VE311 Lab 3

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1. Common-Source with Source Degradation Amplifier

(a) In this part, we first build the circuit below (Figure 1) in Proteus. Our group chose $R_D = 68\ \text{k}\Omega$, $R_S = 8\text{k}\Omega$.

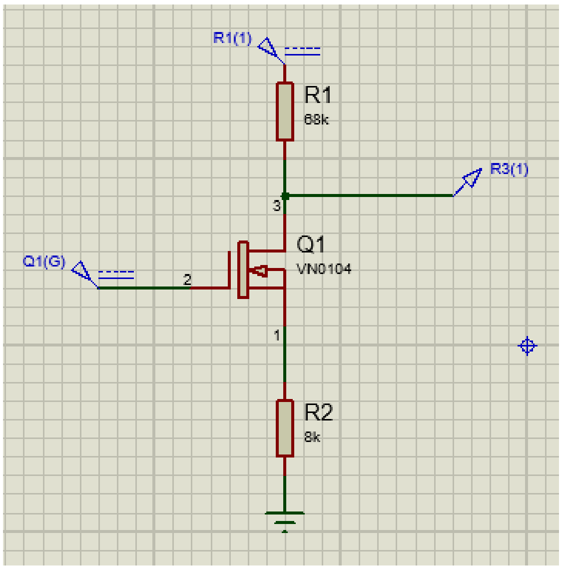

Figure 1. Proteus circuit

Then, we use DC sweep in Proteus to get V_{OUT} vs V_{IN} (Figure 2).

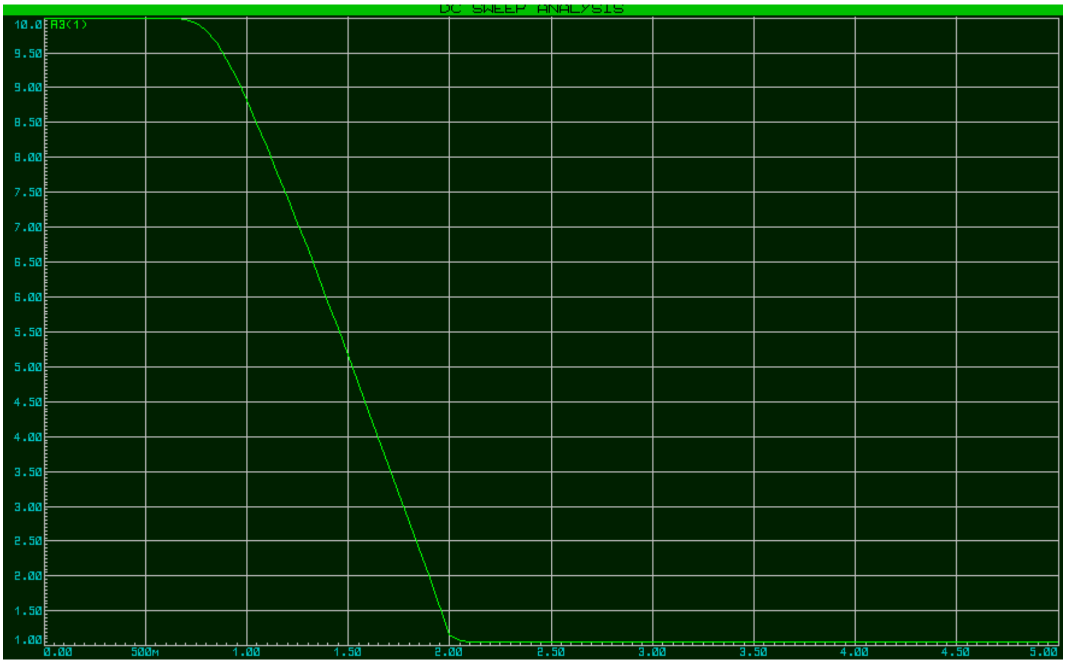

Figure 2. DC sweep

From the figure, we can get (1.49, 5.24), (1.51, 5.08), and we can get

$$|\text{slope}_{1.5}| = \left|\frac{5.08 - 5.24}{1.51 - 1.49}\right| = 8 > 5.$$

And the result is close to R_D/D_S = 68/8 = 8.5.

In lab, we get the following data (Table 1).

V_{IN} (V)	V_{OUT} (V)
0.1	9.950
0.5	6.600
0.6	5.020
0.7	3.420
0.8	1.805
0.9	1.247
1.0	1.421
1.5	2.380
2.0	3.362

Table 1. Measurement result

And we can get the following plot (Figure 3).

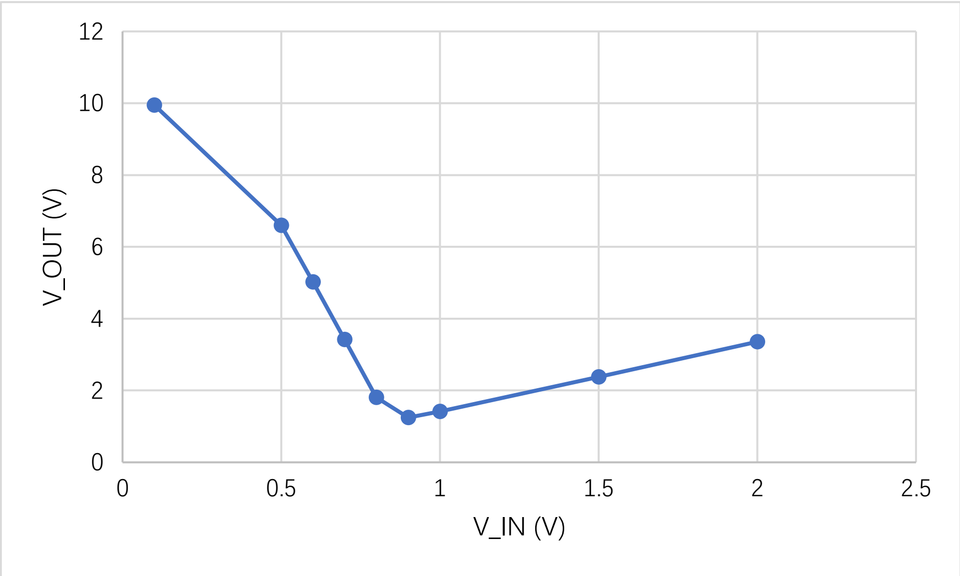

Figure 3. V_{OUT} vs V_{IN} for measurement result

We can calculate the absolute value of slope at 0.8 as

$$|\text{slope}_{0.8}| = \left|\frac{1.805 - 3.42}{0.8 - 0.7}\right| = 16.15.$$

The value we get in lab is about two times of the R_D/D_S = 68/8 = 8.5. The reasons for this may be that the NMOS and the resistor we used in lab are different from those we used in Proteus. Besides, the inner resistance may also cause it.

(b) In this case, we use $V_{in} = 1.5 + 0.01\sin(2\pi 10^2 \cdot \mathrm{time})$. In Proteus, we can get the following figure (Figure 4).

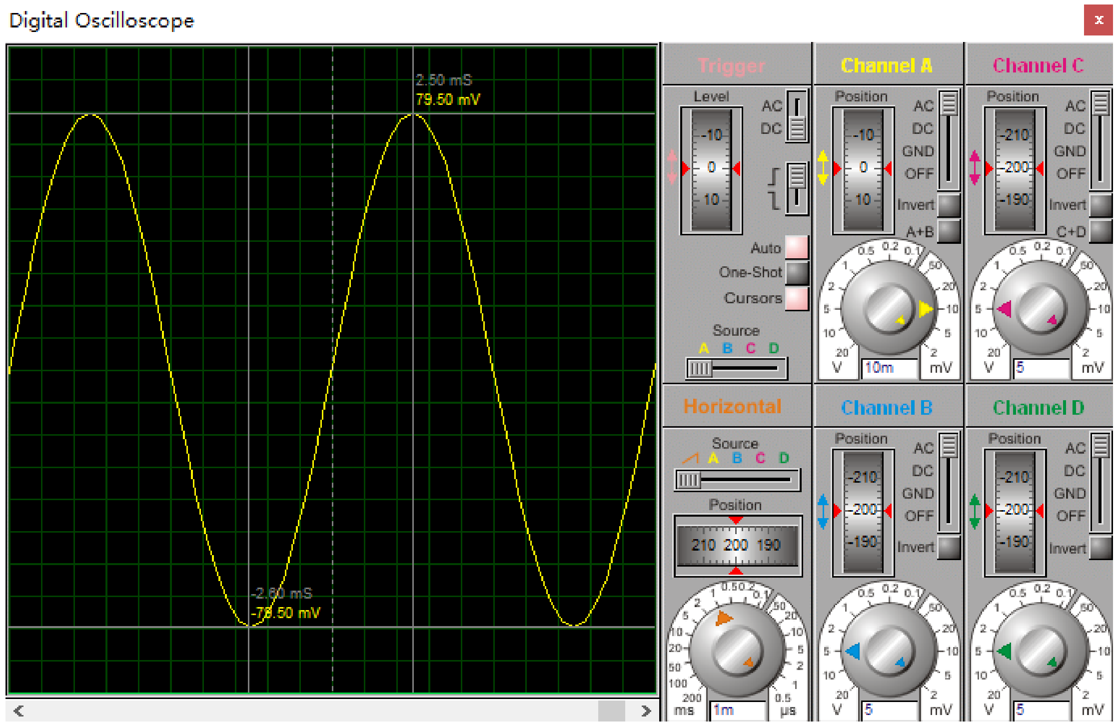

Figure 4. Simulation result

From the cursor, we can get

$$v_{out} = \frac{0.0795 + 0.0785}{2} = 0.079 \text{ V}.$$

Also, from **(a)**, we can get

$$0.01 \times A_v = 0.01 \times 8 = 0.08.$$

They are very close, so we can confirm that the amplitude of v_{out} is equal to $0.01 \times A_v$.

In the lab, we use $V_{in} = 0.8 + 0.01\sin(2\pi 10^2 \cdot \mathrm{time})$ and get the following figure (Figure 5).

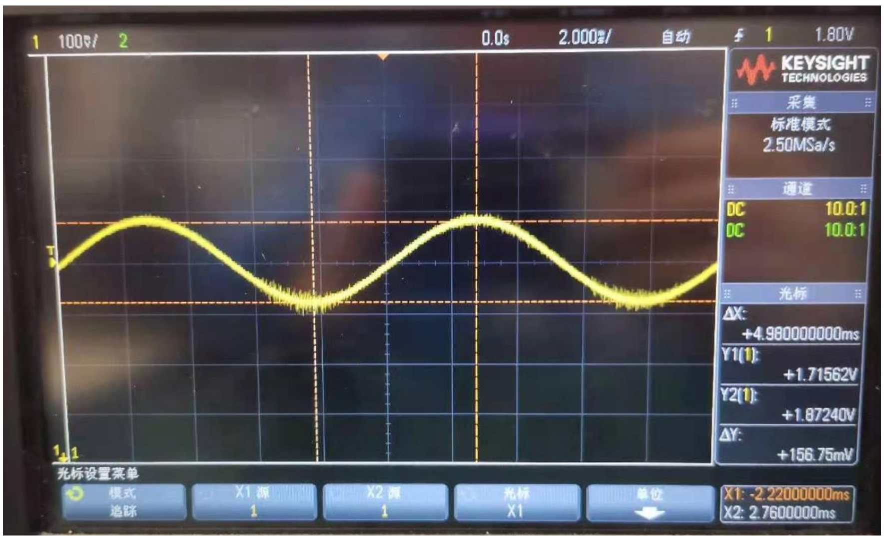

Figure 5. Measurement result for $0.8 + 0.01\sin(2\pi 10^2 \cdot \mathrm{time})$

We can get that $v_{out} = 0.078375$ V. However, it is smaller than $0.01 \times A_v = 0.01 \times 16.15 = 0.1615$. It may be because that there may be some problem with the circuit we built.

(c) We change the circuit to the figure below (Figure 6). Our group chose $R_L = 68\ \text{k}\Omega$.

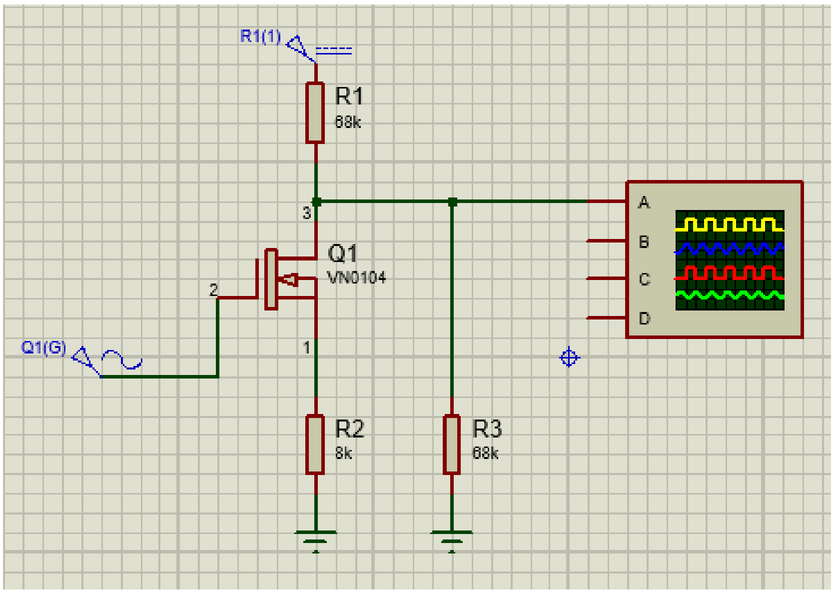

Figure 6. Proteus circuit

We use $V_{in} = 1.5 + 0.01\sin(2\pi 10^2 \cdot \text{time})$. In Proteus, we can get the following figure (Figure 7).

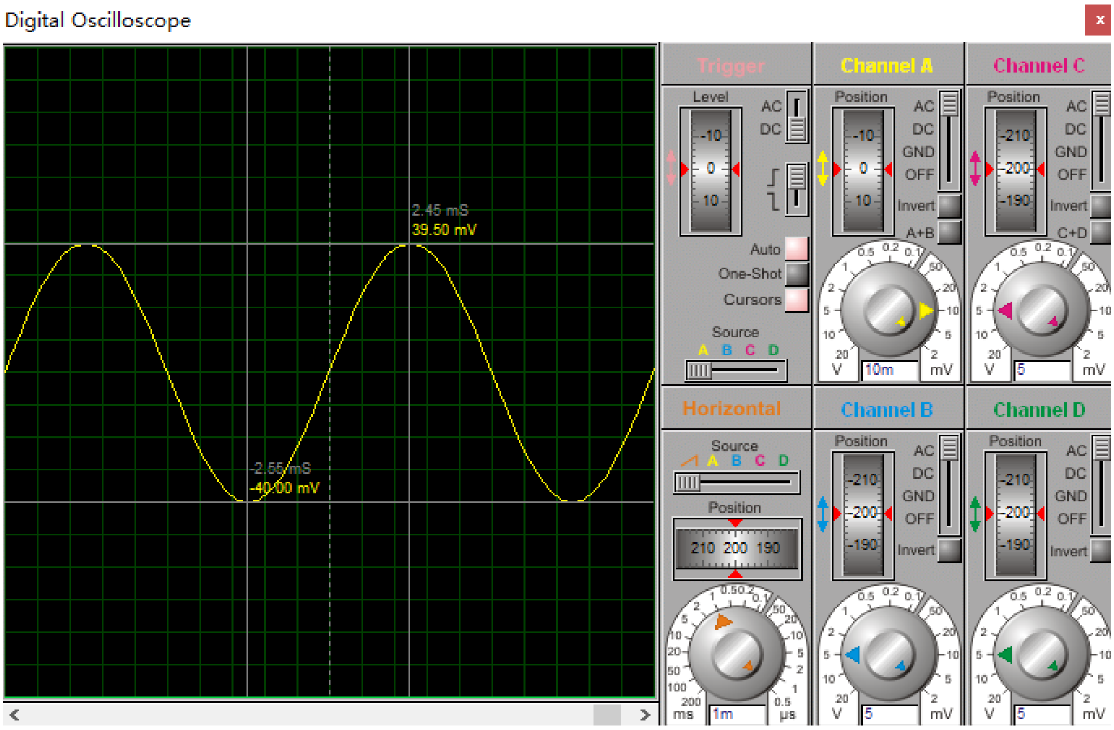

Figure 7. Simulation result

From the cursor, we can get

$$v_{out} = \frac{0.0395 + 0.040}{2} = 0.03975 \text{ V},$$

which is smaller than

$$0.01 \times A_v = 0.01 \times 8 = 0.08.$$

In lab, we use $V_{in} = 0.8 + 0.01\sin(2\pi 10^2 \cdot \text{time})$ and get the following figure (Figure 8).

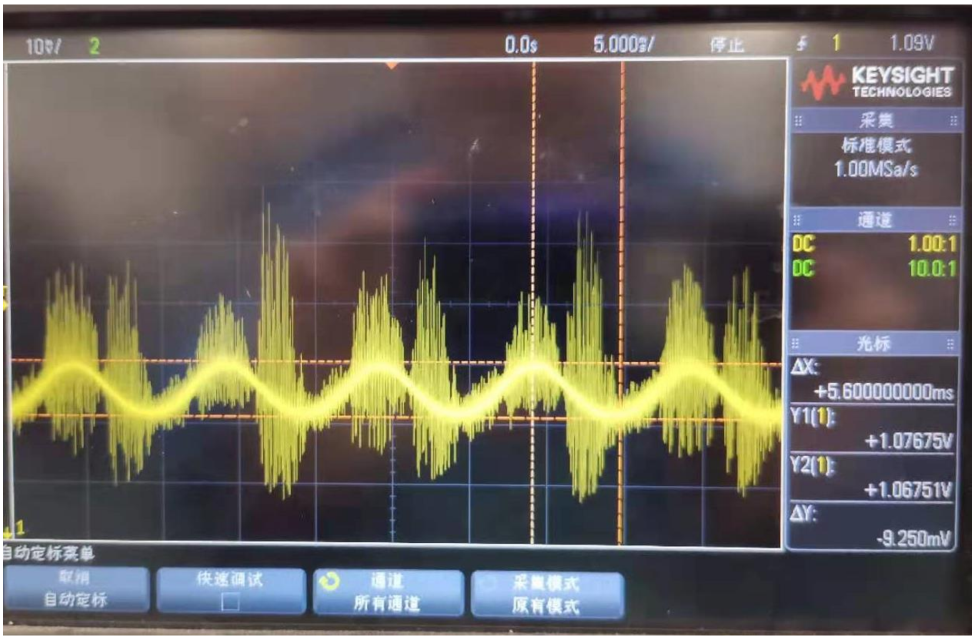

Figure 8. Measurement result

We get that $v_{out} = 0.004625$ V. It is smaller than $0.01 \times A_v$. The reasons for it smaller than $0.01 \times A_v$ may be that in small signal circuit, R_L is in parallel with R_D, so $(R_L || R_D) < 68$ kΩ. Also, $A_v = G_m R_{out}$. In this case G_m does not change but R_{out} becomes small. Therefore, after connecting R_L, the circuit has a new A_v which is smaller than the original one. Therefore, v_{out} becomes smaller.

2. Source follower

(a) In this part, we first build the circuit below (Figure 9) in Proteus. Our group chose $R_S = 470\Omega$.

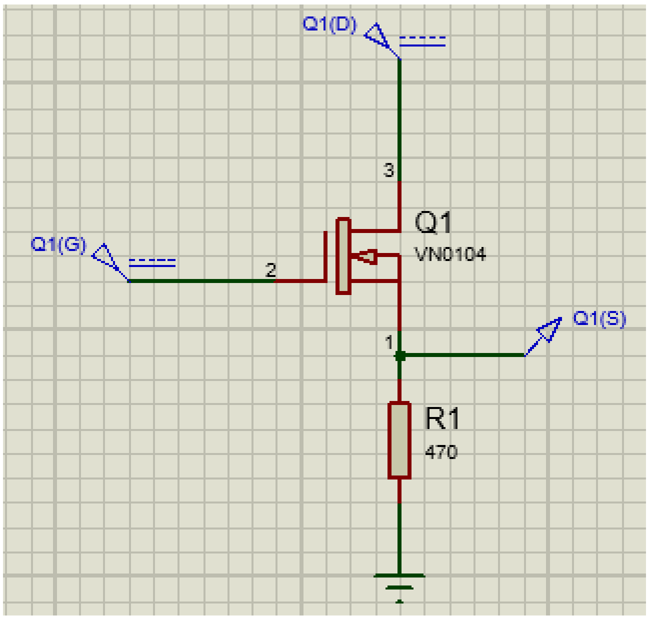

Figure 9. Proteus circuit

Then, we use DC sweep in Proteus to get V_{OUT} vs V_{IN} (Figure 10).

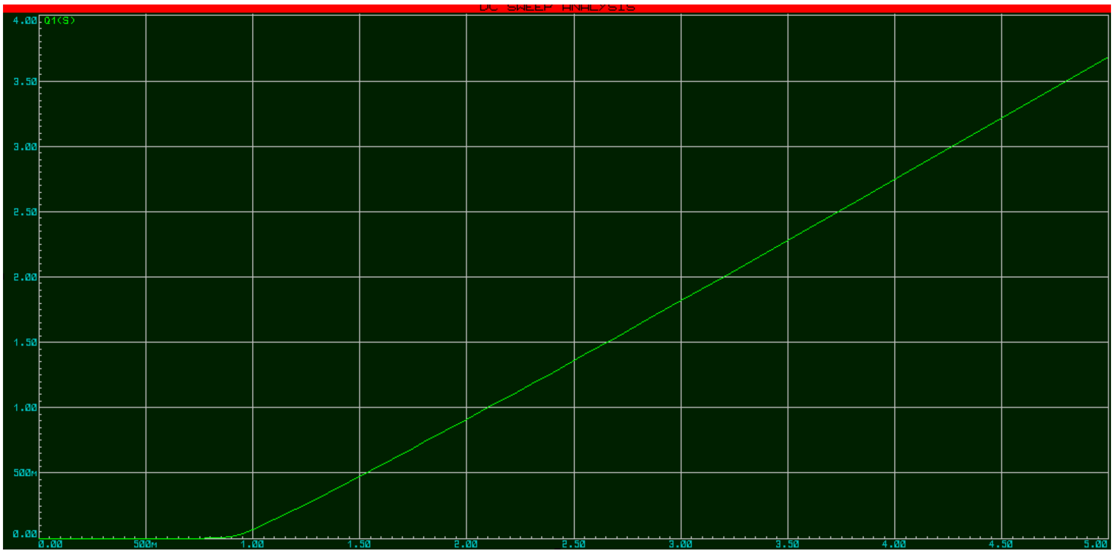

Figure 10. DC sweep

From the figure, we can get (2.99, 1.81), (3.01, 1.83), and we can get

$$|\text{slope}_3| = \left|\frac{1.83 - 1.81}{3.01 - 2.99}\right| = 1 > 0.5.$$

We can see that the voltage gain is very close to the unity.

In lab, we get the following data (Table 2).

V_{IN} (V)	V_{OUT} (V)
0.1	1.444
0.5	1.860
0.6	1.970
0.7	2.090
0.8	2.204
0.9	2.323
1.0	2.440
1.5	3.070
2.0	3.837

Table 2. Measurement result

And we can get the following plot (Figure 11).

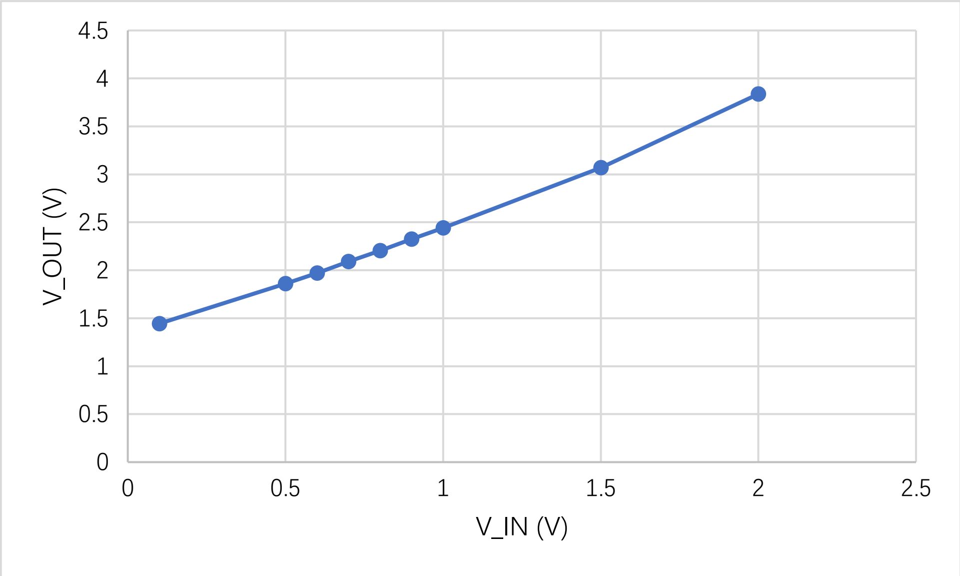

Figure 11. V_{OUT} vs V_{IN} for measurement result

We can calculate the value of slope at 0.8 as

$$|\mathrm{slope}_{0.8}| = \left|\frac{2.204 - 2.090}{0.8 - 0.7}\right| = 1.14 > 0.5.$$

And it is close to the unity.

(b) In this case, we use $V_{in} = 3 + 0.05\sin(2\pi 10^2 \cdot \text{time})$. In Proteus, we can get the following figure (Figure 12).

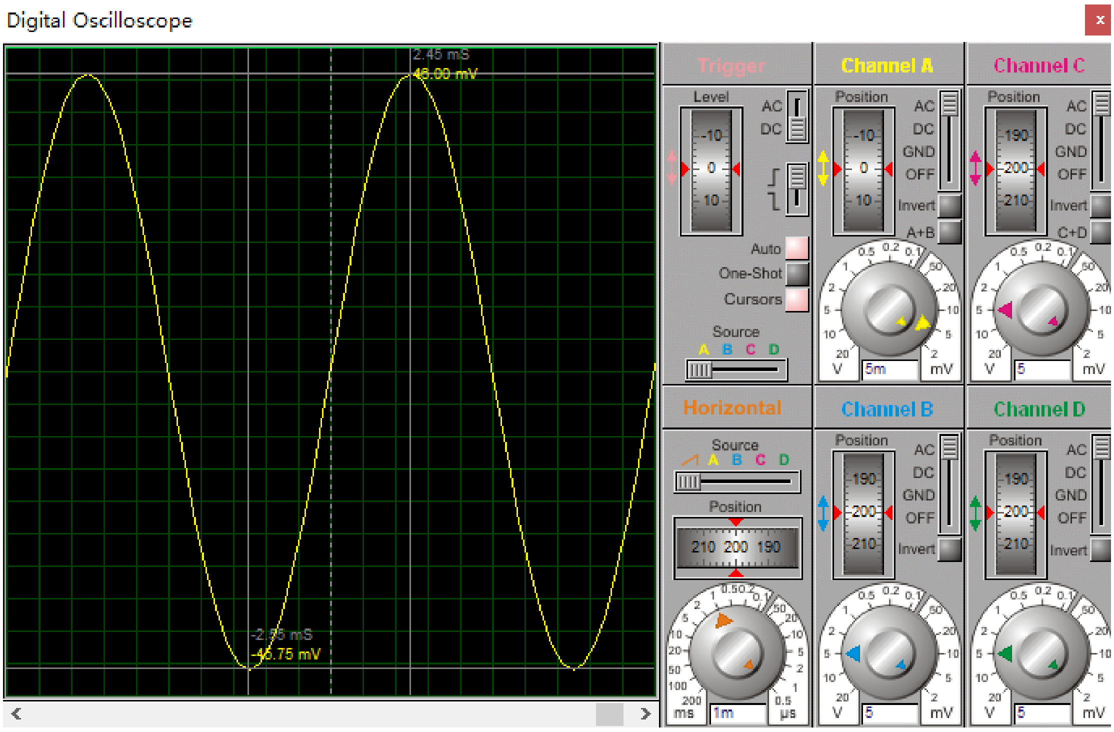

Figure 12. Simulation result

From the cursor, we can get that

$$v_{out} = \frac{0.046 + 0.04575}{2} = 0.045875 \text{ V}.$$

Also, from **(a)**, we have

$$0.05 \times A_v = 0.05 \times 1 = 0.05.$$

They are very close, so we may conclude that the amplitude of v_{out} is equal to $0.05 \times A_v$.

In lab, we use $V_{in} = 0.8 + 0.05\sin(2\pi 10^2 \cdot \text{time})$, and get the following figure (Figure 13).

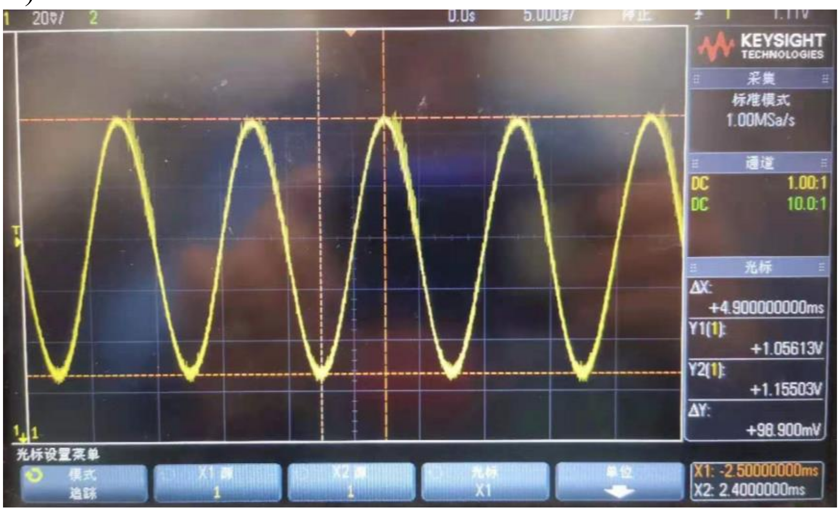

Figure 13. Measurement result for $V_{in} = 0.8 + 0.05\sin(2\pi 10^2 \cdot \text{time})$

We can get that $v_{out} = 0.04945$ V. It is very close to $0.05 \times A_v$. Therefore, we may conclude that the amplitude of v_{out} is equal to $0.05 \times A_v$.

(c) We change the circuit to the figure below (Figure 14). Our group chose $R_L = 68\ \text{k}\Omega$.

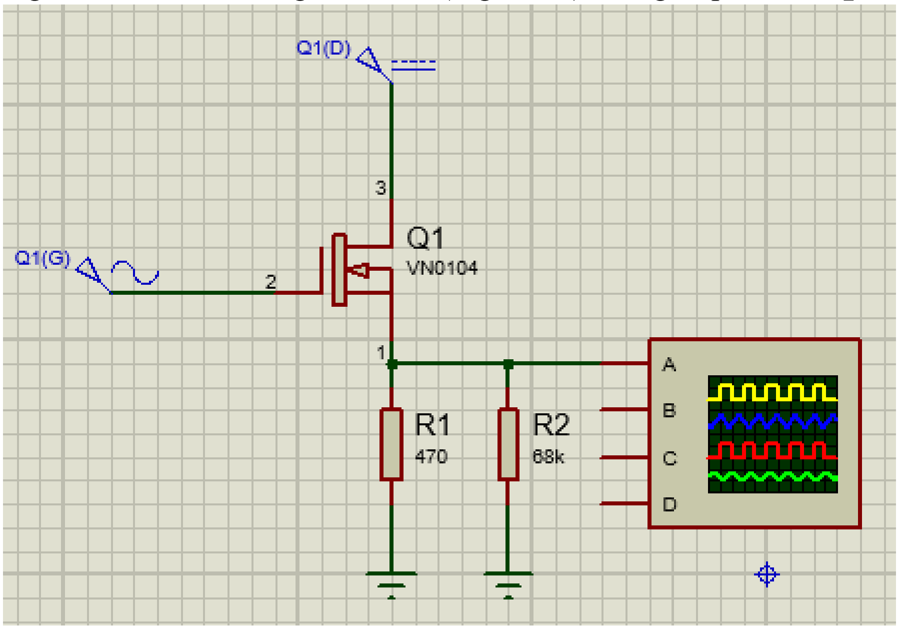

Figure 14. Proteus circuit

We use $V_{in} = 3 + 0.05\sin(2\pi 10^2 \cdot \text{time})$. In Proteus, we can get the following figure (Figure 15).

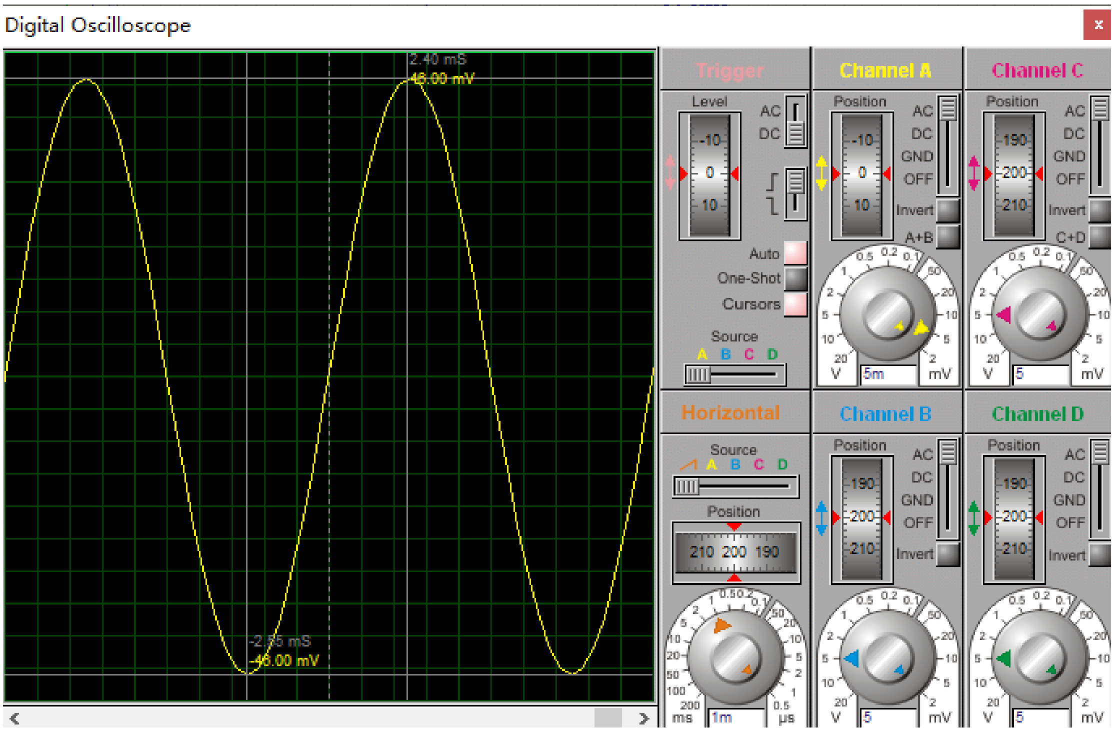

Figure 15. Simulation result

From the cursor, we can get that

$$v_{out} = \frac{0.046 + 0.046}{2} = 0.046\ \text{V}.$$

We can see that it is still around $0.05 \times A_v$. Because R_L is significantly larger than R_S, so $(R_S || R_L) \approx R_S$. Therefore, after adding R_L, v_{out} will not change much.
In lab, we use $V_{in} = 0.8 + 0.05\sin(2\pi 10^2 \cdot \mathrm{time})$, and get the following figure (Figure 16).

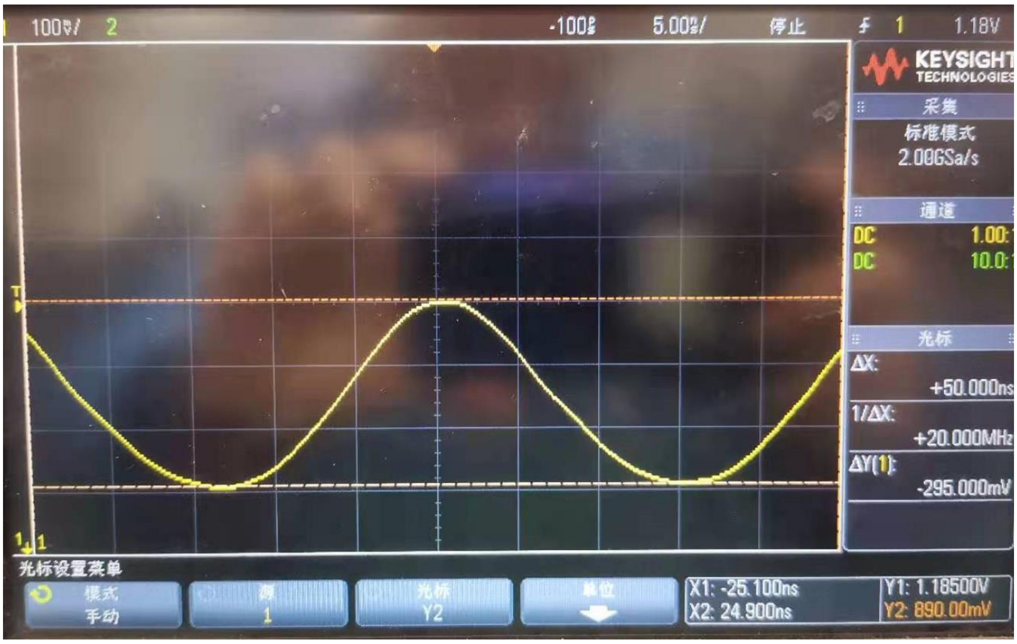

Figure 16. Measurement result for $V_{in} = 0.8 + 0.05\sin(2\pi 10^2 \cdot \mathrm{time})$

We can get that $v_{out} = 0.1475$ V. However, it is not close to $0.01 \times A_v$. It may be because that the NMOS and the resistor we use in lab are different from those used in Proteus. Besides, the inner resistance of the circuit may also lead to it.