UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering
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	Homework 2	**EECS 247**
B.E. Boser	**Due Thursday, September 25, 2003**	**Fall 2003**
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1. Design a 4th order Sallen-Key (two second order sections) low-pass filter with 0.3dB maximum attenuation (worst case) in the passband (0Hz to 500kHz) and a nominal gain of 1. Available resistors exhibit worst-case variations of ±15%, capacitors vary by ±10%. Resistors and capacitors, respectively, vary by the same percentage. E.g. if R_1 increases by 5% from 1kΩ to 1.05kΩ, all other resistors increase also by 5%. Likewise, all capacitors change by equal percentages. Note, however, that resistors and capacitors usually change by different percentages. This is typical for components fabricated on an integrated circuit. What is the minimum frequency with guaranteed 45dB stopband attenuation? Calculate all component values (minimum capacitor area, R_{max}=100kΩ) and verify your result with SPICE.

2. Design a 3rd order elliptic low-pass filter with 10MHz cutoff frequency and 1dB passband ripple and 40dB stopband attenuation. You may use the Tow-Thomas biquad designed in class combined with an additional first order section
$$H(s) = -\frac{K_1 s + K_0}{s + \omega_0}.$$
Use an opamp with negative feedback consisting of two parallel RC sections for realization.
a) Choose component values for unity gain at f=0 and to minimize total capacitor area. The minimum capacitor value that can be fabricated accurately is C_{min}=50fF and the maximum realizable resistor is R_{max}=100kΩ. Verify your result with SPICE.
b) Use SPICE to determine the total noise at the filter output with SPICE in μV rms. Does inverting the order of the first and second order sections change the result? Use noiseless opamps.
c) Scale all capacitors and resistors such that the total noise at the output of the filter is 50μV rms.
d) Now use noisy opamps. Determine the input referred noise level in nV/rt-Hz (at room temperature) that results in doubling the total output noise to 100μV. Find a part (e.g. using the web, manufacturers include ADI, Burr-Brown, National, Maxim) that meets this specification.