ECE 3042

Fall 2009 Homework Problem Set No. 5 for Experiment No. 6

Due Week of October 5

The critical frequency, f_{crit}, for the filters that will be designed is the -3 dB frequency for the low-pass filters, the center frequency for the bandpass filter, the center frequency for the notch filter, and the center frequency for the all-pass filters. The critical frequency is given by

$$f_{crit} = birthday(\mathrm{mod}(6month))\ \mathrm{kHz}$$

where birthday is the day of the year the experimenter was born on. If this is on or after July 1, divide by 2.

1. Design a third-order Butterworth low-pass filter with a dc gain of unity and a -3 dB frequency of $f_3 = f_{crit}$. Use Mathcad to plot the magnitude and phase of the complex transfer function as a function of frequency from one decade below f_3 to two decades above. Make another plot so that the flatness in the passband is displayed (frequency from 0.1 f_c to f_c).

2. Design a third-order Chebyshev low-pass filter with a dc gain of unity and a -3 dB frequency of $f_3 = f_{crit}$. It is to have $1 + 0.2 * Day$ dB of ripple in the pass band where Day is the day of the week the experimenter was born. Use Mathcad to plot the magnitude and phase of the complex transfer function as a function of frequency from one decade below f_3 to two decades above. Make another plot so that the ripple in the passband is displayed (frequency from 0.1 f_c to f_c).

3. Design a second-order bandpass filter with a center frequency of $f_o = f_{crit}$, a $Q = 3$, and a gain of unity at the center frequency. Only one op amp is permitted. Use Mathcad to plot the magnitude and phase of the complex transfer function as a function of frequency from one decade below f_o to one decade above.

4. Design a second-order notch filter with a center frequency of $f_o = f_{crit}$, a $Q = 3$, and a gain of unity at dc and infinity. Use Mathcad to plot the magnitude and phase of the complex transfer function as a function of frequency from one decade below f_o to one decade above.

5. Design a first-order all pass filter with a phase shift of 90^o at the frequency $f_o = f_{crit.}$. Use Mathcad to plot the magnitude and phase of the complex transfer function as a function of frequency from one decade below f_o to one decade above.

6. Design a second-order all pass filter with a center frequency of $f_o = f_{crit}$, a $Q = 3$, and a phase shift of zero at the center frequency. Use Mathcad to plot the magnitude and phase of the complex transfer function as a function of frequency from one decade below f_o to one decade above.

Simulate each of the circuits designed above with both National Instruments and Cadence SPICE. The simulation results should be identical to those obtained with Mathcad.