EE 230
Experiment 6
Spring 2010

Some Linear Applications of Operational Amplifiers

Objectives: The primary objective of this experiment is to investigate some linear applications of the operational amplifier. The effects of noise on amplifier performance will also be investigated. There are 4 parts to this experiment. Since this is a new experiment, we do not know how long it will take to complete so Part 4, which focuses on building a high gain amplifier and on noise, will be extra credit.

Equipment:
Computer with SPECTRE, Signal Express, GP-IB capability, and appropriate IVI drivers
HP E3631A or equivalent power supply (GP-IB Capable)
HP 33220A or equivalent signal generator (GP-IB Capable)
HP 34410A or equivalent multimeter (GP-IB Capable)
TEK DR 3012 or equivalent oscilloscope

Parts:
Assortment of Resistors and Capacitors
4 741 op amps
Amplified Speaker
Photoresistor

Part 1 Integrators

Design an inverting integrator with a unity gain frequency of 1KHz. The topology shown in Fig. 1 is the basic inverting integrator.

a) Compare the theoretical and measured response if the input is a 1V 0-P sinusoid of frequency 500Hz, 1KHz, and 2KHz
b) Add loss to the integrator by placing a large shunt resistor in parallel with the integration capacitor. Size the lossy element so that the dc gain is 50. Repeat part a) with the lossy integrator
c) Using the lossy integrator, compare the theoretical and measured response if the input is a 1V 0-P square wave of frequency 500Hz, 1KHz, and 2KHz
d) The lossy integrator is actually a lowpass filter. Analytically determine the 3dB frequency of this lowpass filter and compare theoretical and measured results.

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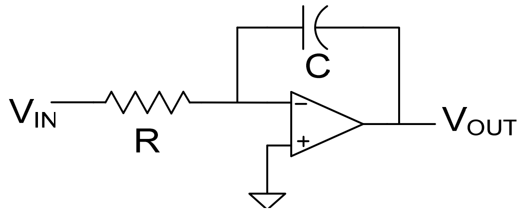

Fig. 1. Basic Inverting Integrator

Part 2 Lowpass Filter

Design a lowpass filter with a dc gain of +10 and a 3dB band edge of 2KHz. Compare theoretical and measured performance

Part 3 Bandpass Filter

Design a second-order bandpass filter that has a peak frequency of 1KHz and a 3-dB bandwidth of 200Hz. There are many bandpass filter structures that can be used. To maintain uniformity across all students working on this experiment, use the bandpass filter structure of Fig. 2. When designing your bandpass filter, establish a systematic process for designing the filter and clearly describe that process in the report. Do not dis-assemble the filter when you complete this part of the experiment. It will be used again on the next part of the experiment.

a) Compare the theoretical and simulated magnitude response with the measured magnitude response over the frequency range from 100Hz to 5KHz.
b) If an input a square wave of frequency 1KHz. is applied, what response is expected? Verify with measured results.
c) Modify your design so that the bandwidth of the filter is dependent upon the light striking a photo resistor. Make the bandwidth change by at least a factor of 2 as the light striking the photo resistor is modulated.

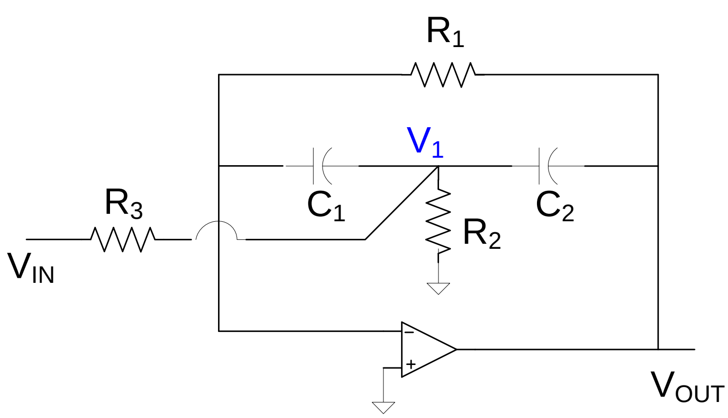

Fig. 2 Bridged-T Bandpass Filter

Part 4 High Gain Amplifier and Noise

There are multiple sources of noise present in any electronic circuit. Noise is usually considered an unwanted property. The circuit shown on the left part of Fig. 3 can generate a very small signal. This could represent a small signal generated by a transducer. Although this small signal is difficult to observe in the laboratory with any equipment we have available, it can be readily observed if passed through an appropriate amplifier. But when amplifying the signal, any noise present on the small signal as well as noise present in the amplifier will be amplified as well. Also shown in Fig.3 is a 3-stage capacitor coupled amplifier. The reason for the capacitor coupling is to reduce the effects of any offset voltages present at the input of the amplifiers.

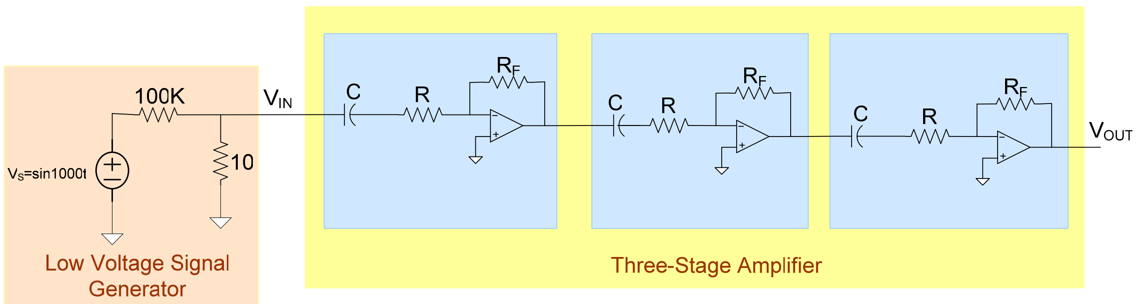

Fig. 3 Small voltage signal generator and capacitor-coupled voltage amplifier

a) Determine the voltage present at the output of the Low Voltage Signal Generator. Report on what you obtain if you use the oscilloscope and the multimeter to measure the signal V_{IN}.

b) Determine the transfer function of one stage of the three-stage amplifier and the transfer function of the overall three-stage amplifier in terms of the parameters C, R, and R_F.

c) Each of the capacitor coupled amplifiers has a first-order highpass response. Determine component values of these amplifiers so that the 3-dB band edge of each stage is 1/10 of the frequency of V_{IN} and so that the magnitude of the gain at higher frequencies (e.g. 1000 rad/sec) of each stage is approximately 100 . Do not use electrolytic capacitors in your design.

d) If no noise is present, determine the desired output voltage and compare with that measured with the oscilloscope.

e) Pass the output of the three-stage amplifier through the bandpass filter designed in Part 2 or this experiment. Comment on what effect the bandpass filter has on the signal output.

e) With V_{IN}=0 (actually short out the input), observe the output voltage on the oscilloscope and compare to what is expected.

f) Pass the output obtained from part e) through the bandpass filter and listen to the output. How does the sound change if the bandwidth is adjusted by varying the light controlling the filter bandwidth?