

Parallel INA1620 Headphone Amplifiers for Higher Output Power

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Introduction

In order to ensure sufficient volume levels from low-sensitivity headphones, a headphone amplifier may be needed to provide significant output power across a wide range of load conditions. This is a challenge, as delivering a given power level into a high impedance headphone load requires a higher output voltage from the amplifier, in turn requiring higher power supply voltages, while delivering the same power level into low impedance headphones demands higher output current from the amplifier.

Limitations to Output Power

Output power from an operational amplifier (op amp) is limited by a number of factors. With high impedance loads, the slew rate of the op amp and full power bandwidth are the primary limiting factors. For low impedance loads, the output current limit of the op amp becomes the limiting parameter. This is further complicated by thermal effects on current limits. High power dissipation within the op amp causes it to heat up. This increase in temperature causes the current limits to decrease, increasing distortion.

This is especially problematic when using higher supply voltages with low impedance loads, as the high output currents required for low impedance loads quickly lead to excessive power dissipation, significantly limiting the available output power. This effect can be seen in [Figure 1](#), which shows the THD+N ratio of a single op amp headphone amplifier over a range of output power levels.

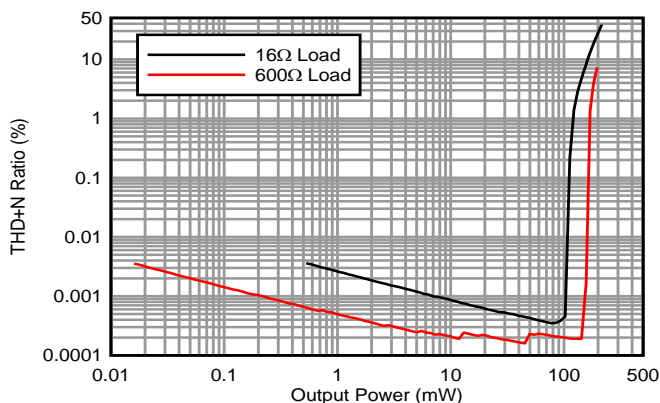


Figure 1. THD+N Ratio vs. Output Power for Single Op Amp Amplifier

With a 600 Ω load, maximum output power before the op amp begins to clip is around 150 mW, where it is limited by the full-power bandwidth of the op amp itself. With a 16 Ω load, the maximum power falls to around 100 mW, limited by available output current and power dissipation. Power supplies for this test were ± 15 V, and the THD+N analysis used a 1 kHz input tone.

Improving Power Output

Power delivered into low impedance headphones can be improved by using lower supply voltages, which reduces power dissipation in the op amp. However, this may not be a solution in all applications as the reduced supply voltage significantly impacts power delivery into high impedance headphones. Selecting a higher-power op amp can help reduce the impact of power dissipation, but many applications can benefit significantly from the higher performance offered by a lower-power op amp such as the INA1620. In these situations, it is possible to use multiple INA1620 devices in parallel to deliver the required output current.

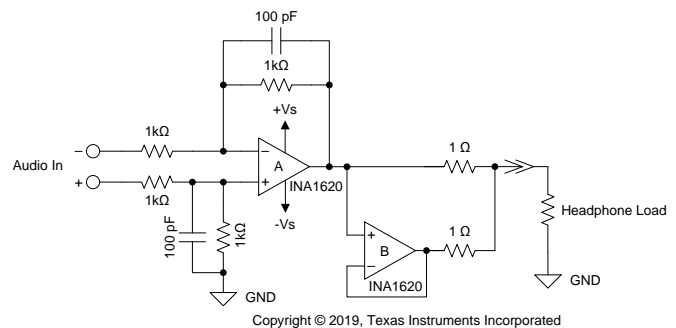


Figure 2. Parallel INA1620 Headphone Amplifiers

[Figure 2](#) shows an INA1620 configured in a parallel configuration. Channel A of the INA1620 is configured as a difference amplifier using the integrated 1 k Ω matched thin-film resistors of the INA1620 to ensure low distortion, excellent CMRR, and compact layout. For more information on the integrated thin-film resistors of the INA1620, refer to the application note [On-Chip Thin Film Resistors Enable High-Performance Audio Circuitry](#) (SBOA312). The output of channel A is buffered by channel B, configured as a unity gain buffer, and the A and B outputs are combined through 1 Ω ballast resistors used to ensure that the A and B outputs share the load current equally. Since the

available output power from the amplifier is limited by the output current limitations (and internal power dissipation) of the op amp itself, paralleling op amps actually gives a quadratic improvement in total output power. With two parallel op amps, the total power output roughly quadruples so long as sufficient supply voltage is available to not become the limiting factor.

Results

Figure 3 shows the THD+N ratio of the parallel INA1620 solution over a range of output power levels. With a 600 Ω load, maximum output power without clipping remains around 150 mW, as the limitation on power delivery for this load is still the full-power bandwidth of the amplifier, a limitation which cannot be overcome by paralleling multiple devices. With a 16 Ω load, the maximum output power without clipping was around 320 mW, a 300% increase from the single op amp solution shown in Figure 1. Power supplies for this test were ±15 V, and the THD+N analysis used a 1 kHz input tone, as before.

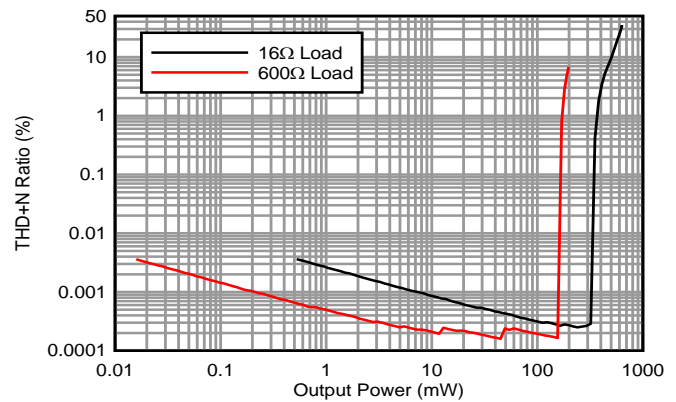


Figure 3. THD+N Ratio vs. Output Power for Parallel Amplifier

Table 1. TI High-Fidelity Headphone Amplifiers

DEVICE	OPTIMIZED PARAMETERS
INA1620	Integrated High-Quality Thin-Film Resistors, Integrated EMI Filters, Ultra-Low Noise, Low Distortion, 32MHz Gain Bandwidth, Shutdown Mode with Reduced Pop/Click
OPA1622	Ultra-Low Noise, Low Distortion, 32MHz Gain Bandwidth, Shutdown Mode with Reduced Pop/Click
OPA1656	Ultra-Low Noise, Low Distortion, FET input, 53MHz Gain Bandwidth.
OPA1688	Low Noise, Low Distortion, FET input, 10MHz Gain Bandwidth

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