

LECTURE - 15

1.) Signal flow in transistors.

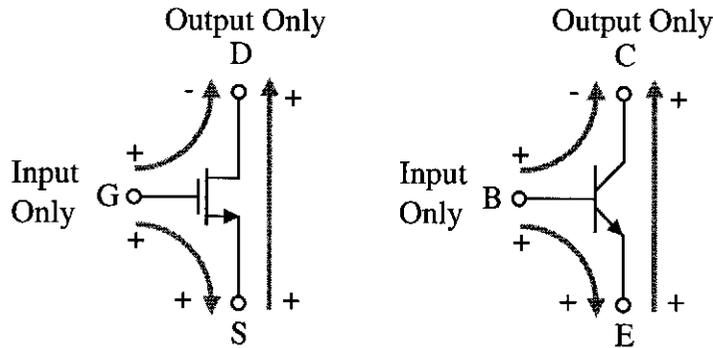
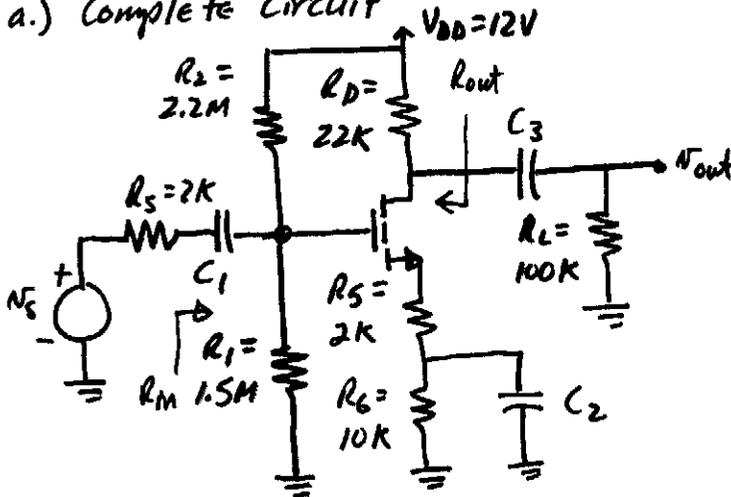


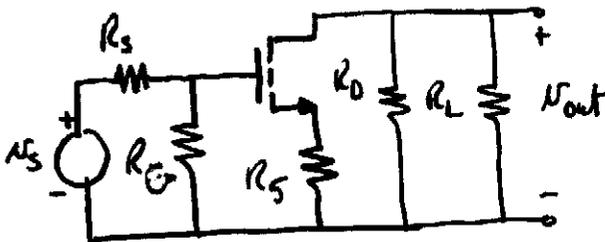
Fig. 4.3-12B

2.) Inverting Amplifiers - Common Source

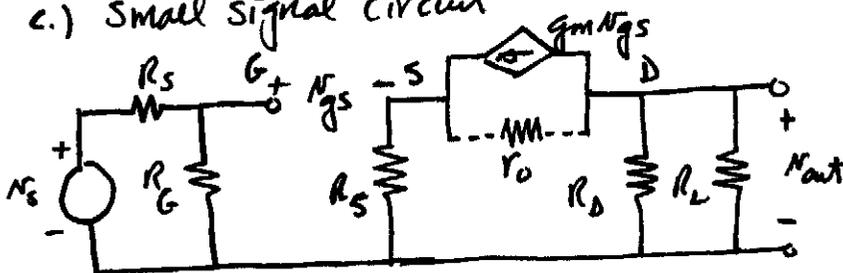
a.) Complete circuit



b.) AC circuit



c.) Small signal circuit



Inverting Amplifiers - CS - Continued

d.) Small-signal calculations -

$$\frac{N_{out}}{N_s} = \left(\frac{N_{out}}{N_{gs}}\right) \left(\frac{N_{gs}}{N_g}\right) \left(\frac{N_g}{N_s}\right)$$

Assume r_o can be neglected -

$$\frac{N_{out}}{N_{gs}} = -g_m(R_D \parallel R_L), \quad \frac{N_g}{N_s} = \frac{R_G}{R_S + R_G}, \quad \frac{N_{gs}}{N_g} = ?$$

$$N_{gs} = N_g - N_s = N_g - g_m N_{gs} R_S \rightarrow \frac{N_{gs}}{N_g} = \frac{1}{1 + g_m R_S}$$

$$\therefore \frac{N_{out}}{N_s} = \frac{-g_m(R_D \parallel R_L)}{1 + g_m R_S} \frac{R_G}{R_S + R_G} \quad R_G = R_1 \parallel R_2 = 0.892 \text{ M}\Omega$$

e.) Assume $K_n = 500 \mu\text{A/V}^2$, $V_{TN} = 1\text{V}$ and $\lambda = 0.02 \text{V}^{-1}$. Evaluate the gain. Solving the dc circuit gives $I_{D_S} = 241 \mu\text{A}$, $V_{D_S} = 3.81\text{V}$ and $V_{G_S} = 1.982\text{V}$.

$$g_m = \sqrt{2K_n I_{D_S} (1 + \lambda V_{D_S})} = \sqrt{2 \cdot 500 \cdot 241 (1 + \frac{3.81}{50})} = 509 \mu\text{S}$$

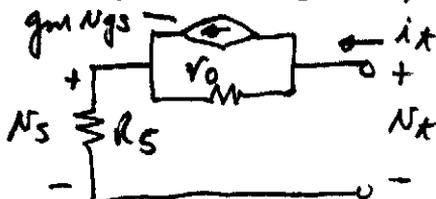
$$r_o = \frac{1}{\lambda + V_{D_S}} = \frac{50 + 3.81\text{V}}{241 \mu\text{S}} = 223 \text{ k}\Omega$$

$$\therefore \frac{N_{out}}{N_s} \approx \frac{(-509 \mu\text{S})(22 \text{ k}\Omega \parallel 100 \text{ k}\Omega)}{1 + (509 \mu\text{S})(2 \text{ k}\Omega)} \left(\frac{892}{894}\right) = \frac{-9.178}{2.018} \left(\frac{892}{894}\right) = \underline{\underline{-4.54 \text{ V/V}}}$$

f.) R_{in} and R_{out}

$$R_{in} = R_G \quad \text{and} \quad R_{out} = R_D \quad \text{if} \quad r_o = \infty$$

What if $r_o \neq \infty$?



$$N_x = (i_x - g_m N_{gs}) r_o + i_x R_S$$

$$\text{but } N_{gs} = N_g - N_s = 0 - N_s = -i_x R_S$$

$$\therefore N_x = i_x [r_o + R_S + g_m r_o R_S] \rightarrow R_x = \frac{N_x}{i_x}$$

$$N_g = 0 \text{ because } N_s = 0 \leftarrow \text{Very important} \quad R_{out} = R_D \parallel R_x$$

Inverting CS Amplifier - Cont'd

f.) Evaluate R_{in} and R_{out}

$R_{in} = R_G = \underline{892\text{K}\Omega}$ $R_{out}(r_o = \infty) = \underline{22\text{K}\Omega}$

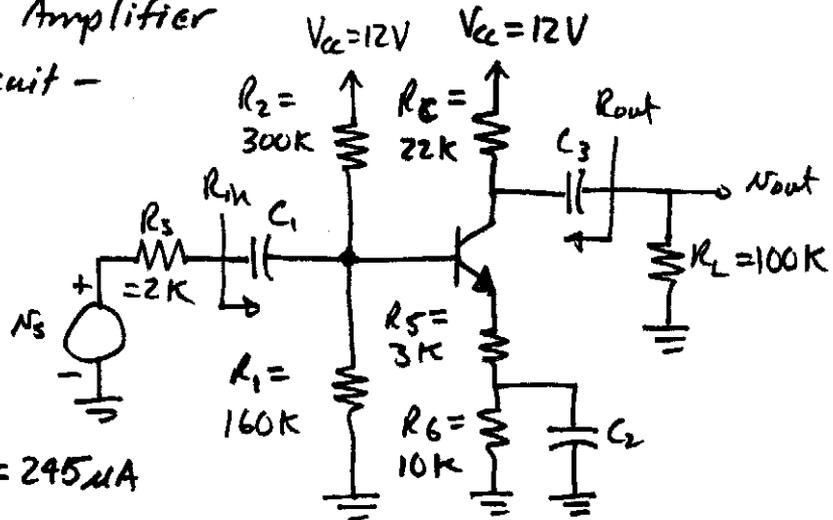
$R_x = r_o + R_S + g_m r_o R_S = 223\text{K} + 2\text{K} + (509)(0.223)2\text{K}$
 $= 225\text{K} + 227\text{K} = 452\text{K}\Omega$

$\therefore R_{out}(r_o \neq \infty) = 22\text{K} \parallel 452\text{K} = \underline{20.98\text{K}\Omega}$ (Not worth the effort)

3) Inverting CE Amplifier

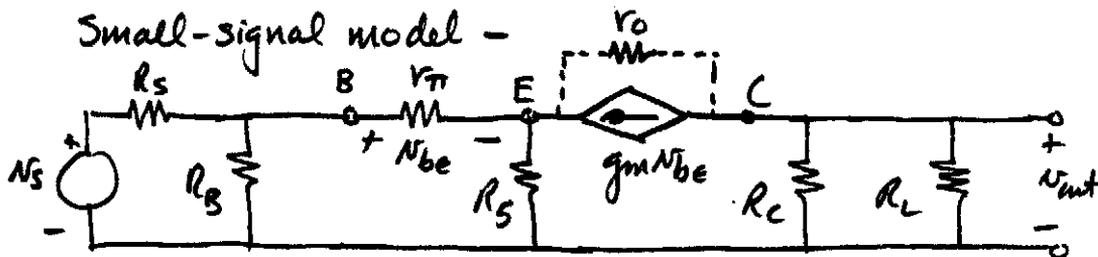
Complete circuit -

$\beta_F = 100$
 $V_A = 50\text{V}$



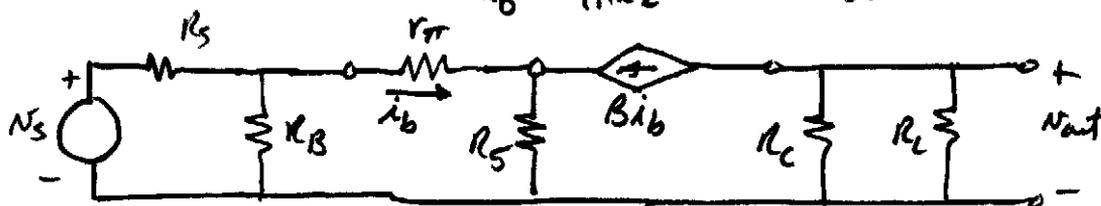
Q-point: $I_C = 245\mu\text{A}$
 $V_{CE} = 3.64\text{V}$

Small-signal model -



OR

$R_B = R_1 \parallel R_2 = 104.35\text{K}\Omega$



$g_m N_{be} = g_m r_{\pi} i_b = \beta_F i_b$

$r_{\pi} = \frac{\beta_F}{g_m} = \frac{V_T \beta_F}{I_C} = \frac{25}{.245} 100 = 10.2\text{K}\Omega$