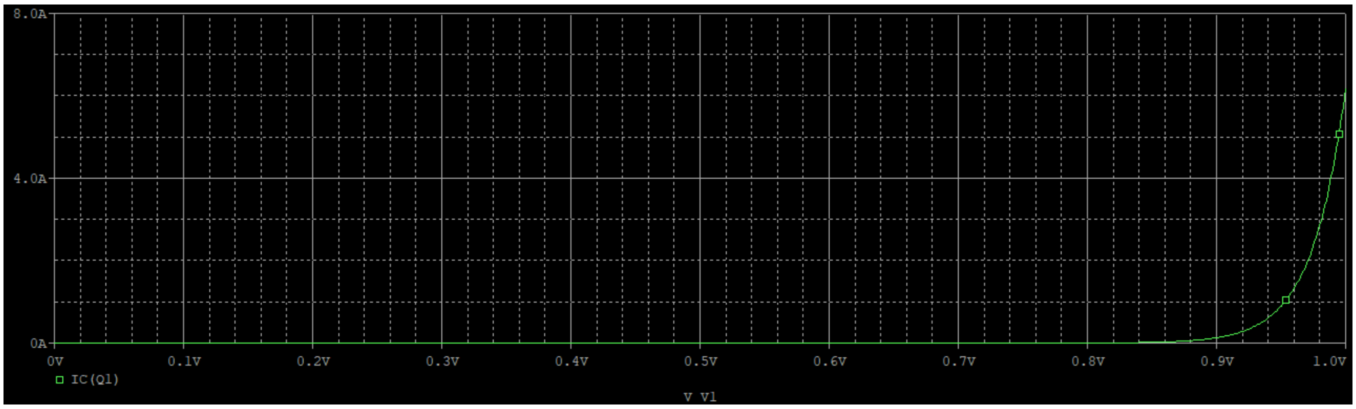
VE 311 Hw 3 周维凯 518021911039

1. (a).

$$I_c = I_S\left(e^{\frac{qV_{BE}}{kT}}-1\right)\left(1+\frac{V_{CE}}{VAF}\right) = 10^{-16}\cdot\left(e^{\frac{0.5}{0.026}}-1\right)\left(1+\frac{1}{100}\right) = 2.27\times10^{-8}\ \text{A}$$

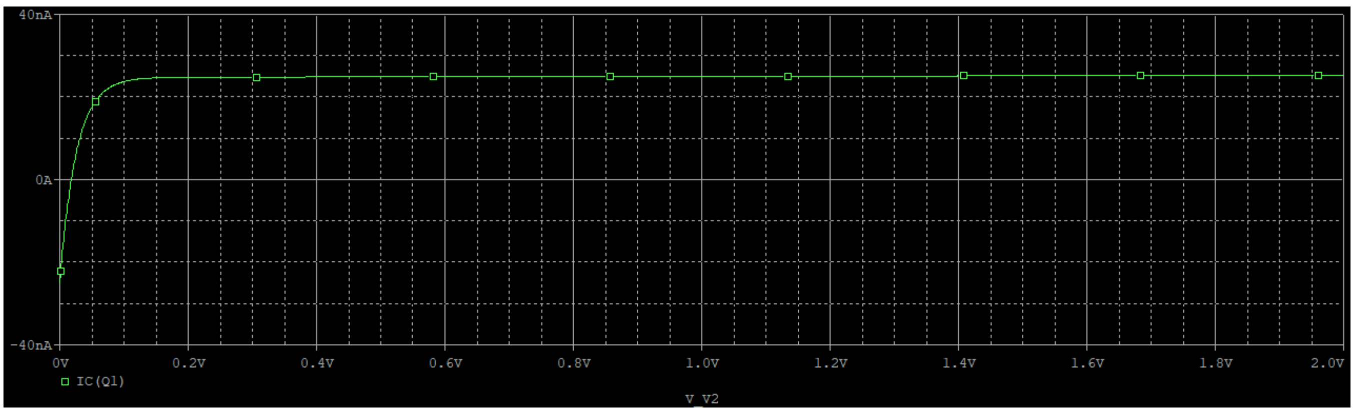
$$g_m = \frac{I_c}{kT/q} = 8.73\times10^{-7}\ \text{A/V} \qquad r_o = \frac{VAF}{I_c} = 4.40\times10^{9}\ \Omega$$

(b).




From the plot, we have $(0.498, 2.3154\times10^{-8})$, $(0.502, 2.7025\times10^{-8})$.
The slope is $9.6775\times10^{-7}$. It is close to the gm in (a).

(C).




From the plot, we have $(0.999, 2.4995\times10^{-8})$, $(1.001, 2.4996\times10^{-8})$.

We have $\dfrac{1.001-0.999}{2.4996\times10^{-8}-2.4995\times10^{-8}} = 2\times10^{9}$. Generally, the order of magnitudes are equal, the difference between 2 and 4.40 maybe because of the precision of the software. We may consider they are close.

2.(a). $A_v = -g_m (R_C \| r_o)$

$$\begin{cases} I_C = I_S \left(e^{\frac{qV_{BE}}{kT}} - 1\right)\left(1 + \frac{V_{OUT}}{VAF}\right) = 10^{-16}\left(e^{\frac{0.5}{0.026}} - 1\right)\left(1 + \frac{V_{OUT}}{100}\right) \\ 3 - 5000 I_C = V_{OUT} \end{cases}$$

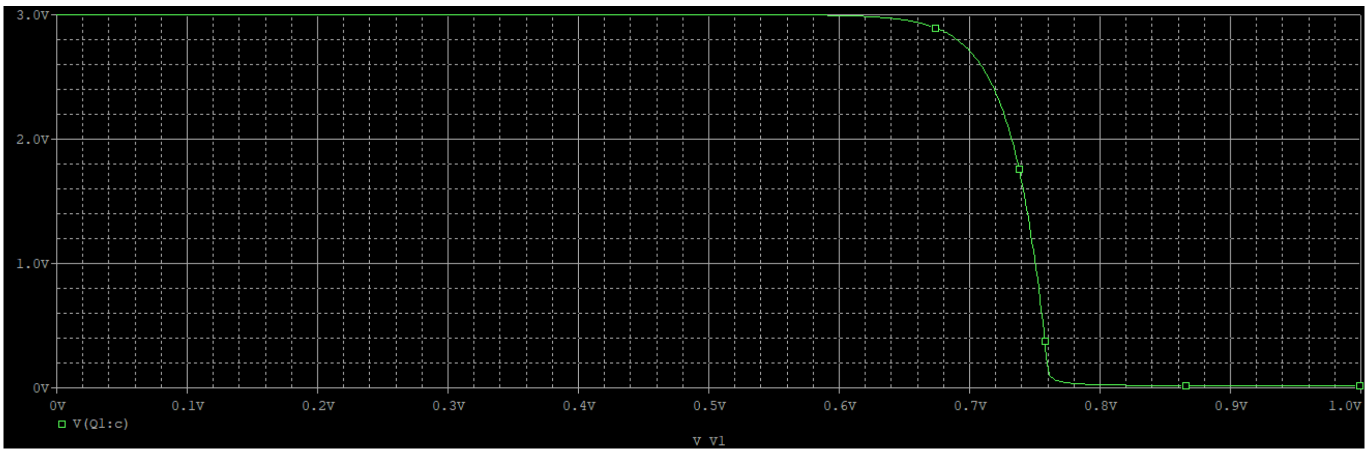
$$\Rightarrow I_C = 2.32 \times 10^{-8} \text{ A}$$

$$g_m = \frac{I_C}{0.026} = 8.91 \times 10^{-7} \text{ A/V}$$

$$r_o = \frac{100}{I_C} = 4.32 \times 10^{9} \ \Omega$$

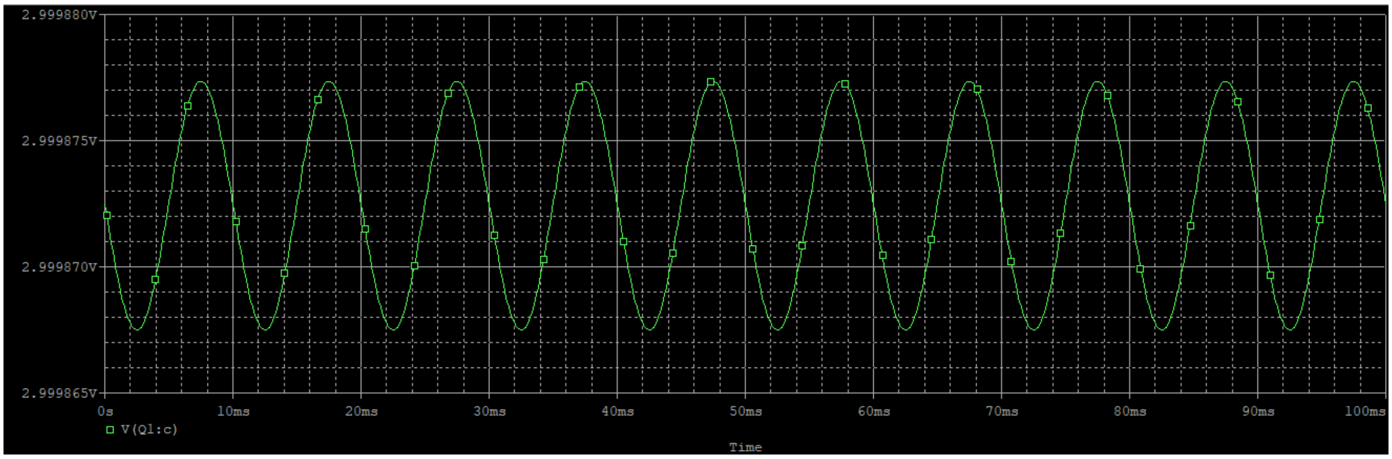
$$A_v = -8.91 \times 10^{-7} \times \left(\frac{5000 \times 4.32 \times 10^9}{5000 + 4.32 \times 10^9}\right) = -4.45 \times 10^{-3}$$

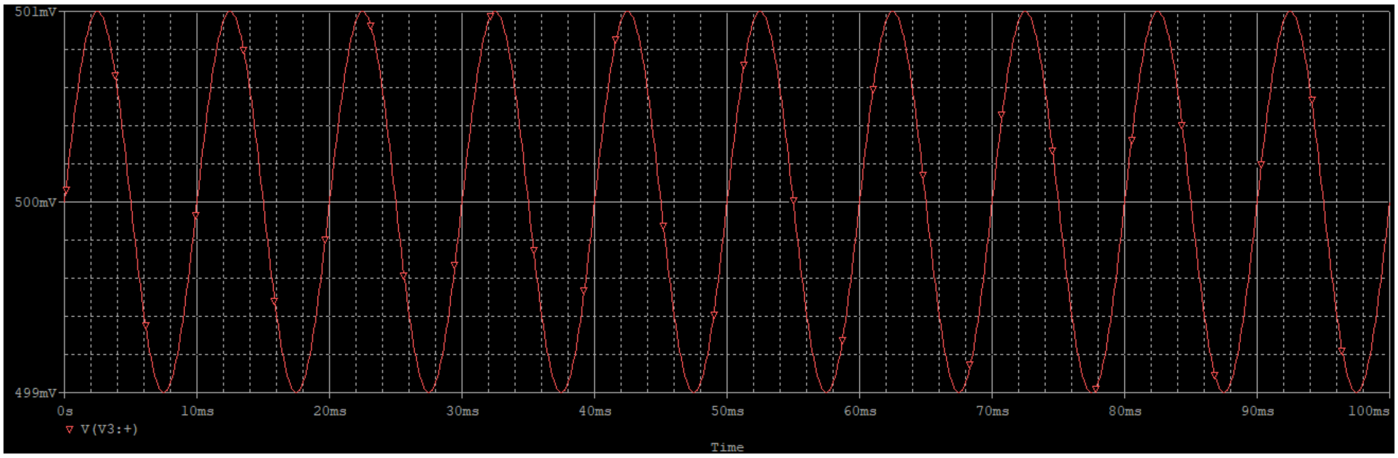
(b).




From the plot, we have (0.48, 2.9999) (0.52, 2.9997). The slope is $-5 \times 10^{-3}$.
It is close to the voltage gain in (a).

(C).




From the plot, we know that $|A_v| = \left|\frac{v_{out}}{v_{in}}\right| = \left|\frac{4.9285\times10^{-6}}{0.001}\right| = 4.9285\times10^{-3}$,

which is close to the voltage gain calculated in (a)