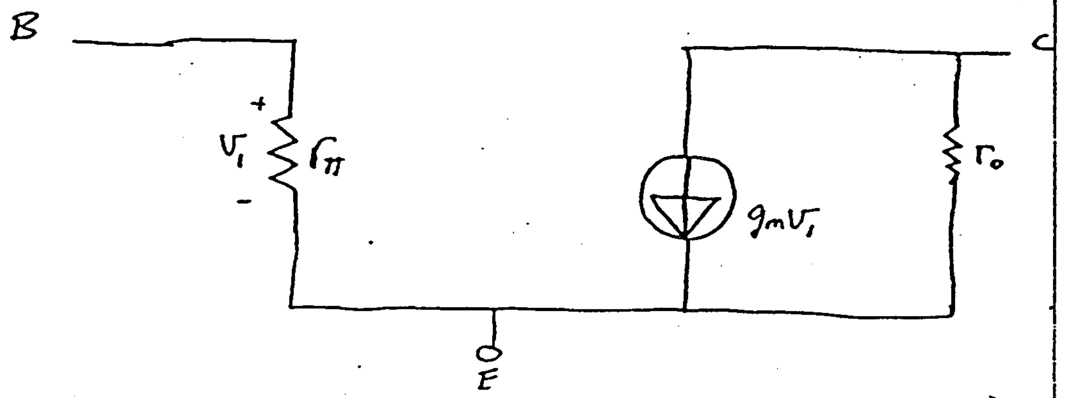
EEC 114
HW #2

1) SMALL SIGNAL MODEL Neglecting $r_b$, $r_c$, $r_{ex}$:

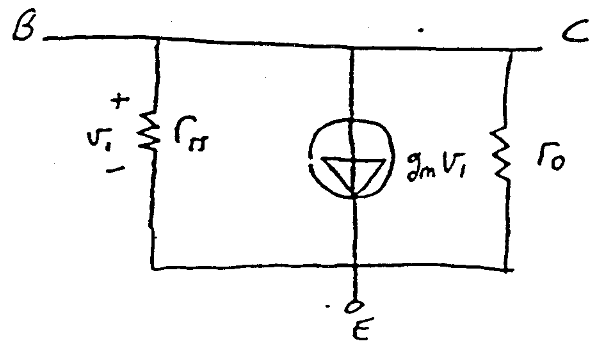



where $r_\pi = \beta/g_m \cong \frac{200}{g_m}$ (Assuming $\beta_o \approx 200$)

$r_o = \frac{1}{\eta g_m} \cong \frac{5\times10^3}{g_m}$ (From fig 2.23 $\eta = 2\times10^{-4}$)

$g_m = \frac{I_C}{V_T}$

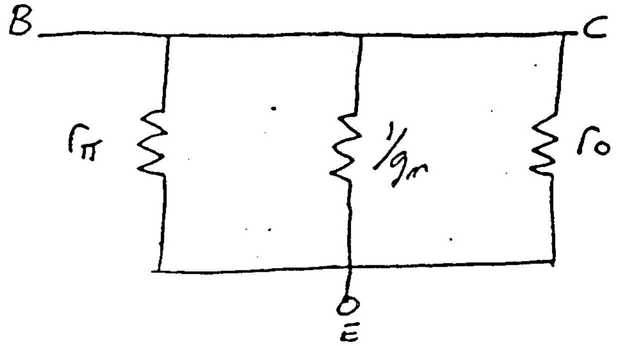
NOW WHEN CONNECTING the BASE TO the Collector:




IT SHOULD Be NOTED that the VOLTAGE CONTROLLED CURRENT SOURCE IS CONTROLLED BY A VOLTAGE ACROSS ITS OWN TERMINALS, IT CAN then Be Replaced BY A RESISTOR OF VALUE $1/g_m$. (NOTE: $I_{current\ source} = g_m V_1$ →

Then $g_m = \dfrac{I_{\text{current source}}}{V_1}$ or $\dfrac{1}{g_m} = \dfrac{V_1}{I_{\text{current source}}} =$ Resistance!! ).

So now the circuit looks like the one Below:




Now as mentioned Before: $r_\pi = \beta/g_m \approx \dfrac{200}{g_m}$

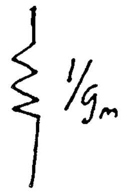
$r_o = \dfrac{1}{\eta g_m} \approx \dfrac{5000}{g_m}$

Well, the equivilant Resistance of the circuit is $r_\pi \| r_o \| 1/g_m = r_\pi \| (r_o \| 1/g_m)$

$$r_o \| \frac{1}{g_m} = \frac{\frac{5000}{g_m} \cdot \frac{1}{g_m}}{\frac{5000}{g_m} + 1/g_m} = \frac{5000/g_m^2}{\frac{5001}{g_m}} = \frac{5000}{5001 g_m} \approx \frac{1}{g_m}.$$ This is true

since $r_o >> \frac{1}{g_m}$. The same is true for $r_\pi$, since $r_\pi >> 1/g_m$

The equivilant resistance of the circuit can ignore $r_\pi$ and $r_o$. Our circuit becomes




2a) IF $R_2 = 100 R_1$

For


$R_{eq} = \dfrac{R_1 R_2}{R_1 + R_2} = \dfrac{100 R_1^2}{101 R_1} = \dfrac{100}{101} R_1 \Leftarrow$ Actual Approx $\Rightarrow R_1$

$\text{Error} = \dfrac{|\text{Actual} - \text{Approx}|}{\text{Actual}}$ Error $= \dfrac{\left|\frac{100}{101} R_1 - R_1\right|}{\frac{100}{101} R_1} = \dfrac{R_1/101}{\frac{100 R_1}{101}} = \dfrac{1}{100} = \boxed{.01 = 1\%}$

2 b) $R_2 = 10R_1$ , CALCULATE ERROR IF $R_1 \| R_2 \approx R_1$

well ACTUAL VALUE IS $\frac{R_2 R_1}{R_2 + R_1} = \frac{10 R_1^2}{11 R_1} = \underline{\frac{10}{11} R_1}$

SO ERROR $= \frac{\left|\frac{10}{11}R_1 - R_1\right|}{\frac{10}{11}R_1} = \frac{\frac{1}{11}R_1}{\frac{10}{11}R_1} = \frac{1}{10} = \boxed{.1 \text{ or } 10\%}$

2 c) $R_2 = R_1$ CALCULATE ERROR IF $R_1 \| R_2 \approx R_1$

Well ACTUAL VALUE IS $\frac{R_1 R_2}{R_1 + R_2} = \frac{R_1^2}{2R_1} = \frac{1}{2}R_1$.

SO ERROR $= \frac{\left|\frac{1}{2}R_1 - R_1\right|}{\frac{1}{2}R_1} = \frac{\frac{1}{2}R_1}{\frac{1}{2}R_1} = \boxed{1 \text{ or } 100\%}$

---

3) $L = 200\mu$
$W = 5\mu$

$$R = \frac{L}{W} R_\square$$

For emitter diffused: $R_\square = 5\Omega/\square$

SO $R = \frac{200\mu}{5\mu} 5 = \underline{200\Omega}$

For BASE Diffused: $R_\square = 100\Omega/\square$

$R = \frac{200\mu}{5\mu} 100\Omega/\square = \underline{4K\Omega}$

For pinch resistor = $R_\square = 5k\Omega/\square$

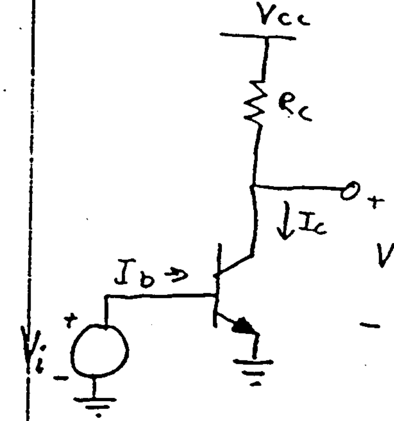
$R = \frac{200\mu}{5\mu} \times 5 k\Omega/\square = 200k\Omega$.

4) Find $R_{IN}$, $g_m$, $R_o$ of the CE Amplifier

IF $R_C = 20k\Omega$

$I_C = 250\mu A$

Assume $r_b = 0$.




$$G_m = g_m = \frac{I_C}{V_T} = \frac{250\mu A}{26mV} = \underline{9.62 mA/V}$$

USING Fig 2.30:

$\beta_o = 200$

$$R_{IN} = r_\pi = \frac{\beta_o}{g_m} = \frac{200}{9.62mA/V} = \underline{20.8 k\Omega}$$

$$R_o = r_o \parallel R_C \qquad r_o = \frac{1}{\eta g_m} = \frac{1}{(2\times10^{-4})(9.62 mA/V)}$$

$\eta \rightarrow 2\times10^{-4}$ (From Fig 2.30)

$$r_o = 519.7K$$

$$R_o = \frac{(519.7k)(20.0k)}{(20.0k)+(519.7k)} \cong \underline{20k}$$

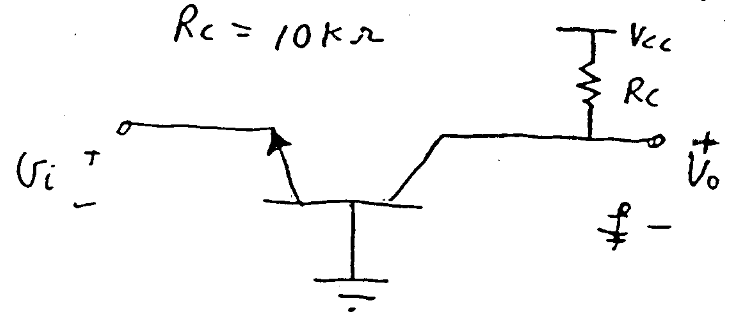
5) Find $R_{in}$, $G_m$, $R_o$

$I_C = 250\mu A$

$R_C = 10k\Omega$

Neglect $r_b$, $r_o$

From Fig. 2.30, $\beta_o = 200$



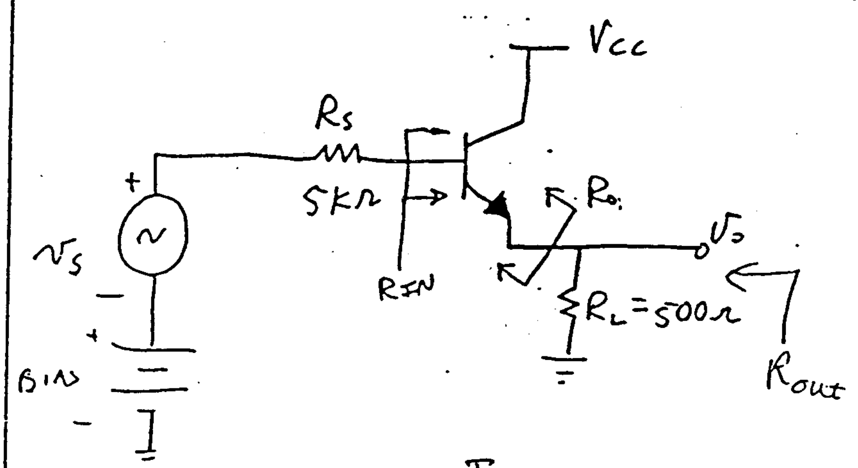

Now $$G_m = g_m = \frac{250\mu A}{26mV} = \underline{9.62 mA/V}$$

$$R_{IN} = \frac{\alpha_o}{g_m} = \frac{\beta_o/(\beta_o+1)}{g_m} = \frac{200}{(201)\,9.62\frac{mA}{V}} = \underline{103\Omega}$$

5 (cont)

$$R_{OUT} = R_C = 10k\Omega$$

6. Find $R_{IN}$, $v_o/v_s$ (Voltage Gain), $R_O$ for the Common Collector Amplifier




$I_C = 1mA$
$\beta_o = 200$

$$g_m = \frac{I_C}{V_T} = \frac{1mA}{26mV} = \underline{38.5mA/V}$$

$$r_\pi = \frac{\beta_o}{g_m} = \frac{200}{38.5mA/V} = \underline{5.2k\Omega}$$

$$R_{IN} = r_\pi + (1+\beta_o)R_L = 5.2k\Omega + (201)(500)$$
$$= \underline{\underline{105.7k\Omega}}$$

$$\frac{v_o}{v_s} = \frac{1}{1+\frac{r_\pi + R_S}{(\beta_o+1)R_L}} = \frac{1}{1+\frac{(5.2K)+5K}{(201)500}} = \underline{\underline{.908}}$$

$$R_o = \frac{R_s + r_\pi}{1+\beta_o} = \frac{5.2K + 5K\Omega}{201} = 50.7\Omega$$

- Including $R_L$

$$R_{out} = R_o // R_L = \frac{(50.7)(500)}{50.7+500} = \underline{\underline{46.1\Omega}}$$