**UNIVERSITY OF CALIFORNIA**
**College of Engineering**
**Department of Electrical Engineering and Computer Sciences**
**NTU IC-776CA**

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| | **Homework 2** | **EECS 247** |
| **B. E. BOSER** | **Due Thursday, October 6, 2005** | **Fall 2005** |

1. Design a filter with the following response:

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

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, passband ripple, and stopband 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 passband 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) Resimulate your filter with "real" opamps 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 (Burr Brown, ADI, 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? Give an example of a signal x'(t) that has the same discrete time representation as x(t).