ADVANCED ELECTRICAL NETWORKS : PROBLEM SET 5

Due 1st May, 11.59pm

1 Problem 1

Design a second order active-RC bandpass filter with $f_o = 1\,\mathrm{MHz}$ and quality factor of 10. The following specifications must be met.

a. Gain at the resonant frequency should be 1.

b. The input resistor must be $100\,\mathrm{K\Omega}$.

You can use an ideal VCVS of gain -1 for the inverting stage. First assume ideal infinite g_m OTAs and determine component values so that the filter is scaled for dynamic range. Then replace the OTAs with transconductors whose i-v relationship is of the form

$$i = g_m v_x \tag{1}$$

(a) Use $g_m = 2m\mathrm{S}$. Plot the frequency response of this filter and compare it with the ideal response. What (if anything) do you notice ? Why ? The graph must have linear x-axis that ranges from 250 kHz and 1750 kHz. The y-axis must be in dB.

(b) Tweak component values so that the desired gain, Q and f_o are achieved. Plot the frequency response now and compare with the ideal.

(c) Now replace the transconductors with the following model

$$i = g_m v_x - g_3 v_x^3 \tag{2}$$

where $g_m = 2m\mathrm{S}$ and $g_3 = 67 \times 10^{-5}\mathrm{A/V}^3$. Simulate IM3 with two input sinusoids with frequencies f and $f + 10\,\mathrm{kHz}$, each with amplitude 0.5 V. Sweep f from 500 kHz to 1500 kHz in steps of 100 kHz. Plot IM3 in dB as a function of f.

(d) Now, use the method of current injection to **compute** what IM3 you should expect. You can write MNA and solve for responses as a function of frequency, or hand calcuate them (!). Clearly explain the process you used. Plot the results of the IM3 you computed and compare with the simulation results you obtained in part (c) above.

(e) Now repeat (a)-(d) above with OTAs admittance scaled by factor of two so that

$$i = 2g_m v_x - 2g_3 v_x^3 \tag{3}$$

What do you notice ? Why ?