

# Operational Amplifiers

1) Measure the voltage gain vs. frequency for a non-inverting amplifier (Simpson P414) with a gain of 0, 20, and 60 dB. Scan the frequency range 10 Hz (or as low as you can go) to 100 kHz. Plot all measurements on a Bode plot. Superimposed on the same plot the theoretical expectations calculated from the op amp's spec sheet (e.g. the figure "Open Loop Voltage Gain vs. Freq."). Measure the input impedance of the amp at several frequencies.

2) Do one of the following:

a) Build an inverting amp (Simpson P412) with a gain of 40 dB. Measure the gain vs. frequency over the range 10 Hz -100 kHz. Measure the input impedance at several frequencies. Compare your results with the theoretical expectations.

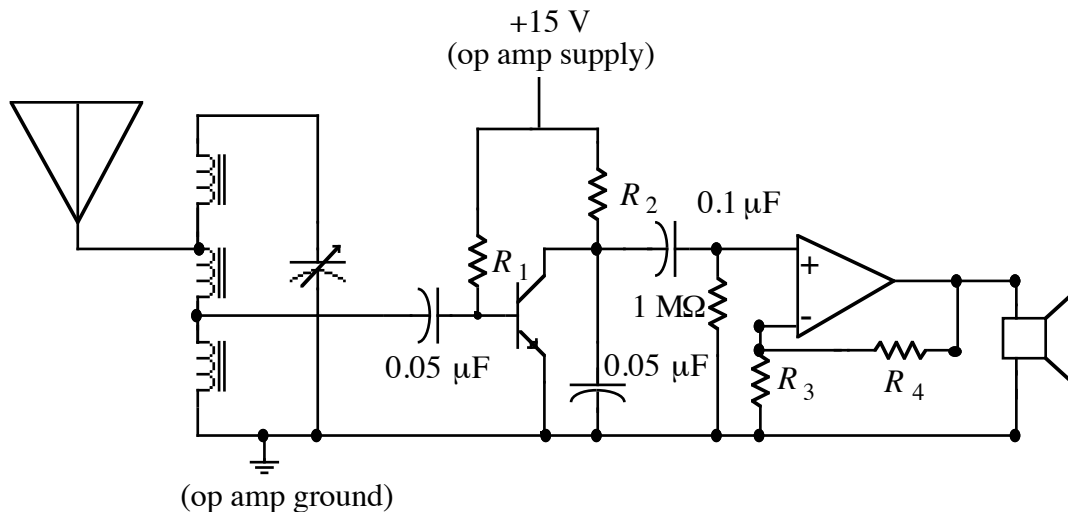
b) Build a summing amplifier (Simpson Sec 10.7). The input voltages can be DC.

c) Build a difference amplifier (Simpson Sec 10.4) with gain of 20 dB.

3a) Build a circuit to perform integration of a 1 kHz square wave, sine wave, and triangular wave. Capture using the input and output waveforms and compare with what is expected for the integrals of each waveform. Start with the square wave. Read the discussion in the Student Manual for the Art of Electronics (Hayes and Horowitz) on P185 before you start.

### 3b) Return of the Radio from Hell:

In the previous lab you built a 3-stage AM radio. The last two stages of the radio amplified the signal so that it would be audible. Replace the last two transistors with a non-inverting amplifier of gain 40 dB. See the circuit below. Pick  $R_1$  and  $R_2$  in the same fashion that they were chosen for the AM radio lab. Pick  $R_3$  and  $R_4$  to give a gain of 40 dB. Compare this version of the radio with the 3-stage version (i.e. which works better). Capture using a picture of the input and output waveforms of each amplifier (2 waveforms/picture) and discuss what you see.



Note: All circuits use a 741 (or equivalent) op amp and the op amp breadboard.