User's Guide

SLOU264–March 2010

TPA2015D1 Audio Power Amplifier Evaluation Module (EVM)

Contents

List of Figures

List of Tables

1 Introduction

This section provides an overview of the Texas Instruments (TI) TPA2015D1 audio power amplifier evaluation module (EVM). It includes a brief description of the module and a list of specifications.

1.1 Description

The TPA2015D1 is a high efficiency Class-D audio power amplifier with battery-tracking SpeakerGuard™ technology and an integrated boost converter. It drives up to 2 W into an 8-Ω speaker from low supply voltages.

The TPA2015D1 audio power amplifier evaluation module is a complete, stand-alone audio board. It contains the TPA2015D1 WCSP (YZH) Class-D audio power amplifier with an integrated boost converter. All components and the evaluation module are Pb-Free.

1.2 TPA2015D1 Specifications

V_{BAT}	Supply voltage range	2.3 V to 5.2 V
I_{DD}	Supply current	3 A Maximum
P_O	Continuous output power per channel, 8 Ω, V_{BAT} = 3.6 V	2 W
V_I	Audio Input Voltage	0 V to V_{BAT}
R_L	Minimum load impedance	6 Ω

SpeakerGuard is a trademark of Texas Instruments.

2 Operation

This section describes how to operate the TPA2015D1EVM.

2.1 Quick Start List for Stand-Alone Operation

Use the following steps when operating the TPA2015D1EVM as a stand-alone or when connecting the EVM into existing circuits or equipment.

2.1.1 Power and Ground

1. Ensure the external power sources are set to OFF.
2. Set the power supply voltage between 2.3 V and 5.2 V. When connecting the power supply to the EVM, make sure to attach the ground connection to the GND connector first and then connect the positive supply to the VDD connector. Verify that the connections are made to the correct banana jacks.

2.1.2 Audio

1. Ensure that the audio source is set to the minimum level.
2. Connect the audio source to the input RCA jack IN. In case of differential audio input ensure that the jumper JP SE is not inserted. In case of a single-ended audio input ensure that the jumper JP SE is inserted, thereby grounding IN+ through the input capacitor C2.
3. Connect speakers (8 Ω to 32 Ω) to the output banana jacks OUT+ and OUT–.
4. **JP OUT** allows the user to connect one the outputs through an RC filter. Note that the user must provide the necessary resistors, R7 and R8.
5. The unfiltered output of the TPA2015D1 can be measured between test points **TP OUT–** and **TP OUT+**

2.1.3 AGC Control

The TPA2015D1 has four selectable inflection point settings: 3.35 V, 3.55 V, 3.75 V, and disabled.

1. Use jumper **AGC** shunted between pins 1 and 2 to select the 3.35 V inflection point (AGC1).
2. Use jumper **AGC** shunted between pins 3 and 4 to select the 3.55 V inflection point (AGC2).
3. Use jumper **AGC** shunted between pins 5 and 6 to select the 3.75 V inflection point (AGC3).
4. Remove the jumper **AGC** to disable the inflection point (battery track) feature. Note that the AGC still works at a limiter level of 6.15 V.

2.1.4 Gain Control

The TPA2015D1 has three gain settings: 6 dB, 15.5 dB, and 20 dB.

1. Use jumper **GAIN** to set the gain as 6 dB, 15.5 dB or 20 dB. To achieve 6 dB, place the jumper between heads 1 and 2; for 20 dB, shunt heads 2 and 3; for 15.5 dB, remove the jumper and let the gain pin float.

2.1.5 Shutdown Controls

1. The TPA2015D1 provides independent shutdown controls for the Class-D amplifier and the boost converter. Pins ENB and END enable the boost converter and Class-D amplifier, respectively. They are active high. Press and hold pushbutton **S1** to place the boost converter in shutdown. Release pushbutton **S1** to activate the boost converter. If END = HIGH, the boost converter only turns on if an audio signal (> 1 V_{PEAK}) is present at one of the inputs (IN+ or IN-).
2. Press and hold pushbutton **S2** to shutdown the Class-D amplifier. Release pushbutton **S2** to activate the Class-D amplifier.

NOTE: The boost converter provides power to the Class-D amplifier. When the boost converter is shut down, the bypass mode will be active and the class-D amplifier will be supplied by the connected external voltage source.

The TPA2015D1 has an auto pass through mode. Under normal operation (END = ENB = HIGH), the boost converter will automatically turn off if no audio signal is present at one of the inputs (IN+ or IN-).

2.2 Boost Settings

The default voltage for the boost converter is 5.5 V and can not be changed. If no audio signal is present, the boost converter is automatically disabled. Once the audio signal is present at IN+ and IN-, the boost converter enables automatically.

2.2.1 Boost Terms

The following is a list of terms and definitions:

C_{MIN}	Minimum boost capacitance required for a given ripple voltage on PVOUT (PVDD).
L	Boost inductor
f_{boost}	Switching frequency of the boost converter.
I_{PVDD}	Current pulled by the Class-D amplifier from the boost converter.
I_{PVDD}	Current pulled by the Class-D amplifier from the boost converter.
I_L	Current through the boost inductor.
PVDD (PVOUT)	Supply voltage for the Class-D amplifier. (Voltage generated by the boost converter output)
VBAT (VDD)	Supply voltage to the TPA2015D1. (Supply voltage to the EVM).
ΔI_L	Ripple current through the inductor.
ΔV	Ripple voltage on PVOUT (PVDD) due to capacitance.

2.2.2 Changing the Boost Inductor

Working inductance decreases as inductor current increases. If the drop in working inductance is severe enough, it may cause the boost converter to become unstable, or cause the TPA2015D1 to reach its current limit at a lower output power than expected. Inductor vendors specify currents at which inductor values decrease by a specific percentage. This can vary by 10% to 35%. Inductance is also affected by dc current and temperature.

Inductor current rating is determined by the requirements of the load. The inductance is determined by two factors: the minimum value required for stability and the maximum ripple current permitted in the application.

Use Equation 1 to determine the required current rating. Equation 1 shows the approximate relationship between the average inductor current, I_L, to the load current, load voltage, and input voltage (I_{PVDD}, PVOUT, and VBAT, respectively.) Insert I_{PVDD}, PVDD, and VBAT into Equation 1 to solve for I_L. The inductor must maintain at least 90% of its initial inductance value at this current.

$$I_L = I_{PVDD} \times \left(\frac{PVDD}{VBAT \times 0.8} \right) \tag{1}$$

The minimum working inductance is 1.3 μH. A lower value may cause instability.

Ripple current, ΔI_L, is peak-to-peak variation in inductor current. Smaller ripple current reduces core losses in the inductor as well as the potential for EMI. Use Equation 2 to determine the value of the inductor, L. Equation 2 shows the relationships among inductance L, VBAT, PVDD, the switching frequency, f_{boost}, and ΔI_L. Insert the maximum acceptable ripple current into Equation 2 to solve for L.

$$L = \frac{VBAT \times (PVDD - VBAT)}{\Delta I_L \times f_{BOOST} \times PVDD} \quad (2)$$

ΔI_L is inversely proportional to L. Minimize ΔI_L as much as is necessary for a specific application. Increase the inductance to reduce the ripple current. Note that making the inductance too large prevents the boost converter from responding to fast load changes properly. Typical inductor values for the TPA2015D1 are 2.2 µH to 4.7 µH.

Select an inductor with a small dc resistance, DCR. DCR reduces the output power due to the voltage drop across the inductor.

2.2.3 Changing the Boost Capacitor

The value of the boost capacitor is determined by the minimum value of working capacitance required for stability and the maximum voltage ripple allowed on PVOUT in the application. The minimum value of working capacitance is 4.7 µF. Do not use any component with a working capacitance less than 4.7 µF.

For X5R or X7R ceramic capacitors, Equation 3 shows the relationships among the boost capacitance, C, to load current, load voltage, ripple voltage, input voltage, and switching frequency (I_{PVOUT}, PVOUT, ΔV, VDD, f_{boost} respectively). Insert the maximum allowed ripple voltage into Equation 3 to solve for C. A factor of about 1.5 is included to account for capacitance loss due to dc voltage and temperature.

$$C = 1.5 \times \frac{I_{PVDD} \times (PVDD - VBAT)}{\Delta V \times f_{BOOST} \times PVDD} \quad (3)$$

For aluminum or tantalum capacitors, Equation 4 shows the relationships among the boost capacitance, C, to load current, load voltage, ripple voltage, input voltage, and switching frequency (I_{PVOUT}, PVOUT, ΔV, VDD, f_{boost} respectively). Insert the maximum allowed ripple voltage into Equation 4 to solve for C. Solve this equation assuming ESR is zero.

$$C = \frac{I_{PVDD} \times (PVDD - VBAT)}{\Delta V \times f_{BOOST} \times PVDD} \quad (4)$$

Capacitance of aluminum and tantalum capacitors is normally insensitive to applied voltage, so there is no factor of 1.5 included in Equation 4. However, the ESR in aluminum and tantalum capacitors can be significant. Choose an aluminum or tantalum capacitor with an ESR around 30 mΩ. For best performance with tantalum capacitors, use at least a 10-V rating. Note that tantalum capacitors must generally be used at voltages of half their ratings or less.

2.3 Power Up

1. Verify the correct connections as described in Section 2.1
2. Verify the voltage setting of the power supply is between 2.3 V and 5.2 V, and turn on the power supply. Proper operation of the EVM begins.
3. Adjust the audio signal source as needed.

3 Reference

This section includes the EVM schematic, board layout reference, and parts list.

3.1 TPA2015D1 EVM Schematic

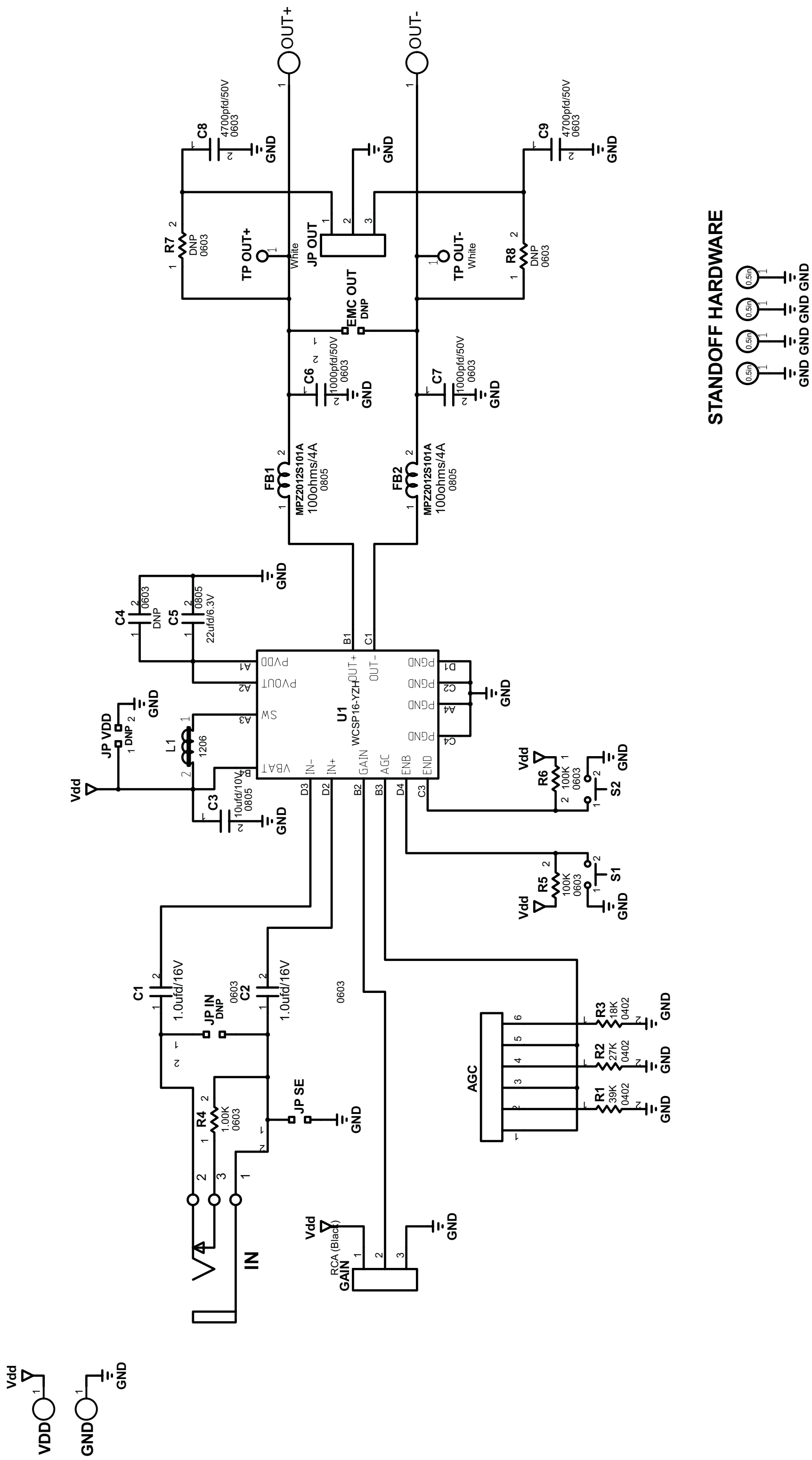
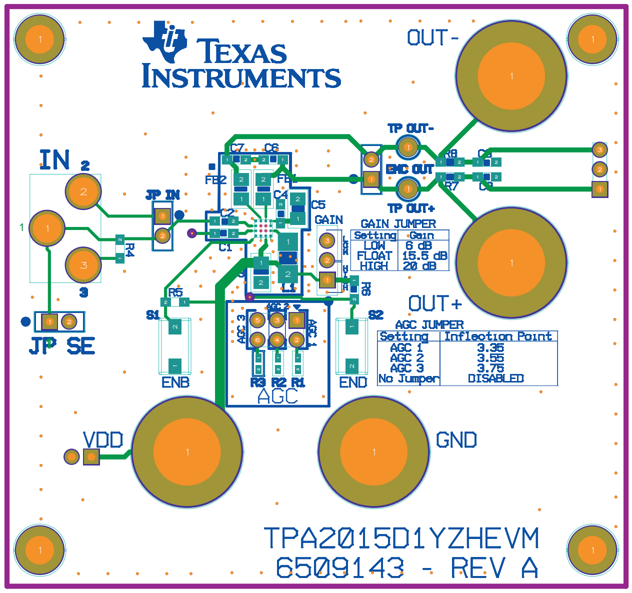
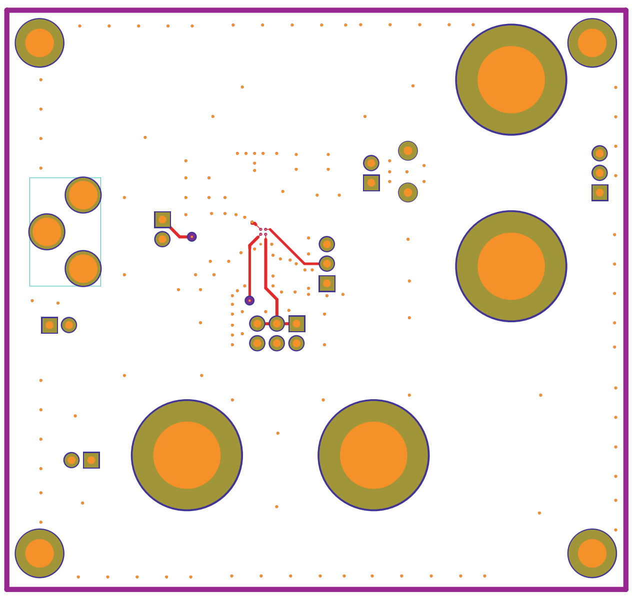


Figure 1. TPA2015D1 EVM Schematic

3.2 TPA2015D1 EVM PCB Layers



Top Layer



Bottom Layer

Figure 2. TPA2015D1 EVM – Top and Bottom Layers

3.3 TPA2015D1 EVM Parts List

Table 1. TPA2015D1 EVM Parts List

QTY	REF DES	Vendor and Part Number	Manufacturer and Part Number	Description
SEMICONDUCTORS				
1	U1	TEXAS INSTRUMENTS TPA2015D1YZH	TEXAS INSTRUMENTS TPA2015D1YZH	1.4 W CLASS-D AUDIO AMP W/BOOST AND SMARTGAIN WCSP16-YZH ROHS
CAPACITORS				
2	C6, C7	DIGI-KEY 445-1293-1	TDK CORP C1608C0G1H102J	CAPACITOR SMD0603 CERM 1000 pF, 50 V, 5% COG ROHS
1	C8, C9	DIGI-KEY PCC1780CT	PANASONIC ECJ-1VB1H472K	CAPACITOR SMD0603 CERM 4700 pF, 50 V, 10% X7R ROHS
2	C5	DIGI-KEY 587-1958-1-ND	TAIYO YUDEN LMK212BJ226MG-T	CAPACITOR SMD0805 CERM 22 µF, 10 V, 20% X5R ROHS
2	C3	DIGI-KEY 490-3905-1	MURATA GRM21BR71A106KE51L	CAPACITOR SMD0805 CERM 10 µF, 10 V, 10% X7R ROHS
2	C1, C2	DIGI-KEY 587-1241-1	TAIYO YUDEN EMK107B7105KA-T [(1)]	CAPACITOR SMD0603 CERM 1.0 µF, 16V, 10% X7R ROHS
RESISTORS AND INDUCTORS				
2	R5, R6	DIGI-KEY P100KGCT	PANASONIC ERJ-3GEYJ104V	RESISTOR SMD0603 THICK FILM 100 kΩ, 5%, 1/10 W ROHS
1	R4	DIGI-KEY 311-1.00KHRCT	YAGEO RC0603FR-071KL	RESISTOR SMD0603 THICK FILM 1.00 kΩ, 1%, 1/10 W ROHS
1	R1	DIGI-KEY P39KJCT-ND	YAGEO ERJ-2GEJ393	RESISTOR SMD0402 THICK FILM 39 kΩ, 5%, 1/16 W
1	R3	DIGI-KEY P18KJCT-ND	TAGEO ERJ-2GEJ183	RESISTOR SMD0402 THICK FILM 18 kΩ, 5%, 1/16 W
1	R2	DIGI-KEY P27KJCT-ND	YAGEO ERJ-2GEJ273	RESISTOR SMD0402 THICK FILM 27 kΩ, 5%, 1/16 W
1	L1	NEWARK 490-5114-1-ND	MURATA LQM2HPN2R2MG0L	INDUCTOR 2.2 µH, 20%, 1300 mA, 1008
2	FB1, FB2	DIGI-KEY 445-1567-1	TDK MPZ2012S101A	FERRITE BEAD SMD0805 100 Ohms 4 A, 100 MHz, ROHS
HEADERS AND JACKS				
2	GAIN, JP OUT	DIGI-KEY 2663S-03	NORCOMP 26630301RP2	HEADER 3 PIN, PCB 2.0 mm ROHS
4	JP IN, JP SE, JP VDD, EMC OUT	DIGI-KEY 2663S-02	NORCOMP 26630201RP2	HEADER 2 PIN, PCB 2.0 mm ROHS
1	AGC	DIGI-KEY 2764R-03	NORCOMP 27640602RP2	HEADER 2 x 3 PIN PCB-RA 2.0 mm ROHS
1	IN	NEWARK 65K7770	SWITCHCRAFT PJRAN1X1U01X	JACK, RCA 3-PIN PCB-RA BLACK ROHS
TESTPOINTS, SWITCHES, AND TRIMPOT				
2	TP OUT+, TP OUT–	DIGI-KEY 5002K	KEYSTONE ELECTRONICS 5002	PC TESTPOINT, WHITE, ROHS
2	S1	DIGI-KEY EG4344CT	E-SWITCH TL1015AF160QG	SWITCH, MOM, 160G SMT 4 x 3 mm ROHS
8	GAIN, JP OUT, JP IN, JP SE, JP VDD, EMC OUT, AGC	DIGI-KEY SP2-001E	NORCOMP INC. 810-002-SP2L001	SHUNT, BLACK Au FLASH 2 mm LS

(1) Do not substitute parts

Table 1. TPA2015D1 EVM Parts List (continued)

QTY	REF DES	Vendor and Part Number	Manufacturer and Part Number	Description
BINDING POSTS				
4	GND, VDD, OUT+,OUT–	DIGI-KEY J587	EMERSON NPCS 111-2223-001	BINDING-POST, NONINSULATED, THRU, ROHS
STANDOFFS AND HARDWARE				
4	HW1, HW2, HW3, HW4	DIGI-KEY 2027K	KEYSTONE 2027	STANDOFF, 4-40 0.5IN 3/16IN DIA ALUM RND F-F
4	HW1, HW2, HW3, HW4	DIGI-KEY H342	BUILDING FASTENERS PMS 440 0025 PH	4-40 SCREW, STEEL 0.250 IN
COMPONENTS NOT ASSEMBLED				
R7, R8, C4				

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of -0.3 V to 6 V and the output voltage range of -0.3 V to VDD +0.3 .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

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 85°C. The EVM is designed to operate properly with certain components above 85°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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