Active Lowpass & Highpass Filters

By: Eugene J. Evancoe
Electronic Technology Department Chair
Saddleback College
Mission Viejo, CA

Purpose:

This experiment has the following main purposes:

1. Give additional practice with the basic equations for 2nd order Sallen & Key active filters.
2. Give laboratory measurement practice in frequency response measurements and characterizations of filters.
3. Provide both analysis and general recognition experience with 2nd order Sallen & Key active filters with different response characteristics(i.e. Butterworth, Chebyshev, Bessel responses).

In the first 2 parts of the experiment, 2 predesigned filters will be analyzed and tested. In the last (extra credit) part of the experiment, filter specifications will be given and the filter will be designed and tested. For all circuits, only the LF347 op amp will be used. The op amps will be powered with ±15V. The spectrum analyzer will not be used in this experiment - the function generator, frequency counter, and oscilloscope will be used to take frequency response and time response data. It is very important to measure the actual value of all components, and use those values in calculations.

Equipment:

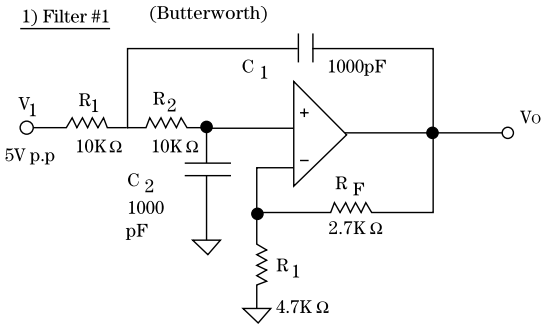
- Agilent 54600B oscilloscope
- Agilent 33120A Function/Arb Generator
- LF 347 Op amp

Procedure:

1) Filter #1

a) Using the equations given on the class notes, calculate the expected center frequency and Q (=1/DF). Record on Data Sheet.

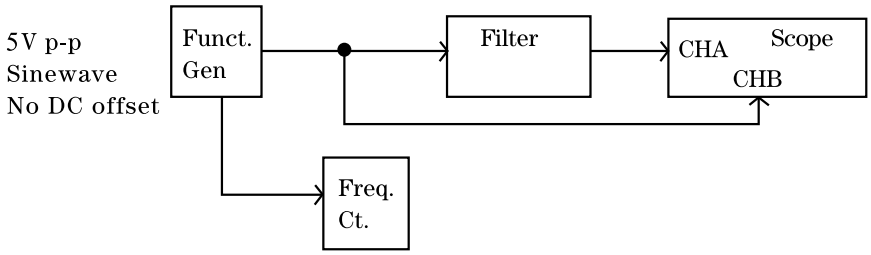
b) Measure and plot the voltage gain (Vo/VI) at the following frequencies: calc fo, fo/10, fo/2, 2fo, 10fo, 100fo. For the measurements, keep V_I at 5Vp-p from function generator, monitor frequency on freq. counter, and measure Vo (p-p) with the oscilloscope. Record data on Data Sheet.



Important - Monitor the input and check/re-adjust to proper 5V p-p at each frequency.

Use semilog paper to plot the frequency response of the voltage gain: AV in dB vs. freq. Be sure to measure the 3dB freq and stopband rolloff rate and record on Data Sheet.

c) Change the function generator to a squareware with amplitude 5V p-p, frequency = 2KHZ. Before taking measurements, verify that scope probes are properly compensated and compensate if necessary. Display Vo vs. time, showing approximately 2 cycles. For the Butterworth filter, you should see noticeable overshoot (ringing) at the output pulse edges.



2) Filter #2

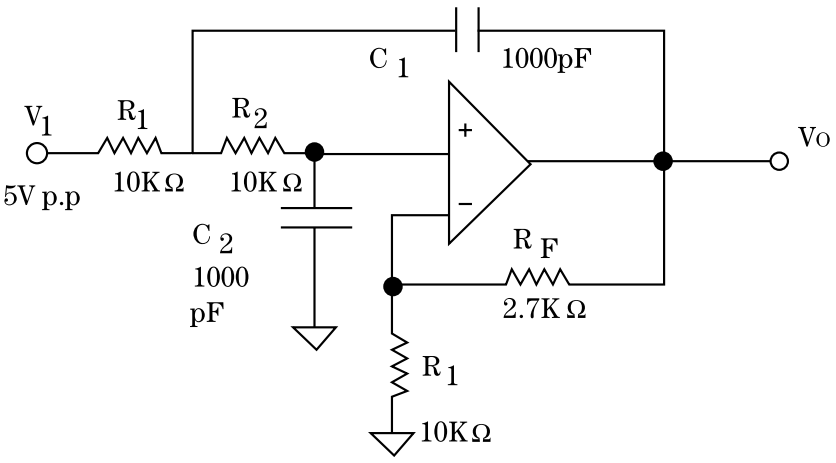
This filter does not have the Butterworth response. By testing you are to determine its cutoff frequency, stopband rolloff rate, pulse response, and finally whether it is a Chebyshev or Bessel filter and why (based on the measured data). (The actual 3dB freq. (is not equal to) fo for a Chebyshev or Bessel filter; still use fo from Filter #1 to calculate the frequencies listed.)

a) Measure and plot the frequency response data at the fo (from Filter #1) multiples listed on data sheet. Record on Data Sheet, including the measured 3dB freq. and stopband rolloff rate.

b) Measure and plot the pulse response on Data Sheet. Keep the function generator at 5V p-p, 2KHZ.

c) From the data collected, plotted, and drawn in steps a) and b), determine the filter type and record on Data Sheet.

2) Filter #2 (Type to be determined by student)



3) Extra Credit

Design, build, and test a 3rd order Chebyshev highpass filter (fo = 10KHZ, max passband ripple = 1dB). Use class notes to get required fo & Q for each stage. (Ask instructor for assistance if necessary). In the testing phase, you only need to determine the measured f-3dB and stopband rolloff rate (dB/dec). In your report, list your calculations, circuit schematic with element values, measured f-3dB and stopband rolloff rate, and sketch (not plot) the measured frequency response curve. Include all extra credit information on a separate sheet.

Data Sheet

Filter #1

Calculated fo = _____

Calculated Q = _____

Measured Frequency Response Data:

Frequency			Data	
fo multiple	HZ	Vo p-p	[Av]	[Av] in dB
fo/10				
fo/2				
fo				
2fo				
10fo				
100fo				

Attach Av (dB) vs freq. plot separately

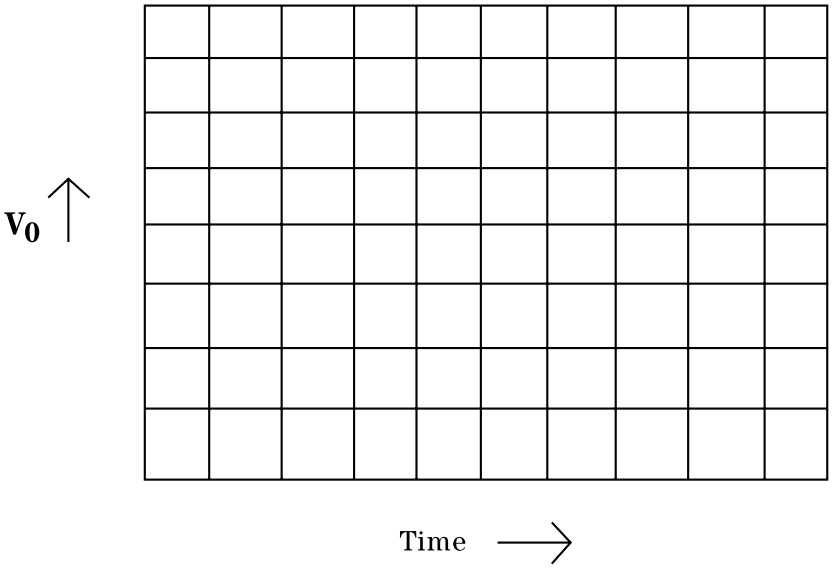
meas. f-3dB = _____

meas. Stopband rolloff (dB/dec)= _____

Pulse Response:

V/div.= _____

time/div._____



Filter #2

Measured Frequency Response Data:

Frequency			Data	
fo* multiple	HZ	Vo p-p	[Av]	[Av] in dB
0.1 fo				
0.2 fo				
0.4 fo				
0.6 fo				
0.8 fo				
fo				
2 fo				
4 fo				
6 fo				
8 fo				
10 fo				
100 fo				

* fo = value from Filter #1

measured f-3dB

= _____

measured stopband

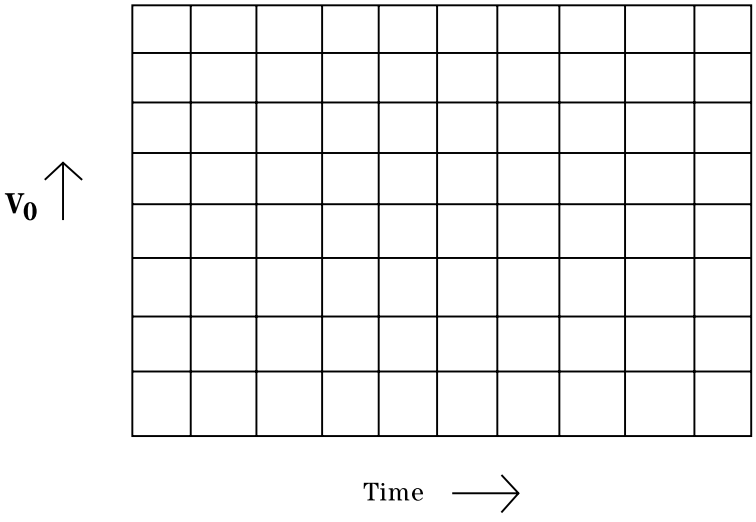
rolloff (dB/dec)

= _____

Pulse Response:

V/div.= _____

time/div._____



Filter type:

(circle and explain)

Chebyshev/Bessel

Why?