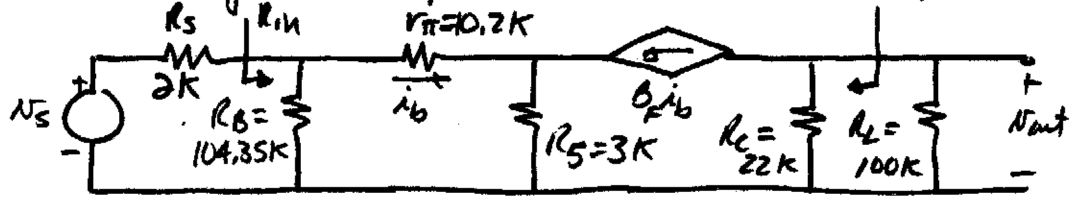
LECTURE 16

1.) Inverting CE Amplifier – Continued



$$R_{in} = R_B \,||\, [r_\pi + (1+\beta_F)R_E] = 104.35K \,||\, 313.2K = \underline{\underline{78.3k\Omega}}$$

$$R_{out} \approx R_C = \underline{\underline{22k\Omega}}$$

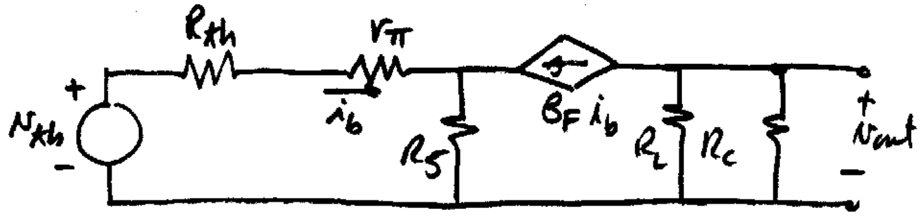
$$\frac{v_{out}}{v_S} = \left(\frac{v_{out}}{i_b}\right)\left(\frac{i_b}{v_S}\right) \qquad \frac{v_{out}}{i_b} = -g_m(R_C||R_L)$$

$$i_b = \frac{v_S}{R_S + R_{in}} \times \frac{R_B}{R_B + r_\pi + (1+\beta_F)R_E}$$

$$\therefore \frac{v_{out}}{v_S} = \frac{-\beta_F(R_C||R_L)R_B}{(R_S+R_{in})[R_B + r_\pi + (1+\beta_F)R_E]}$$

$$= \frac{-100(18.03K)(104.35K)}{(80.3K)[104.35K + 313.2K]} = \underline{\underline{-5.61 \text{ V/V}}}$$

Text: Calculates $\frac{v_{out}}{v_{th}}$ What is the difference?

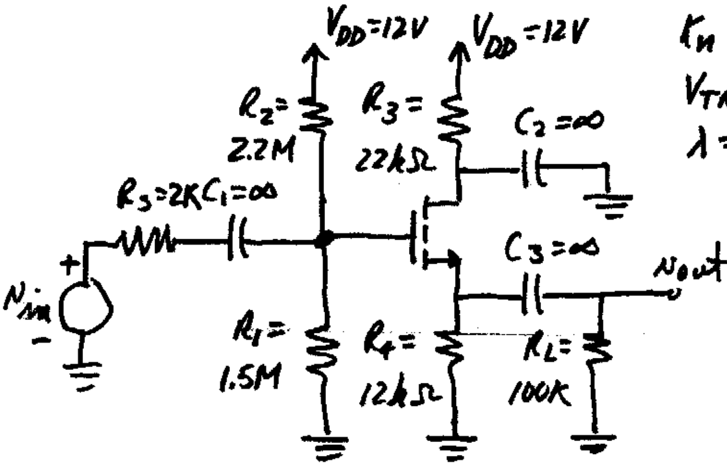


$$R_{th} = R_S || R_B = 1.96k\Omega \approx R_S$$

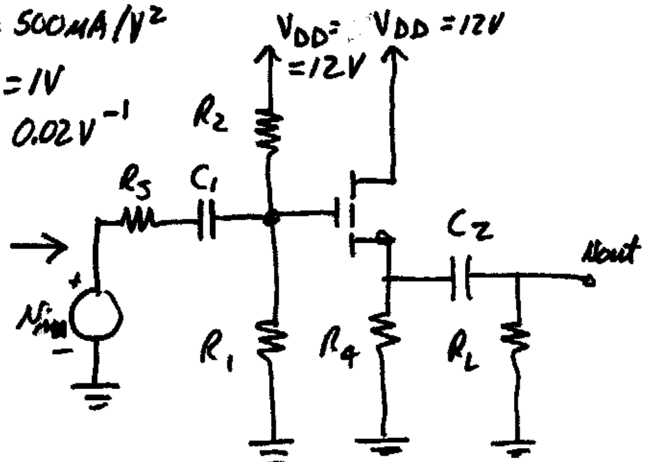
$$v_{th} = \frac{R_B}{R_S + R_B} v_S = \frac{104.35}{106.35} v_S \approx v_S$$

$$\frac{v_{out}}{v_{th}} = \frac{-\beta(R_C||R_L)}{R_{th} + r_\pi + (1+\beta_F)R_E} = \frac{-1803K}{(1.96 + 10.2 + 303)K} = -5.72 \text{ V/V}$$

2.) Common Drain Amplifier (Source Follower)



$K_n = 500\mu A/V^2$
$V_{TN}=1V$
$\lambda = 0.02V^{-1}$

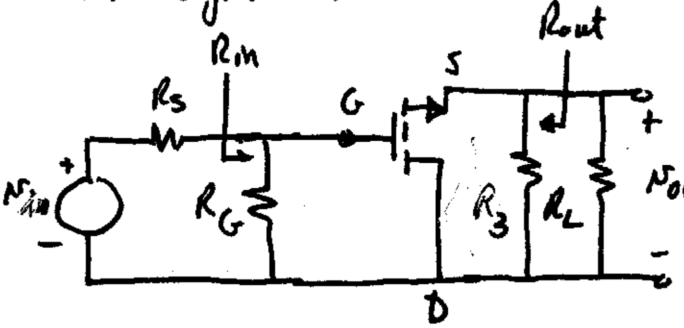


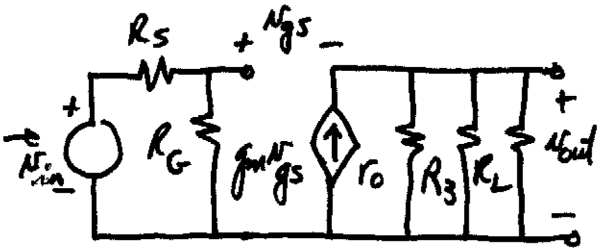
R_3 accomplishes nothing so remove it.

Q point: $I_{DS}=241\mu A$, $V_{DS}=3.81V$

Small signal model -

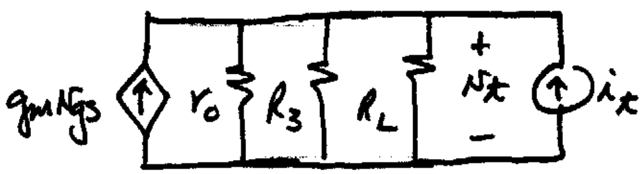
$R_G = R_1 \| R_2 = 892k\Omega$





$$g_m = \sqrt{2K_n I_{DS}(1+\lambda V_{DS})} = 509\mu S \qquad r_o = \frac{\frac{1}{\lambda}+V_{DS}}{I_{DS}} = 223k\Omega$$

$\therefore R_{in} = R_G = \underline{\underline{892k\Omega}}$ $\qquad R_{out}=?$ Be careful, consider the following



$$R_{out} = \left.\frac{v_x}{i_x}\right|_{v_{in}=0}$$

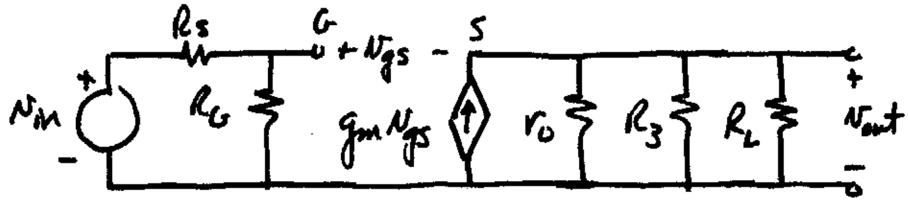
$$\Sigma i=0 \rightarrow \quad -g_m v_{gs} + g_o v_x + G_3 v_x + G_L v_x = i_x$$

But $v_{gs} = v_g - v_s = 0 - v_s$ (because the input, $v_{in}=0$)

$$\therefore \frac{v_x}{i_x} = \frac{1}{g_m + g_o + G_3 + G_L} \approx \frac{1}{g_m} = \underline{1.96K\Omega} \quad (1.76K\Omega \text{ otherwise})$$

2.) CD Amplifier - Cont'd

Find $\frac{v_{out}}{v_{in}}$ -



$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_{in}}\right) = \left[g_m(r_o \| R_3 \| R_L)\right]\left[\,?\,\right]$$

$$v_{gs} = v_g - v_s = \left(\frac{R_G}{R_S+R_G}\right)v_{in} - g_m v_{gs}(r_o \| R_3 \| R_L)$$

$$v_{gs}\left[1 + g_m(r_o \| R_3 \| R_L)\right] = \left(\frac{R_G}{R_S+R_G}\right)v_{in}$$

$$\therefore \frac{v_{gs}}{v_{in}} = \frac{\frac{R_G}{R_S+R_G}}{1+g_m(r_o \| R_3 \| R_L)}$$

$$\frac{v_{out}}{v_{in}} = \left(\frac{R_G}{R_S+R_G}\right)\frac{g_m(r_o \| R_3 \| R_L)}{1+g_m(r_o \| R_3 \| R_L)} = \left(\frac{892}{894}\right)\left(\frac{30.5}{1+30.5}\right) = \underline{\underline{0.966\ V/V}}$$