Mikroelektronische Schaltungen und Systeme

Übung 1

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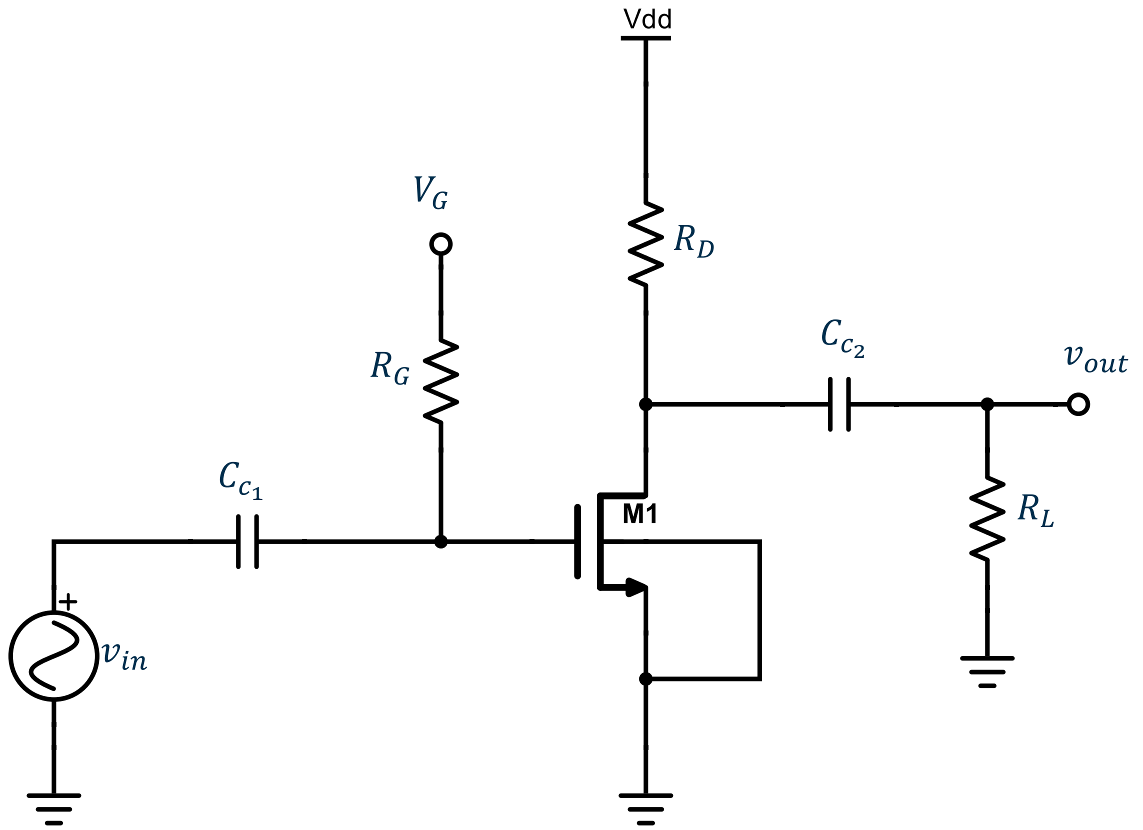
Task 1.1

In the circuit below following MOSFET and circuit parameters are provided:



- $V_{TH} = 0.7V$
- $V_{ov} = V_{GS} - V_{TH} = 0.5\ V$
- $\mu_n C_{ox} = 200 \frac{\mu A}{V^2}$
- $I_D = 1mA$
- $R_L = 6k\Omega$
- $\mathrm{R_G} \to \infty, C_{c_{1,2}} \to \infty$
- $L = 200nm$
- $A_v = \frac{v_{out}}{v_{in}} = -4$

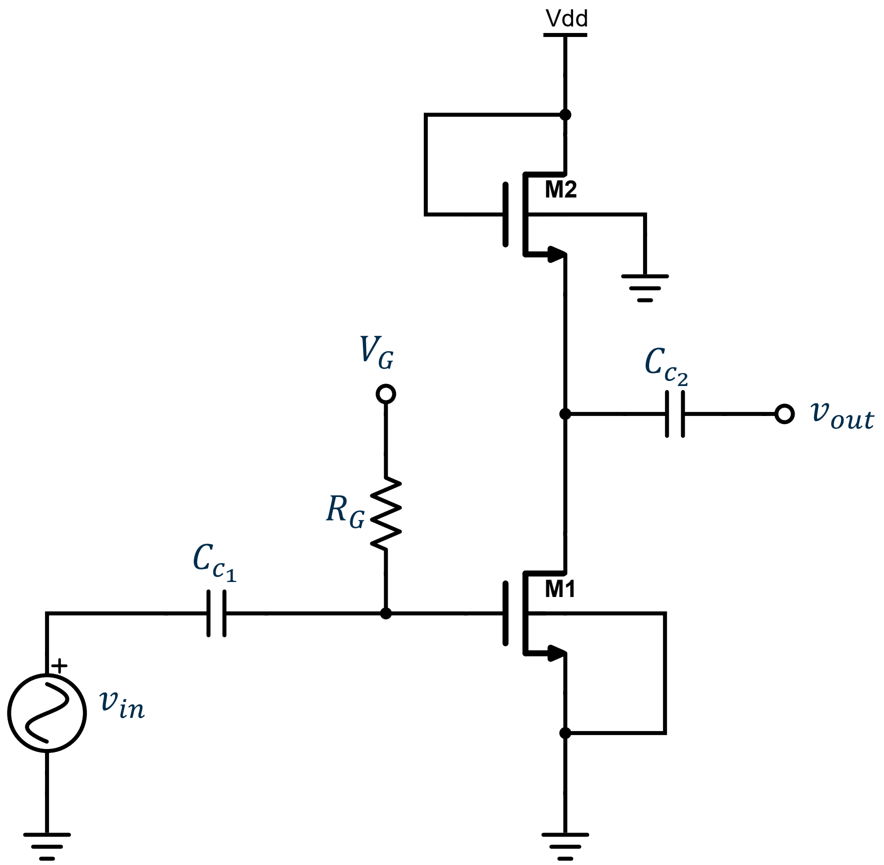
Channel-length modulation can be ignored.

a) Calculate g_m, transistor width W, and R_D.

b) Find the minimum supply voltage $V_{DD_{min}}$ to keep the transistor in saturation and determine the DC power consumption P_{DC}.

Task 1.2

The circuit from Task 1.1 will be changed as following:

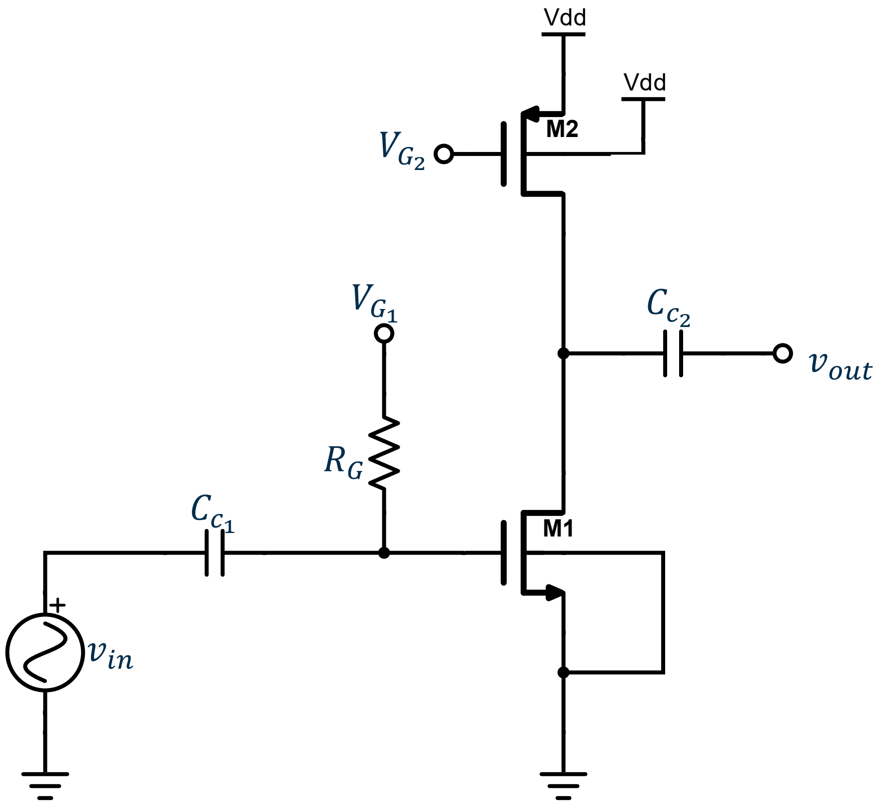


- R_L is removed and R_D is replaced with a diode-connected NMOS transistor. All paramaters of M1 remains the same.

a) Determine the required $(W/L)_{M2}$ to achieve the same voltage gain magnitude $|A_v| = 4$, and calculate the new DC power consumption P_{DC}.

Task 1.3

The circuit from Task 1.2 is further modified:



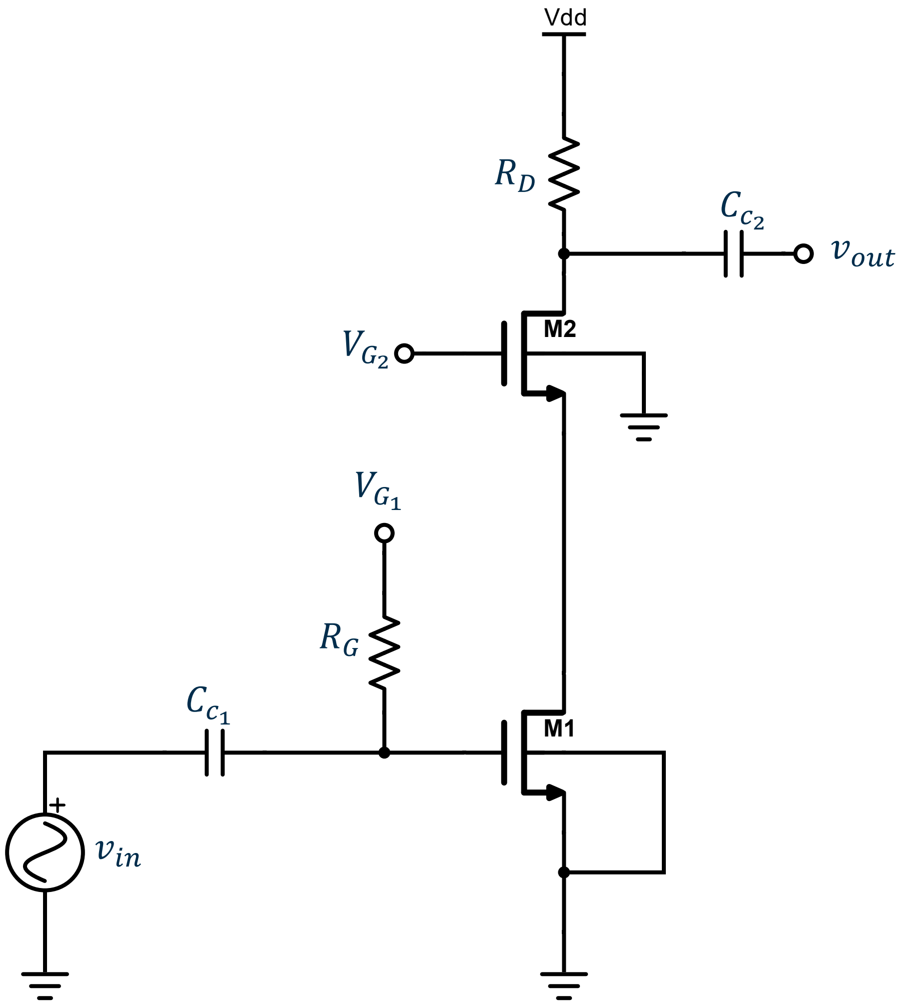
- Replace the diode-connected load with a **current-source PMOS load** with following parameters (M1 remains the same):
  - $|V_{TH_P}| = 0.5V$
  - $\lambda_n = \lambda_p = 0.1\ V^{-1}$
  - $\mu_p C_{ox} = 50 \frac{\mu A}{V^2}$
  - $|V_{ov}| = 0.5V$

a) Calculate the small-signal gain A_v.

b) Determine the required gate bias voltage V_{G_2}, and calculate the DC power consumption P_{DC}.

Task 2.1

For the cascode amplifier below following circuit parameters are provided:



- $V_{TH} = 0.7V$
- $V_{ov} = V_{GS} - V_{TH} = 1\ V$
- $\mu_n C_{ox} = 200 \frac{\mu A}{V^2}$
- $I_D = 1mA$
- $R_D = 1k\Omega$
- $\mathrm{R_G} \rightarrow \infty, C_{c_{1,2}} \rightarrow \infty$
- $L = 200nm$
- $\lambda_n = 0.01\ V^{-1}$

a) Calculate g_{m_1}, g_{m_2}.

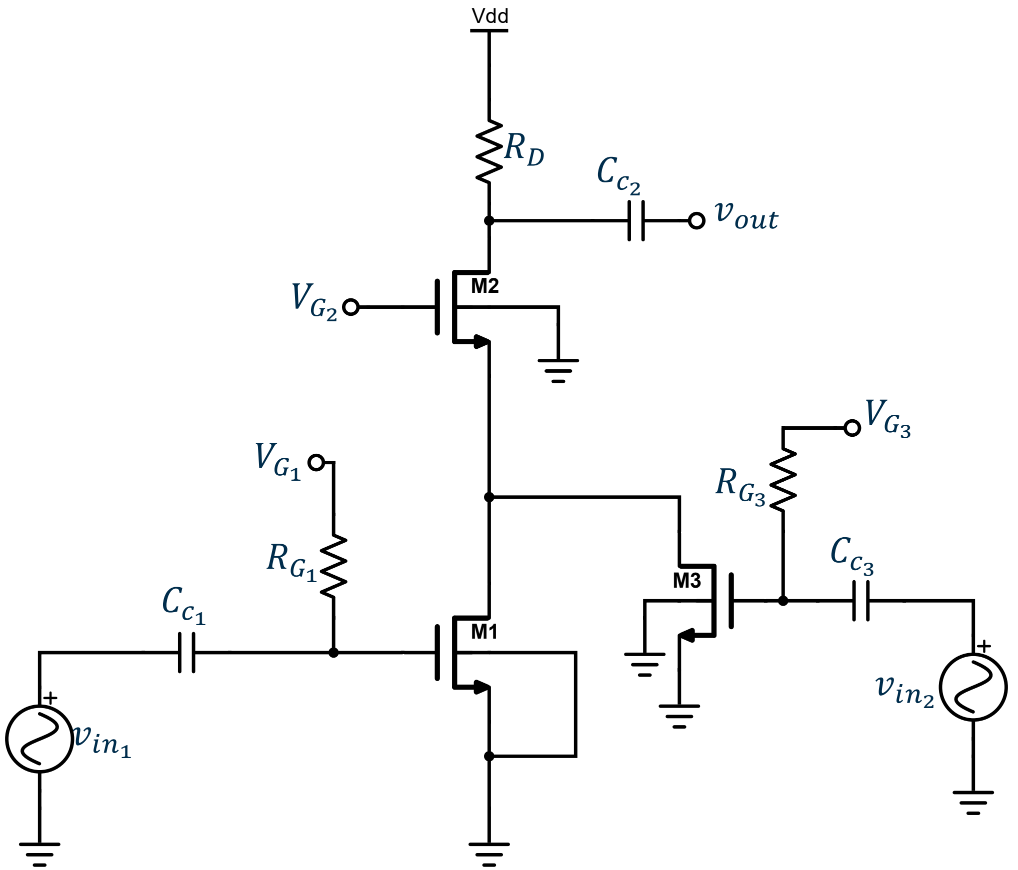
b) Determine transistor width W_1, W_2.

c) Find the minimum V_{DD} to keep both transistors in saturation.

d) Calculate the small-signal gain A_v.

Task 2.2

The amplifier from Task 2.1 is modified as following by include a second input stage.
Following circuit parameters are provided with M1 and M3 being identical:



- $V_{TH} = 0.7V$
- $V_{ov} = V_{GS} - V_{TH} = 1\ V$
- $\mu_n C_{ox} = 200\frac{\mu A}{V^2}$
- $I_{D_1} = I_{D_3} = 1mA$
- $R_D = 1k\Omega$
- $\mathrm{R}_{\mathrm{G}_{1,3}} \to \infty, C_{c_{1,2,3}} \to \infty$
- $L = 200nm$

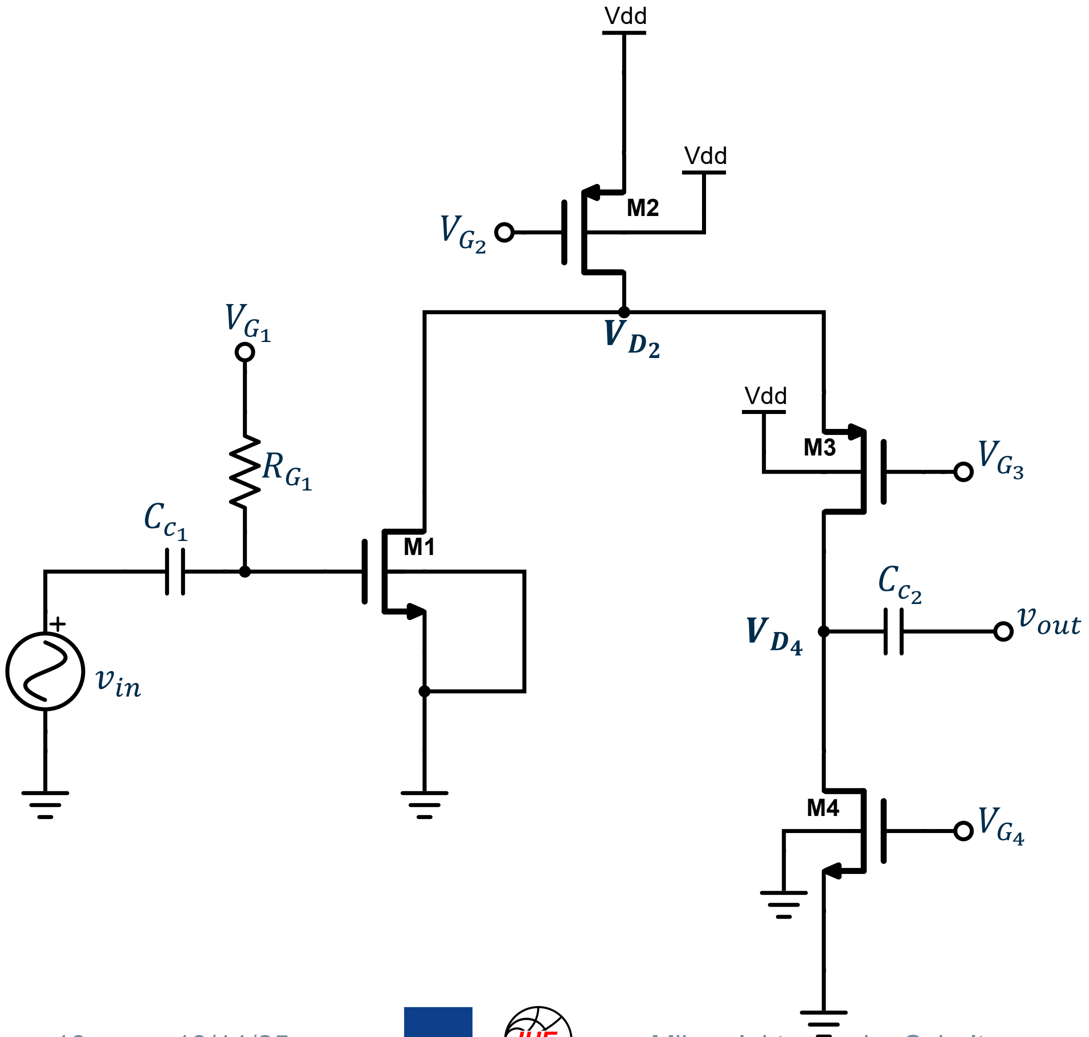
The two input signals are:

- $v_{in_1}(t) = 1\mu V cos(2\pi 10^6 t + 5°)$
- $v_{in_2}(t) = 5\mu V cos(2\pi 10^6 t + 35°)$.

a) Determine $v_{out}(t)$.

Task 2.3

For the circuit below, following circuit parameters are provided:



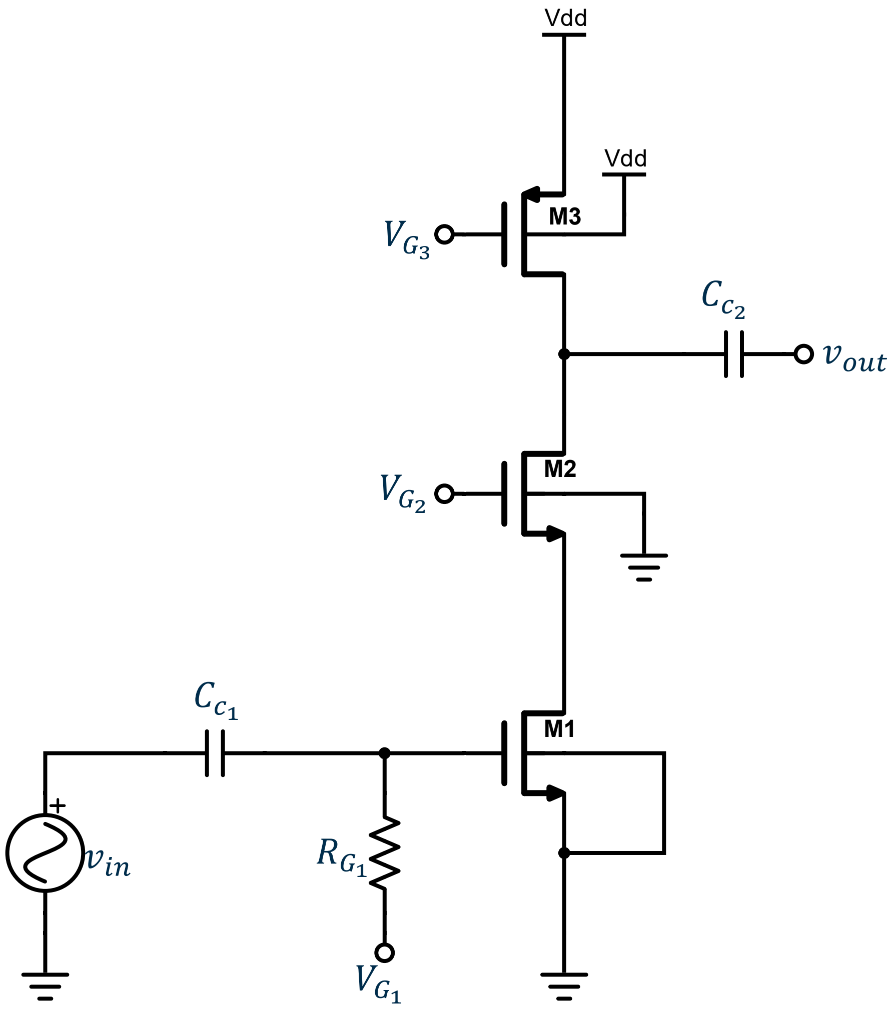
- $V_{TH_N} = |V_{TH_P}| = 0.4V$
- $V_{ov} = |V_{GS}| - |V_{TH}| = 0.6\ V$
- $\mu_n C_{ox} = 200 \frac{\mu A}{V^2}$
- $\mu_p C_{ox} = 50 \frac{\mu A}{V^2}$
- $I_{D_1} = I_{D_{3,4}} = 1mA$
- $\mathrm{R}_{G_1} \to \infty, C_{c_{1,2}} \to \infty$
- $L = 200nm$
- $\lambda_N = \lambda_P = 0.05V^{-1}$

Furthermore, assume $V_{D_4} = 0.6V$, $V_{D_2} = 1.2V$

a) Calculate DC operating points of each transistor and calculate the small-signal gain A_v.

Task 3

For the circuit below, following parameters are provided:



- $V_{TH_N} = |V_{TH_P}| = 0.2V$
- $V_{ov} = |V_{GS}| - |V_{TH}| = 0.4\,V$
- $\mu_n C_{ox} = 200\,\frac{\mu A}{V^2}$
- $\mu_p C_{ox} = 50\,\frac{\mu A}{V^2}$
- $I_D = 4mA$
- $\mathrm{R}_{G_1} \to \infty, C_{c_{1,2}} \to \infty$
- $L = 200nm$
- $\lambda_N = \lambda_P = 0.01V^{-1}$

It can be assumed that all transistors are operated in saturation region.

a) Calculate the output noise voltage density and input-referred noise voltage density.

b) Compare the noise performance of this amplifier to that of a single-ended common-source amplifier with a current-source load (i.e., without M2).