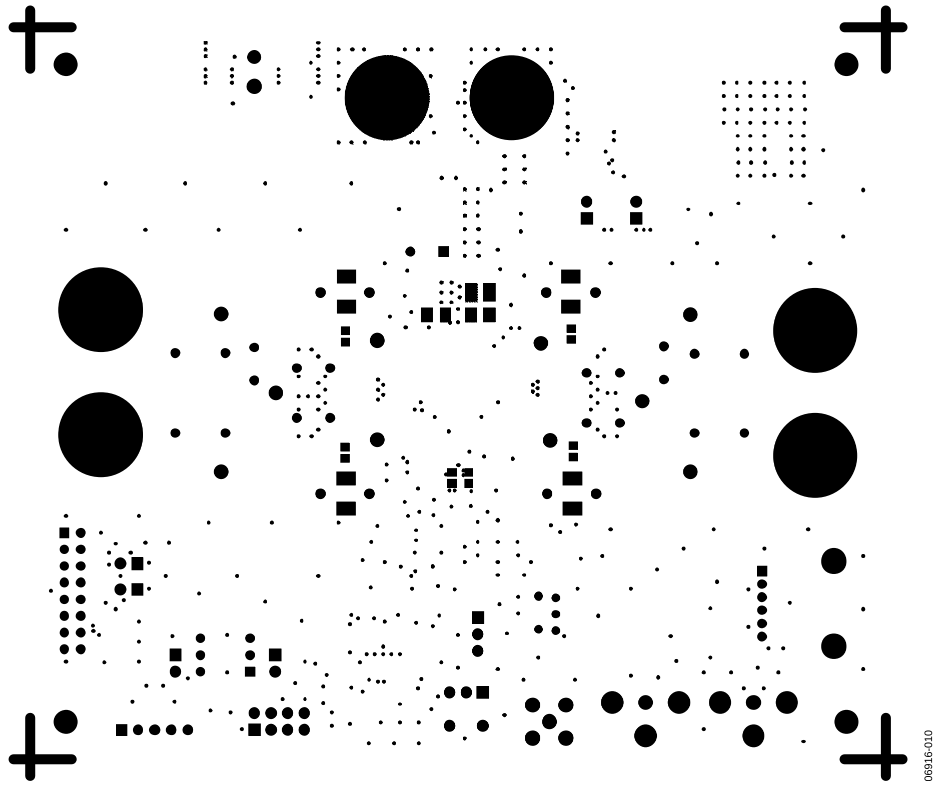


Figure 12. Bottom Solder Mask

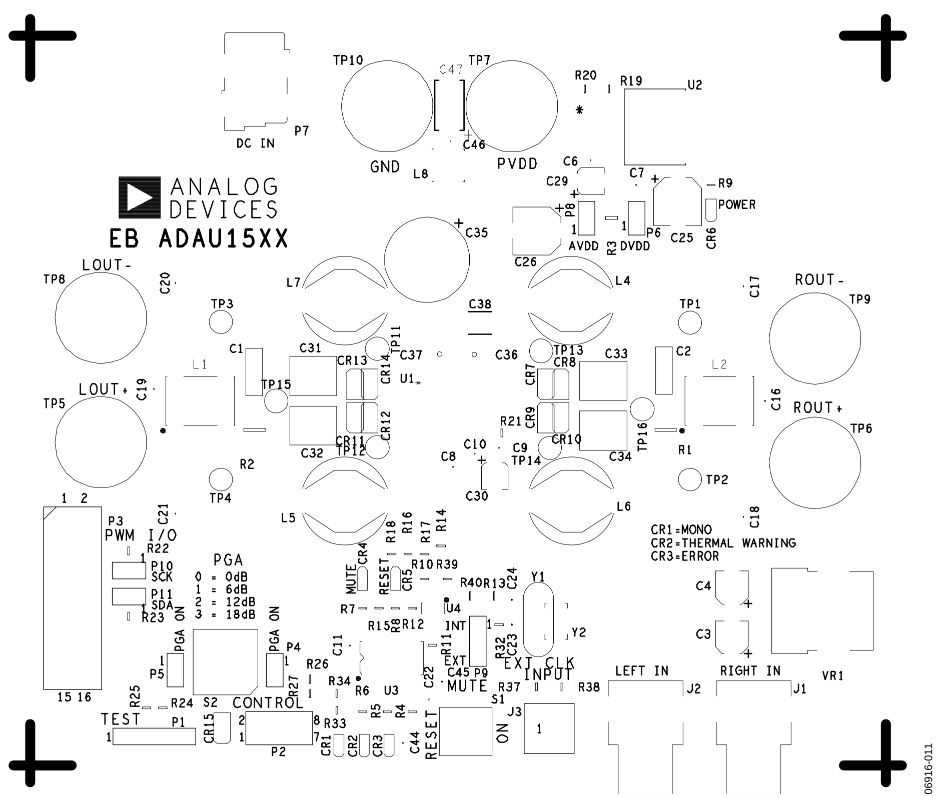
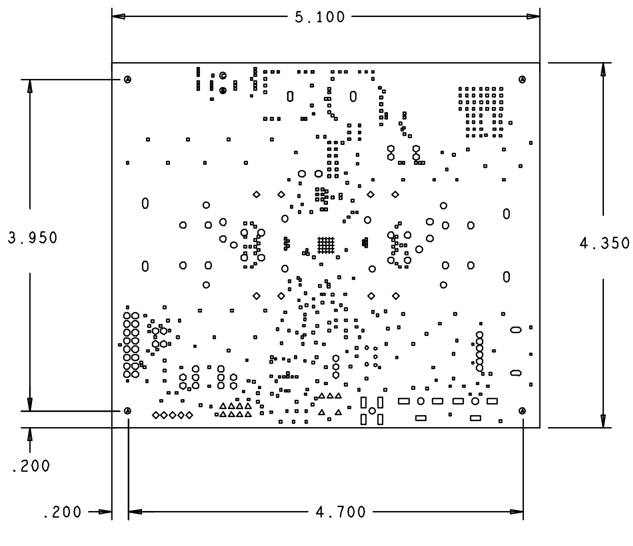


Figure 13. Top Silkscreen



HOLE TOLERANCE

UNLESS SPECIFIED
PLATED: +/- .003
NON PLATED: +/- .002

DRILL CHART: TOP to BOTTOM				
ALL UNITS ARE IN MILS				
FIGURE	SIZE	TOLERANCE	PLATED	QTY
▫	8.0	+2.0/-8.0	PLATED	443
·	12.0	+2.0/-12.0	PLATED	25
∘	28.0	+3.0/-3.0	PLATED	3
∘	30.0	+3.0/-3.0	PLATED	2
○	35.0	+3.0/-3.0	PLATED	50
◇	40.0	+3.0/-3.0	PLATED	13
△	45.0	+3.0/-3.0	PLATED	13
○	47.0	+3.0/-3.0	PLATED	15
○	63.0	+3.0/-3.0	PLATED	13
▯	67.0	+3.0/-3.0	PLATED	4
▭	90.0	+3.0/-3.0	PLATED	6
⬭	115.0	+3.0/-3.0	PLATED	2
◎	166.0	+3.0/-3.0	PLATED	4
0	172.0	+3.0/-3.0	PLATED	6
⊙	63.0	+2.0/-2.0	NONPLATED	1
◉	71.0	+2.0/-2.0	NONPLATED	1
⊗	125.0	+2.0/-2.0	NONPLATED	4

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Figure 14. Fabrication Drawing

ORDERING INFORMATION

BILL OF MATERIALS

Table 3.

Qty[1]	Reference Designator	Description	Supplier	Supplier Part No.
1	PCB	PCB EB-ADAU15XX, Rev C2, 4-layer, 5.1" × 4.15"		
2	C1, C2	Capacitor film metal polyester, 0.1 µF, 10%, 63 V	Digi-Key	BC1621-ND
2	C3, C4	Capacitor aluminum electrolytic SMD 10 µF, ±20%, 16 V	Mouser	661-EMV160ADA100MD
9	C6 to C11, C44 to C46	Capacitor MLCC Y5V SMD 0603, 0.1 µF, –20% +80%, 50 V	Digi-Key	PCC2153CT-ND
NF	C22, C39, C40	Capacitor MLCC Y5V SMD 0603, 0.1 µF, –20% +80%, 50 V	Digi-Key	PCC2153CT-ND
10	C12 to C21	Capacitor MLCC X7R SMD 0603, 1000 pF, 10%, 50 V	Digi-Key	PCC1772CT-ND
NF	C23, C24	Capacitor MLCC NPO SMD 0402, 22 pF, 5%, 50 V	Digi-Key	311-1018-1-ND
2	C25, C26	Capacitor aluminum electrolytic SMD 47 µF, ±20%, 16 V	Digi-Key	565-2103-1-ND
2	C29, C30	Capacitor aluminum electrolytic SMD 4.7 µF, ±20%, 25 V	Digi-Key	493-2106-2-ND
4	C31 to C34	Capacitor film metal polyester, 1 µF, 10%, 63 V	Digi-Key	BC1622-ND
ALT	C31 to C34	Capacitor film metal polyester, 1 µF, 5%, 50 V	Digi-Key	P4675-ND
1	C35	Capacitor aluminum electrolytic 2200 µF, 20%, 25 V	Mouser	647-UVZ1E222MHD
2	C36, C37	Capacitor MLCC X7R SMD 1206, 0.1 µF, 10%, 50 V	Digi-Key	PCC104BCT-ND
NF	C41, 42	Capacitor MLCC X7R SMD 1206, 0.1 µF, 10%, 50 V	Digi-Key	PCC104BCT-ND
1	C38	Capacitor MLCC X5R SMD 1210, 1 µF 10% 50 V	Digi-Key	PCC2303CT-ND
NF	C43	Capacitor MLCC X5R SMD 1210, 1 µF 10% 50 V	Digi-Key	PCC2303CT-ND
1	C47	Capacitor tantalum 33 µF, 25 V, 20%, SMD 7343	Digi-Key	399-3819-2-ND
5	CR1 to CR5	LED red SMD 0603	Digi-Key	511-1298-1-ND
1	CR6	LED green SMD 0603	Digi-Key	511-1299-1-ND
NF	CR7 to CR14	Diode Schottky barrier SMD CRS01	Digi-Key	CRS01CT-ND
1	CR15	Diode Schottky barrier SMD CRS01	Digi-Key	CRS01CT-ND
1	J1	Connector-PCB RCA jack, right angle, red	Connect-Tech	CTP-021-A-S-R
1	J2	Connector-PCB RCA jack, right angle, white	Connect-Tech	CTP-021-A-S-W
1	J3	Connector-PCB coax SMA straight	Digi-Key	J500-ND
2	L1, L2	Common-mode inductor 5 A	Digi-Key	445-2217-1-ND
4	L4 to L7	Inductor shielded, 15 µH, 6 A, 10%	Kwang-Sung Elec Ltd.	8080PH-150K
1	L8	Common-mode inductor power SMD	Murata	DLW5BTN101SQ2
1	P1	Connector-PCB 0.1" header male single row 5-pin	Digi-Key	WM6505-ND
ALT	P1	Connector-PCB 0.1" header male single row 5-pin	Digi-Key	SAM1038-05-ND
1	P2	Connector-PCB 0.1" header male dual row 8-pin	Digi-Key	WM7508-ND
1	P3	Connector-PCB 0.1" header male dual row 16-pin	Digi-Key	WM7516-ND
6	P4 to P6, P8, P10, P11	Connector-PCB 0.1" header male single row 2-pin	Digi-Key	WM6502-ND
1	P7	Connector-PCB DC power jack SMD	Digi-Key	CP-002AHPJCT-ND
1	P9	Connector-PCB 0.1" header male single row 3-pin	Digi-Key	WM6503-ND
NF	R1, R2	Resistor thick film SMD 2512, 8.2 Ω, 5%, 1 W	Digi-Key	PT8.2XCT-ND
NF	R3	Resistor thick film SMD 1206, 4.7 Ω, 1%, 0.25 W	Digi-Key	P4.7AJCT-ND
6	R4 to R9	Resistor thick film SMD 0603, 470 Ω, 5%, 0.1 W	Digi-Key	P470GCT-ND
4	R10 to R12, R14	Resistor thick film SMD 0603, 100 kΩ, 1%, 0.1 W	Digi-Key	P100KHCT-ND
1	R13	Resistor thick film SMD 0603, 47.5 Ω, 1%, 0.1 W	Digi-Key	P47.5HCT-ND
5	R15, R16, R21, R34, R39	Resistor thick film SMD 0603, 0 Ω	Digi-Key	P0.0GCT-ND
NF	R17, R18, R32, R33, R40	Resistor thick film SMD 0603, 0 Ω	Digi-Key	P0.0GCT-ND
1	R19	Resistor thick film SMD 0603, 249 Ω, 1%, 0.1 W	Digi-Key	P249HCT-ND
1	R20	Resistor thick film SMD 0603, 402 Ω, 1%, 0.1 W	Digi-Key	P402HCT-ND
2	R22, R23	Resistor thick film SMD 0603, 2 kΩ, 1%, 0.1 W	Digi-Key	P2.00KHCT-ND
2	R24, R25	Resistor thick film SMD 0603, 1 kΩ, 1%, 0.1 W	Digi-Key	P1.00KHCT-ND
2	R26, R27	Resistor thick film SMD 0603, 10 kΩ, 1%, 0.1 W	Digi-Key	P10.0KHCT-ND
NF	R28 to R31	Resistor thick film SMD 2010, 10 Ω, 1%, 0.5 W	Digi-Key	P10.0ACCT-ND
2	R37, R38	Resistor thick film SMD 0603, 100 Ω, 1%, 1/16 W	Digi-Key	P100YCT-ND
1	S1	Switch subminiature toggle 3-way SPDT	Newark	96C4344
1	S2	Switch rotary 4-position BCD	Apem	PT65112
10	TP1 to TP4, TP11 to TP16	Connector PCB test point, white	Digi-Key	5007K-ND

Qty[1]	Reference Designator	Description	Supplier	Supplier Part No.
3	TP5 to TP7	Connector binding post, red	Mouser	530-111-0702-001
3	TP8 to TP10	Connector binding post, black	Mouser	530-111-0703-001
1	U1	IC ADAU1592 stereo switching amplifier 2x15W	Analog Devices, Inc	ADAU1592CPZ
1	U2	IC-linear regulator adj, LM317, D2PAK-3	Digi-Key	LM317D2TR4OSCT-ND
1	U3	IC-logic Hex inverter 74HC14, SO-14	Digi-Key	MM74HC14M-ND
NF	U4	IC-reset generator 3 V	Digi-Key	497-3349-1-ND
ALT	U4	IC-reset generator 3 V	Digi-Key	ADM811-3TARTZ-RL-ND
1	VR1	Resistor variable, 10 KA	Mouser	688-RK12L12C0A0G
NF	Y1	Quartz crystal 24.576 MHz, HC49U	Digi-Key	300-8512-ND
1	Y2	Ceramic resonator 24.576 MHz	Murata	CSTCW24M5X51-B0
ALT	Y2	Ceramic resonator 24.576 MHz, SMD	Murata	CSTLS24M5X51-B0
4		Washer lock #4	Digi-Key	H729-ND
4		Screw 4-40 × 1/4"	Digi-Key	H703-ND
4		Standoff 4-40 × 3/4"	Digi-Key	1921CK-ND
1		Antistatic bag		
1		Corrugated packing box		
7	P4 to P6, P8, P9, P10, P11	Shorting link, 0.1", black	Digi-Key	S9001-ND

[1] NF: not fitted or do not populate; ALT: alternate or equivalent.

ORDERING GUIDE

Part No	Description
EVAL-ADAU1513EBZ[1]	Evaluation Board ADAU1513
EVAL-ADAU1590EBZ[1]	Evaluation Board ADAU1590
EVAL-ADAU1592EBZ[1]	Evaluation Board ADAU1592

[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.

EB06916-0-10/07(0)