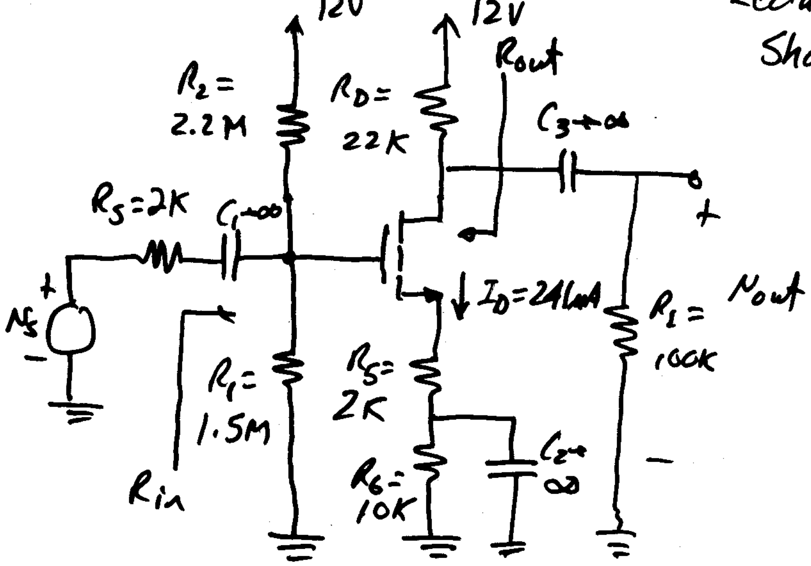
Common Source Example

2/16 → 2/20
Lecturer will be
Shakeel.



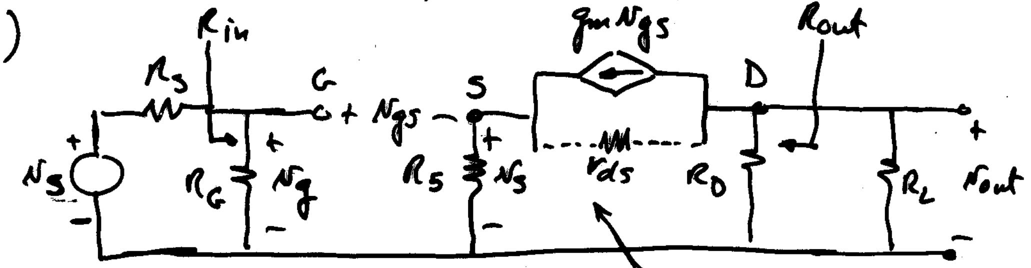
$V_{DS} = 3.81V$
$V_{GS} = 1.982V$
$k_n = 500uA/V^2$
$V_{TN} = 1V$
$\lambda = 0$

$\lambda = 0.02$

1.) $g_m = \sqrt{2 K_n I_{DS}} = \sqrt{2 \cdot 500 \cdot 241} \cong 500uS$ $(509uS)$

$r_{ds} = \infty$ $(223K\Omega)$

2.)



A good simplification

$R_G = R_1 || R_2 = 0.892M\Omega$

$R_{in} = R_G = 892k$

$R_{out} = R_D = 22K\Omega$

$R_{out}(r_{ds} \neq \infty) = 20.98\,k\Omega$

$\frac{v_{out}}{v_s} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_s}\right)$

"v_{ab} trick" → $v_{ab} = v_a - v_b$

$\frac{v_{out}}{v_{gs}} = -g_m (R_D || R_L)$, $\frac{v_{gs}}{v_s} = ?$

$v_{gs} = v_g - v_s$

Note that $v_s = g_m R_S v_{gs}$

If we let

$\frac{v_{gs}}{v_s} = \left(\frac{v_{gs}}{v_g}\right)\left(\frac{v_g}{v_s}\right)$

$v_{gs} = v_g - g_m R_S v_{gs}$

$v_{gs}(1 + g_m R_S) = v_g$

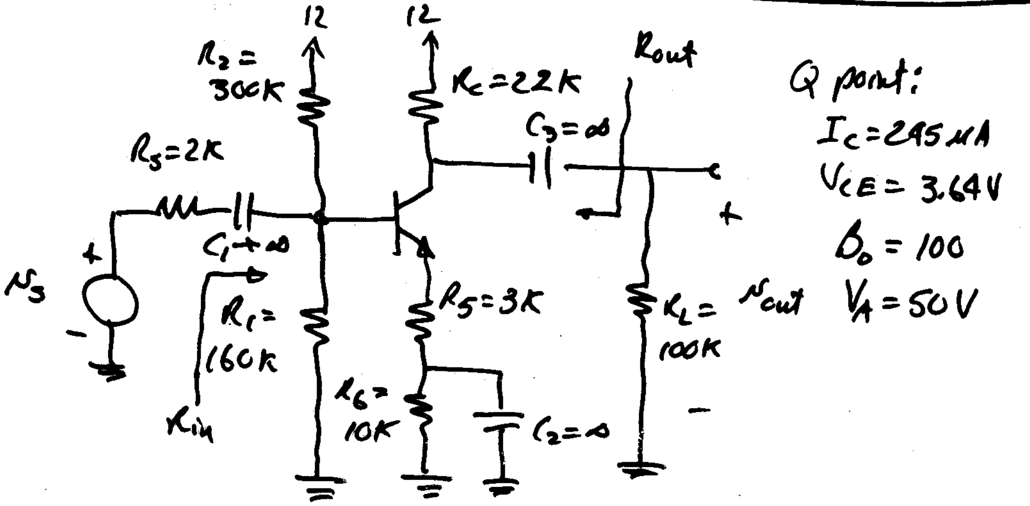
Cont'd -

$$\frac{v_{gs}}{v_o} = \left(\frac{1}{1+g_m R_S}\right)\left(\frac{R_G}{R_S+R_G}\right)$$

$$\therefore \quad \frac{v_{out}}{v_s} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_g}\right)\left(\frac{v_g}{v_s}\right) = \frac{-g_m (R_D \| R_L) R_G}{(1+g_m R_S)(R_G+R_S)}$$

$$\frac{v_{out}}{v_s} = \frac{\overset{509}{(-500\mu S)}(22K\|100K)}{1+(500\mu S)(2K)}\left(\frac{892}{894}\right) = -4.54\ \frac{V}{V}$$

Common Emitter Amplifier with Emitter Degeneration



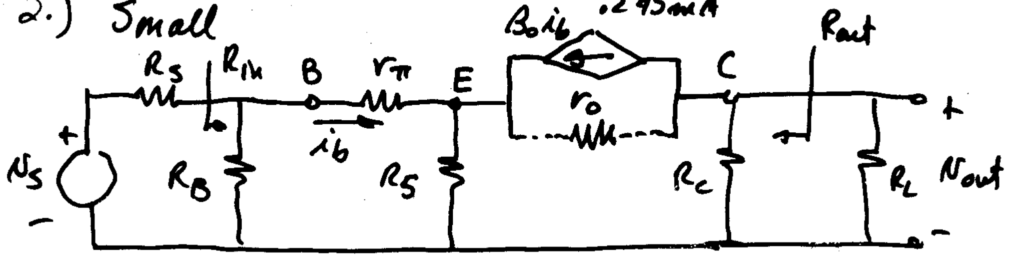
Q point:
$I_c = 245\mu A$
$V_{CE} = 3.64V$
$\beta_o = 100$
$V_A = 50V$

1.) SS model parameters

$$r_\pi = \frac{\beta_o}{g_m} = \frac{\beta_o V_t}{I_c} = \frac{100 \cdot 25mV}{0.245mA} = 10.2k\Omega$$

$$r_o = \frac{V_A + V_{CE}}{I_c} \dashrightarrow \infty \qquad \frac{53V}{.245mA} \approx 100k\Omega$$

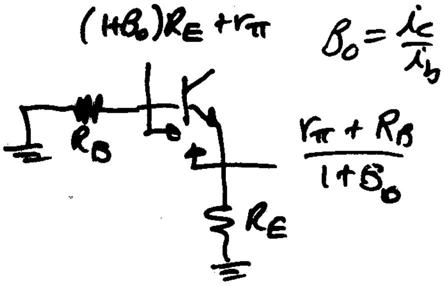
2.) Small



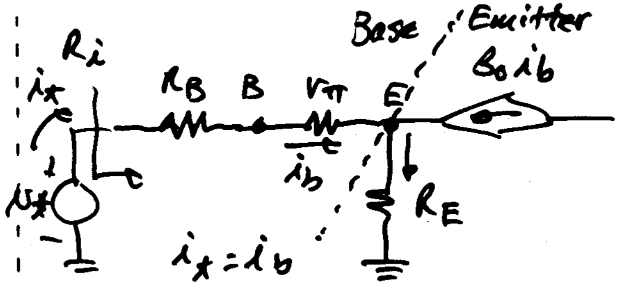
$R_B = R_1 \| R_2 = 104.35k\Omega$

BJT Example - Cont'd

$$R_{in} = R_B \| \left[r_\pi + (1+\beta_o) R_S \right]$$



$\beta_o = \frac{i_c}{i_b}$

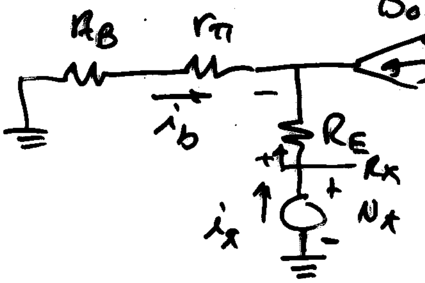


Impedance transformation

$i_x = i_b$

$$v_x = i_b \left[R_B + r_\pi + R_E(1+\beta_o) \right]$$

$$\therefore \boxed{R_i = \frac{v_x}{i_x} = \frac{v_x}{i_b} = R_B + r_\pi + R_E(1+\beta_o)}$$



$$R_x = \frac{v_x}{i_x} = ?$$

$$v_x = -(1+\beta_o) i_b R_E - i_b (r_\pi + R_B)$$

$$v_x = -i_b \left[r_\pi + R_B + (1+\beta_o) R_E \right]$$

$$= -i_b \frac{(1+\beta_o)}{(1+\beta_o)} \left[r_\pi + R_B + (1+\beta_o) R_E \right] = i_x \left[R_E + \frac{r_\pi + R_B}{1+\beta_o} \right]$$

$$\therefore \frac{v_x}{i_x} = R_x = R_E + \frac{r_\pi + R_B}{1+\beta_o}$$

Base-Emitter Impedance Reflection Principle:

1. Resistance looking into the base is r_π plus $(1+\beta_o)$ times the resistance from the emitter to ground.
2. Resistance looking into the emitter is r_π plus the resistance from the base to ground, both divided by $(1+\beta_o)$