

# TPA2013D1 Boost Converter Component Specification

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## ABSTRACT

Loss of output power is a common problem in battery-powered systems as the battery discharges. This problem can be overcome with a boost converter to power the audio power output amplifiers, like the converter and amplifier in the Texas Instruments TPA2013D, a single-chip solution. Passive components used with the converter dramatically affect its operation, so it is necessary to choose these components carefully. This application report provides a set of rules to enable the user to make appropriate choices.

## 1 Introduction

A common problem in battery-powered systems is loss of audio output as the battery discharges. Audio power must be reduced or limited to the level available at minimum battery voltage or distortion becomes unacceptable. It is possible to overcome this problem by using a boost converter, a switching device that boosts battery output to a fixed higher voltage, to power the audio amplifiers. TI's TPA2013D1 combines a high-efficiency boost converter with a class-D amplifier to provide an efficient single-chip solution to the problem.

Basics of boost circuit operation are conceptually fairly simple, but the selection of passive components to support the boost circuit can be complicated. However, it is possible to recommend components that work effectively at several different output power levels. These components can be specified in table form to eliminate the problem of component selection for users. That is the intent of this application report.

## 2 TPA2013D1 Configuration

The full circuit for the TPA2013D1 is shown in the following reference schematic, which includes its boost converter and class-D amplifier and the required supporting passive components. The passive components are input and output capacitors  $C_i$  and  $C_o$  and the switching inductor  $L_i$  plus feedback resistors  $R_f$  and  $R_g$ .

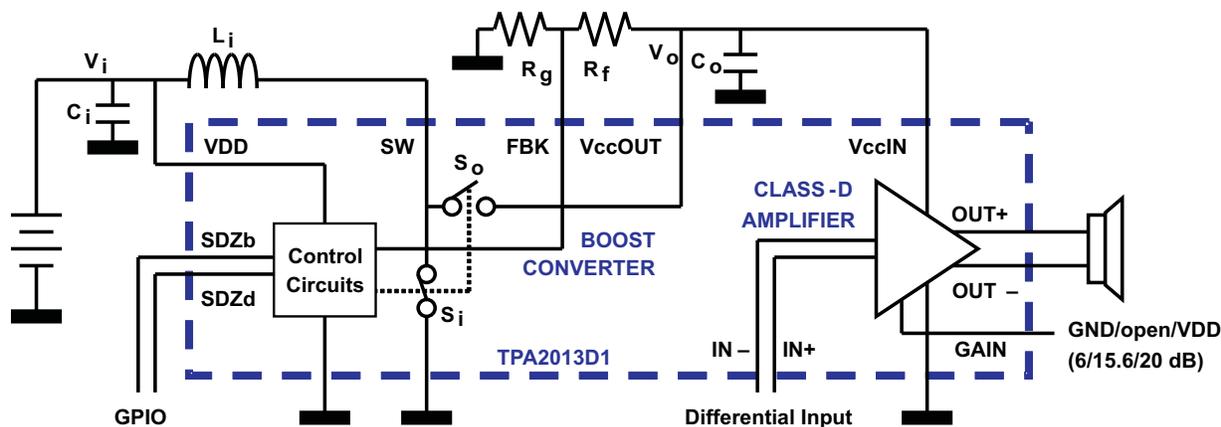


Figure 1. TPA2013D1 Circuit Configuration

The passive components must have the following characteristics.

- The inductor must maintain nearly its full-rated value at the input current required at peak output power.
  - It is important to realize that peak inductor current is typically nearly twice output current, because output power equals input power divided by circuit efficiency. So, peak input current is approximately peak output current multiplied by output voltage  $V_{CC}$  and divided by input voltage  $V_{DD}$ , plus 10% for the efficiency, typically 90% or more for the boost circuit. Because  $V_{CC}$  is greater than  $V_{DD}$ , peak inductor current is typically nearly twice peak output current. Inductor  $L_1$  must be rated for this peak current.
- Input and output capacitors must maintain nearly their full nominal values at the voltages applied to them.
  - The value of output capacitor  $C_o$  determines peak-to-peak output ripple voltage  $\Delta V$ . High values of  $\Delta V$  can cause difficulty with EMC, so  $C_o$  must be chosen to limit  $\Delta V$  to a low value like 30 mV.
- The feedback resistor must have a value of 500 k $\Omega$  to provide optimal stability.

For the reasons supporting these rules, see TI application report *Passive Component Selection for TPA2013D1 Boost Converter* ([SLOA127](#)), which provides full descriptions and equations regarding passive components.

These rules lead to the recommended sources and part numbers for the capacitors and inductor shown in the following table. A pair of equations that specify how to select the feedback resistors follows the table.

### 3 Input Capacitor

Input capacitor  $C_1$  is a 10- $\mu$ F, 10-V component. The value of input capacitor  $C_1$  generally does not vary with application. The following part numbers are recommended.

Kemet – C1206C106K8PACTU  
 TDK – C3216X5R1A106KT  
 Murata – GRM32ER61A106KA01B  
 Taiyo Yuden – LMK316BJ106KL-TR

### 4 Switching Inductor and Output Capacitor

Class-D Output Power (W) <sup>(1)</sup>	Class-D Load ( $\Omega$ )	Minimum $V_{DD}$ (V)	Required $V_{CC}$ (V)	Max $I_L$ (A)	L ( $\mu$ H)	Inductor Vendor Part Numbers	Max $\Delta V$ (mVpp)	C <sup>(2)</sup> ( $\mu$ F)	Capacitor Vendor Part Numbers
1	8	3	4.3	0.70	3.3	Toko DE2812C Coilcraft DO3314 Murata LQH3NPN3R3NG0	30	10	Kemet C1206C106K8PACTU Murata GRM32ER61A106KA01B Taiyo Yuden LMK316BJ106ML-T
					4.7			22	
1.6	8	3	5.5	1.13	4.7	Murata LQH32PN4R7NN0 Toko DE4514C Coilcraft LPS4018-472	30	22	Murata GRM32ER71A226KE20L Taiyo Yuden LMK316BJ226ML-T
					3.3			33	
2	4	3	4.6	1.53	3.3	Murata LQH55PN3R3NR0 Toko DE4514C	30	33	TDK C4532X5R1A336M
					6.2			47	
2.3	4	1.8	5.5	2	6.2	Sumida CDRH5D28NP-6R2NC	30	47	Murata GRM32ER61A476KE20L Taiyo Yuden LMK325BJ476MM-T
					3.3			33	

<sup>(1)</sup> All power levels are calculated at 1% THD unless otherwise noted.

<sup>(2)</sup> All values listed are for ceramic capacitors.

Other components might work effectively at the power levels shown in the preceding table, but they must maintain the important characteristics of the recommended components to do so.

- If different inductors are used, they must have saturation current and DCR ratings at least as good as those of the recommended inductors.
- If different capacitors are used, they must have dc voltage ratings of at least 10 V and be made of X5R, X7R, or better material.
- Their effectiveness must be verified in comparison to the recommended components before committing to their use.

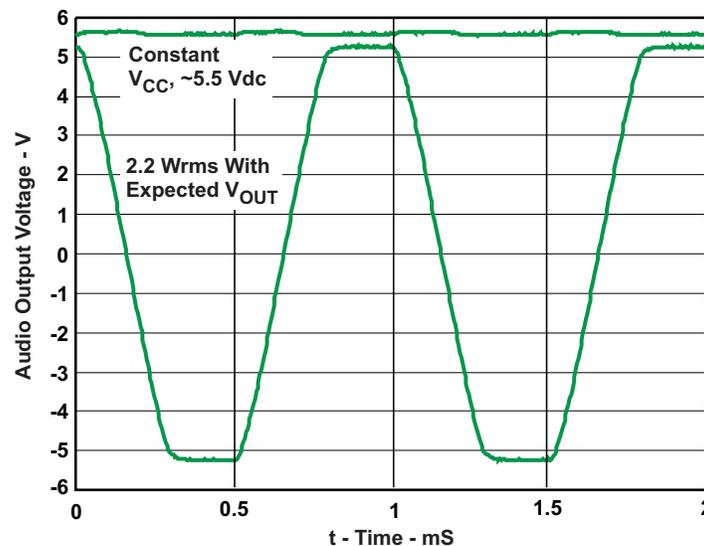
## 5 Feedback Resistors

The following equations are used to determine values for the feedback resistors.

- $R_f = 499 \text{ k}\Omega$ . This value helps maintain stability with the LC filter selections in the preceding table.
- $R_g = R_f \times 0.5 / (V_{CC} - 0.5)$ , where the value 0.5 is an internal feedback reference.

## 6 Results With Recommended Components

The second set of recommended components, producing 1.6 W into 8  $\Omega$  at 10% THD+N from 5.5 Vdc, includes a 4.7- $\mu\text{H}$  inductor and a 10- $\mu\text{F}$  capacitor. The result with these components is shown in the following graph. Clipping is flat, indicating that the boost circuit output voltage, the power supply to the amplifier, is essentially constant. The boost circuit operates as expected with these components.

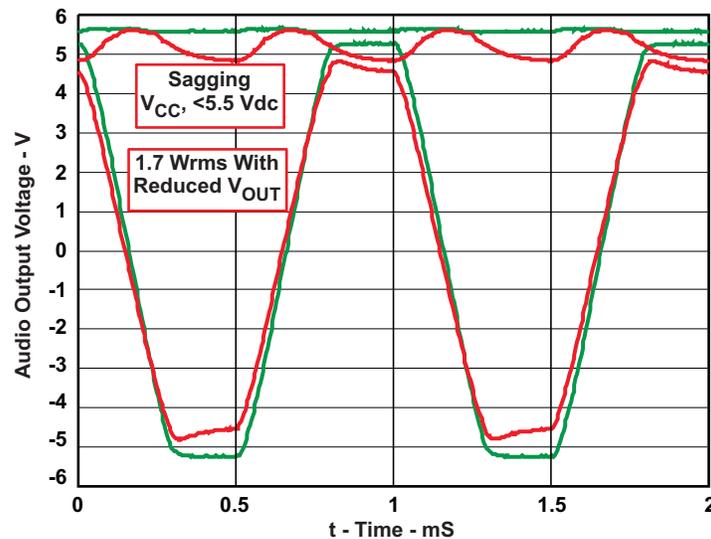


**Figure 2. Output Power With Recommended Inductor**

Output power is 2.2 W, approximately what is expected. (Output power at 10% THD+N is about 26% more than output power at 1% THD+N with flat clipping like that shown in the following graph.)

## 7 Results With Components That Are Not Recommended

The result with nonrecommended components can fail to meet expectations. An example is shown in the following graph, where it is compared to the result in the preceding graph. Output power at 10% THD+N is reduced to 1.7 W. In addition, clipping is not flat, indicating that the boost circuit cannot maintain a constant output voltage but instead produces high output ripple. With nonrecommended components, the boost circuit does not perform as expected and causes early clipping.



**Figure 3. Output Power With Saturating Inductor – Not Recommended**

The difference between the two results is simply the inductor. In both cases, the nominal inductor value is  $4.7 \mu\text{H}$ , but in the second case the inductor saturates at low output currents. So, it does not permit the boost converter to transfer the energy for the TPA2013D1 to reach its rated output. This demonstrates the importance of selecting appropriate passive components for TPA2013D1. Applying the guidelines of this document makes that selection an easier process.

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