Homework 5

VE311 - Electronic Circuits Fall 2021

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5.1

According to the formula:

$$A_v = -gm \cdot R_D$$

$$gm = \frac{\partial I_D}{\partial V_{IN}} = \mu_n C_{ox} \frac{W}{L_{\text{eff}}} (V_{IN} - V_{TH})$$

And in this question $|A_v| > 10$, so

$$W > \frac{10\,(L - 2L_D)}{\mu_n C_{ox} (V_{IN} - V_{TH}) R_D} = \frac{10 \times (2 - 0.08 \times 2)}{0.035 \times \frac{8.85\times10^{-12}\times3.9}{9\times10^{-9}} \times (0.9 - 0.7) \times 15000} = 45.694\mu m$$

The output

$$I_D = \frac{1}{2}\mu_n C_{ox} \frac{W}{L_{\text{eff}}} (V_{IN} - V_{TH})^2$$

$$V_{OUT} = V_{DD} - R_D I_D$$

And it's given $V_{\text{OUT}} = 2.5$ V, then

$$W = \frac{(V_{DD} - V_{OUT})(L - 2L_D)}{\frac{1}{2}\mu_n C_{ox} (V_{IN} - V_{TH})^2 R_D} = \frac{2.5 \times (2 - 0.08 \times 2)}{0.5 \times 0.035 \times \frac{8.85\times10^{-12}\times3.9}{9\times10^{-9}} \times (0.9 - 0.7)^2 \times 15000} = 114.236\mu m$$

Therefore, $W_{\text{drawn}} = 114.236\mu$m

5.2

The simulation result is here. The slope at $V_{IN} = 0.9$ V is

$$A_v = \frac{3.2 - 1}{0.95 - 0.85} = 22$$

The simulation result is almost the same as theoretical value.

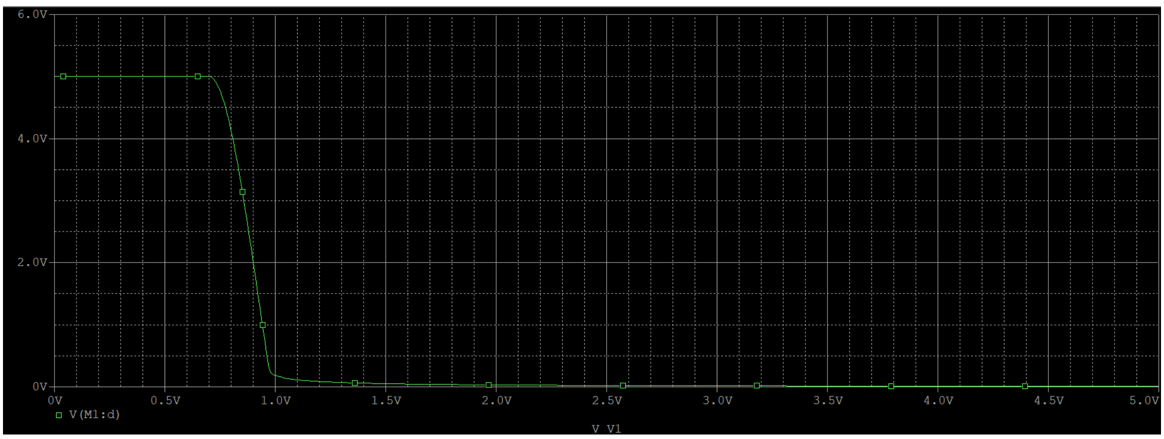

Figure 1: problem 2

5.3

The simulation result is here.
When $v_{\text{in}} = 0.01, v_{\text{out}} = \frac{2.23-1.77}{2} = 0.23, A_v = 23$.
When $v_{\text{in}} = 0.1, v_{\text{out}} = \frac{4.05-0.2}{2} = 1.925, A_v = 19.25$.
When $v_{\text{in}} = 1, v_{\text{out}} = \frac{5-0.1}{2} = 2.45, A_v = 2.45$.
As we can see in this question, gain A_v decreases with the increase of B, and the first two simulations are almost the same as value 22, but the third simulation differs from the theoretical value. Because the voltage gain A_v is under the assumption of small signal, but in this problem, the value of sine part is relatively high and the formula is not correct here.

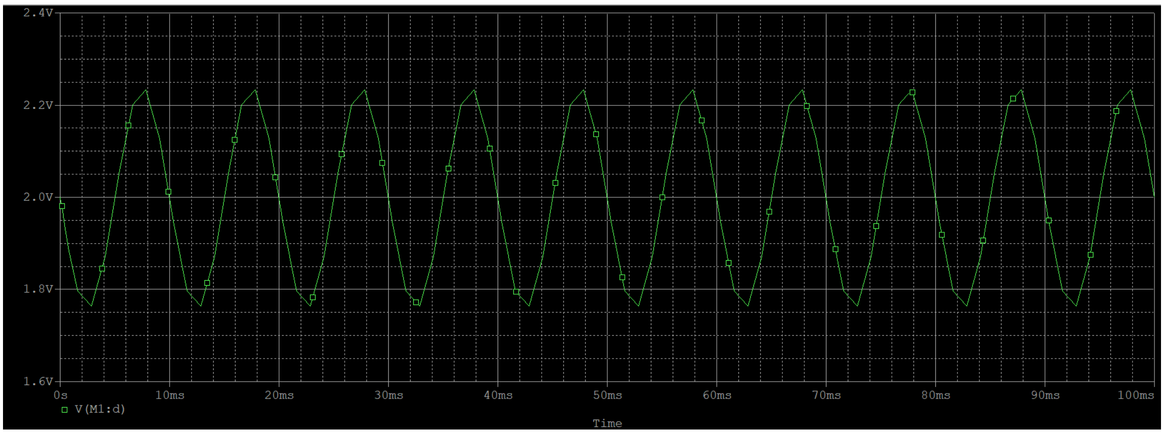

Figure 2: problem 3 0.01V

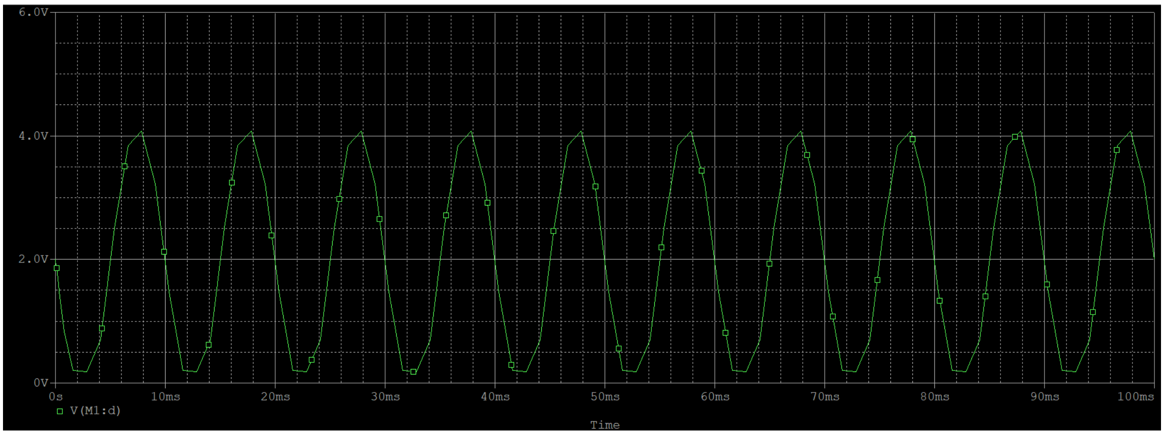

Figure 3: problem 3 0.1V

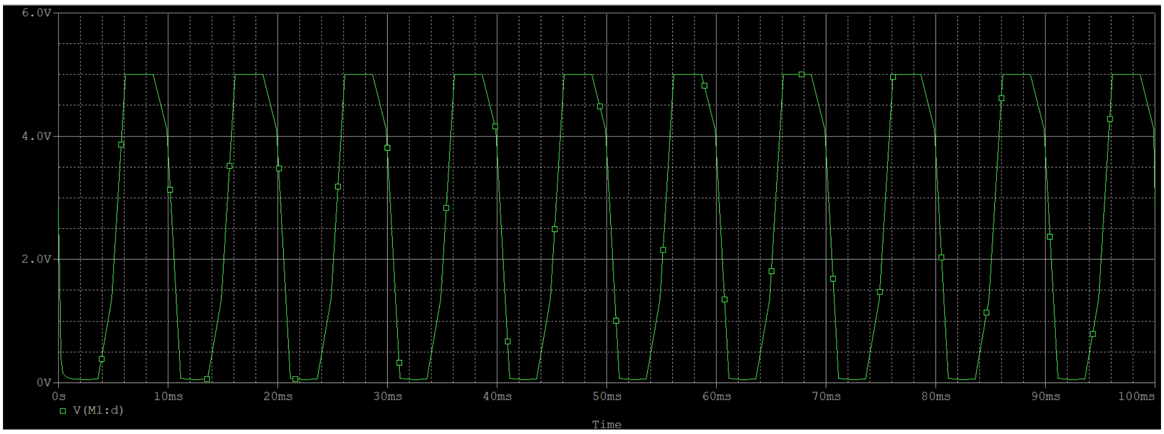

Figure 4: problem 3 1V