EE539: Analog Integrated Circuit Design; HW6

Nagendra Krishnapura (nagendra@iitm.ac.in)

due on 26 Mar. 2008

0.18 μm technology parameters: $V_{Tn} = 0.5$ V; $V_{Tp} = 0.5$ V; $K_n = 300\ \mu A/V^2$; $K_p = 75\ \mu A/V^2$; $A_{VT} = 3.5\, mV\ \mu$m; $A_\beta = 1\%\,\mu$m; $V_{dd} = 1.8$ V; $L_{min} = 0.18\ \mu$m, $W_{min} = 0.24\ \mu$m; Ignore body effect unless mentioned otherwise.

For all MOS transistors, use $A_d = A_s = 2WL_{min}$; and $P_d = P_s = 2(W + 2L_{min})$

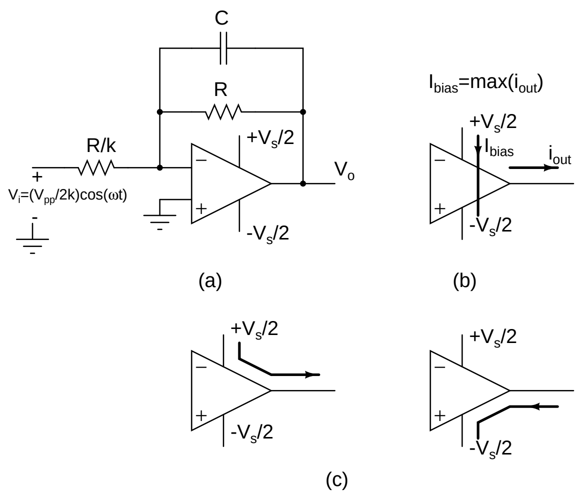

Figure 1:

1. Determine the rms signal, rms noise, signal to noise ratio (as a ratio of mean squared quantities) at the output of Fig. 1. Assume an low frequency input. What is the amplifier's transfer function? The opamp can be either (i) class A (Fig. 1(b)): In this case a constant current I_{bias}, equal to the highest possible output current) is drawn from the amplifier; or (ii) class B (Fig. 1(c)): In this case, currents out of the opamp are drawn from the positive supply and currents into the opamp are pushed into the negative supply. In each case, calculate the power dissipation. Relate the power dissipation to amplifier specifications: gain, bandwidth, and signal to noise ratio.

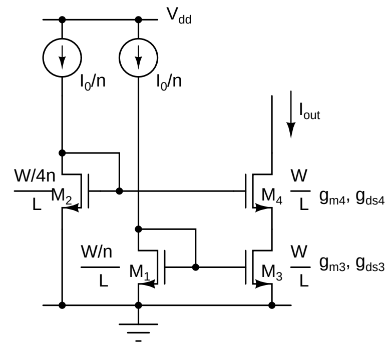

Figure 2:

2. Determine the output current in Fig. 2. Determine the output noise current in terms of small signal parameters of M_3 and M_4. Which of the devices primarily contribute to the noise? Determine the output current error due to current factor and threshold mismatches ($\Delta\beta_{13}, \Delta V_{T13}$ between M_1 and M_3, and $\Delta\beta_{24}, \Delta V_{T24}$ between M_2 and M_4). Which of the mismatches is more critical?

3. Fig. 3 shows a simple current mirror and a cascode current mirror delivering 100 μA from a 10 μA reference. The maximum voltage at the output can be 1.1 V.

   (a) Design the simple mirror with $L = 2\,\mu$m. Minimize its noise.

   (b) Design the cascode current mirror for the same output voltage constraint with $L = 2\,\mu$m for $M_{1,2}$. Choose $M_{3,4}$ as you wish subject to the constraints that the output impedance should be as high as possible at all frequencies and that the output thermal noise spectral density should not increase by more than 3 dB when compared to the simple current mir-

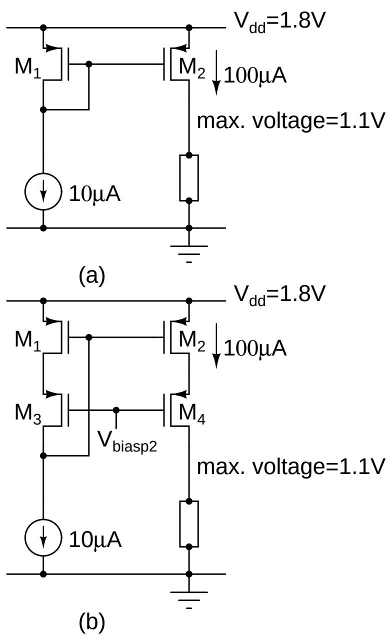

Figure 3:

ror. Provide an arrangement to generate V_{biasp2}.

Plot the output impedance and output current noise spectral density in for the two mirrors (Terminate the output with a 1.1 V dc source). What is the relative noise contribution from different devices? Plot the dc output current as the output voltage is varied from 0 to 1.8 V.

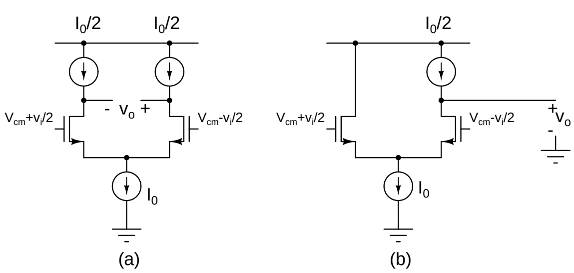

Figure 4:

4. Determine the small signal dc gains of the two amplifiers in Fig. 4. The transistors can be modeled using g_m and g_{ds}. Explain the results.

5. Calculate the small signal tail node voltage v_x in Fig. 5. v_i is a small signal increment. The transistors can be modeled using g_m and g_{ds}.

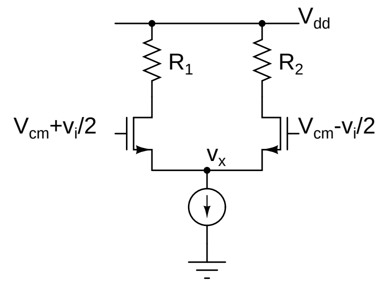

Figure 5:

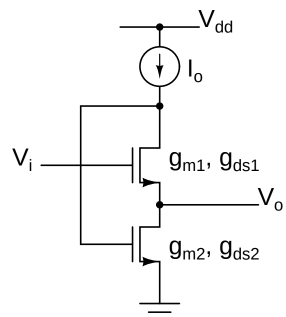

Figure 6:

6. Calculate the output resistance of the circuit in Fig. 6. What happens to R_{out} if $g_{ds1} = 0$ or $g_{ds2} = 0$?