Homework 6

VE311 - Electronic Circuits Fall 2021

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6.1

6.1.1

The voltage gain A_v

$$A_v = -\frac{gm_1}{gm_2} = -\frac{V_{DD} - V_{OUT} - |V_{TH2}|}{V_{IN} - V_{TH1}} = -5 = -\sqrt{\frac{\mu_{\mathrm{n}}(W/L)_1}{\mu_{\mathrm{p}}(W/L)_2}}$$

From above questions, we can calculate that $V_{\mathrm{OUT}} = 3.2$ V The current

$$\frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_1 = \frac{1}{2}\mu_p C_{ox}\left(\frac{W}{L}\right)_2 (A_v)^2$$

where $x = \left(\frac{W}{L}\right)_2$

$$x = 35.7$$

When $V_{OUT} = V_{IN'} - V_{TH1}$

$$\frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_1 (V_{IN'} - V_{TH1})^2 = \frac{1}{2}\mu_p C_{ox}\left(\frac{W}{L}\right)_2 (V_{DD} - (V_{IN'} - V_{TH1}) - |V_{TH2}|)^2$$

Then $V_{IN'} = 1.40$ V and finally we can get $0.7V \leq V_{IN} \leq 1.40$ V

6.1.2

The simulation is here. We can calculate the number here.

$$A_v = \frac{4.2 - 2.7}{1 - 0.7} = -5$$

The error is 0%, which may because that λ and γ are both 0.

6.1.3

The simulation is here. We can calculate the number here.

$$|A_v| = \frac{v_{out}}{v_{in}} = \frac{3.2105 - 3.2057}{0.001} = 4.8$$

The error is 4%, Since λ and γ have been set to 0, the reason may be a deviation in image reading, but it does not affect the specific values

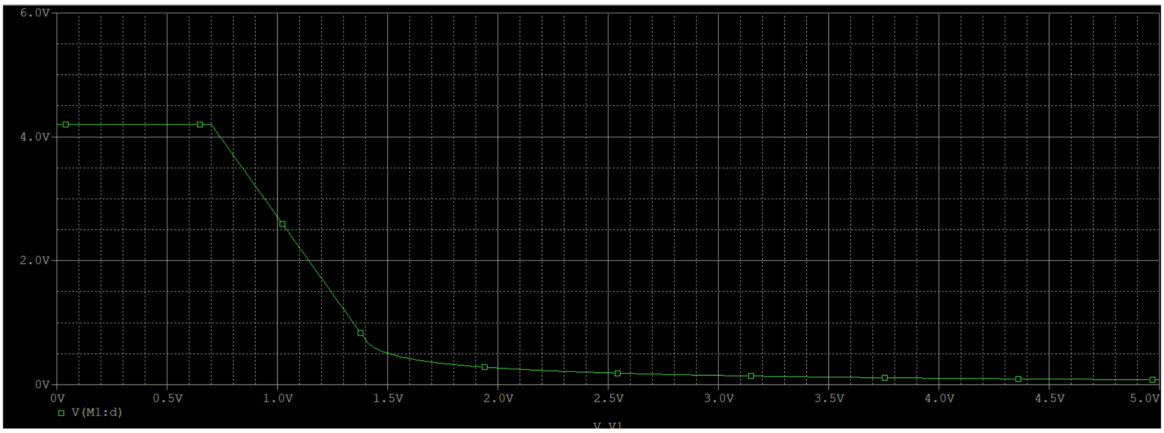

Figure 1: problem 1.2 plot

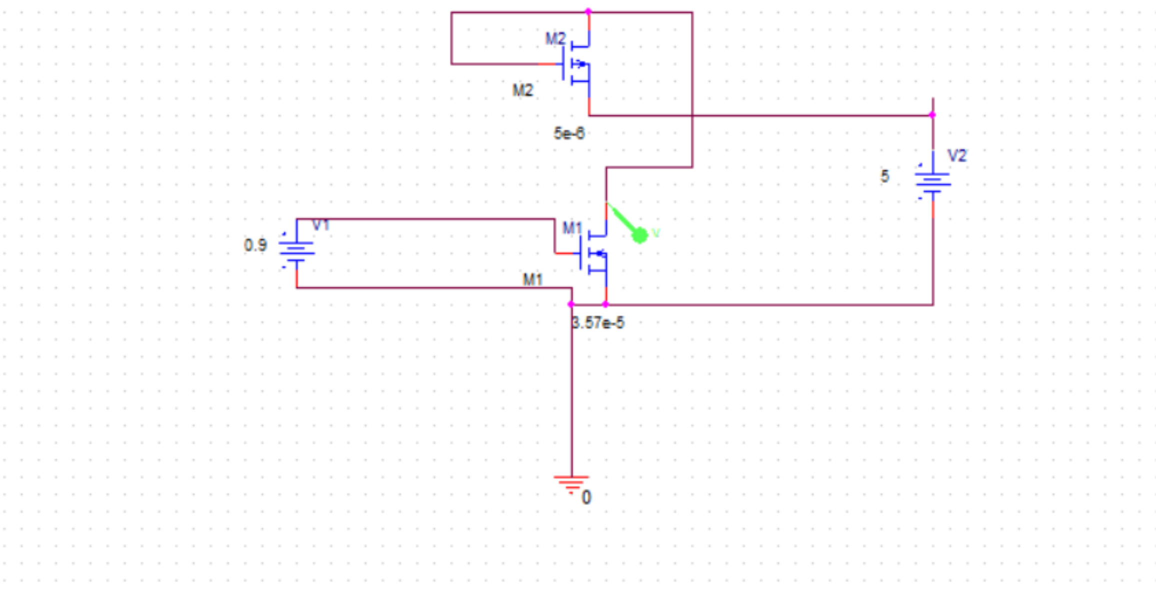

Figure 2: problem 1.2 simulation diagram

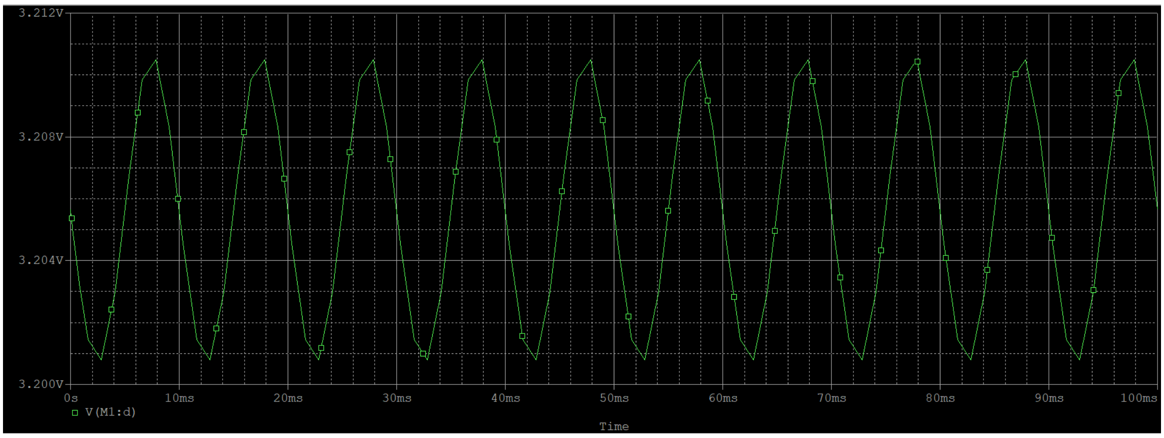

Figure 3: problem 1.3 plot

6.2

6.2.1

According to the formula, we have:

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{IN} - R_S I_D - V_{TH})^2$$
$$= \frac{1}{2} \times 0.035 \times \frac{8.85 \times 10^{-12} \times 3.9}{9 \times 10^{-9}} \times 100 \times (1.2 - 20000 I_D - 0.7)^2$$

Then $I_D = 2.824 \times 10^{-5} A$
And we can calculate gm

$$gm = \frac{2I_D}{V_{IN} - R_S I_D - V_{TH}} = -8.7075 \times 10^{-4}$$

The voltage gain

$$G = -\frac{gm}{1 + gmR_s} = -5.3046 \times 10^{-5}$$
$$R_{out} = R_D = 100 \times 10^3$$
$$A_v = GR_{out} = -5.3046$$

Which is almost the same as the theoretical value:

$$A_v \approx -\frac{R_D}{R_S} = -5$$

6.2.2

The simulation is here. We can calculate the number here.

$$A_v = \frac{5 - 3.75}{1.0 - 0.7} = -4.167$$

The error is relative big, this may be due to its own width and errors in reading the value.

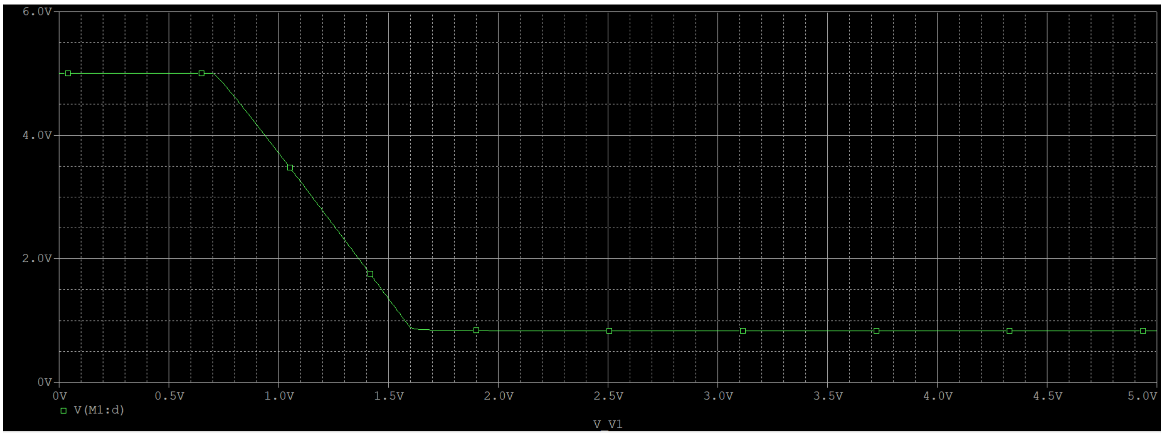

Figure 4: problem 2.2 plot

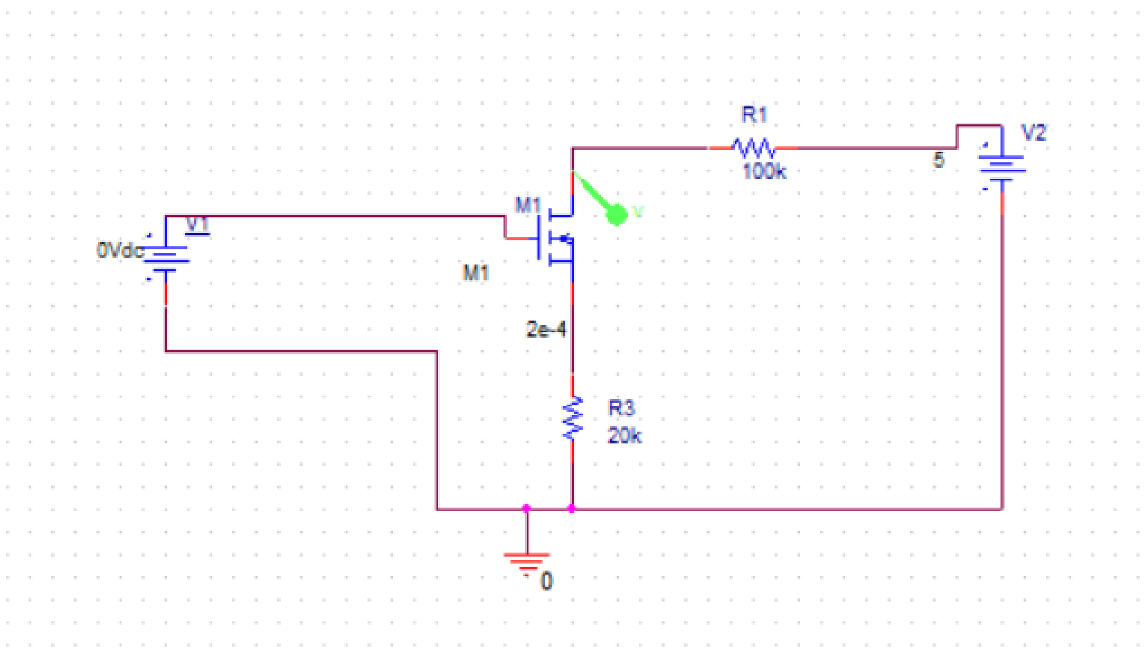

Figure 5: problem 2.2 simulation diagram

6.2.3

The simulation is here. We can calculate the number here.

$$|A_v| = \frac{v_{out}}{v_{in}} = \frac{2.7805 - 2.776}{0.001} = 4.5$$

The error is relative big, this may be due to its own width and errors in reading the value.

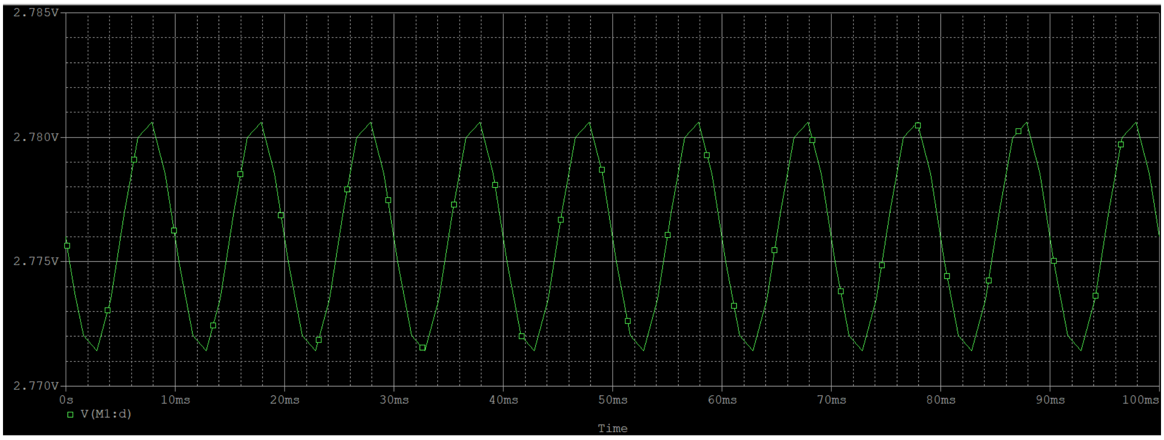

Figure 6: problem 2.3 plot