N247 HW1 Solution

1 Question 1

$$Q = \frac{\omega_0}{BW} = \frac{1MHz}{250KHz} = 4$$

2 Question 3

The equations simplify to

$$\omega_0 = \frac{\sqrt{2}}{RC} \tag{1}$$

$$Q = \frac{\sqrt{2}}{4-K} \tag{2}$$

$$G = \frac{K}{4-K} \tag{3}$$

For C=1pF, we find

$$R = \frac{\sqrt{2}}{\omega_0 C} \approx 220K\Omega \tag{4}$$

$$K = 4 - \frac{\sqrt{2}}{Q} \approx 3.65 \tag{5}$$

$$G = \frac{K}{4-K} = 10.42 \tag{6}$$

The sensitivity of the Quality Factor to the value of K can be calculated as

$$S_K^Q = \frac{\partial Q}{\partial K}\frac{K}{Q} = K \cdot \frac{\partial \log(Q)}{\partial K} = \frac{K}{4-K} = G = 10.42 \tag{7}$$

Spectre simulations results: Command used the bandiwdth and center frequency are reported in SK.ocn(see website). Comment: the variation in Q is larger than predicted by sensitivity analysis. The reason is nonlinear dependance of Q on K. The last column of the table above reports calculated values of Q with changing K, considering the nonlinear relation. The agreement with simulations is almost perfect.

K	ω_0 [Hz]	BW	Q	G[dB]	Q(calc)
3.65	1M	255K	4	20.67	4
3.65*1.05	1M	117.2K	8.44	27	8.44
3.65*0.95	1M	376K	2.65	16.27	2.5

Tab. 1: Simulation Results

3 Question 4

Simulating with 4 50fF stray capacitors I obtained: $\omega_0 = 912KHz, Q = 2.82, PG = 17dB$

4 Question 5

Since the sensitivity of Q to K for this example is approximately 10 , in order to control Q within 10% we need to control K within 1%. Since for an amplifier with finite gain A_v, $K \approx K_{id}(1 - K_{id}/Av)$, $K_{id}/A_v \leq .01$ or $A_v \geq 364$. Since $A_v^{Min} = 2/3A_{v0}$, $A_{v0} \geq 560$.