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EL 351 - Linear Integrated Circuits Laboratory
Active Filter Design and Test

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Equipment:

- Agilent 54622A Deep-Memory Oscilloscope
- Agilent E3631A Triple-Output DC power supply
- Agilent 33120A Function Generator
- Agilent 34401A Digital Multimeter

Introduction:

Active filters are used extensively for signal conditioning in electronic circuits. For example, the input to an electrocardiograph (heart monitor) might have a low-pass filter, with a cutoff frequency of 10 Hz, to suppress power-line noise. Filters can be of the following types: low-pass, high-pass, band-pass, notch (band-reject), and all-pass. There are many circuit topologies that can be used to make an active filter. In this experiment, you will design and test a two-pole low-pass filter using a "Sallen-Key" Voltage-Controlled Voltage Source (VCVS) circuit. Refer to *The Art of Electronics*, written by Horowitz and Hill, for information on designing this kind of filter.

Procedure:

I. Design of Active Filter

1. You are to design a 2-pole low-pass filter, with 3-dB frequency of 400 Hz, and a Chebyshev response with 2 dB of ripple in the pass band. In the Sallen-Key circuit below, use a 20 kΩ potentiometer for feedback resistor RB, a 5.1 kΩ resistor for RA, and 0.05 µF for C. R can be determined using the design tables in *The Art of Electronics*.
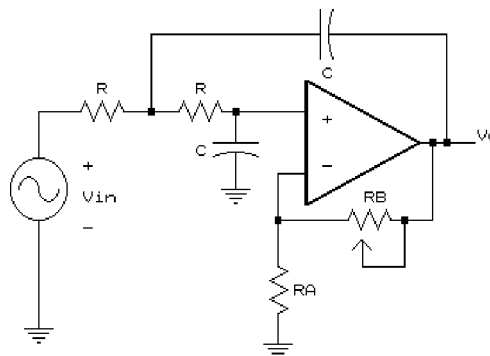
2. Construct the circuit, being sure to adjust RB to set the gain for the proper value to give the 2 dB Chebyshev response. Let Vin = 1.0 V_{RMS} sinusoid. Vary the frequency from well below the breakpoint frequency to well above it, to verify that it is a low-pass filter, and that there is some ripple in the pass band.

3. Measure the pass band gain of the filter.

4. Take data to make a graph of filter gain magnitude vs. frequency, from 1 Hz. to the frequency at which the gain drops to 50 dB below the pass band gain.

5. Now change the gain (by adjusting RB) so the pass band gain is 2.9 V/V. Observe the frequency response in the pass band, in the transition region (between pass band and the stop band). Do not record specific data (as in step 4), but do note the differences and **sketch** the gain vs. frequency.

6. Construct a graph of gain vs. frequency, using the data from step 4. Use semi-log graph paper to accommodate the wide range of frequencies.

II. When a Filter Loop Gain Becomes One

1. Deaden the input voltage by disconnecting the generator (Vin), being sure to replace the generator by a short to ground. Raise the gain, by increasing RB, until sinusoidal oscillation occurs. Carefully record the Vo waveform, and note the frequency of oscillation.

Lab Report:

In addition to the normal parts of the lab report, comment on the graph you made in I.6, mentioning the pass band gain, the ripple in the pass band, the breakpoint frequency, and the slope of the gain (dB per octave and dB per decade) above the breakpoint frequency.