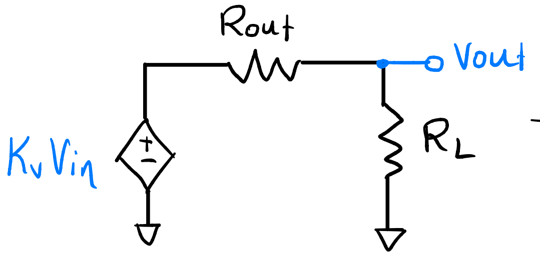
EHB 262E - Electronics II

Homework-1 Solutions

(50p)

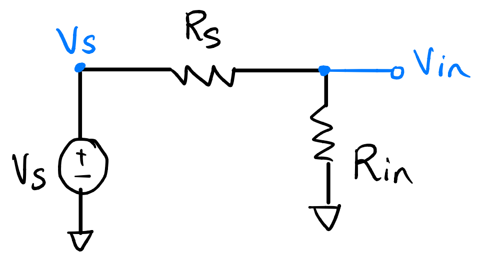
1) a) $\frac{V_{out}}{V_s} = \frac{V_{out}}{V_{in}} \times \frac{V_{in}}{V_s}$. Let's start with $\frac{V_{out}}{V_{in}}$



$\Longrightarrow$ Using resistive divider:

$$V_{out} = K_v V_{in} \frac{R_L}{R_L + R_{out}} \Rightarrow \frac{V_{out}}{V_{in}} = K_v \frac{R_L}{R_L + R_{out}}$$

Let's find $\frac{V_{in}}{V_s}$ now:



$\Longrightarrow$ Using resistive divider again:

$$V_{in} = V_s \cdot \frac{R_{in}}{R_{in} + R_s} \Longrightarrow \frac{V_{in}}{V_s} = \frac{R_{in}}{R_{in} + R_s}$$

Finally, gain equation is $\frac{V_{out}}{V_s} = \frac{R_{in}}{R_{in} + R_s} \times K_v \times \frac{R_L}{R_L + R_{out}}$

b) $\frac{V_{out}}{V_s} = \frac{1k}{1k + 10k} \times 100 \times \frac{100}{100 + 100k} \cong 0.009 \ \frac{V}{V}$

As you can see, we actually do not amplify the signal, we attenuate it. This is because R_{in} is too small and R_{out} is too large with respect to R_s and R_L, respectively. In order to get high gain, R_{in} must be large (ideally infinite) and R_{out} must be small (ideally zero). Through this course, we will see that some amplifier topologies have this characteristics.

(50p)

2) $$g_m = \frac{\partial i_C}{\partial v_{BE}}\bigg|_{v_{BE}=V_{BE,Q}} = I_S \cdot e^{\frac{v_{BE}}{V_T}} \cdot \frac{1}{V_T}\bigg|_{v_{BE}=V_{BE,Q}} = \underbrace{I_S e^{\frac{V_{BE,Q}}{V_T}}}_{I_{C,Q}} \cdot \frac{1}{V_T}$$

$$g_m = \frac{I_{C,Q}}{V_T} \longrightarrow$$

i) If we move to the left, $I_{C,Q}$ decreases and slope is less steep.

ii) If we move to the right, slope is more steep.

So, the derived equation agrees with characteristics.