# Homework 7

VE311 - Electronic Circuits Fall 2021

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## 7.1

### 7.1.1

Circuit 1: $G_m = -gm_1, \quad R = R_D \| r_{o1}$

$$A_v = -g_{m_1}\left(R_D \| r_{o1}\right)$$

$$gm_1 = \mu_n C_{ox}\frac{W}{L'}\left(V_{GS} - V_{TH}\right) = 0.035 \times \frac{8.85 \times 10^{-12} \times 3.9}{9 \times 10^{-9}} \times \frac{50}{1.84} \times (1 - 0.7) = 1.0942 \times 10^{-3}$$

$$r_{01} = \infty$$

$$A_v = -g_{m_1}\left(R_D\right) = -10.942$$

Circuit 2: $G_m = -gm_1, \quad R = R_D \| R_L \| r_{o1}$

$$A_v = -g_{m_1}\left(R_D \| R_L \| r_{o1}\right)$$

$$gm_1 = \mu_n C_{ox}\frac{W}{L'}\left(V_{GS} - V_{TH}\right) = 0.035 \times \frac{8.85 \times 10^{-12} \times 3.9}{9 \times 10^{-9}} \times \frac{50}{1.84} \times (1 - 0.7) = 1.0942 \times 10^{-3}$$

$$r_{01} = \infty$$

$$A_v = -g_{m_1}\left(R_D \| R_L\right) = -1.8237$$

Circuit 3: There are two A here, and we should multiply them. $G_{m1} = -gm_1 = -10.942, \quad G_{m2} = -gm_2$

$$V_{out} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)\left(V_{IN} - V_{out} - V_{TH}\right)^2 R_L = 1.608V$$

$$gm_2 = \mu_n C_{ox}\frac{W}{L'}\left(V_{GS} - V_{TH}\right) = 0.035 \times \frac{8.85 \times 10^{-12} \times 3.9}{9 \times 10^{-9}} \times \frac{20}{1.84} \times \left(V_{out} - 0.7\right) = 1.3247 \times 10^{-3}$$

$$A_{v2} = -g_{m_2}\left(\frac{1}{gm_2} \| R_L\right) = 0.72599$$

$$A_v = 0.72599 - 10.942 = -7.9438$$

### 7.1.2

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

$$|A_{v1}| = \frac{v_{out}}{v_{in}} = \frac{4.25 - 2}{1.1 - 0.9} = 11.25$$

$$|A_{v2}| = \frac{v_{out}}{v_{in}} = \frac{0.7 - 0.35}{1.1 - 0.9} = 1.75$$

$$|A_{v2}| = \frac{v_{out}}{v_{in}} = \frac{2.15 - 0.8}{1.1 - 0.9} = 6.75$$

The error is relatively small in 1 and 2, but in circuit 3, the error is somehow big. Since $\lambda$ and $\gamma$ have been set to 0, the reason may be a deviation in image reading, but it does not affect the specific values. But in circuit 3, we multiply two A here, maybe the internal effect influence the result.

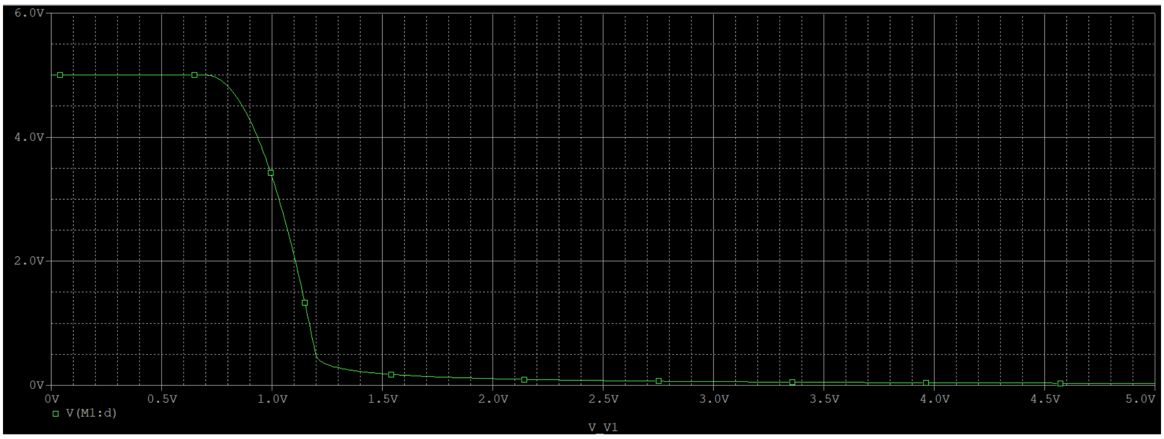


Figure 1: problem 1.2.1 plot

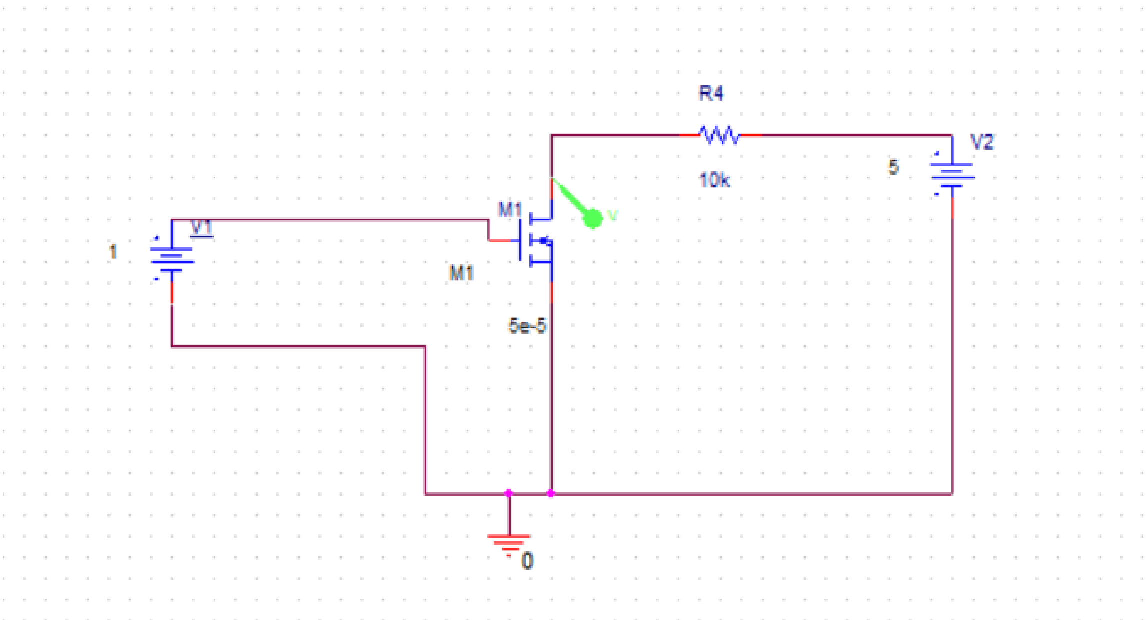


Figure 2: problem 1.2.1 circuit

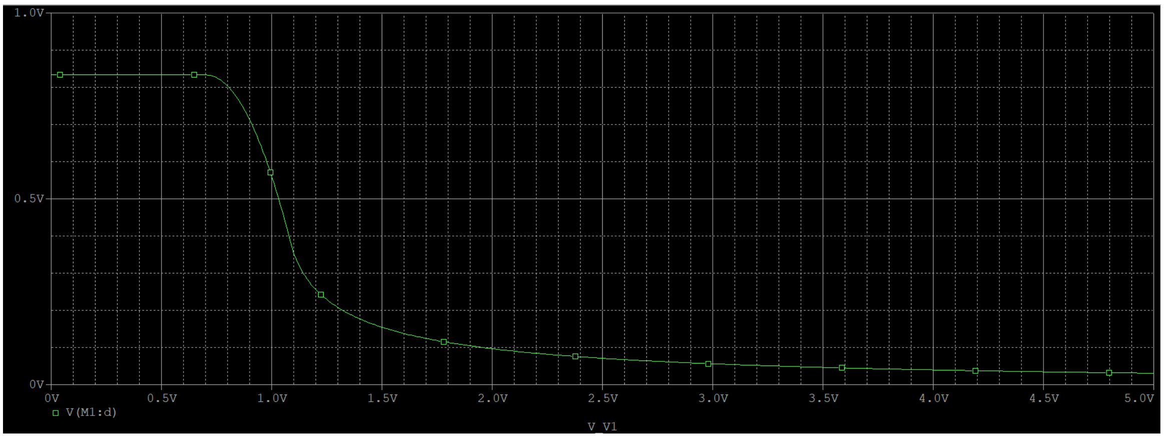


Figure 3: problem 1.2.2 plot

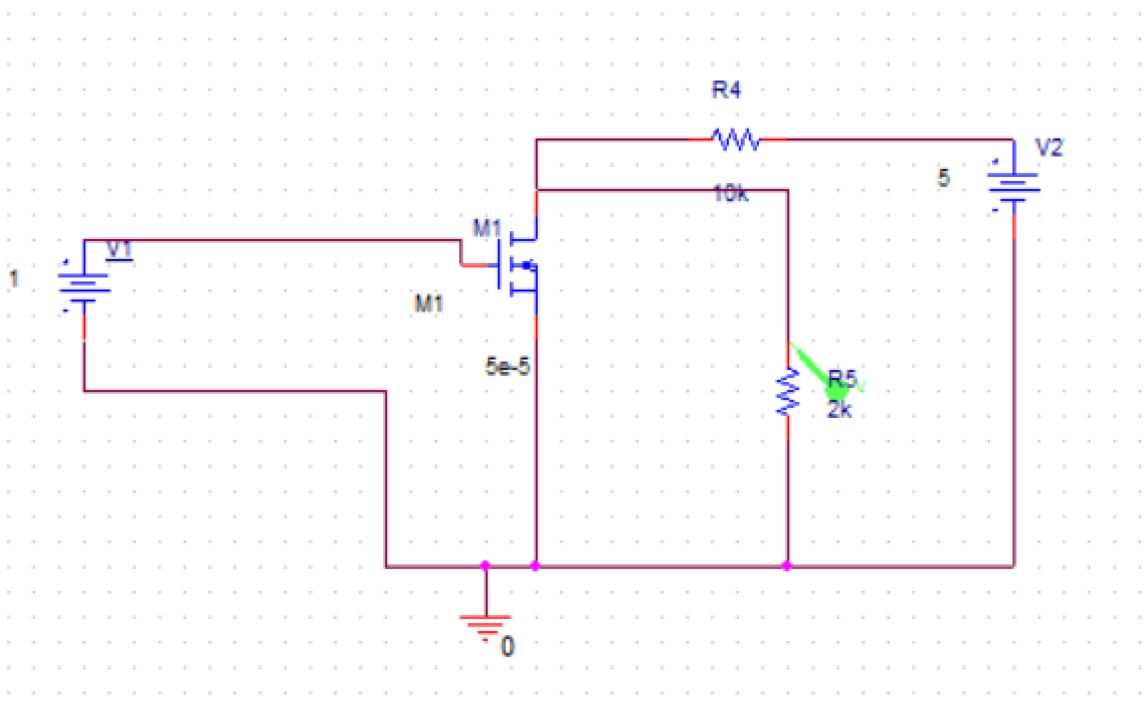


Figure 4: problem 1.2.2 circuit

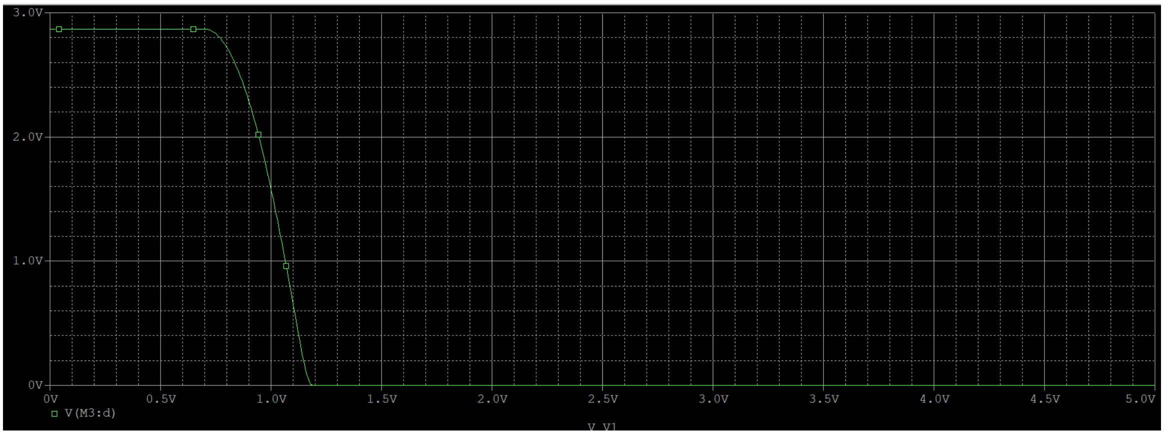


Figure 5: problem 1.2.3 plot

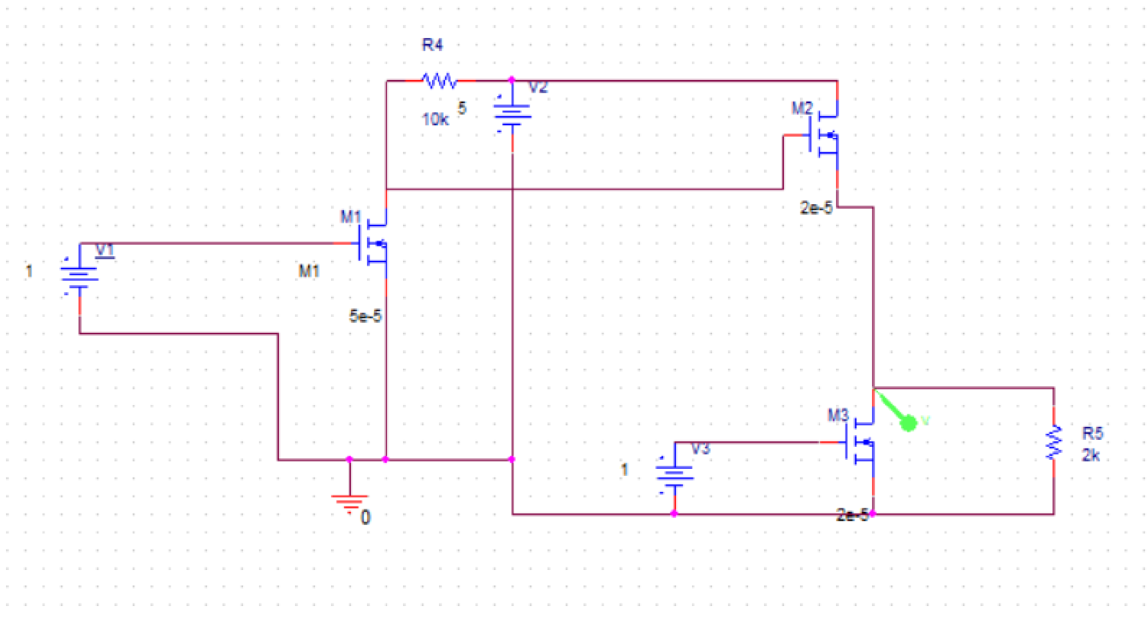


Figure 6: problem 1.2.3 circuit

### 7.1.3

We can find that when the amplitude of the input voltage gradually increases, the output voltage also increases proportionally, but in the last case, since the small signal is basically the same as the DC voltage, we cannot see the sinusoidal output waveform, the magnification reaches the maximum value.

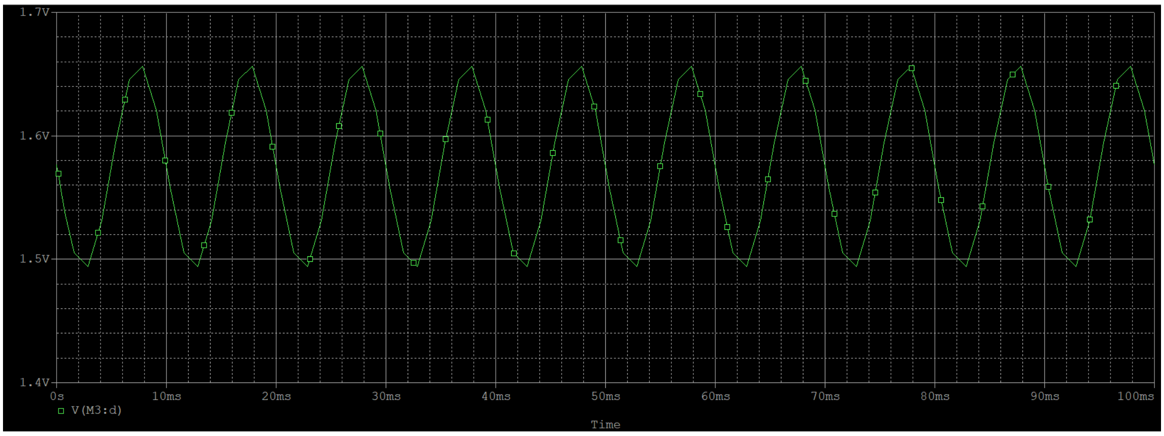


Figure 7: problem 1.3 0.01V

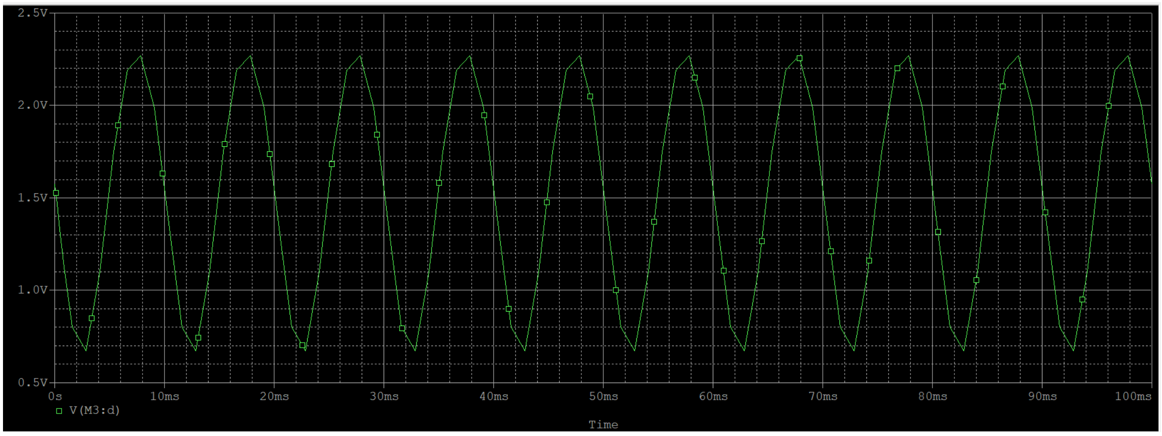


Figure 8: problem 1.3 0.1V

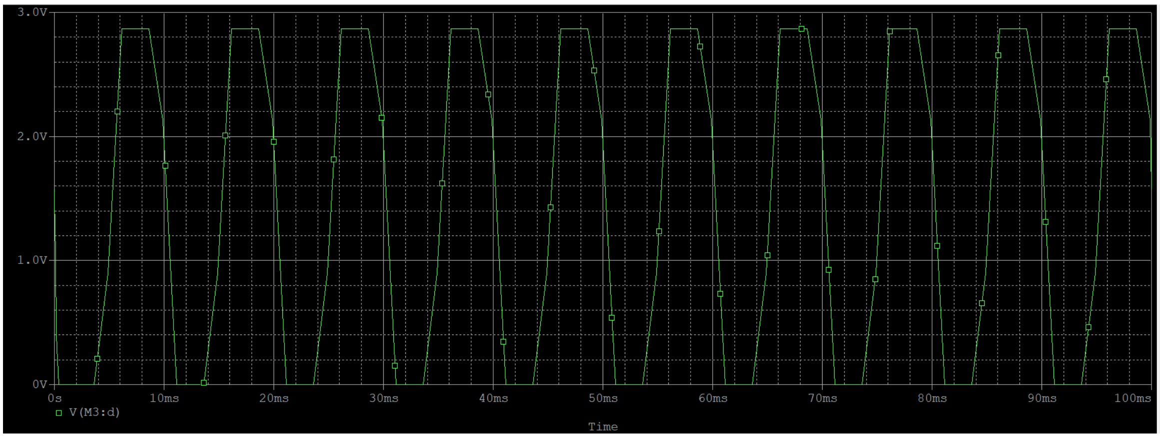


Figure 9: problem 1.3 1V

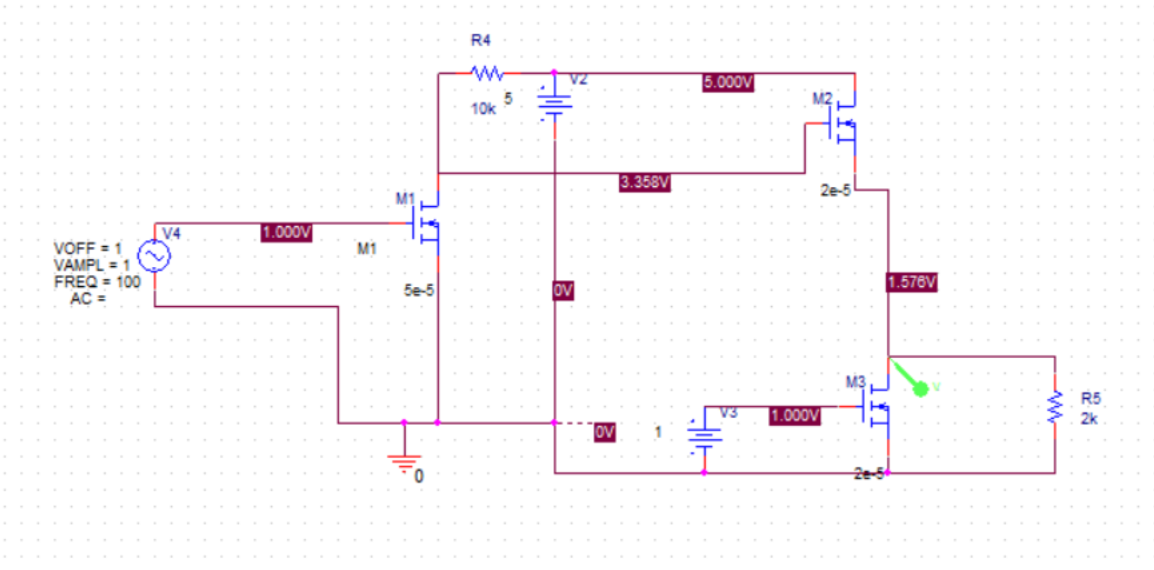


Figure 10: problem 1.3 circuit