ACTIVE FILTER DESIGN : PROBLEM SET 7

1 Multiple Input Transconductors

In the last assignment you designed a 3rd order Chebyshev filter as a cascade of biquads. Consider the biquad you used, redrawn in Figure 1. At the bandpass node, three transconductors are coming together, with their output currents being summed (with appropriate signs) and integrated onto the set of integrating capacitors denoted by C_1.

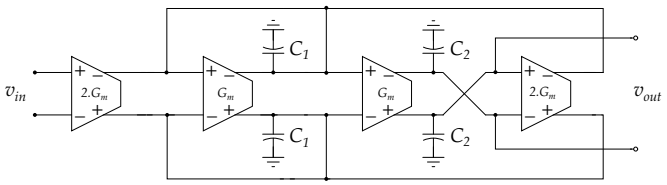

Figure 1: Biquad used in Assignment 5.

a. What is the maximum current flowing into C_1 and C_2 ?

b. What is the quiescent current flowing through the "cascode" arms of the three transconductors coming together at the bandpass node ?

c. Consider the improved design shown in Figure 2. This is a 3-input transconductor, where the current summing is performed at the cascode node, rather than the output node. The PMOS cascode device and the the NMOS current sources of the output stage operate with currents of I. Analyze the performance of this circuit and compare with the case where you shorted the three transconductors at the output. The parameters you must consider are transconductor DC gain, linearity, output noise and parasitic pole.

d. Based on the single input design you have from the previous assignment, design a three input transconductor so that you can use it for the biquad section of the Chebyshev filter. If you did a good job of the previous design, it should be very straightforward to extend it to the three input case. What is the DC gain now ? What about the parasitic pole ?

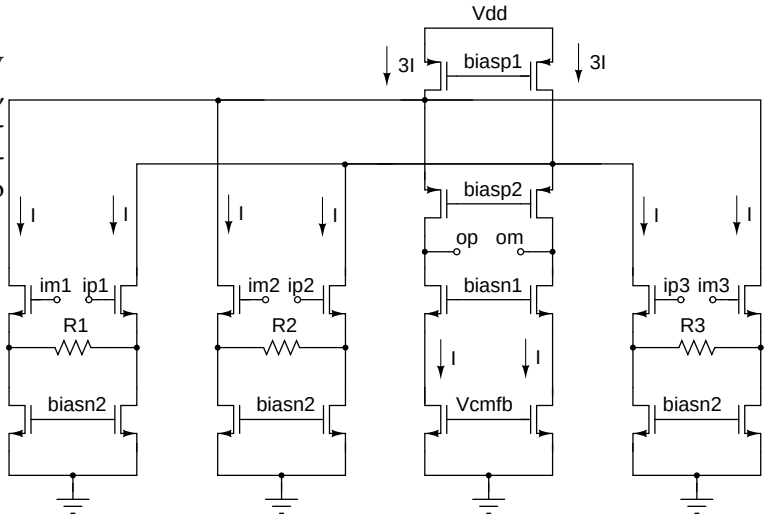

Figure 2: Three input transconductor.

a. On the same plot, compare the AC responses of the MOSFET based transconductor with a resistor based one. Can you explain why there are differences ?

b. For the tunable transconductor, on the same plot, show the integrator AC response for the nominal gate voltage of the MOSFET, as well as gate voltages $\pm\, 0.1\,\mathrm{V}$ from the nominal value.

2 Voltage Tunable Transconductor

Replace the transconductance setting resistor in the single input transconductor by a MOSFET, so that at 300K, you get a third harmonic distortion of less than 1% for a $1\,\mathrm{V_{pp,diff}}$ input sine wave. What is the gate overdrive of the MOSFET ? Configure the transconductor as an integrator (use capacitors of $5\,\mathrm{pF}$ to ground as integrating capacitors).

3 Resistor Servo Tuning Loop

Redesign the Chebyshev Filter with tunable transconductors. Implement a resistor servo tuning loop to slave one transconductor to a stable resistor. Use the control voltage developed in the servo loop to control all the transconductors in the filter. To demonstrate that your servo loop works, sweep the temperature from $0 - 100^o\mathrm{C}$ at intervals of $25\,^o\mathrm{C}$ and plot the frequency response of the filter. What is the variation in the passband edge over the temperature range of interest ?