Spring 2004; E4215: Analog Filter Synthesis and Design; HW8

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1. (6 pts.) A continous time first order filter has a transfer function

$$H_c(s) = \frac{2}{1 + s/\omega_p}$$

$\omega_p = 2\pi \times 20\,$krad/s. Transform $H_c(s)$ into discrete time transfer functions $H_d(z)$ using a) bilinear transformation, b) LDI transformation. The sampling frequency $f_s = 1\,$MHz.

Plot the magnitude and phase responses of H_c and H_d with the real frequency (Hz) from 0 to 1 MHz along the x axis. Are the magnitude and phase responses the same for all the cases? Comment on the results.

Repeat for $\omega_p = 2\pi \times 200\,$krad/s.

2. (8 pts.) Design the above filter ($H_c(s)$ or $H_d(z)$) as

   (a) a continuous time opamp-RC filter

   (b) bilinear transformed switched capacitor filter (for this, assume that both the input V_i and its inverted form $-V_i$ are available)

   (c) switched capacitor version of a) with the resistor replaced by a switched capacitor

   (d) Noninverting delayed switched capacitor integrator whose magnitude response is equal to that of the LDI transformed filter at dc and the 3 dB frequency (i.e., the pole of the SC integrator should be adjusted such that its -3dB frequency is the same as that of the LDI transformed filter).

Do it for both $\omega_p = 2\pi \times 20\,$krad/sand $\omega_p = 2\pi \times 200\,$krad/s. In each case, give the schematic and the component values.

3. (8 pts.) Simulate each of the filters designed in problem 3 in Cadence. Plot the magnitude and phase responses.

4. A second order filter has a transfer function has the form

$$H(s) = \frac{N(s)}{1 + (s/Q_p\omega_p) + (s/\omega_p)^2}$$

(a) (1 pt.) What is N(s) for lowpass, bandpass, highpass, and band elimination filters? (In each case, assume that the gain in the center of the passband is unity)

(b) (3 pts.) Transform each of these into a discrete time filter using bilinear transformation. Assume that $Q_p = 4$ and $\omega_p = f_s/10$, where f_s is the sampling frequency.

(c) (4 pts.) Sketch the pole zero plots of the continumous time filters and their discrete time counterparts.