

Homework 8

VE311 - Electronic Circuits Fall 2021

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8.1

8.1.1

Since $\gamma = 0$, $gm_b = 0$

For the first circuit,

$$i_x = \frac{V_x}{r_{01}}$$

$$R_{out} = \frac{V_x}{i_x} = r_{01}$$

For the second circuit,

$$V_a = i_x r_{01}$$

$$gm_2 V_a + \frac{V_a - V_x}{r_{02}} + i_x = 0$$

$$R_{out} = \frac{V_x}{i_x} = r_a + r_{02} + r_{01} r_{02} gm_2$$

8.1.2

(i) $I_D = \frac{1}{2} \mu_n \text{Cox} \left(\frac{W}{L_{\text{eff}}} \right)_1 (V_a - V_{TH})^2 (1 + \lambda V_x) = 2.1884 \times 10^{-4} \text{ A}$

$$r_{01} = \frac{1}{I_D \lambda} = 4.5695 \times 10^4 \Omega = R_{out}$$

(ii)

$$I_{D1} = \frac{1}{2} \mu_n \text{Cox} \left(\frac{W}{L_{\text{eff}}} \right)_1 (V_a - V_{TH})^2 (1 + \lambda V_m)$$

$$I_{D2} = \frac{1}{2} \mu_n \text{Cox} \left(\frac{W}{L_{\text{eff}}} \right)_2 (V_b - V_m - V_{TH})^2 [1 + \lambda (V_x - V_m)]$$

$$I_{D1} = I_{D2}$$

$$V_m = 1.2708 \text{ V}, I_{D1} = I_{D2} = 2.0555 \times 10^{-4} \text{ A}$$

$$r_{01} = \frac{1}{I_{D1} \lambda} = 4.865 \times 10^4 \Omega = r_{02}$$

$$gm_2 = \frac{2I_{D2}}{V_b - V_m - V_{TH}} = 1.794 \times 10^{-3}$$

$$R_{out} = r_{01} + r_{02} + r_{01} r_{02} gm_2 = 4.343 \times 10^6 \Omega$$

The cascode increases R_{out} at a very large scale.

8.1.3

(i)

$$V_x \geq V_a - V_{TH}$$

$$V_{min} = 1.2 - 0.7 = 0.5 \text{ V}$$

(ii)

$$V_x \geq V_b - V_{TH}$$

$$V_{min} = V_b - V_{TH} = 2.2 - 0.7 = 1.5 \text{ V}$$

8.1.4

(i)

$$R_{out} = \frac{\Delta V_x}{\Delta I_x} = \frac{5 - 1}{(275 - 200) \times 10^{-6}} = 5.33 \times 10^4 \Omega$$

$$V_{x_{min}} = 0.5 \text{ V}$$

(ii)

$$R_{out} = \frac{\Delta V_x}{\Delta I_x} = \frac{5 - 3}{(206.12 - 205.82) \times 10^{-6}} = 6.67 \times 10^6 \Omega$$

$$V_{x_{min}} = 1.5 \text{ V}$$

In the manual calculation of the third question, we have obtained the theoretical value. Here we find that the simulated magnitude is basically the same as the theoretical value. The slight difference may come from the slope is too small, and the picture is not clear.

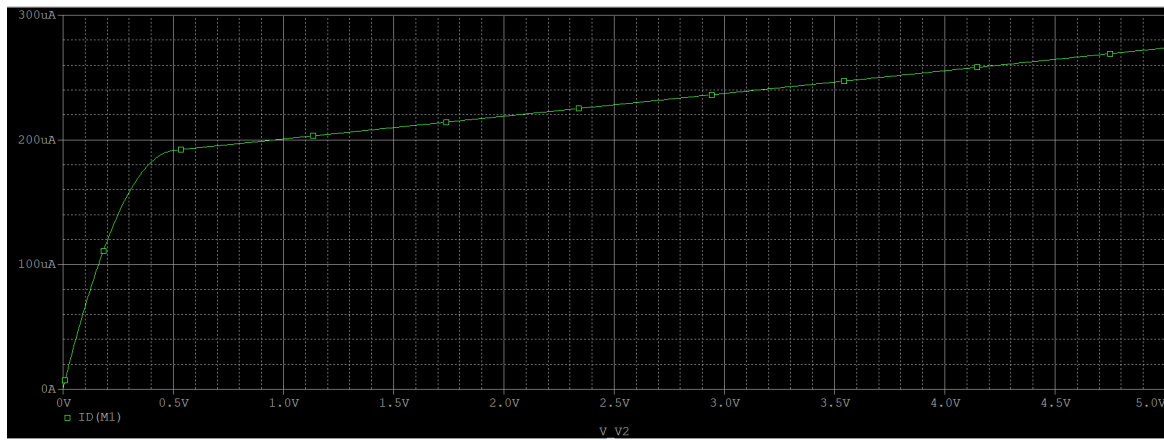


Figure 1: problem 8.4.1 plot

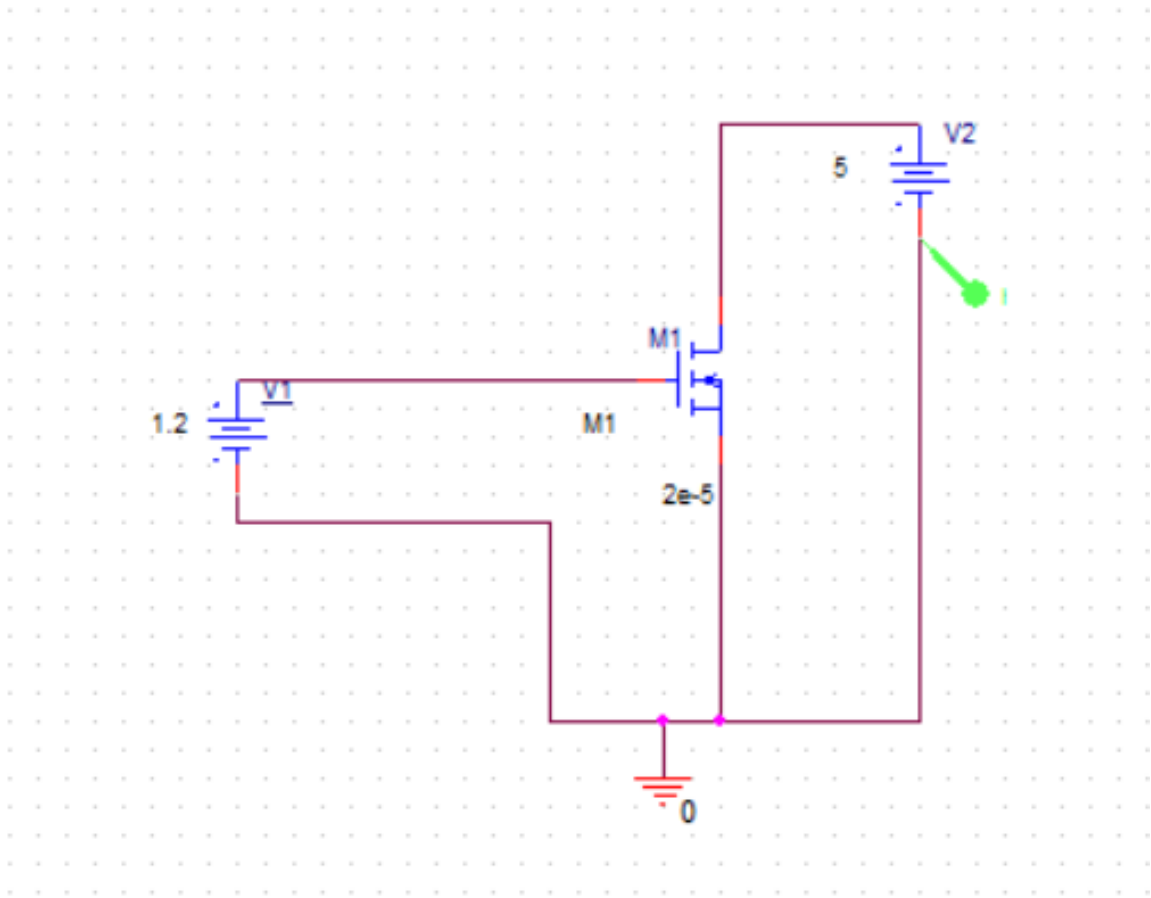


Figure 2: problem 8.4.1 circuit

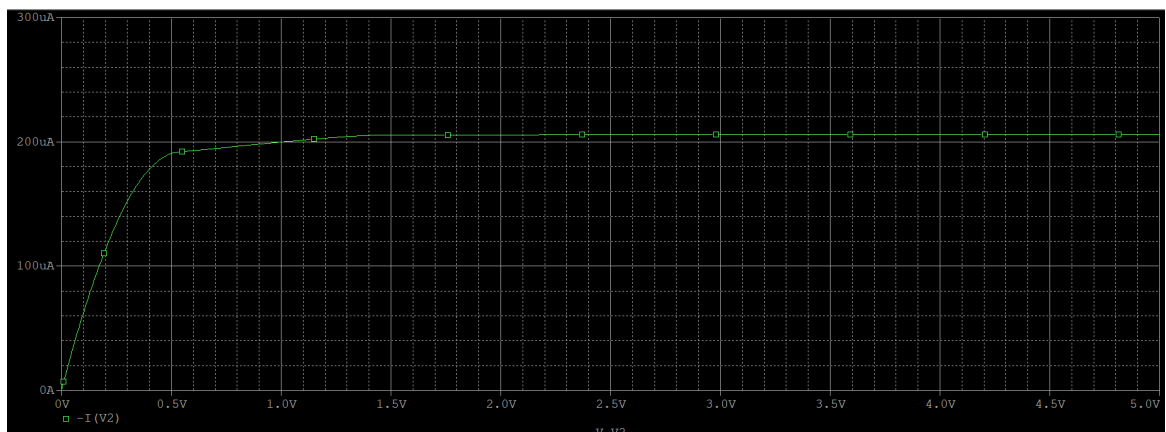


Figure 3: problem 8.4.2 plot

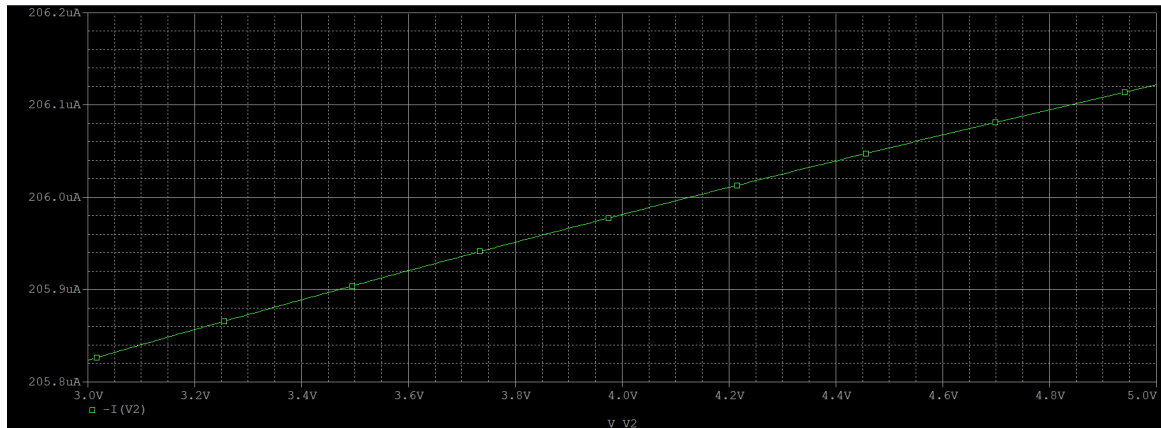


Figure 4: problem 8.4.2 zoom in

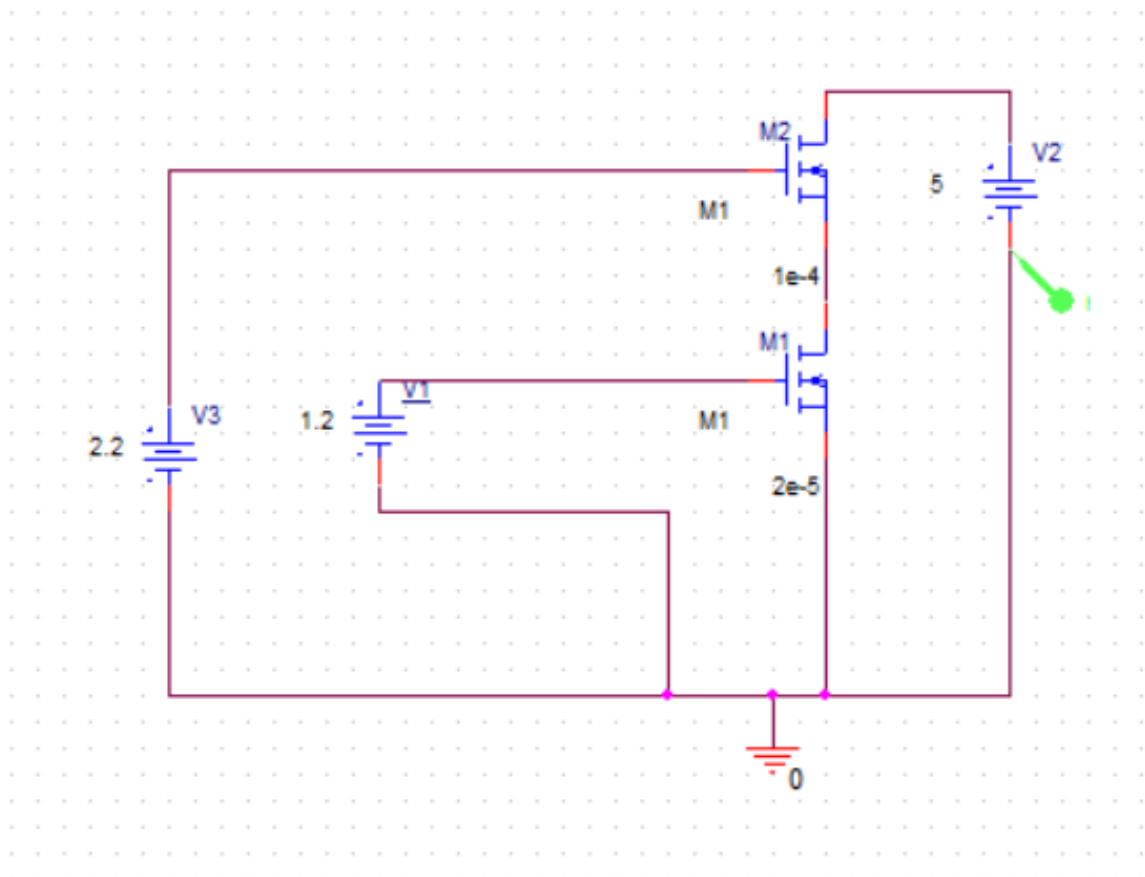


Figure 5: problem 8.4.2 circuit