# 1 Problem 1

## 1.1 (a)

$$I_c = I_s \exp(\frac{qV_{BE}}{KT} - 1)(1 + \frac{V_{CE}}{V_A}) = 10^{-16} \exp(\frac{0.7}{0.0259} - 1)(1 + \frac{V_{CE}}{100}) = 5.47 \cdot 10^{-5} * (1 + 0.01 * V_{OUT})$$

$$V_{OUT} = V_{CC} - R_c * I_c = 3 - 5000 I_c$$

$$V_{OUT} = 2.72(V)$$

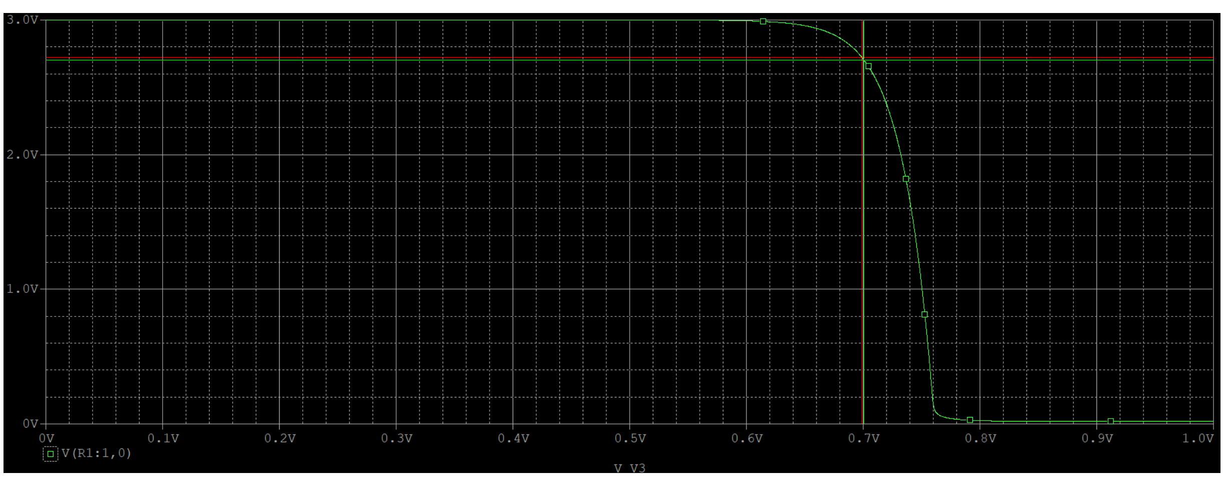
$$I_c = \frac{3 - 2.9}{5000} = 5.6 \cdot 10^{-5}(A)$$

$$gm = \frac{q \cdot I_c}{KT} = \frac{5.6 \cdot 10^{-5}}{0.0259} = 2.162 \cdot 10^{-3}$$

$$r_0 = \frac{V_A}{I_c} = \frac{100}{2.07 \cdot 10^{-5}} = 1.79 \cdot 10^6(\Omega)$$

$$A_v = -gm(R_c || r_0) = -2.162 \cdot 10^{-3} \cdot \frac{5000 * 1.79 \cdot 10^6}{5000 + 1.79 \cdot 10^6} = -10.78$$

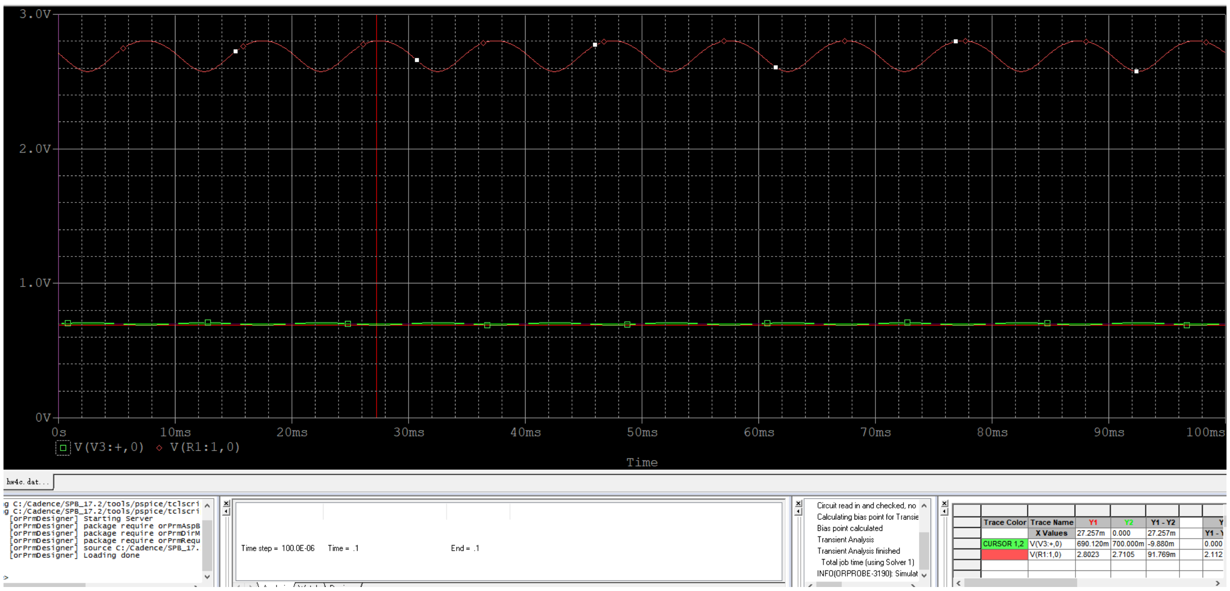
## 1.2 (b)




$$A_v = \frac{18}{-1.7} = -10.6$$

The slope is about -10.6, which is a little bigger than calculated one in (a)

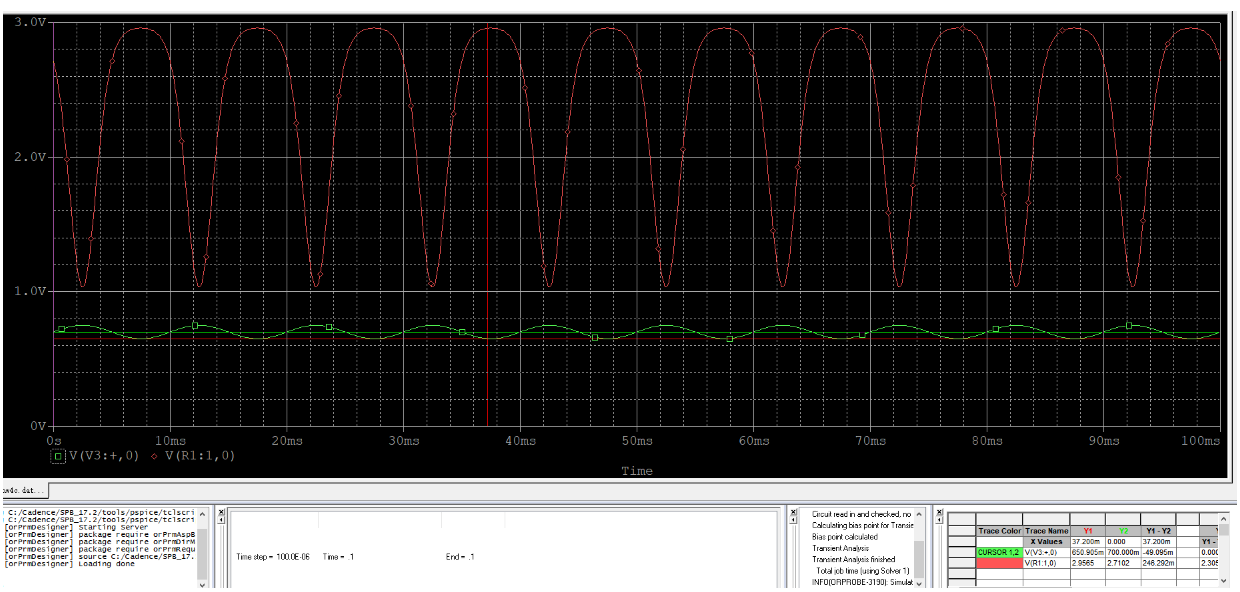
## 1.3 (c)




$$|A_v| = |\frac{(2.8 - 2.9)}{0.69 - 0.7}| \approx 10$$

The value is very close to part (b) and (a) but the absolute value is a bit smaller.

## 1.4 (d)



$$|A_v| = |\frac{(2.96 - 2.9)}{0.65 - 0.7}| \approx 47.2$$

The value is much more greater than calculated one in previous part, I think it's because the amplitude is so big that the input signal can't be considered as a small signal any more. As a result, the derivative for $V_{BE}$ can't be applied any more gm has changed.