Name: Key ID #

Problem #1 *(7.5points)*

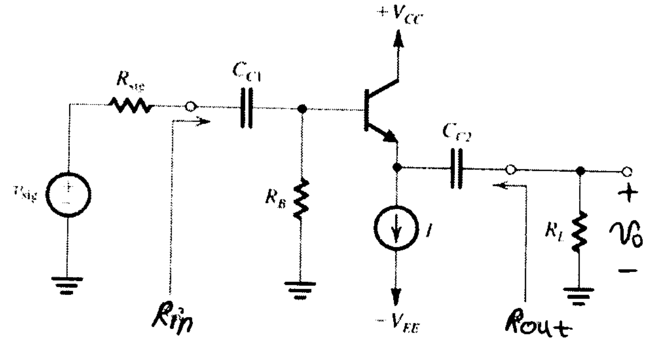
Consider the amplifier circuit shown below, R_{sig} =500Ω, R_L =475Ω, and β=100 (ignore r_o).

i. Find **expressions for R_{in}, R_{out}**, voltage gain $A_v = v_o/v_{sig}$. *4 points*

ii. Design R_B and I to have R_{in}= 25KΩ **and** R_{out}= 30Ω then, *2 points*

a. Find the voltage gain v_o/v_{sig}. *0.75points*

b. Find the maximum swing *of* v_o *(t)* without distortion (Hint: based on the most negative current allowed on R_L). *0.75points*

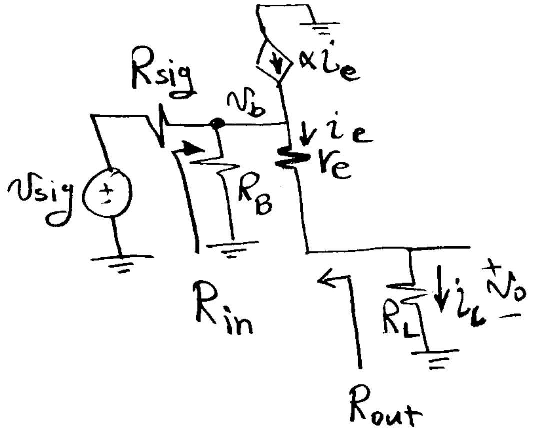


i. (*) Small Signal Analysis

T-model

$$\frac{v_o}{v_{sig}} = \frac{v_b}{v_{sig}} \cdot \frac{v_o}{v_b}$$

$$A_v = \frac{v_o}{v_{sig}} = \frac{R_{in}}{R_{in}+R_{sig}} \cdot \frac{R_L}{R_L+r_e} \quad (*)$$



$$R_{in} = R_B \,||\, [(\beta+1)(r_e+R_L)] \quad (*)(*)$$

$$R_{out} = r_e + \frac{(R_B || R_{sig})}{(\beta+1)}$$

ii.

$$R_{out} = 30\Omega = r_e + \frac{R_B || 500}{101}$$ — very small ≤ 5Ω

$$\Rightarrow r_e = 25 = \frac{V_T}{I_E} = \frac{25m}{I} \Rightarrow \underline{I = 1mA} \quad (*)$$

$$R_{in} = R_B \,||\, [101(25+475)] = R_B \,||\, 50.5K$$

$$R_{in} = 25K\Omega \Rightarrow \underline{R_B = 50K\Omega} \quad (*)(*)$$

a) $$A_v = \frac{25K}{25k+500} \cdot \frac{475}{500} = 0.93 \text{ V/V}$$

b) i_L is limitted by I in the negative cycle ⇒

maximum swing = ± I×R_L = ±0.475 V

Consider the amplifier circuit shown below, (ignore r_o)

i. Find **expressions for R_{in}, R_{out}**, voltage gain $A_v = v_o/v_{sig}$. <u>*3.5 points*</u>

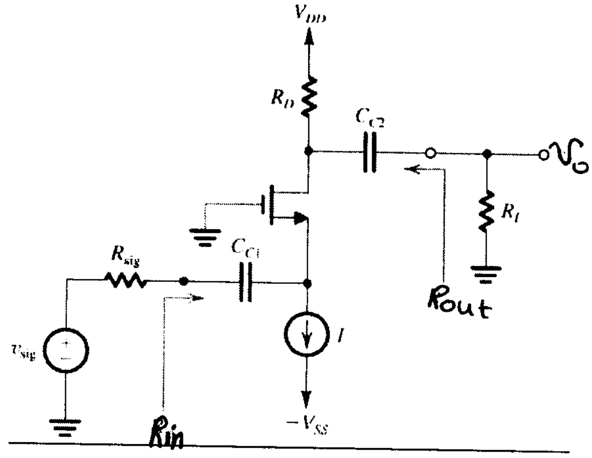
ii. Given that V_{DD}=10V, R_{sig} =500Ω, R_L =10KΩ, V_t=1V, $k'_n(W/L)$=1mA/V^2

a. Design resistors R_D and I to have $g_m = 1mA$ and V_D = 6V. <u>*2.5 points*</u>

b. Calculate voltage gain v_o/v_{sig}. <u>*0.5 points*</u>

c. Find $v_o(t)$ and $v_D(t)$ for $v_{sig}(t)$=0.2sin100t. <u>*1 points*</u>

i. small signal Analysis

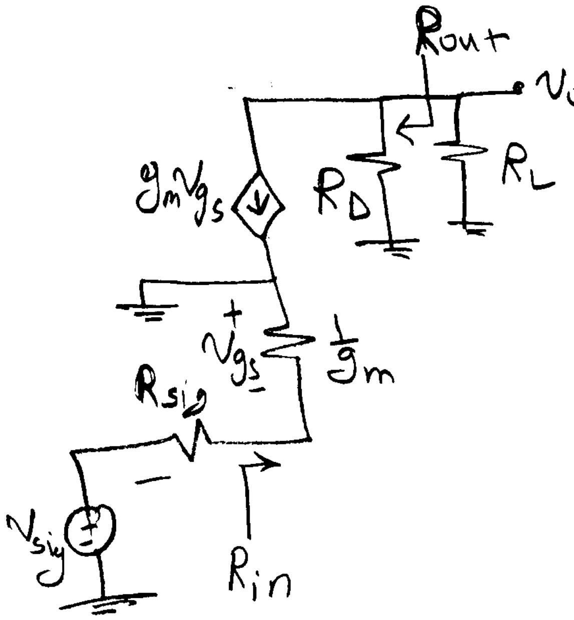


$$R_{in} = \frac{1}{g_m}$$ ✱

$$R_{out} = R_D$$ ✱✱

$$A_v = \frac{v_o}{v_{sig}} = \frac{-g_m v_{gs}(R_D \| R_L)}{-g_m v_{gs}\left(\frac{1}{g_m} + R_{sig}\right)}$$

$$= \frac{R_D \| R_L}{\frac{1}{g_m} + R_{sig}}$$ ✱✱✱



ii.

a) $g_m = K_n' \frac{W}{L}(V_{GS} - V_t) = 1mA$

$\Rightarrow$ <u>$V_{GS} = 2V$</u>

$I = I_D = \frac{1}{2} K_n' \frac{W}{L}(V_{GS} - V_t)^2$

<u>$= 0.5\ mA$</u> ✱

$$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{10-6}{0.5m} = 8K\Omega$$

b) $$\frac{v_o}{v_{sig}} = \frac{8K \| 10K}{\frac{1}{1m} + 500} = 2.96\ V/V$$

c) $v_o(t) = 2.96 \times 0.2 \sin 100t = 0.59 \sin 100t$ V

<u>$v_D(t) = V_D + v_d(t) = V_D + v_o(t) = 6 + 0.59 \sin 100t$ V</u>