

**UNIVERSITY OF CALIFORNIA**  
**College of Engineering**  
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**NTU IC-776CA**

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**Homework 1**  
**Due Thursday, Jan 26, 2006**

**EECS 247**  
**Spring 2006**

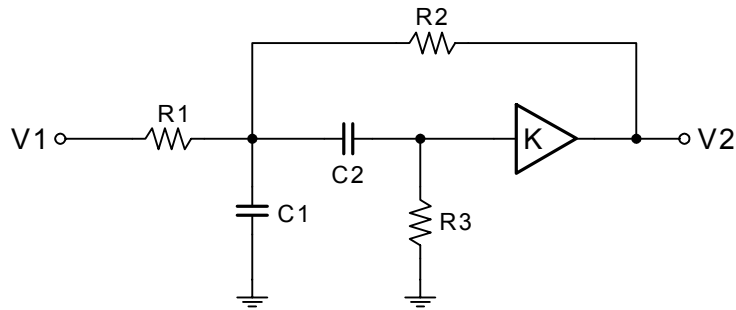
*Note: You need to show zoom-in plots of your filter response around the passband and stopband corners, for both MATLAB and SPICE results, to demonstrate that you meet the specs.*

Design a 2<sup>nd</sup> order (i.e. single biquad) bandpass filter with 1MHz center frequency and 250kHz 3dB-bandwidth.

- a) Calculate  $\omega_p$  and  $Q_p$ .
- b) Plot a 3D perspective view of the magnitude response of the filter.
- c) Implement the filter with a 2<sup>nd</sup> order Sallen-Key section (see next page). Calculate all element values and the amplifier gain  $K$ . For simplicity make all capacitors 1pF and choose all resistors equal size. Calculate also the resulting filter gain  $G$ .
- d) Verify the transfer function with SPICE for nominal values and with a 5% variation of  $K$ . By how much are  $\omega_p$  and  $Q_p$  changing?
- e) Calculate the sensitivity  $S_K^{Q_p}$  and compare the analytical and simulation results.
- f) Return to nominal component values but add two 5% shunt capacitors from both terminals of  $C_2$  to ground. By how much are  $\omega_p$  and  $Q_p$  changing?

(The Sallen-Key bandpass filter design equations are shown on the next page)

**Second-order Sallen-Key bandpass section:**



Design equations:

Transfer function	$H_{BP}(s) = \frac{G \frac{\omega_0}{Q} s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2}$
Center frequency	$\omega_0 = \sqrt{\frac{R_1 + R_2}{R_1 R_2 R_3 C_1 C_2}}$
Quality factor	$Q = \frac{\omega_0}{\frac{1}{R_1 C_1} + \frac{1}{R_3 C_2} + \frac{1}{R_3 C_1} + \frac{1-K}{R_2 C_1}}$
Gain	$G = \frac{\frac{K}{R_1 C_1}}{\frac{1}{R_1 C_1} + \frac{1}{R_3 C_2} + \frac{1}{R_3 C_1} + \frac{1-K}{R_2 C_1}}$