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EECE 226L
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Midterm Audio Project

Objective:

Create an audio amplifying filter that uses potentiometers and op amps to allow interactive manipulation of which frequencies of sound are amplified and heard through a speaker.

The design I used as a reference to create my design can be found in the textbook *Design with Operational Amplifiers and Analog Integrated Circuits* by Sergio Franco on page 133-134. The design I used as a reference is a audio amplifier that incorporates active tone control in the design. The form of tone control in this design is bass and treble control. Using two potentiometers, you can manipulate the bass frequencies, which are lower frequencies ranging from 20 Hz to 250 Hz, and treble frequencies, which are higher frequencies ranging from 6 kHz to 20 kHz.

Equations and Definitions:

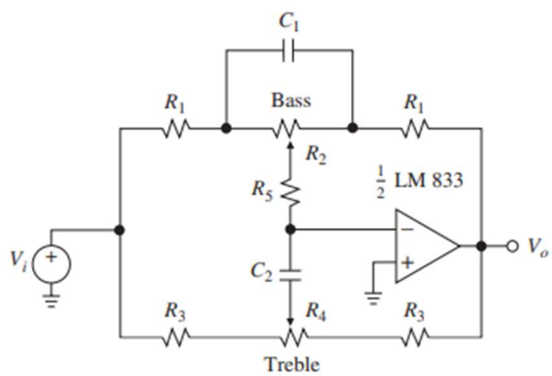

Figure 1: Bass and Treble Active Tone Control Amplifier

(1) $$\frac{R_3}{R_1 + R_3 + 2R_5} \leq A_T \leq \frac{R_1 + R_3 + 2R_5}{R_3}$$

(2) $$f_T = \frac{1}{2\pi R_3 C_2}$$

(3) $$\frac{R_1}{R_1 + R_2} \leq A_B \leq \frac{R_1 + R_2}{R_1}$$

(4) $$f_B = \frac{1}{2\pi R_2 C_1}$$

1. The range of variability of the treble gain (AT)
2. Equation of the frequency of the treble control
3. The range of variability of the bass gain (AB)

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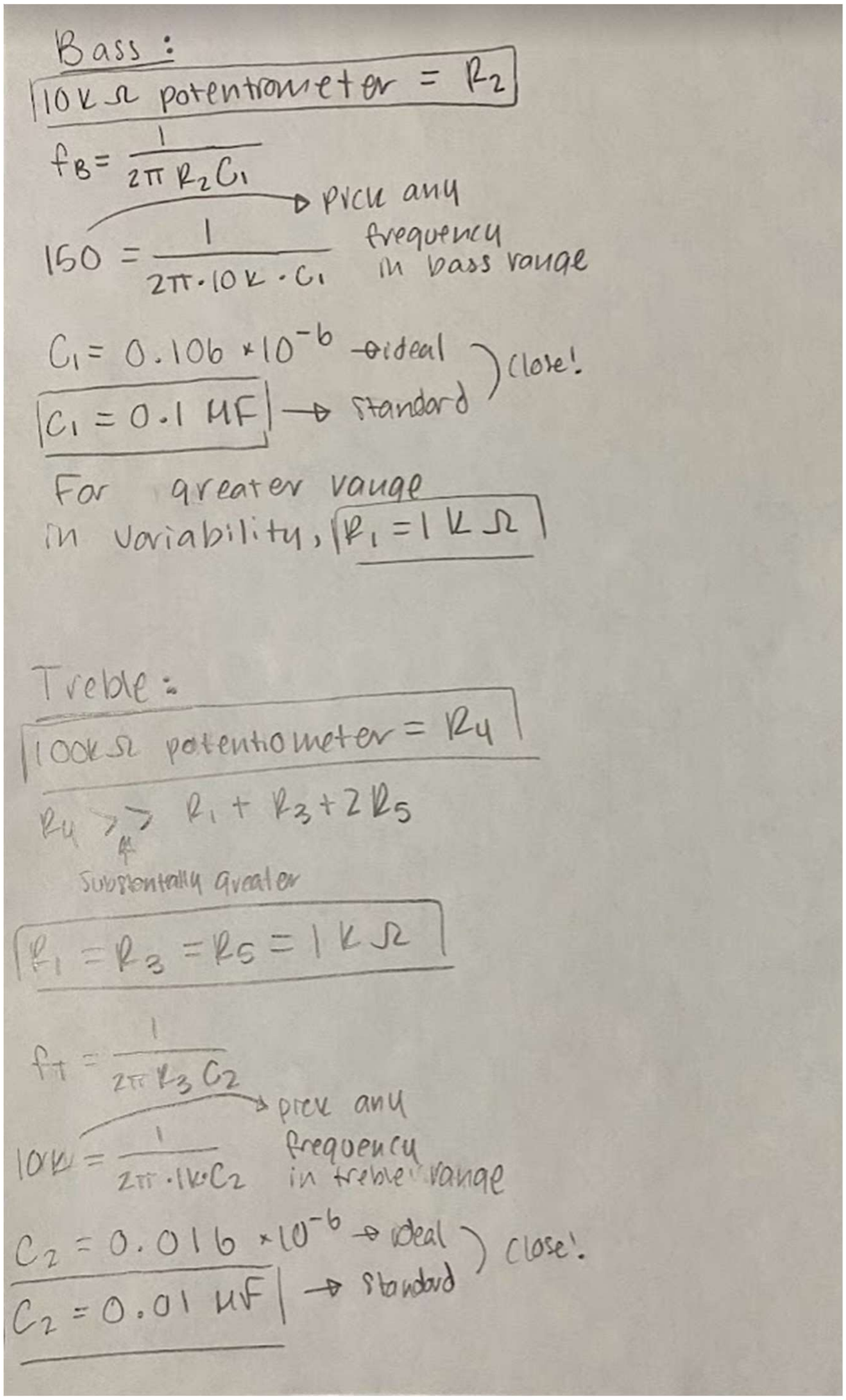
(4) Equation of the frequency of the bass control

All equations and relations above can be found in Sergio Francos textbook on pages 133-134

Supplemental Calculations



Bass:

$\boxed{10\,k\Omega \text{ potentrometer} = R_2}$

$f_B = \frac{1}{2\pi R_2 C_1}$

$150 = \frac{1}{2\pi \cdot 10k \cdot C_1}$ → pick any frequency in bass range

$C_1 = 0.106 \times 10^{-6}$ → ideal

$\boxed{C_1 = 0.1\ \mu F}$ → standard

close!

For greater range in variability, $\boxed{R_1 = 1\,k\Omega}$

Treble:

$\boxed{100k\Omega \text{ potentiometer} = R_4}$

$R_4 >> R_1 + R_3 + 2R_5$

substantially greater

$\boxed{R_1 = R_3 = R_5 = 1\,k\Omega}$

$f_T = \frac{1}{2\pi R_3 C_2}$

$10k = \frac{1}{2\pi \cdot 1k \cdot C_2}$ → pick any frequency in treble range

$C_2 = 0.016 \times 10^{-6}$ → ideal

$\boxed{C_2 = 0.01\ \mu F}$ → standard

close!

Figure 2: Calculations using equations (1) – (4)

In the calculations, I started with the potentiometer values since that is the most limited component in lab. For the bass and treble components, I then chose a frequency that falls in the ranges of frequency. For the bass frequency, I chose 150 Hz and for the treble frequency I chose 10k Hz. For the resistors R1, R3, and R5, I picked 1k ohm to make for easy calculations and it worked out to capacitance values that are close to standard values in lab. C1 came to be 0.1uF and C2 came to be 0.01 uF. With this, the potentiometer value I chose for R4 was 100k ohm so that R4 would be substantially larger than R1+R3+2R5.

Circuit Schematic

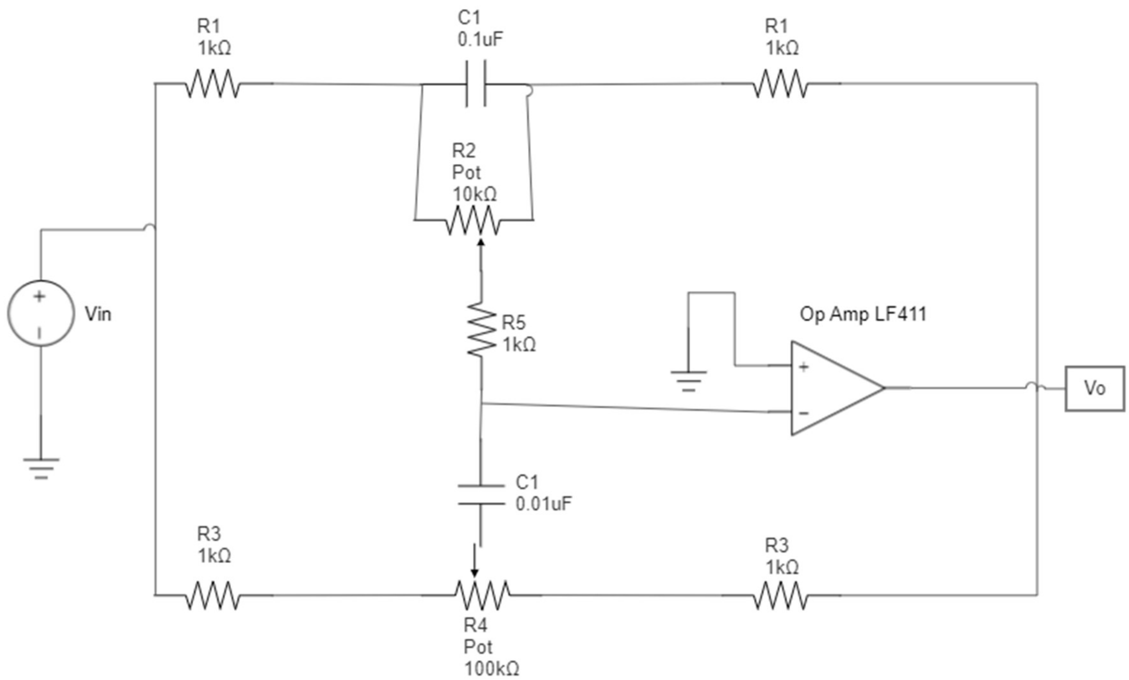


Figure 3: Treble and Bass Active Tone Control circuit schematic based off Figure 2

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Expectations and Simulations

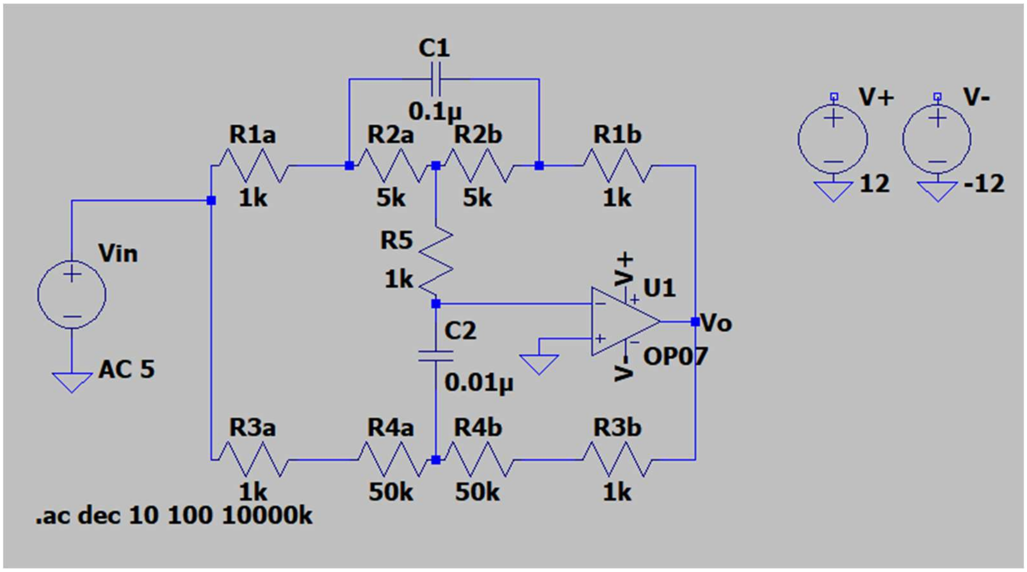

Figure 4: LTSpice Circuit Schematic

In the LTSpice Circuit in Figure 4, the potentiometer is split into two resistors to simulate the resistance distribution as the wiper is moved.

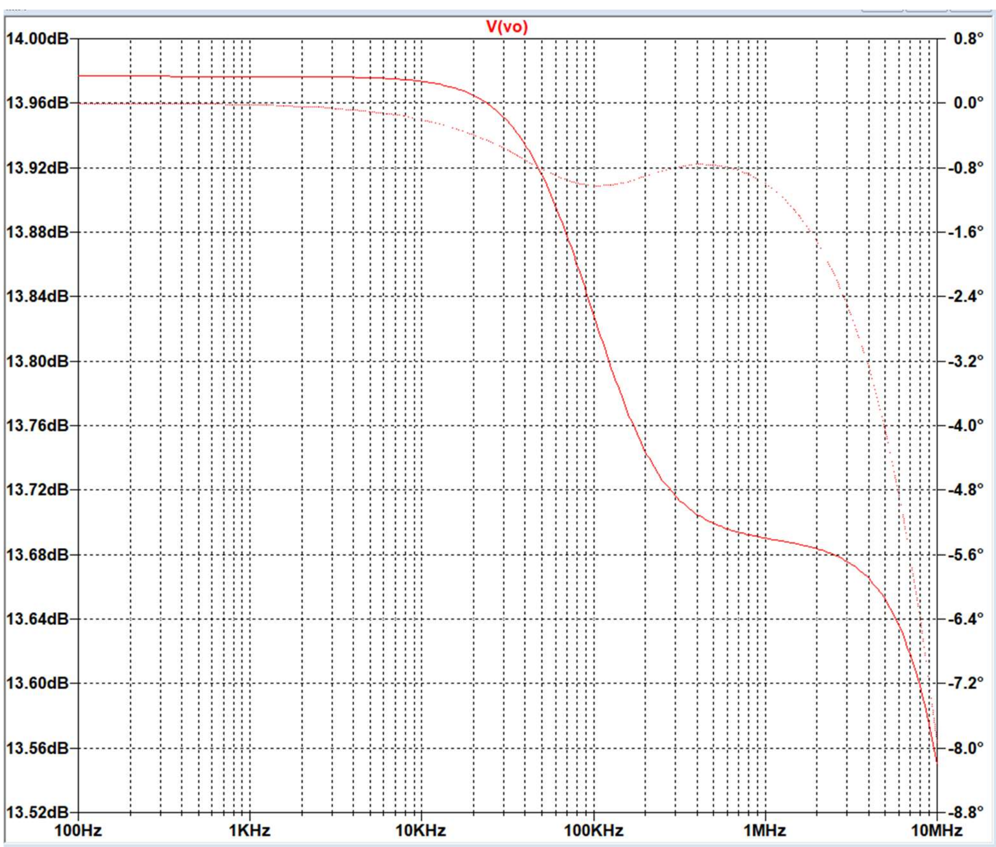

Figure 5: AC Sweep Analysis of Figure 4 at 5Vpp from 100 Hz to 10 MHz

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Bass Frequency:

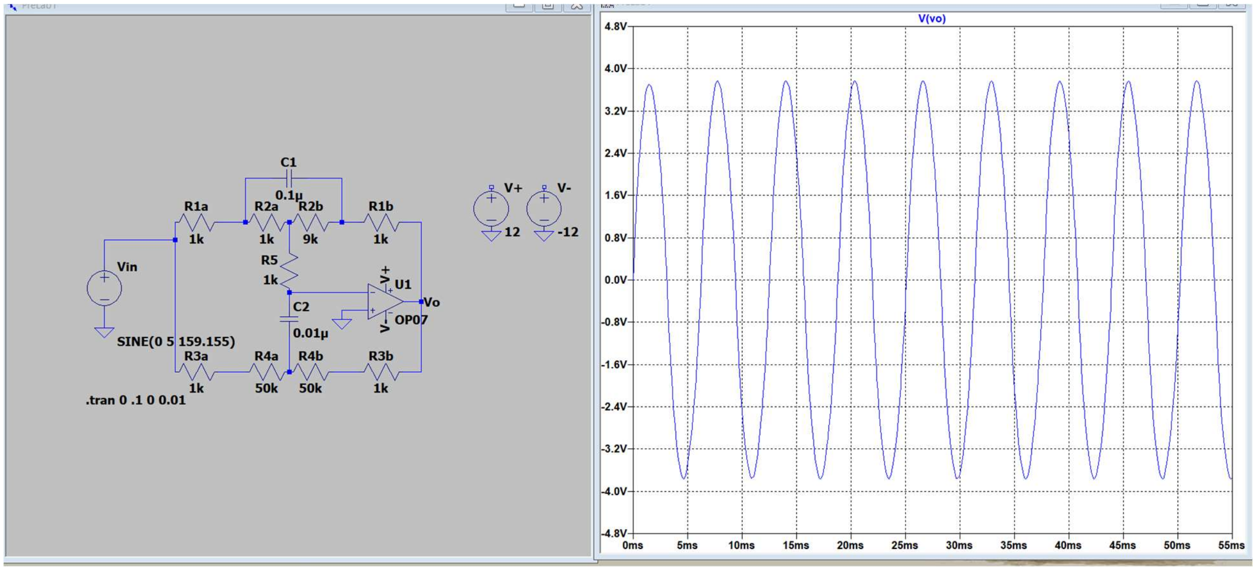

Figure 6: Figure 4 at 5 Vpp and 159.155 Hz (fb) with maximum output voltage of 3.8 Vpp

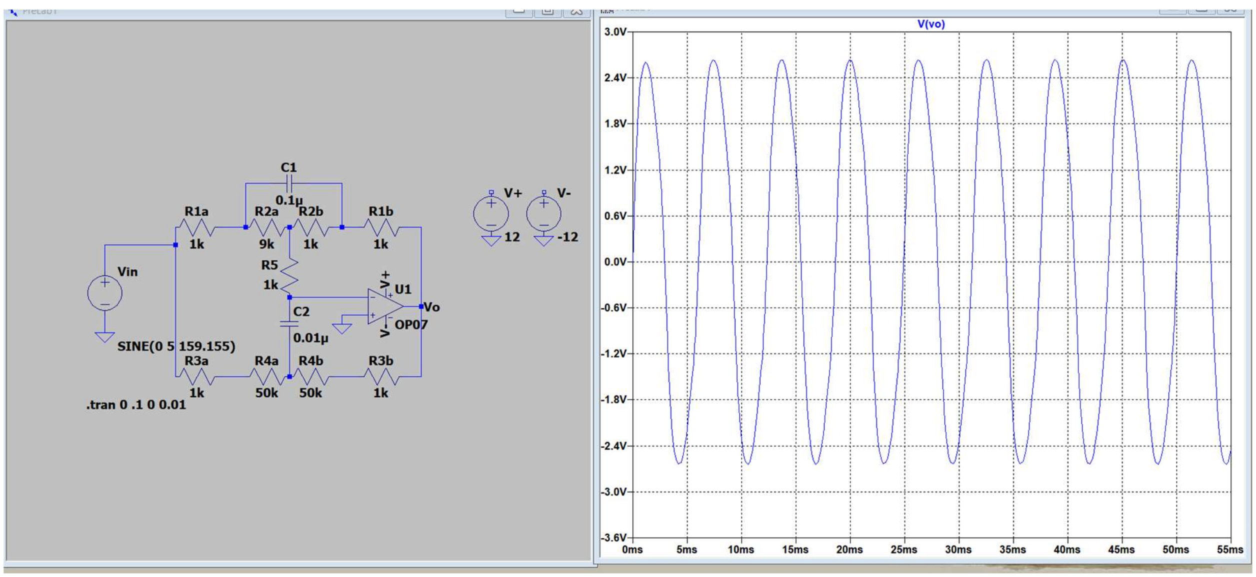

Figure 7: Figure 4 at 5 Vpp and 159.155 Hz (fb) with minimum output voltage of 2.6 Vpp

Treble Frequency

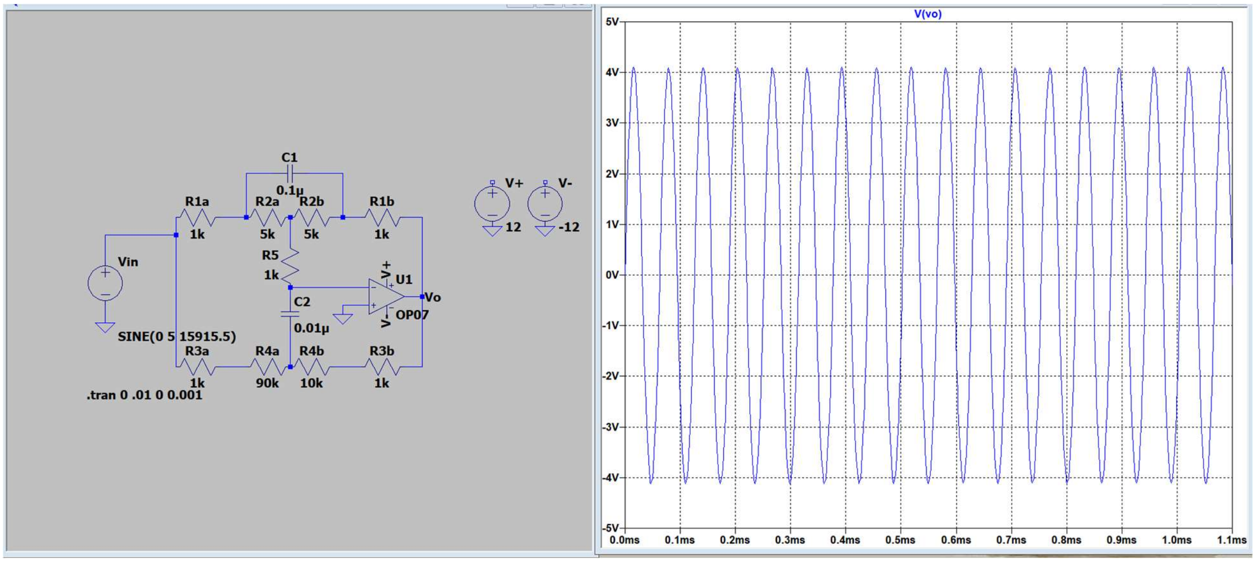

Figure 8: Figure 4 at 5 Vpp and 15915.5 Hz (ft) with maximum output voltage of 4.1 Vpp

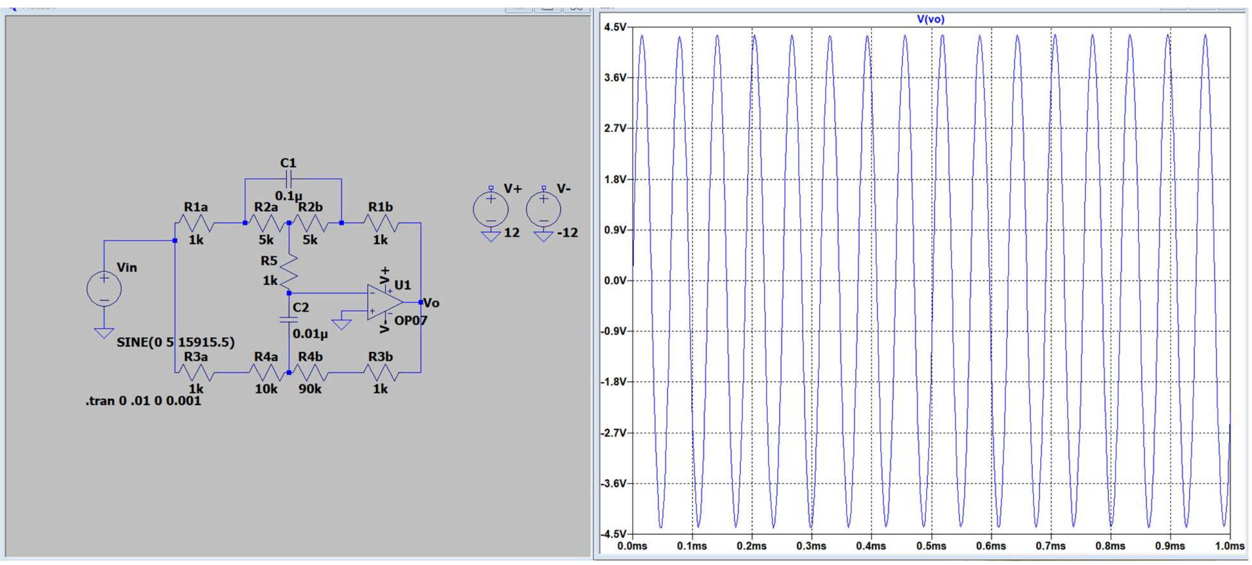

Figure 9: Figure 4 at 5 Vpp and 15915.5 Hz (ft) with minimum output voltage of 4.4 Vpp

NOTE: The range of variability of the treble gain is less than that of the range of variability of the bass gain because greater manipulation of bass in sound and music is more desirable than the manipulation of treble in sound and music.

Expectations:

When inputting a single frequency signal into the circuit system of Figure 4, only manipulate one of the potentiometers at a time. If your input frequency signal is between 20 Hz to 250 Hz, only potentiometer R2 will affect the voltage output. If your input frequency is between 6 kHz to 20 kHz, only potentiometer R4 will affect the voltage output. Using the circuit schematic of Figure 4, you can find a difference of 0.8 Vpp between the maximum and minimum voltage output for the bass frequency and a difference of 0.3 Vpp between the maximum and minimum voltage output for the treble frequency.