Fundamentals of Analog & Mixed Signal VLSI Design
Exercise 6 (30.10.2024)

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Problem 1 Gain stage with diode-connected MOSFET

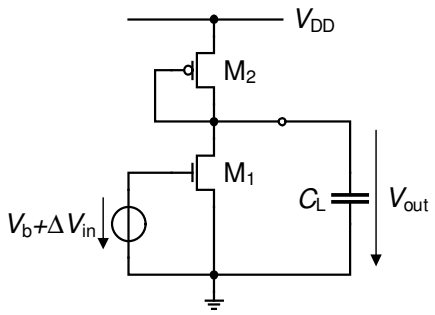

Figure 1: Schematic of the gain stage with diode-connected MOSFET.

Fig. 2 shows the schematic of a simple gain-stage with a diode-connected MOSFET load.

- Draw the small-signal schematic including all the noise sources.
- Derive the small-signal transfer function $A_v(s) \triangleq \Delta V_{out}/\Delta V_{in}$. Give the DC gain A_{dc} and cut-off frequency f_c.
- How should M_1 and M_2 be biased to maximize the DC voltage gain?
- What is the maximum achievable voltage gain?
- Calculate the input-referred noise resistance R_{nin} and split it in terms of the input-referred thermal noise resistance R_{nt} and flicker noise resistance R_{nf}.
- Calculate the input-referred thermal noise excess factor $\gamma_{neq} \triangleq G_{m1} \cdot R_{nt}$.
- How should M_1 and M_2 be biased to minimize the input-referred thermal noise excess factor?
- Design the amplifier for a DC gain $A_{dc} = 10$ a cut-off frequency $f_c = 1\ MHz$. Use the following parameters

$$V_{T0n} = 0.455\ V \quad n_{0n} = 1.27 \quad I_{spec\square n} = 715\ nA$$
$$V_{T0p} = 0.445\ V \quad n_{0p} = 1.31 \quad I_{spec\square p} = 173\ nA$$

  with $U_T = 25.875\ mV$.

Problem 2 Gain stage with feedback resistor

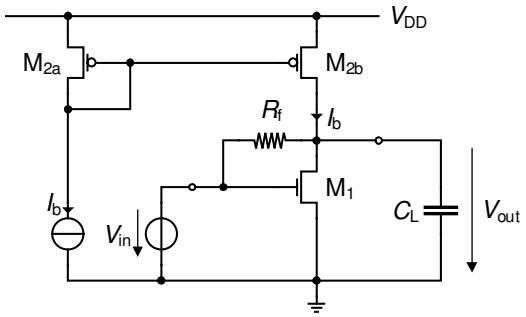

Figure 2: Schematic of the gain stage with feedback resistor.

Fig. 2 shows the schematic of a simple gain-stage with a feedback resistor.

- Draw the small-signal schematic including all the noise sources.
- Derive the small-signal transfer function $A_v(s) \triangleq \Delta V_{out}/\Delta V_{in}$. Give the DC gain A_{dc} and cut-off frequency f_c assuming that $G_{m1} \cdot R_f \gg 1$.
- Calculate the input-referred noise resistance R_{nin} and split it in terms of the input-referred thermal noise resistance R_{nt} and flicker noise resistance R_{nf}.
- Calculate the input-referred thermal noise excess factor $\gamma_{neq} \triangleq G_{m1} \cdot R_{nt}$.
- How should M_1, M_{2a} and M_{2b} be biased to minimize the input-referred thermal noise excess factor?
- Design the amplifier for a DC gain $A_{dc} = 10$ a cut-off frequency $f_c = 1\,MHz$. Use the following parameters

$$V_{T0n} = 0.455\,V \quad n_{0n} = 1.27 \quad I_{spec\square n} = 715\,nA$$
$$V_{T0p} = 0.445\,V \quad n_{0p} = 1.31 \quad I_{spec\square p} = 173\,nA$$

  with $U_T = 25.875\,mV$.