

Feel free to do one of the following tasks as your final project. I personally prefer the engineering task since we have already done several simulation tasks in the course assignments. In my view, you become familiar with many practical points while doing the engineering task. However, you need to have access to common laboratory equipment to do the engineering task.

ENGINEERING TASK

Task 1

The circuit shown in Fig. 1 is called Sallen active lowpass filter, where the triangle abstracts an op-amp amplification circuit with the gain K .

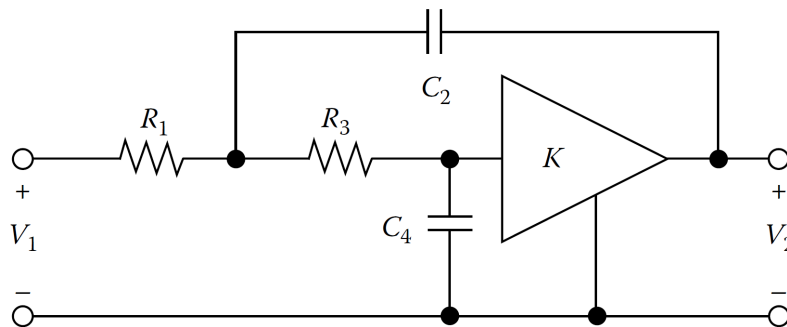


Figure 1: Sallen active lowpass filter.

(a) Calculate the frequency response of the active filter if $R_1 = R_2 = R$ and $C_1 = C_2 = C$.

(b) Determine suitable values for R , C , and K such that the active filter has the amplitude response of a Butterworth filter $|H(j\omega)| = \frac{3-\sqrt{2}}{\sqrt{1+(\frac{\omega}{\omega_c})^4}}$ with the cutoff frequency of $\omega_c = 2\pi$ krad/s, or equivalently, $f_c = 1$ KHz.

(c) Build the designed Butterworth filter on a breadboard and validate its amplitude response using a function generator and an oscilloscope. You can use an op-amp circuit to create the amplifier with the gain K .

(d) Prepare a short report and describe your work concisely. Use suitable figures to better describe the designed filter and to make your report more readable and understandable. Take a short video of yourself demonstrating the amplitude response of the designed filter.

(e) **Bonus!** Use the same procedure to design a highpass filter with a cut off frequency $f_c = 1 \text{ kHz}$ using the Sallen active highpass filter shown in Fig. 2.

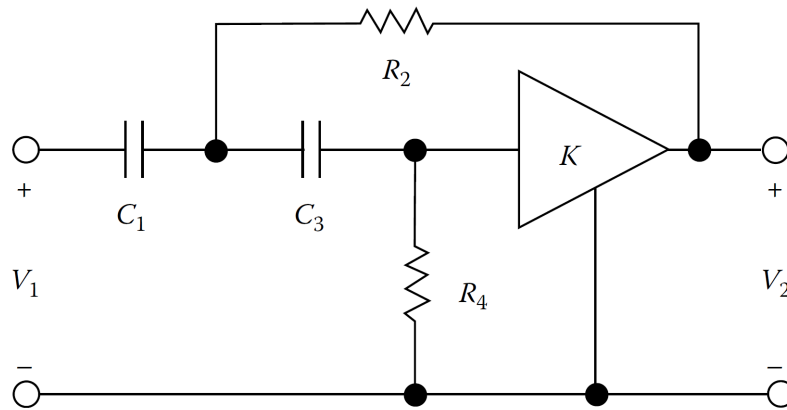


Figure 2: Sallen active highpass filter.

(f) **Bonus!** Write your report in \LaTeX .

SIMULATION TASK

Task 2

Here, we intend to create a simple virtual oscilloscope and function generator.

- (a) Create a MATLAB/Python function named "generator" that emulates a function generator. The function takes the wave type (sinusoidal, square, triangle), frequency, amplitude, and offset level and generates real-time samples of the corresponding periodic signal continuously over time.
- (b) Create a MATLAB/Python function named "oscilloscope" that emulates a simple oscilloscope. The function takes the waveform samples generated by the function generator developed in the previous part along with volts/div selector value, vertical position, time/div selector value, horizontal position, trigger level, and trigger slope. Then, it displays the received waveform on a screen. The screen should be real-time and display the received waveform continuously over time.
- (c) Prepare a short report and describe your work concisely. Use suitable figures to better describe the developed codes and to make your report more readable and understandable. Take a short video of yourself demonstrating the operation of the developed function generator and oscilloscope.
- (d) **Bonus!** Create a GUI for the oscilloscope and function generator to graphically take the setting values of the function generator and oscilloscope. A sample GUI is shown in Fig. 3.

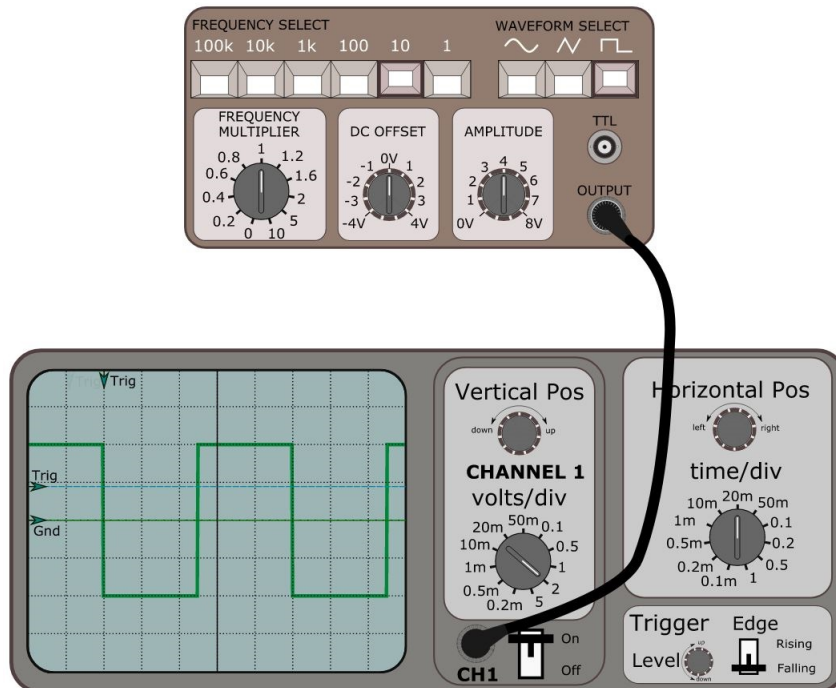


Figure 3: A sample GUI for the virtual oscilloscope and function generator..

- (e) **Bonus!** Write your report in \LaTeX .