

Fundamentals of Analog & Mixed Signal VLSI Design

Exercise 3 (2.10.2024)

Christian Enz

Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland

Problem 1 Cascode stage

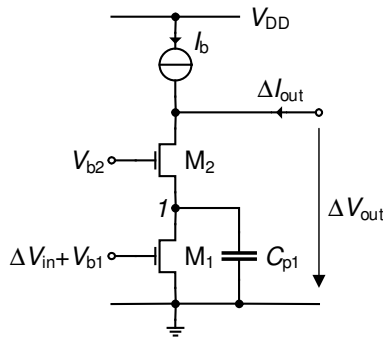


Figure 1: Cascode stage.

The schematic of the basic cascode stage is shown in Fig. 1.

1.1 Small-signal analysis

- Draw the small-signal equivalent schematic of the circuit assuming that the transistors are biased in saturation.
- Calculate the dc equivalent transconductance $G_{meq} \triangleq \Delta I_{out} / \Delta V_{in} |_{\Delta V_{out}=0}$ assuming that $G_{ms2} \gg G_{ds1}, G_{ds2}$.
- Calculate the output conductance $G_{out} = \Delta I_{out} / \Delta V_{out}$ neglecting capacitance C_{p1} . How does it compare to the output conductance G_{ds1} of M1?
- What is the effect of the parasitic capacitance C_{p1} at node 1 on the output conductance?

1.2 Noise analysis

- Calculate the output noise conductance G_{nout} and input-referred noise R_{nin} neglecting capacitance C_{p1} . Separate the input-referred noise resistance in its thermal and 1/f noise contributions $R_{nin}(f) = R_{nt} + R_{nf}(f)$.
- Calculate the cascode noise excess factor $\gamma_{cas} = G_{meq} \cdot R_{nt}$. How does it compare to the noise coming from M1 only?
- What is the effect of the parasitic capacitance C_{p1} at node 1 on the input-referred noise?

Problem 2 The Simple OTA

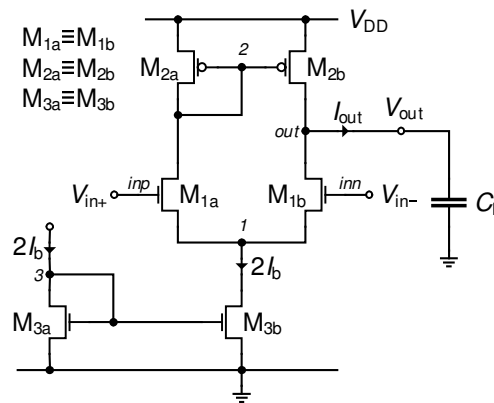


Figure 2: The simple OTA.

The schematic of the simple differential OTA is shown in Fig. 2.

2.1 Small-signal analysis

- Draw the small-signal equivalent schematic of the circuit assuming the transistors are biased in saturation.
- Calculate the differential dc transconductance $G_{md} \triangleq I_{out}/V_{id}$ where $V_{id} \triangleq V_{in+} - V_{in-}$ is the differential input voltage.
- Calculate the unity-gain frequency ω_u (or gain-bandwidth product).

2.2 Noise analysis

- Draw the small-signal equivalent schematic of the circuit assuming the transistors are biased in saturation including all the noise sources.
- Estimate the output noise conductance.
- Calculate the input-referred thermal noise PSD and the equivalent thermal noise resistance R_{nt} .
- Calculate the input-referred flicker noise PSD and the equivalent flicker noise resistance $R_{nf}(f)$.