

EE213 Lab 9: Type I Chebyshev High Pass Filter

Spring 2014

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1 Objective

The objective of this laboratory is to investigate the properties of Chebyshev type I filters and the MATLAB commands `cheb1ord()` and `cheby1()`. A Chebyshev type I high pass filter is to be designed and realized to meet a given set of specifications.

2 Lab

2.1 Magnitude and Phase and Poles and Zeros of First Order Chebyshev Filters

A type I Chebyshev filter is specified by three parameters: the order, which is a positive integer, usually less than ten, the ripple, which is a positive number (typically in units of dB), usually less than three, and the ripple band frequency, which is also a positive number (in Hz or normalized radians). The filter type is low pass, high pass, band pass, or band stop.

2.1.1 Exercises

1. Use the MATLAB commands `cheby1()` and `freqs()` to investigate the effects of these three parameters on the magnitude and phase of the filter for low pass filters in the pass band; use the `bode()` command to determine the effects of the three filter variables on the stop band and transition band characteristics of the filter.
2. Write a paragraph that thoroughly discusses the effects of these three parameters on the magnitude and phase of a type I Chebyshev low pass filter.
3. Discuss the behavior of the poles and zeros of a type I Chebyshev low pass filter as the order, ripple, and ripple band frequency of the filter vary; compare your poles and zeros to those for a Butterworth low pass filter.
4. Repeat (2) and (3) for highpass, bandpass, and bandstop filters.

2.2 Determining the Parameters of Type I Chebyshev Filters

The MATLAB command `cheb1ord()` can be used to determine the parameters of a type I Chebyshev filter with any pass band, stop band, pass band gain, and stop band gain.

2.2.1 Exercises

1. Use the MATLAB documentation for `cheb1ord()` to determine how to specify the frequencies and attenuation of both the pass band and stop band.
2. Write a paragraph that specifies how to determine the parameters of type I Chebyshev and Butterworth filters with any specified pass band and stop band.
3. The MATLAB command `cheby1()` can be used to determine a type I Chebyshev filter with any order, ripple, and ripple band. Use the MATLAB documentation for `cheby1()` to determine how to specify the transfer function, the poles and zeros, and state space representation for a Chebyshev filter with any parameters and pass band. Write a paragraph that specifies how to determine the transfer function of type I Chebyshev and Butterworth filters with any specified parameters and pass band.

2.3 Cascade Realizations of High Pass Filters

The Sallen-Key biquad shown below is commonly used to realize a pair of poles and of zeros for Butterworth and Chebyshev type one high pass filters. Since the output of this biquad is the output of an op amp, the cascade of these biquads can be used to realize any Butterworth or type I Chebyshev high pass filter with an even number of poles and zeros.

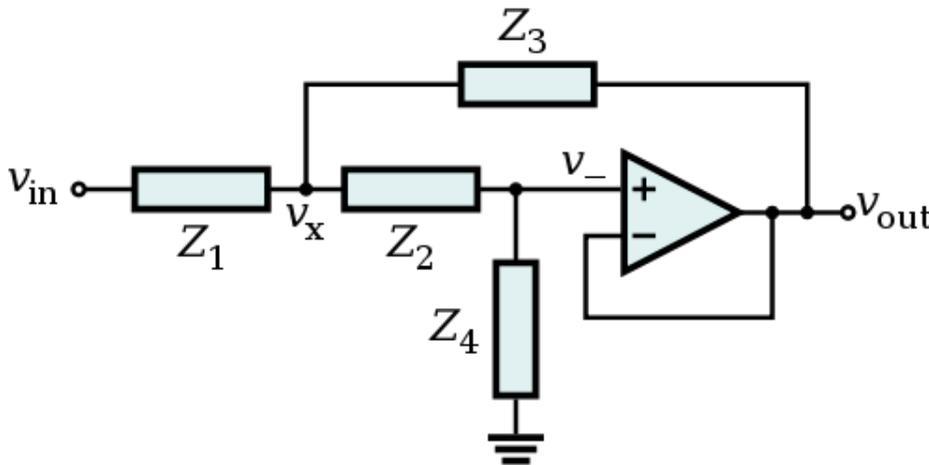


Figure 1: Generic Sallen-Key filter topology. Retrieved from https://en.wikipedia.org/wiki/File:Sallen-Key_Generic_Circuit.svg

2.3.1 Exercises

1. Determine a circuit with a single real pole, a single zero at the origin, and an output that is the output of an op amp; with this circuit and Sallen-Key biquads, any Butterworth or type

I Chebyshev high pass filter can be realized as a cascade of simple single op-amp circuits.

2. Use MATLAB to determine the transfer function of the Sallen-Key highpass biquad.
3. Find element values for an equal capacitor realization of a transfer function of the form $\frac{\hat{s}^2}{\hat{s}^2 + b\hat{s} + 1}$, where $\hat{s} = s/\omega_0$. Find element values for your single pole and zero filter of the preceding paragraph to realize a transfer function of the form $\frac{g\hat{s}}{\hat{s} + 1}$.
4. Use Matlab commands to find a realization of a Chebechev high pass filter to meet the following specifications; at most 2 dB down at frequencies above 5kHz and at least 40dB down at frequencies below 4kHz. After you find the transfer function and filter order discuss the biquads and opamp circuits that you would use to find a circuit realization. Use a Sallen Key high pass biquad with equal value capacitors.