

DirectPath™ Ground Centered Headphone Amplifier

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ABSTRACT

A DirectPath™ amplifier is an amplifier where the signal is centered with respect to ground (or, a ground centered amplifier). Ground centering avoids the need for large DC blocking output capacitors, saving board space and cost. This application report compares traditional headphone amplifiers to DirectPath amplifiers.

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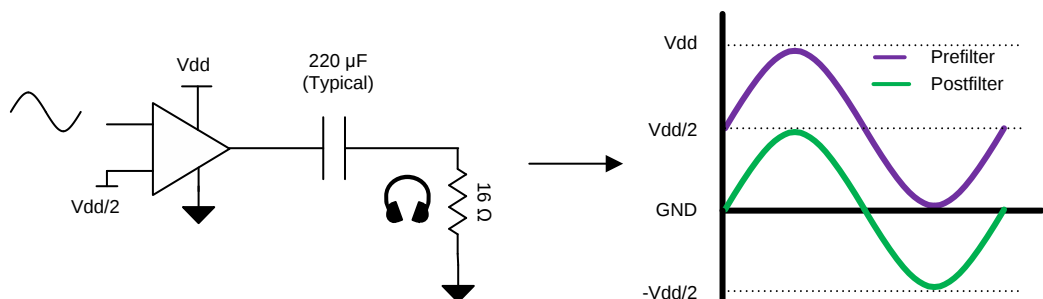
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1 Traditional Headphones

To understand the advantages of ground centered headphone amps, first understand how traditional headphone amplifiers work. Traditional headphone amplifiers operate on a single rail voltage (V_{dd}). Because it operates off a single rail, the highest possible output voltage of the amplifier is V_{dd} and the minimum possible is ground. In order to get the maximum possible swing, the amplifier must be DC biased (centered) halfway between the maximum and minimum, which is $V_{dd}/2$. Headphones, however, can be damaged by a DC signal. In order to prevent this, a high-pass filter must be used to remove the DC bias. The filter is created by adding a capacitor in series with the headphones, which normally have a resistance of $16\ \Omega$. Figure 1 shows the amplifier configuration and effect on the output signal.



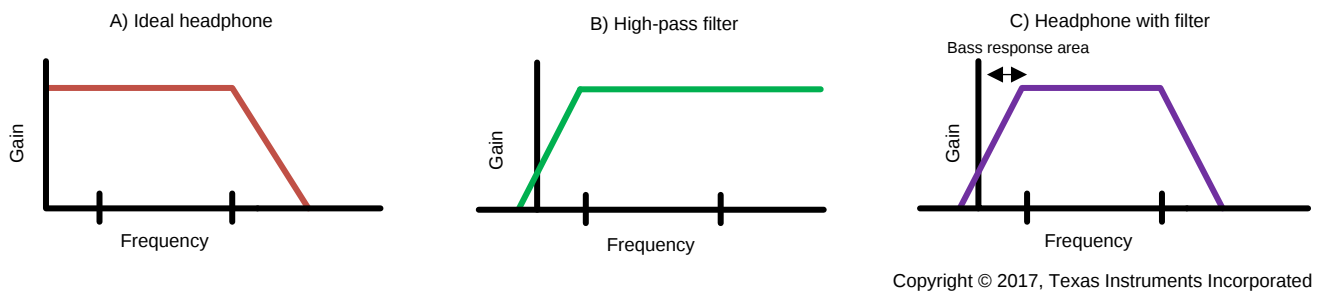
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Figure 1. Traditional Amplifier Configuration and Output Signals

The cutoff frequency of a high-pass filter determines which signal frequencies are attenuated and which frequencies are unaffected. The gains of all signals with a frequency below the cutoff frequency are attenuated so they cannot pass through the rest of the system. Frequencies above the cutoff frequency are unaffected by the filter. A DC signal is a signal with frequency equal to zero. Equation 1 shows how to calculate the cutoff frequency of the high-pass filter:

$$f_c = \frac{1}{2\pi R_L C} = \frac{1}{2\pi (16 \Omega)(220 \mu F)} = 45.237 \text{ Hz} \quad (1)$$

In order to remove DC bias, the cutoff frequency simply needs to be greater than zero; the problem with this, however, is the closer the cutoff frequency is to zero, the larger and more expensive the required capacitor is. The low-frequency bass range is 20 to 60 Hz, so the smaller the capacitor used, the more bass response is cut off. A normal compromise is to use a 220-μF capacitor, which will cut off frequencies below 45 Hz. Capacitor sizes vary from application to application and is more heavily influenced by system specifications. Figure 2 shows how the frequency response of a headphone is affected by the high-pass filter.

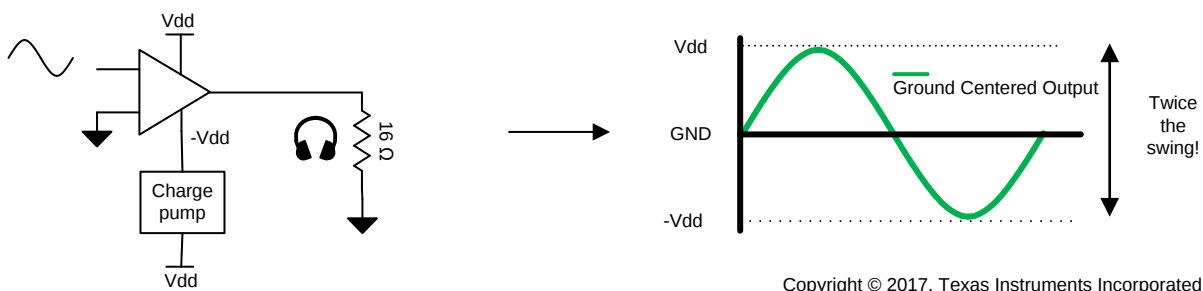


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Figure 2. Frequency Response of: (a) Ideal Headphones, (b) High-Pass Filter, and (c) Headphones With Filter Output

2 Ground Centered Headphones

Ground centered amplifiers use additional circuitry around the amplifier to remove the need for both a DC bias, and therefore output capacitors, while still using a single supply. This is done by using an integrated charge pump. The charge pump takes the supply voltage Vdd and reverses the polarity to -Vdd. These values become the maximum and minimum output values for the amplifier, centering the output at ground and allowing twice the swing of a traditional amplifier.



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Figure 3. Ground Centered Amplifier Configuration and Output Signal

3 Summary

Ground centered headphones:

- Remove the need for output capacitors saving space and cost
- Improves bass response
- Removes pop and click effects associated with a DC bias

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