

## Oscilloscope Addendum

### I. Introduction

Signals within the range of 16 Hz to 20 kHz are in the range of human hearing. This provides a great opportunity to get a better understanding of time varying signals. In this lab you will output signals from the computer and listen to them on headphones while also viewing them on the oscilloscope. You will begin by observing pure sinusoidal signals produced by Matlab. Then you will observe the addition of two sinusoids to see beat frequency properties. You will build a simple RC circuit and use it as a low pass filter. You will then use this filter with music from an internet radio station as well.

### II. Setup

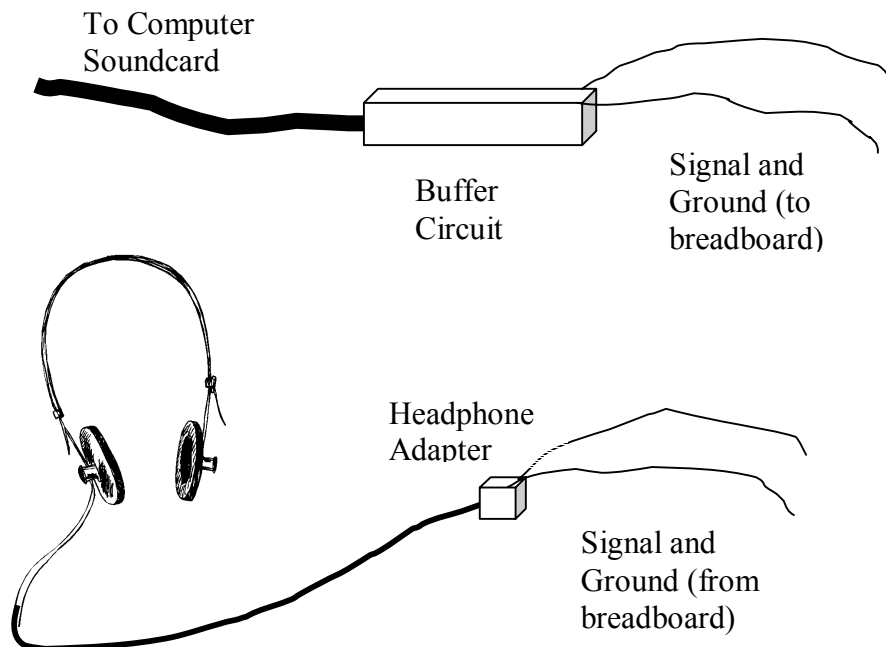


Figure 1: Setup for observing sound from the computer

### III. Hands On

#### A. Initial Setup

1. Download beat.m and freq.m from the ee43 web page.
2. Open the file in Matlab
3. Plug the wires from the buffer (figure 1) into the breadboard. Connect the wires leading the headphones to these wires.
4. Connect the scope probe to signal and ground

#### B. Pure sinusoids

1. Use the freq function to create a sinusoidal signal at 1 kHz (i.e. type `freq(1000)` in the Matlab command window). View it on the scope and listen to it. Draw this signal.
2. Play around with signals at other frequencies. What is the lowest frequency you can hear?
3. Use the beat function to create the sum of two frequencies. What is the beat frequency? Draw the combined signal.

Note: For those of you who haven't had the chance to see beat frequencies in physics yet, here's a quick lesson. Beat frequencies are obtained by outputting the sum of frequencies that are close to each other. The math behind it comes from the trigonometric identities:

$$\sin(x) + \sin(y) = 2 * \sin((x + y)/2) * \cos((x - y)/2)$$

We see that the frequencies added together produce a sine wave that is multiplied or "modulated" by a cosine. We'll draw pictures of this modulation in the labs to give you a better understanding of what you will be hearing.

#### C. Filtered Signals

1. Set up the RC circuit in figure 2.
2. Output a single sinusoid at 500 Hz from Matlab.
3. Start with the potentiometer turned to its lowest value. Turn it up (very slightly) till the filtered signal (A2) is half the amplitude of the input signal (A1). What is the resistance of the potentiometer at this point?
4. Play around with filtering other frequencies. What are some of your observations?

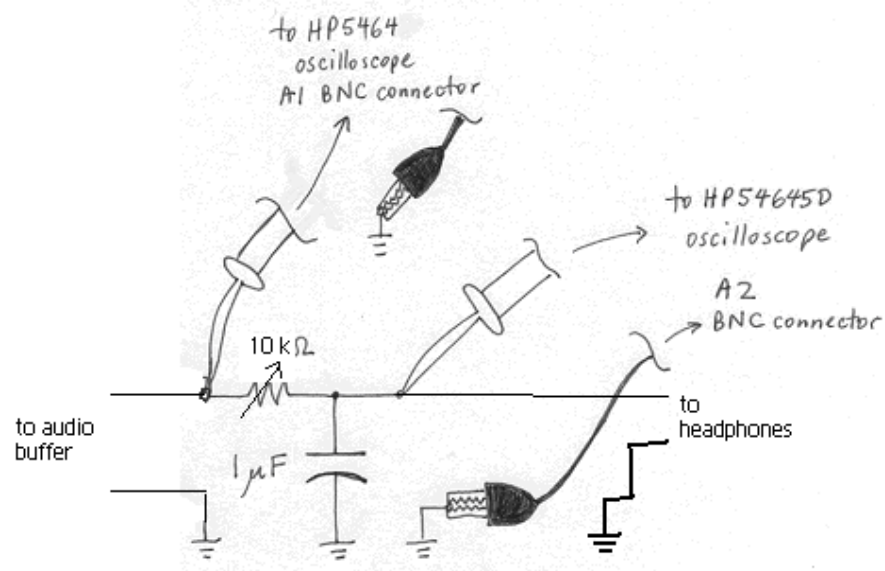


Figure 2: RC Circuit for Filtering

#### D. Filtering music

1. Go to <http://www.shoutcast.com> and find an internet radio station to filter. Note: The filtering is most apparent with classical music.
2. Play around with the potentiometer. Can you filter out high frequency sounds (treble) without also cutting the low frequency components (bass)?
3. Can you see the difference between the filtered and unfiltered music on the scope?