

**SIMON FRASER UNIVERSITY  
SCHOOL OF ENGINEERING SCIENCE**

**Summer 2006  
ENSC 320: ELECTRIC CIRCUITS II**

LABORATORY: DESIGN and IMPLEMENT an ACTIVE FILTER

**Objectives**

Telephone speech signals have bandwidth of 300 - 3,400 Hz. Design a low pass filter to suppress interference by attenuating interference signals by at least 30 dB starting at 11 kHz. The telephone signal should not be attenuated more than 0.5 dB.

**Design**

- Examine Butterworth and Chebyshev filter realizations that meet the specifications.
- Plot frequency responses using MATLAB.
- Select the most appropriate filter type, order, and filter parameters.
- Design the filter using Sallen-Key stages with an overall gain in the range 2 to 3.
- Simulate your design using PSPICE.
- Build the filter circuit, test it, and compare its performance to the specifications and to PSPICE predictions.

**Background and Preparation**

- Read *Hints for Effective Op Amp Circuit Design* from the *Supplementary Notes and Demos section* of the ENSC 320 Spring 2005 web site. It covers practical issues in making your circuits work.
- View the animations of how R and C component tolerances affect the frequency responses of 5th order filters, also on the *Supplementary Notes and Demos section* of the ENSC 320 Spring 2005 web site.
- Read *Lab 1, section Useful Resources* of the ENSC 320 Spring 2006 web site.

**Parts**

Register your lab team with the TA. Collect a kit with various components from Marius Haiducu. The kit contains:

- quad op amp: TL074CP
- various resistors ( $k\Omega$  range)
- capacitors in the nF range:
  - 22 nF caps, quantity 4
  - 10 nF caps, quantity 4
  - 3.3 nF caps, quantity 4
  - 1 nF caps, quantity 4
- power supply isolation capacitors ( $0.1 \mu\text{F}$ , quantity 4).

### Test Measurements

- Input a sinusoidal wave of 2 V peak-to-peak and plot the frequency response (magnitude and phase Bode plots) for the range from 10 Hz to 1 MHz.
- Compare your results with PSPICE simulations.

### Design Notes

- Choose resistors so that the overall gain is not so high that the voltages exceed the power rails.
- Use capacitors above 100 pF, preferably in the nF range.
- Use clean voltage supplies (i.e.,  $0.1 \mu\text{F}$  capacitors at  $+V_{cc}$  and  $-V_{cc}$ , where  $V_{cc} = 12 \text{ V}$ ).

### Optional

When you have your circuit working, try couple of optional steps (they will not affect your mark):

- Filter speech and noise. There are some black (beige, actually) boxes available with amps, summers, a noise source, and tunable switched capacitor filters.
- Find a microphone, add some noise with bandwidth 20 kHz or so, and listen to the result with and without the filter you built.
- Redesign a second order stage with very small capacitors, such as 10 pF. You will probably find your circuit oscillating, instead of amplifying.

### Lab Report

Include title page and a **maximum** of additional **10** pages. Describe your design and the performance of your implementation. Explain differences between your expectations and the actual filter performance.