UNIVERITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences
NTU 247

	Homework 2	**NTU 247**
B. E. Boser	**Due Thursday, February 1, 2007**	**Spring 2007**

1. Design a filter with the following response:

$$\frac{s\left(s^2+9.839\times10^{12}\right)\left(s^2+2.081\times10^{13}\right)}{\left(s+2.34\times10^{7}\right)\left(s^2+5.831\times10^{5}s+4.066\times10^{13}\right)\left(s^2+4.243\times10^{6}s+7.811\times10^{13}\right)}$$

a) What kind of a filter is this (low-pass, band-pass, etc)?
b) Plot the magnitude response using MATLAB. What are the filter cutoff-frequency, pass-band ripple, and stop-band attenuation?
c) Realize the filter with a cascade of Tow-Thomas biquads and a single first-order section (that you will have to "invent" yourself). Use C=100pF for all capacitors. Choose the amplifier gains such that the pass-band outputs of all amplifiers are equal to 1V for a 1V input. Show your result in SPICE and compare with MATLAB.
d) Determine the total noise at the filter output in μV rms. Use SPICE and noiseless operational amplifiers with 1GHz unity-gain bandwidth.
e) Rescale the capacitors to meet a 100μV rms noise target.
f) Re-simulate your filter with "real" opams with 20MHz unity-gain bandwidth and 10kΩ equivalent noise resistance. How do the amplitude response and total noise change? Change the specifications for the operational amplifier to get less than 1dB error in the magnitude response up to 10MHz and 200μV rms noise. Are the new amplifier specs realistic? Check the web to find an appropriate part (Texas Instruments, Analog Devices, Maxim, Linear Technology, National Semiconductor …).

2. Consider the analog signal $x(t)=\cos(2\pi f_1 t)+\cos(2\pi f_2 t)+\cos(2\pi f_3 t)$ with $f_1=0.5MHz$, $f_2=3MHz$, $f_3=6MHz$.

a) What is the minimum sampling frequency f_S that avoids aliasing?
b) Assume that we sample $x(t)$ at $f_S=5MHz$. What is the discrete time signal obtained after sampling? Can we reconstruct the original signal from the discrete time sequence? Given an example of a signal $x'(t)$ that has the same discrete time representation as $x(t)$.