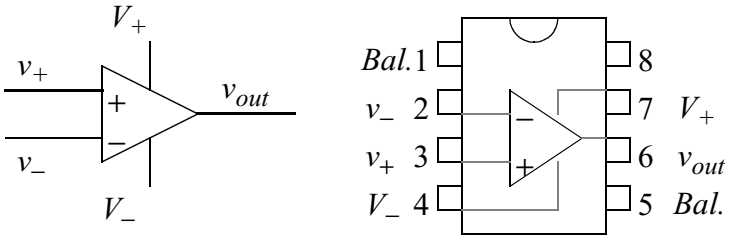
Physics 475, Laboratory 8
Active Filters

Overview

The purpose of these is to use feedback to build active analog filters.

Components

The TL071 op-amp is an integrated circuit based on JFET inputs and biploar transistor outputs (BIFET) and comes in an 8-pin dual in-line package (DIP). The connections for the chip looking down with the notch facing up is:



Background

Active filters are characterized by their behavior towards gain and phase shift as functions of both the frequency and time. The unity gain Sallen Key active filter is a 2-pole filter with bootstrapping. The break frequency is $\omega_b = \frac{1}{\sqrt{R_1 C_1 R_2 C_2}}$

and the damping factor is $d_0 = \frac{1}{Q} = (R_1 + R_2)C_2\omega_b$.

With a variable gain for negative feedback and matching $R_1 = R_2 = R$, $C_1 = C_2 = C$, the gain and damping are independent of the break frequency $\omega_b = \frac{1}{RC}$.

$$A_0 = 1 + \frac{R_3}{R_4}$$

$$d_0 = 3 - A_0 = 2 - \frac{R_3}{R_4}$$

As with a mechanical oscillator the gain vs. frequency curve can be descibed as

overdamped ($d_0^2 > 2$),

underdamped ($d_0^2 < 2$),

or critically damped ($d_0^2 = 2$).

1. Chebyshev Filter

Connect a TL071 op-amp to form the variable gain Sallen Key circuit in figure 1. Select R and C such that f_b = 1 kHz. Use a 10 kΩ potentiometer for R_g so that R_3 is the feedback part of R_g and R_4 is the remainder.

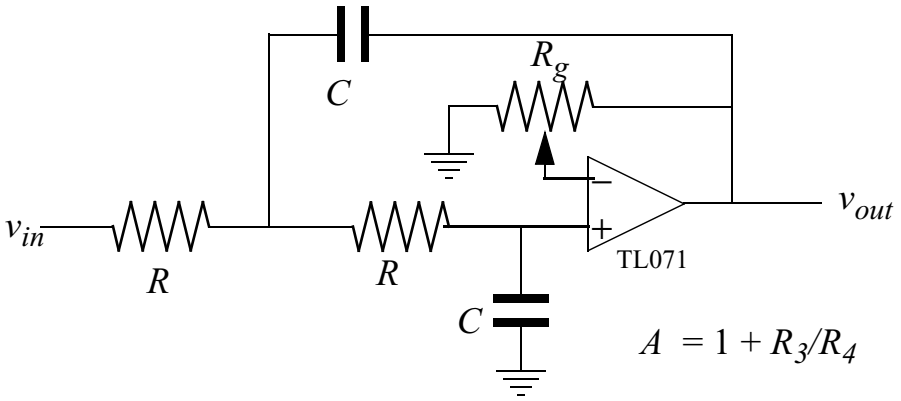


Figure 1: Variable Gain Sallen Key Filter

Adjust the potentiometer so that d_0 = 0.767 to provide an underdamped response. Using a sine wave input measure and graph the filter gain and phase shift as a function of frequency. What is the gain roll-off as a function of frequency in dB/octave? Set the function generator to provide v_{in} with a square wave of 100 Hz. Graph the transient response at the rising edge and note the rise time, overshoot and settling time.

2. Bessel Filter

Adjust the potentiometer for the circuit in part 1 so that d_0 = 1.732 to provide an overdamped response. Repeat the measurements from part 1.