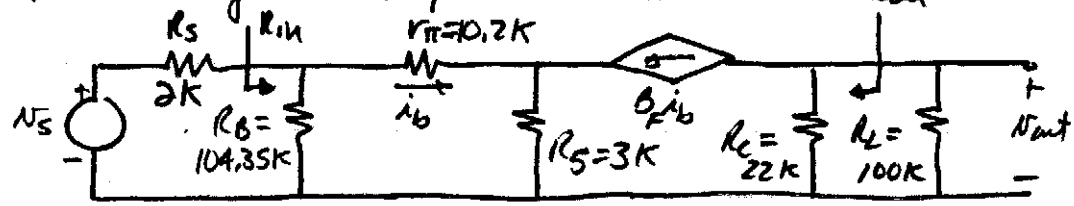
LECTURE 16

1.) Inverting CE Amplifier – Continued



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

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

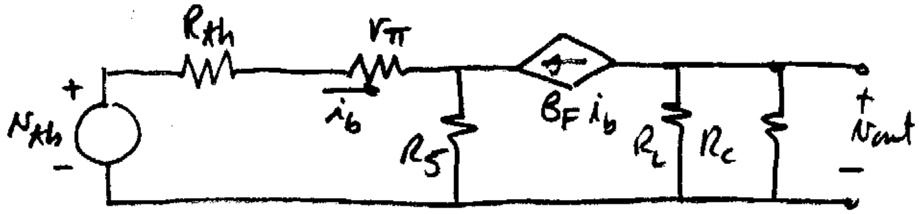
$$\frac{v_{out}}{v_s} = \left(\frac{v_{out}}{i_b}\right)\left(\frac{i_b}{v_s}\right) \qquad \frac{v_{out}}{i_b} = -g_m(R_c \| R_L)$$

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

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

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

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

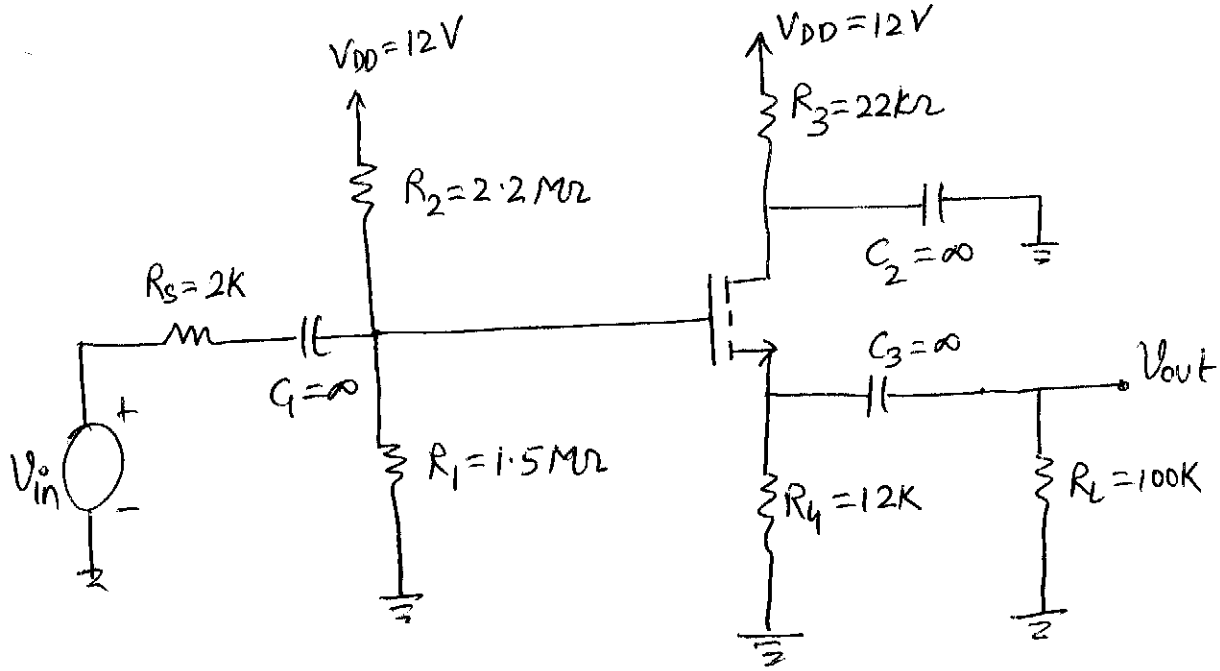


$$R_{th} = R_s \| R_B = 1.96k\Omega \approx R_s$$

$$v_{th} = \frac{R_B}{R_s + R_B} v_s = \frac{104.35}{106.35} v_s \approx v_s$$

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

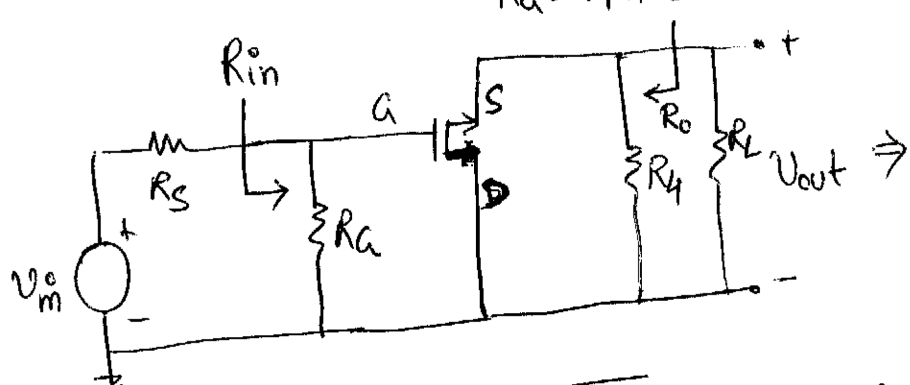
Common Drain Amplifier (Source follower)



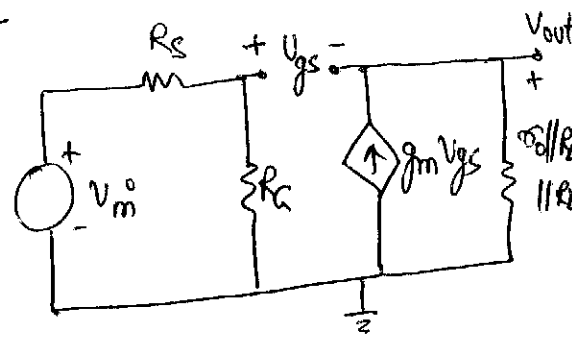
Q point ⇒ $I_{DS} = 241\ \mu A$, $V_{DS} = 3.81\ V$

Small-signal model

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



⇒



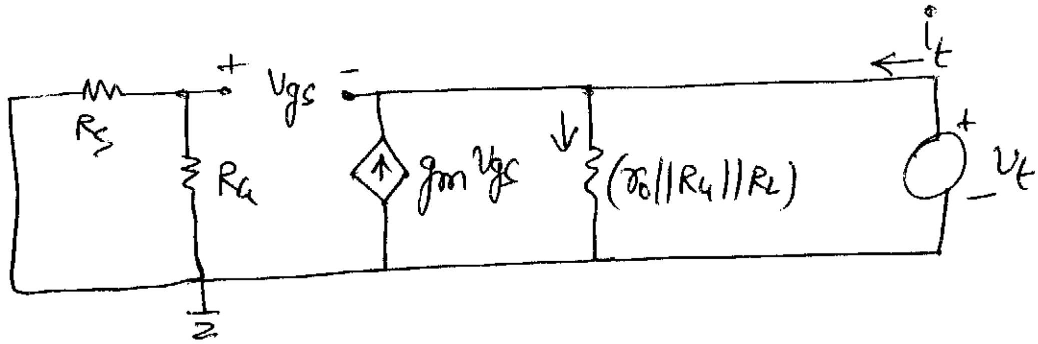
$g_m = \sqrt{2 k_n I_{DS} (1 + \lambda V_{DS})} = 509\ \mu S$; $r_o = \dfrac{\frac{1}{\lambda} + V_{DS}}{I_{DS}} = 223 K\Omega$

Rin

$R_{in} = R_G = 892\ K\Omega$.

Rout = ??

Rout



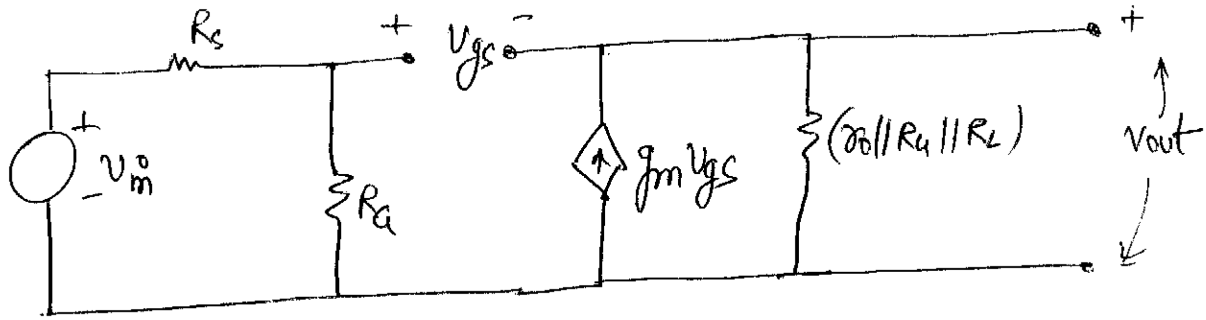
$$v_g = 0, \quad v_s = v_t \Rightarrow v_{gs} = -v_t$$

$$g_m v_{gs} + i_t = \frac{V_t}{(r_o || R_4 || R_L)} = V_t \left(\frac{1}{r_o} + \frac{1}{R_4} + \frac{1}{R_L} \right)$$

or, $$-g_m V_t + i_t = V_t \left(\frac{1}{r_o} + \frac{1}{R_4} + \frac{1}{R_L} \right)$$

or $$R_{in} = \frac{V_t}{i_t} = \frac{1}{\left(g_m + \frac{1}{r_o} + \frac{1}{R_4} + \frac{1}{R_L} \right)} \cong \frac{1}{g_m} = 1.96\,k\Omega$$

$$\frac{V_{out}}{V_{in}} = ??$$



$$\frac{V_{out}}{V_{in}} = \left(\frac{V_{out}}{V_{gs}}\right)\left(\frac{V_{gs}}{V_{in}}\right)$$

$$\left(\frac{V_{out}}{V_{gs}}\right) = \left\{ g_m \cdot (r_o \| R_4 \| R_L) \right\}$$

$$\left(\frac{V_{gs}}{V_{in}}\right) = ??$$

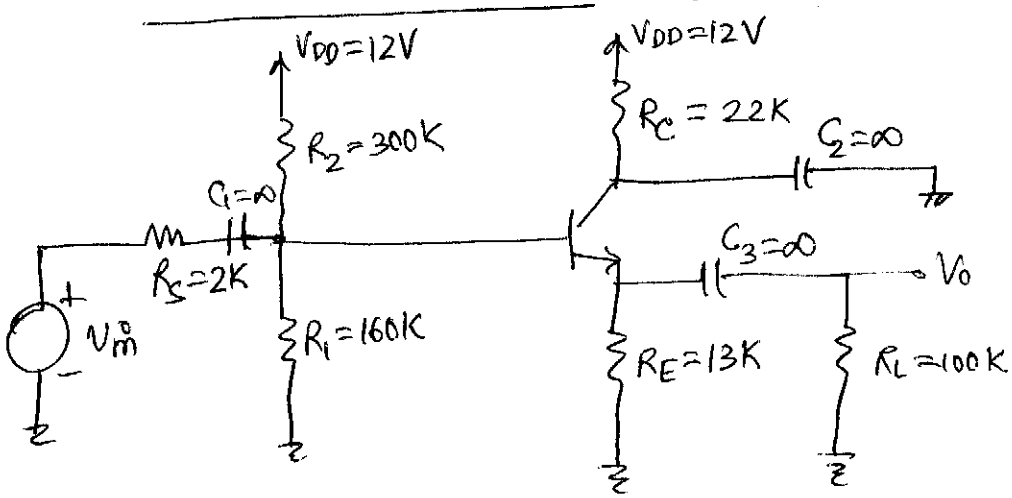
$$V_{gs} = V_g - V_s = \left(\frac{R_G}{R_G + R_S}\right) V_{in} - \left\{ g_m V_{gs} (r_o \| R_4 \| R_L) \right\}$$

$$V_{gs} \left[1 + g_m (r_o \| R_4 \| R_L) \right] = \frac{R_G}{(R_G + R_S)} \cdot V_{in}$$

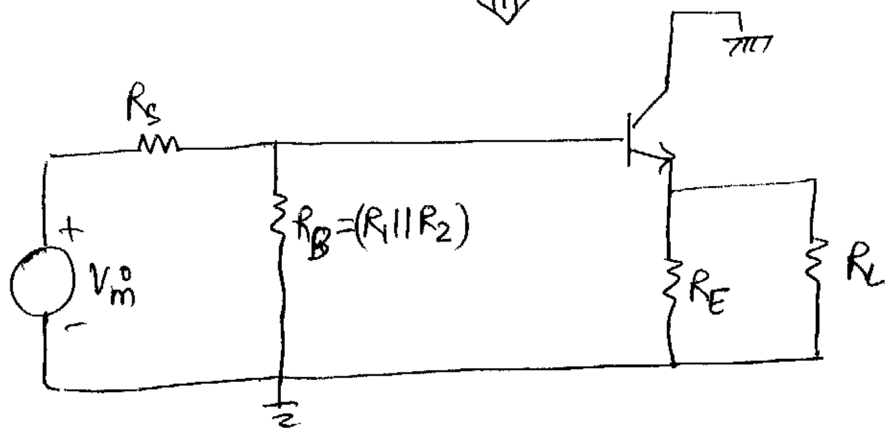
$$\frac{V_{gs}}{V_{in}} = \frac{R_G}{(R_S + R_G)\ \left\{ 1 + g_m (r_o \| R_4 \| R_L) \right\}}$$

$$\frac{V_{out}}{V_{in}} = \left(\frac{R_G}{R_S + R_G}\right) \cdot \left[\frac{g_m (r_o \| R_4 \| R_L)}{1 + g_m (r_o \| R_4 \| R_L)} \right] = 0.837.$$

Common Collector (Emitter Follower)



⇓



$R_B = R_1||R_2 = 104.35K$

Q point:

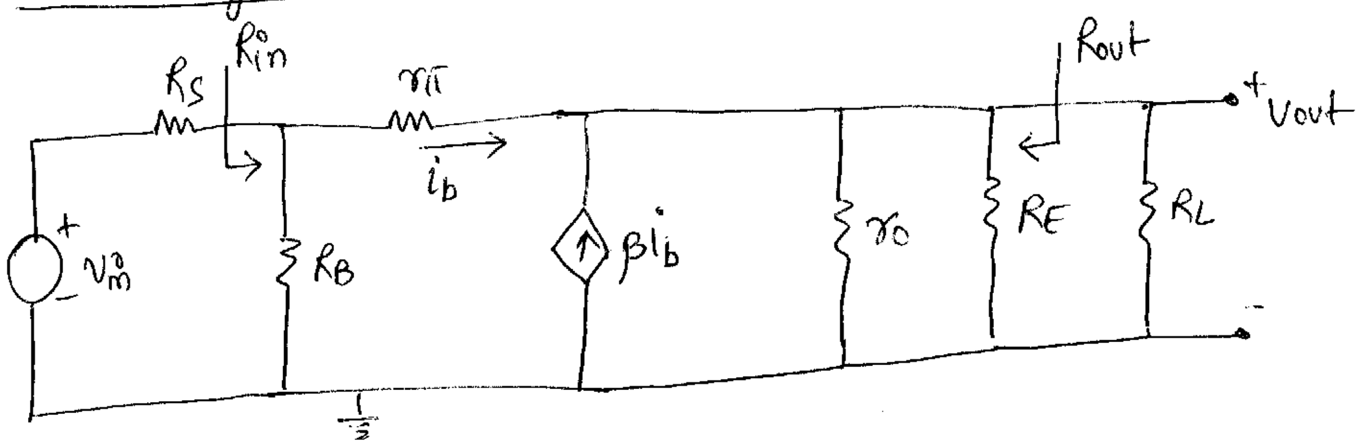
$I_C = 245\,\mu A$

$V_{CE} = 3.64V$

$g_m = \frac{I_C}{V_t} = 9.8mS; \quad r_\pi = \frac{\beta_F}{g_m} = 10.2K\Omega$

$r_o = \frac{V_A + V_{CE}}{I_C} = \frac{103.64}{245\,\mu A} = 423K\Omega$

Small-signal model



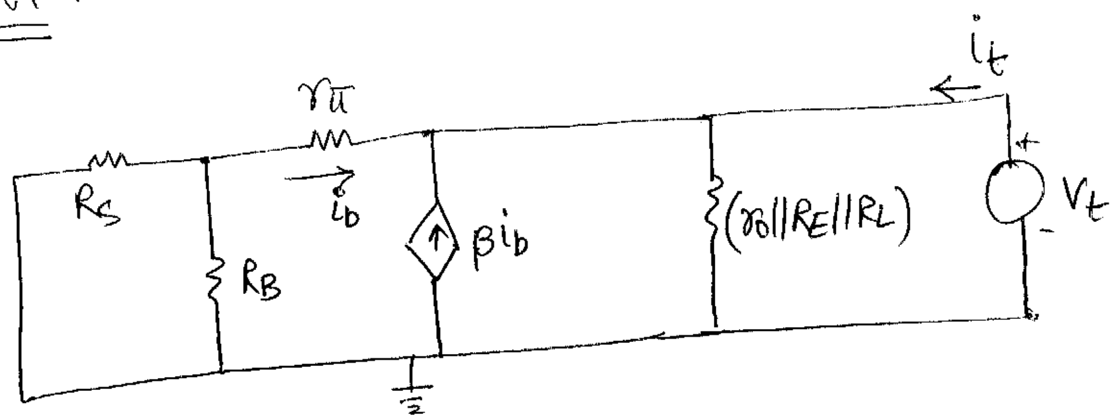
R_{in}

$$R_{in} = R_B \| \{ r_\pi + (1+\beta_F)(r_o \| R_E \| R_L) \}$$

$$= 104.35K \| \{ 10.2K + (101)(11.2K) \}$$

$$= \underline{95.6 K\Omega}$$

R_{out}



$$i_t + i_b + \beta_F i_b = \frac{V_t}{(r_o \| R_E \| R_L)}$$

$$i_t + (1+\beta_F) i_b = V_t \left(\frac{1}{r_o} + \frac{1}{R_E} + \frac{1}{R_L} \right)$$

$$i_b = - \frac{V_t}{\{ r_\pi + (R_S \| R_B) \}}$$

$$i_t - \frac{(1+\beta_F) V_t}{\{ r_\pi + (R_S \| R_B) \}} = V_t \left(\frac{1}{r_o} + \frac{1}{R_E} + \frac{1}{R_L} \right)$$

$$i_t = V_t \left[\frac{1}{r_o} + \frac{1}{R_E} + \frac{1}{R_L} + \frac{(1+\beta_F)}{\{ r_\pi + (R_S \| R_B) \}} \right]$$