# Audio Tone Control Using The TLC074 Operational Amplifier

*Dee Harris* *Mixed-Signal Products*

**ABSTRACT**

This application report describes the design and function of a stereo high-fidelity tone control using a single TLC074 quad operational amplifier. A rail-to-rail operational amplifier is used to provide a midpoint supply voltage and signal ground, allowing the use of a single power supply.

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# 1 Introduction

Tone controls allow the frequency response of the audio system to be adjusted to compensate for the response of speakers and their enclosures or the listening room, or to simply provide a more pleasing sound.

In this design, a variation of the classic and very popular Baxandall[1], negative feedback tone control circuit provides the familiar Hi-Fi tone control with *cut...flat...boost* response for both bass and treble frequencies. A single bass control adjusts both channels simultaneously and a single treble control adjusts both channels.

A pair of slide pots adjusts the volume of each channel independently. The circuit provides a gain of 6 dB at the maximum volume setting when both tone controls are at their midpoints (flat).

# 2 Circuit Description

Each of the two separate channels of the tone control circuit is basically an active filter built around an IC operational amplifier. An active filter design was chosen over a passive filter circuit because active filters have the frequency-response adjusting components located in the feedback loop of the filter amplifiers, providing much lower THD, little or no insertion loss, and a symmetrical response about the axis in both boost and cut, compared with most passive designs. Each channel also includes an input buffer amplifier to provide some gain and isolation from source impedance variations.

A block diagram of the right channel of the tone control circuit is shown in Figure 1. The left channel is identical.

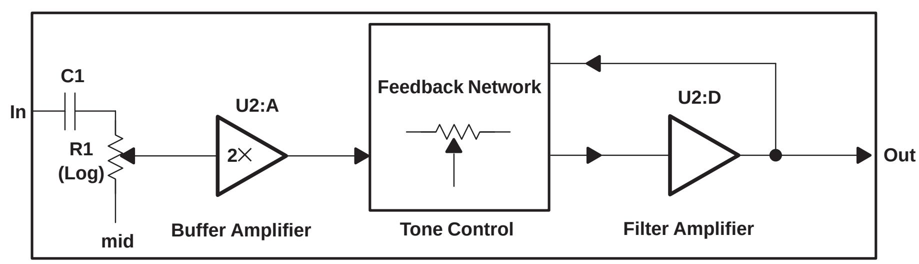



**Figure 1. Tone Control Block Diagram**

One dual-element slide pot adjusts the bass response from approximately –20 dB of cut, to flat, to approximately 20 dB of boost for both channels simultaneously. Another dual-element slide pot adjusts the treble response of both channels through the same range.

Mid-range frequencies are not affected by the tone controls. An overall flat response (no boost or cut at frequency extremes) is obtained when the tone controls are at their mid-point position.

The composite frequency response range curves shown in Figure 2 are provided by the component values indicated in the schematic (Figure 3).

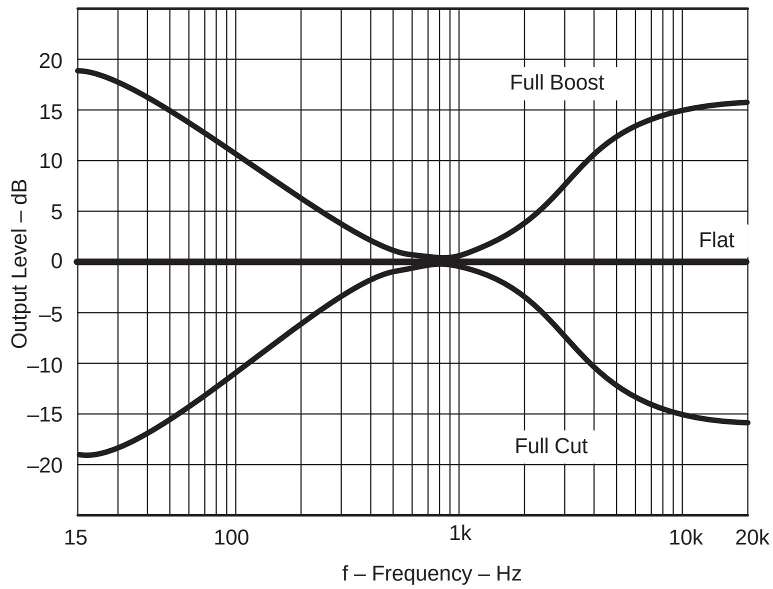
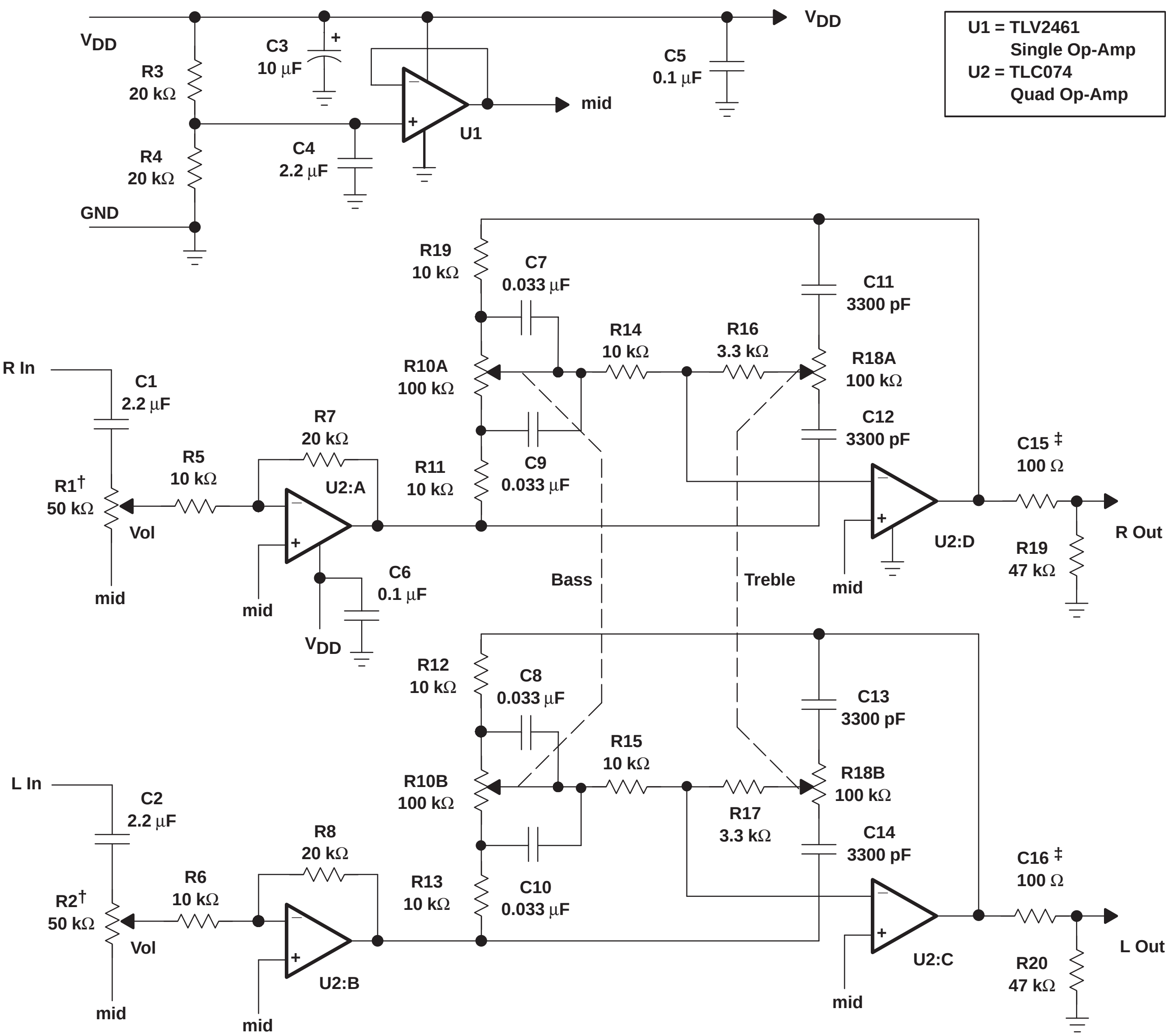



**Figure 2. Tone Control Composite Frequency Response Range**

A single TLC074 quad operational amplifier IC contains all the amplifiers required for buffering and filtering both left and right channels. A TLV2461 operational amplifier IC is connected to provide a virtual ground for proper operation of the TLC074 from a single supply voltage.

Figure 3 shows the tone control schematic diagram.




† Volume controls are audio taper (log) potentiometers.

‡ Component locations marked C15 and C16 on the SLOP109 EVM board should be populated with 100-Ω resistors.

**Figure 3. Audio Tone Control Schematic Diagram**

The input buffer amplifier provides a gain of approximately 2 (RF/RIN) with the specified resistor values. Input capacitor C1 blocks dc and sets the minimum low-frequency response of the tone control circuit at approximately 16 Hz (–3 dB) with the value of 2.2 µF. Volume control R1 has an audio taper to provide a perceived linear response in volume, proportional to the physical position of the slider. The adjustment range of the buffer amplifier is from 0 V to approximately 2 times (6 dB) the audio signal input voltage.

The tone adjusting action in each channel of the tone control circuit is provided by an equalizing amplifier (or active filter) created by placing a frequency-dependent negative feedback network around an operational amplifier. Almost any overall gain-versus-frequency characteristic can be defined by the design of the feedback network.

## 3 Tone Control Frequency Response

The overall tone control circuit frequency response can be shifted up or down by changing the values of capacitors C7, C9, C11, and C12 in the tone adjusting networks.

To shift the frequency response downward, for example, increase the values of the capacitors in the tone adjusting networks. Doubling the values of C7, C9, C11, and C12 shifts the break frequency downward a full octave (Case B, Figure 4). Conversely, halving the values of C7, C9, C11, and C12 shifts the break frequency upward a full octave. (1 octave up = ½ $C_X$ and 1 octave down = 2 $C_X$.)

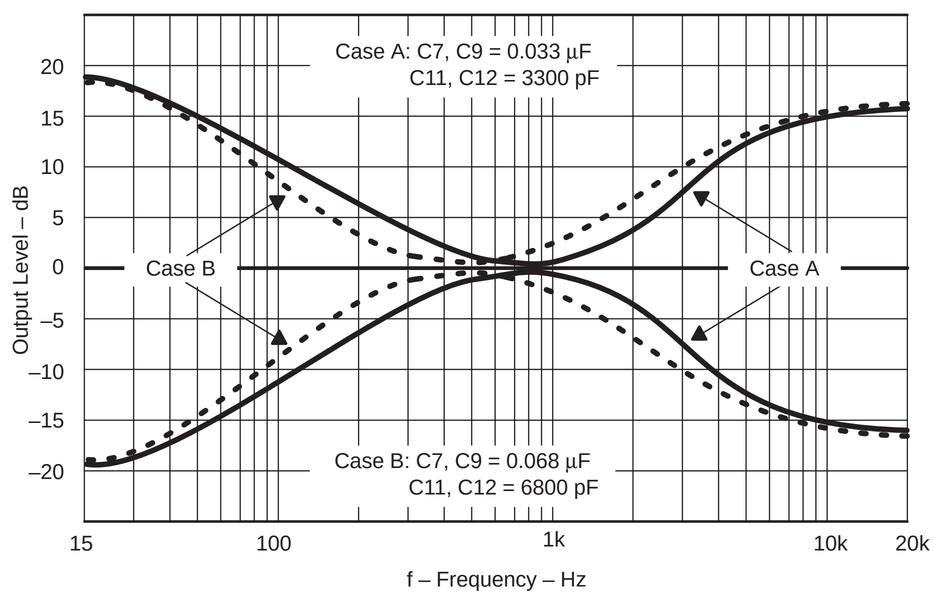



**Figure 4. Bass and Treble Tone Control Response**

Note that to keep the boost and cut break frequencies the same, the value of C7 must equal that of C9, and the value of C11 must equal that of C12. In addition, although the bass and treble break frequencies can be adjusted separately if desired, to maintain the overall shape and symmetry of the response, all four capacitors must be increased or decreased by the same factor.

## Measured Performance

Figures 5, 6, and 7 are measurements from the TI Tone Control EVM (SLOP109), using the TLC074 IC amplifier. All measurements taken with Vdd = 5 V, Vin = 100 mVrms, $R_L$ = 47 kΩ, and f = 3 kHz.

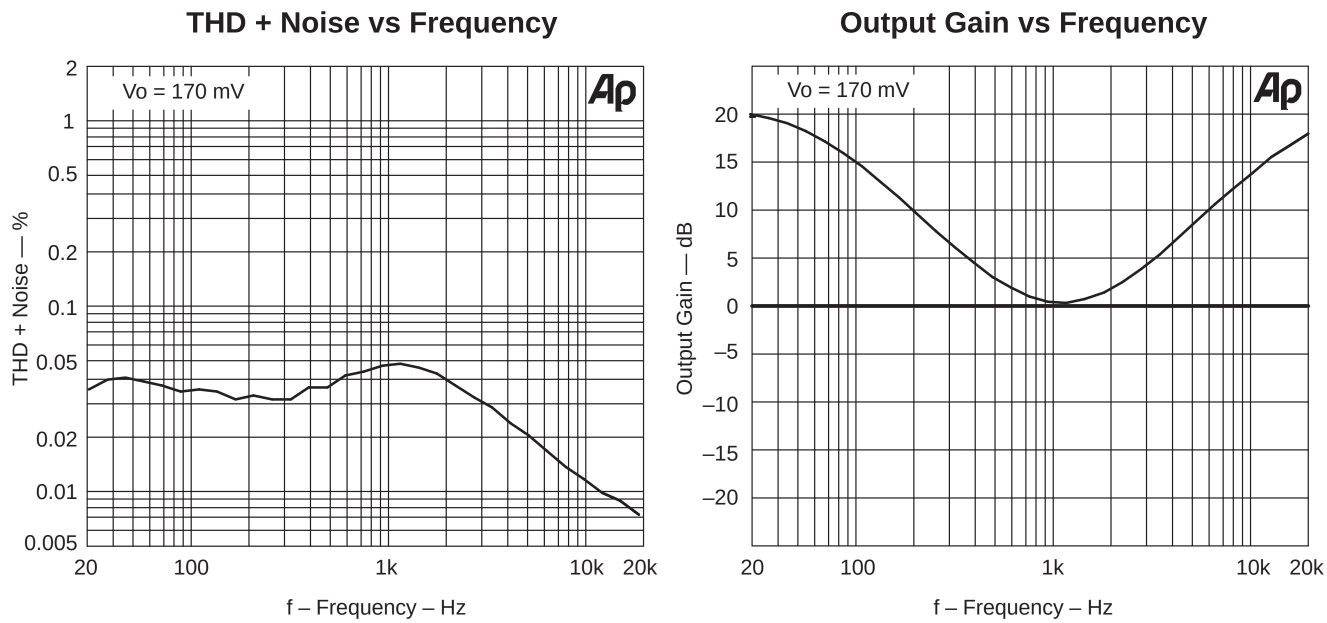



**Figure 5. Maximum Bass and Treble Boost**

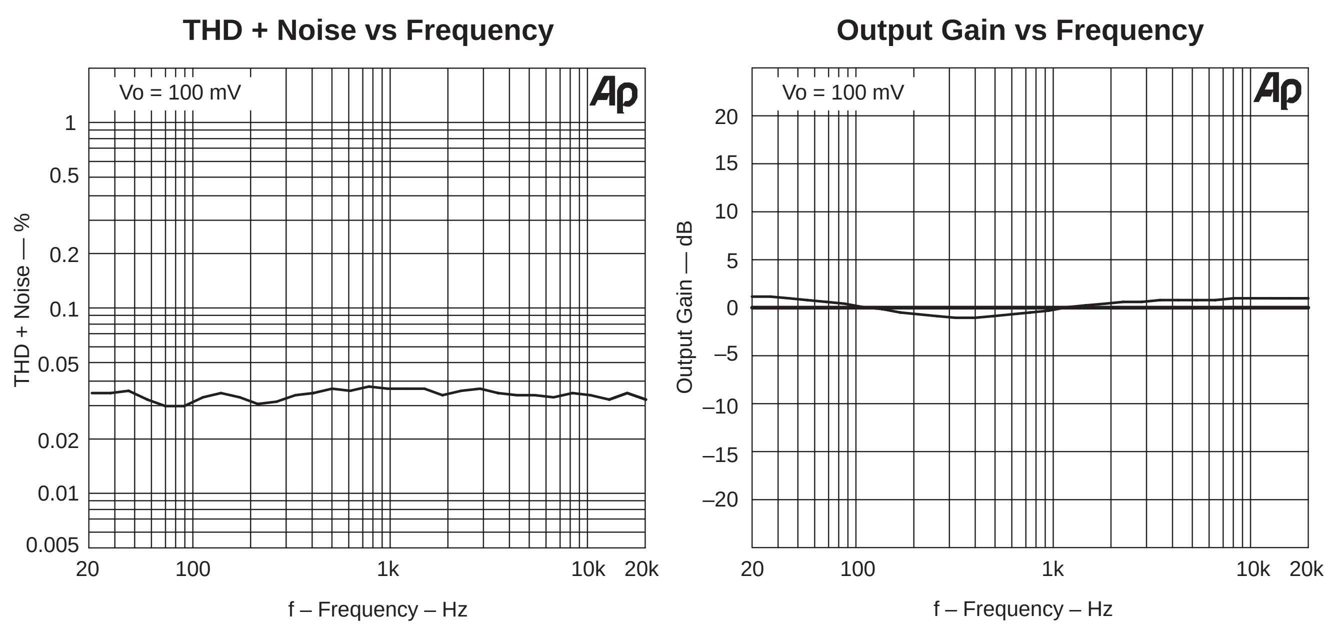



**Figure 6. Bass and Treble Flat**

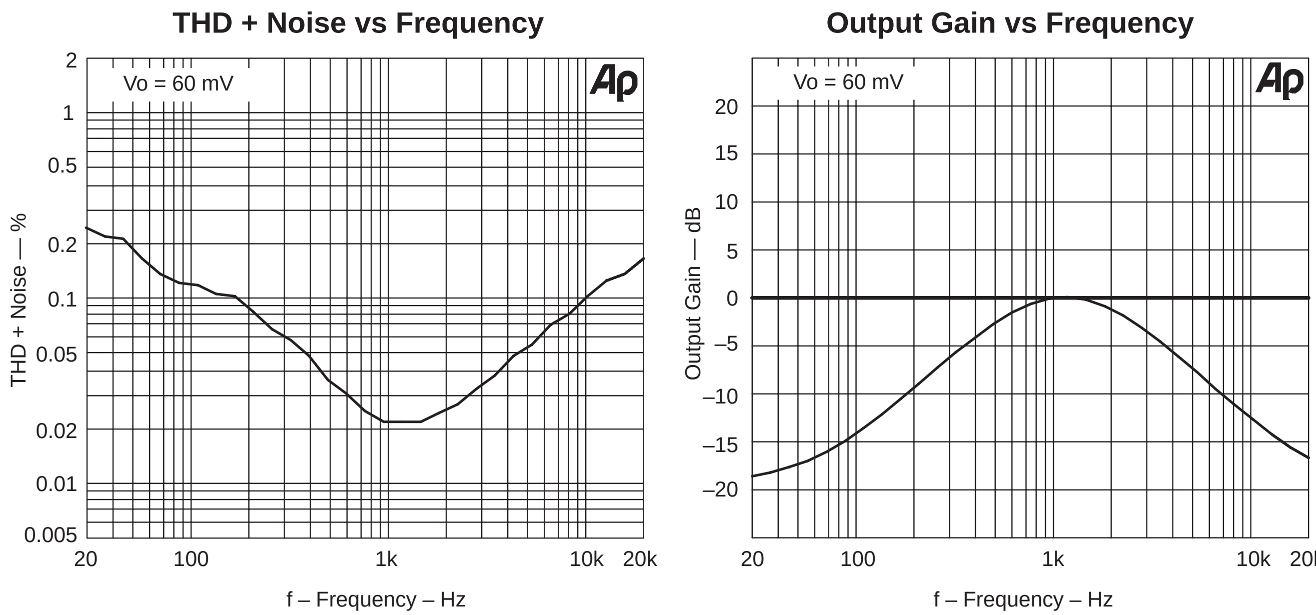



**Figure 7. Maximum Bass and Treble Cut**

## 4 Summary

The familiar Baxandall Hi-Fi tone control is updated from vacuum tubes with modern high-performance operational amplifiers. Two channels (for stereo) can be implemented using only two very small IC packages and a few small passive components. This design places the frequency determining components in the feedback loop of an operational amplifier, reducing distortion and insertion loss, and providing symmetrical boost and cut responses.

## 5 References

1. *Negative-Feedback Tone Control*, by P. J. Baxandall, Wireless World, October 1952.

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