E4215: Analog Filter Synthesis and Design: HW3

Nagendra Krishnapura (nkrishnapura@mltc.com)

due on 11 Feb. 2003

In addition to the problems here, problems 1, 2, 3 from HW2 are also due on 11 Feb. 2003.

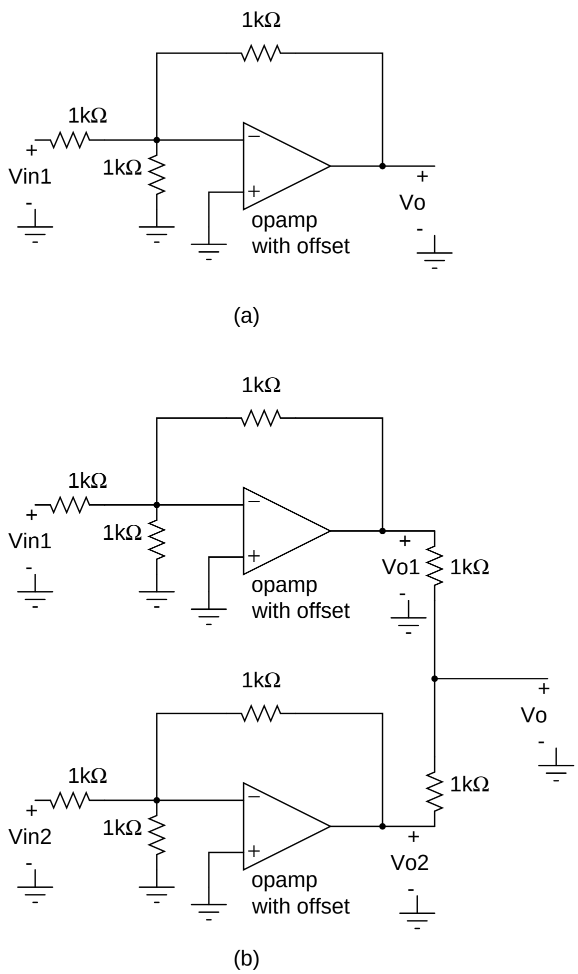

Figure 1:

1. (9 pts.) The opamps in Fig. 1 have an input referred offset voltage V_{os}, but are otherwise ideal ($A_0 = \infty$). For Fig. 1(a), derive the expression relating the output V_o to the input V_{in1} and the offset V_{os}. Draw the dc transfer characteristics V_o vs. V_{in1} including the effect of offset assuming that $V_{os} > 0$. Show the input referred offset and the output offset of the amplifier in Fig. 1(a) on this plot. (Hint: In a circuit with multiple inputs, try using superposition).

   If the standard deviation of V_{os} is $\sigma = 5\,\text{mV}$, what is the standard deviation of the input referred offset and the output offset of the amplifier in Fig. 1(a).

   What is the net output offset (in the output V_o) of the circuit in Fig. 1(b)? (Hint: Use the results related to Fig. 1(a) to determine V_{o1} and V_{o2}. Relate V_o to V_{o1} and V_{o2})

2. (5 pts.) In Fig. 2(a), determine $V_{p,max}$, the maximum value of V_p such that the output $v_o(t)$ is sinusoidal. The opamp has the characteristic shown in Fig. 2(b) (The slope of the vertical part is ∞. Sketch $v_o(t)$ when $V_p = V_{p,max}/2$ and when $V_p = 2V_{p,max}$

3. (3 pts.) In Fig. 3, $v_o = f(v_i) = v_i + a_2 v_i^2 + a_3 v_i^3$. If $v_i = V_p \cos(\omega t)$, express $v_o(t)$ as a sum of sinusoids. Find the ratio of the 2$^{\text{nd}}$ and 3$^{\text{rd}}$ harmonic amplitudes to that of the fundamental.

   If $a_2 = 10^{-3}\,\text{V}^{-1}, a_3 = 10^{-3}\,\text{V}^{-2}$, find the input peak V_p such that the second harmonic is 60 dB below the fundamental. Repeat the exer-

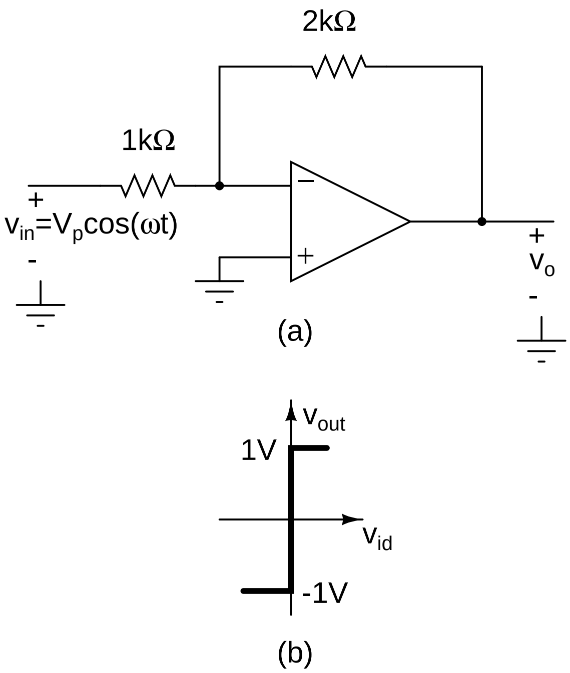

Figure 2:

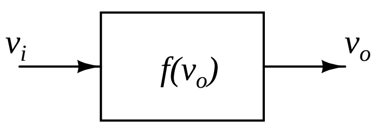

Figure 3:

cise for the third harmonic.

4. (3 pts.) Assuming ideal transconductors[1], derive expressions relating V_o to V_i in Fig. 4(a) and to V_{i1} and V_{i2} in Fig. 4(b).

   Repeat for Fig. 4(a) assuming that the transconductor g_{mx} has an output resistance r_{ox} and input and output capacitances C_{ix}, C_{ox}. $x = \{1, 2\}$ for the two transconductors in Fig. 4(a).

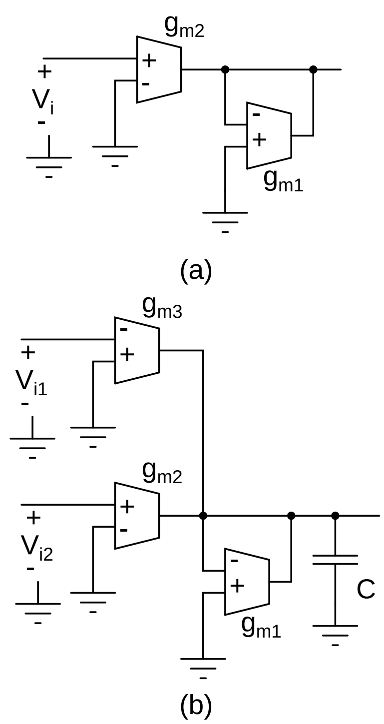

Figure 4:

[1] voltage controlled current source