March 20, 2018

ECEN 474/704

Homework #3

Due: 3-27-2018, 5:00PM

Homeworks will not be received after due.

Instructor: Sam Palermo

1. **(60 points)** Wilson Current Mirror
   a) Derive the following expression for the low-frequency output impedance of the Wilson current mirror shown below. Assume that γ=0 for all transistors and that the input reference current source is ideal (infinite output impedance). What specifically is A_V? (10 points)

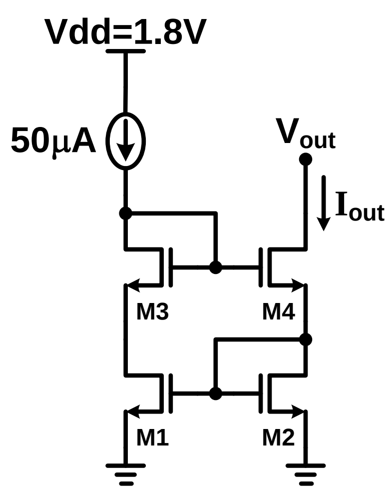
$$r_{out} \cong g_{m4}(1 + A_v)\left(\frac{1}{g_{m2}}\right)r_{o4}$$

   b) Design the current mirror with a 1:2 input current to output current ratio to satisfy the following specifications.
      - I_{in}=50μA
      - Low-frequency output impedance ≥ 2MΩ for an output voltage ≥ 0.7V.

Design procedure counts for 25 points.

Turn in the following to validate the design performance:

- Schematic with transistor sizes, DC operating points, and the bias current labeled (5 points)
- Print-out with small-signal device parameters for V_{out}=0.7V. Highlight the critical small-signal parameters, such as g_m, g_{ds}, etc. (5 points)
- Characterize the current mirror by performing a DC sweep of V_{out} from 0-1.8V and plotting the output current. (5 points)
- Use the above DC sweep data to plot the output impedance vs V_{out}. (5 points)
- Plot the AC frequency response of the output impedance from 10Hz=100MHz with V_{out}=0.7V. Use a log-log scale to clearly identify the location of poles and zeros. Explain the frequency response. (5 points)



2. **(40 points)** Open-Circuit Time Constants Bandwidth Estimation

Use the open-circuit time constants bandwidth estimation technique outlined in Lecture 10 to estimate the bandwidth of the cascode amplifier below. Assume that both transistors are operating in saturation, $\gamma=\lambda=0$, and the same following element values:

$$C_{gs}=220fF,\ C_{sb}=130fF,\ C_{gd}=45fF,\ C_{db}=90fF,\ g_m=12mA/V$$