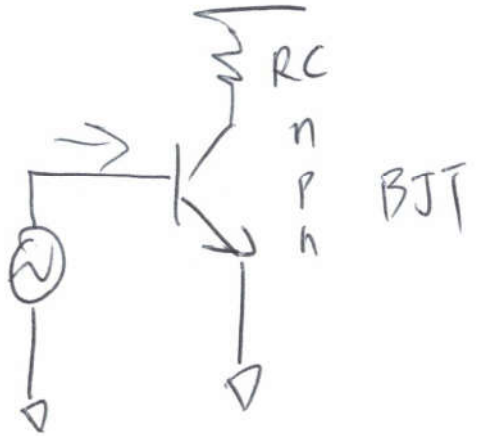
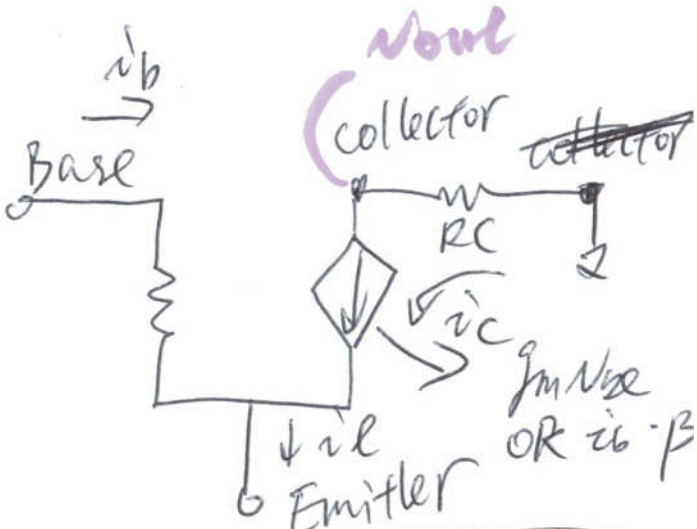


Small signal model

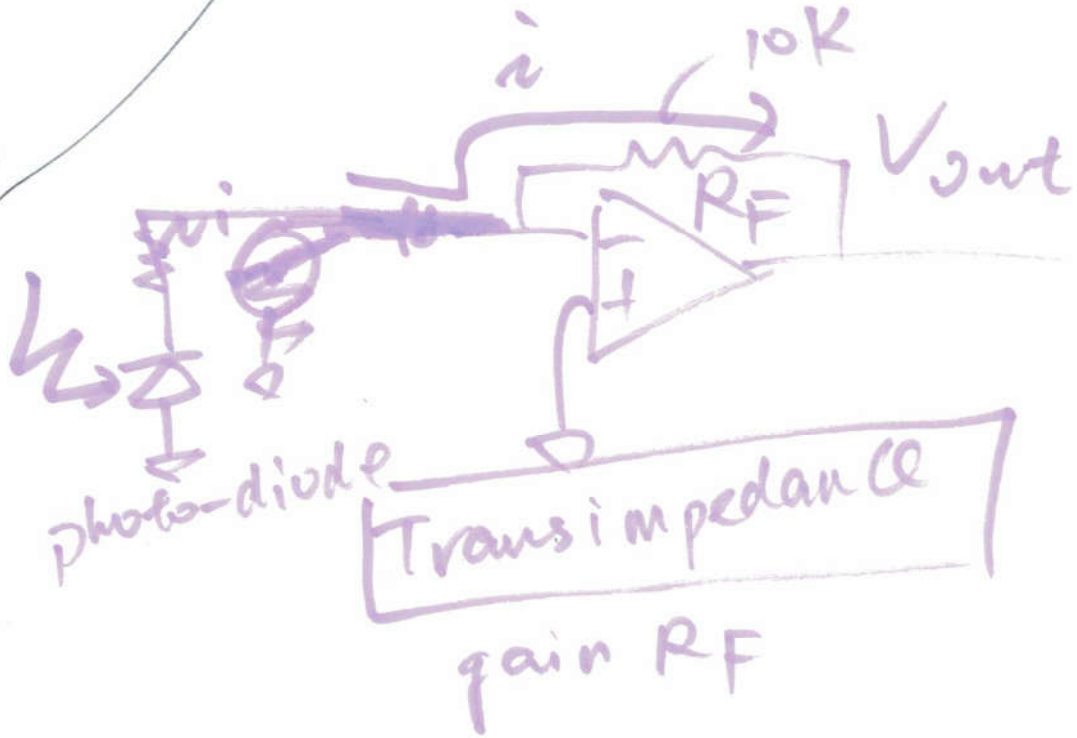


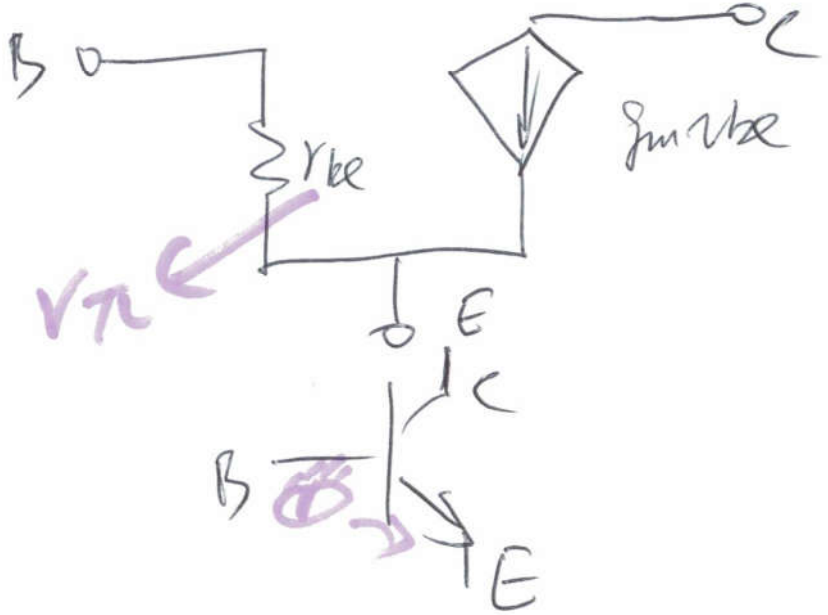
$g_m v_{be}$ voltage controlled current source

$i_b \cdot \beta$ current controlled current source

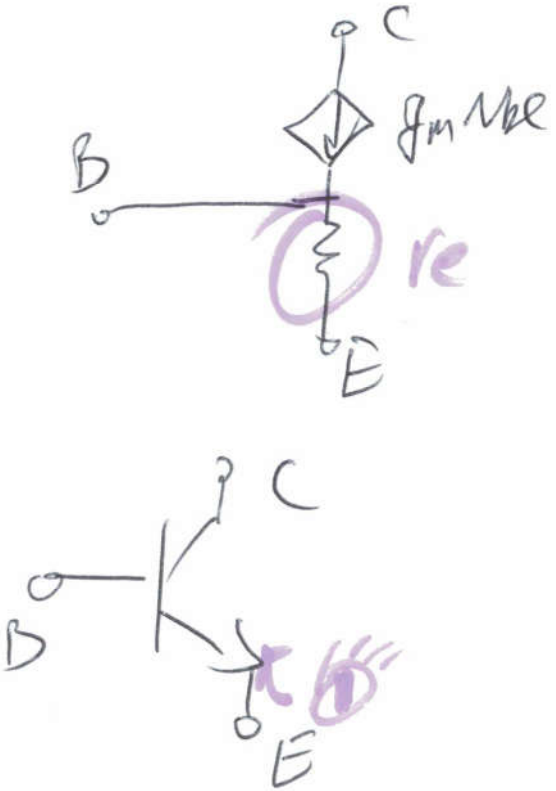
dependent source

$\frac{v_{out}}{i_c} = R_C$





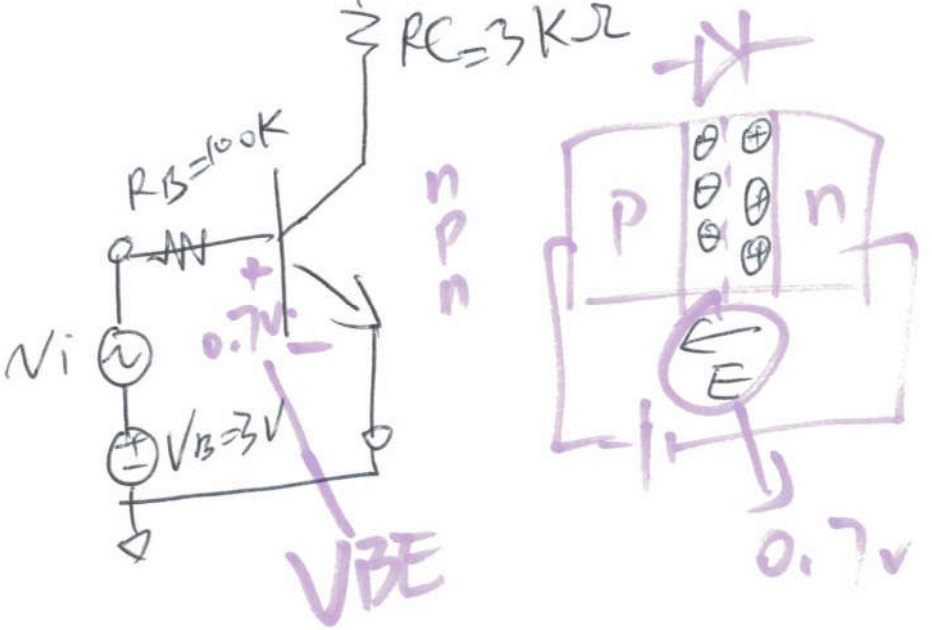
Hybrid-π model



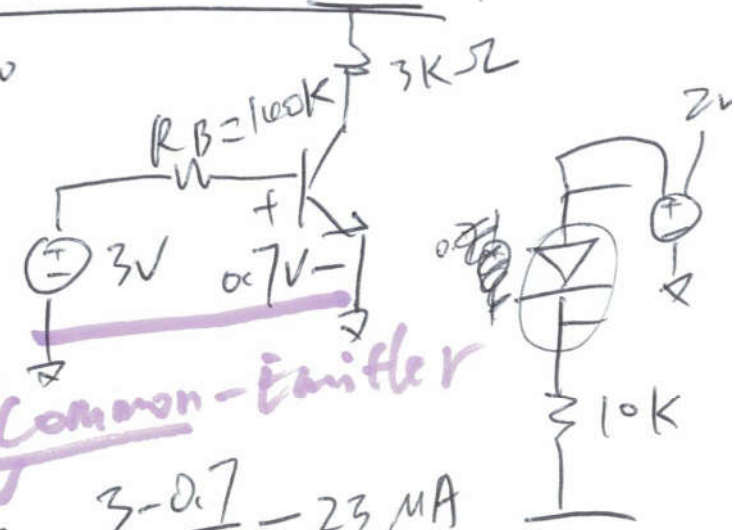
The T-model.

P410 7.5. Examples.

DC operating points:



β=100



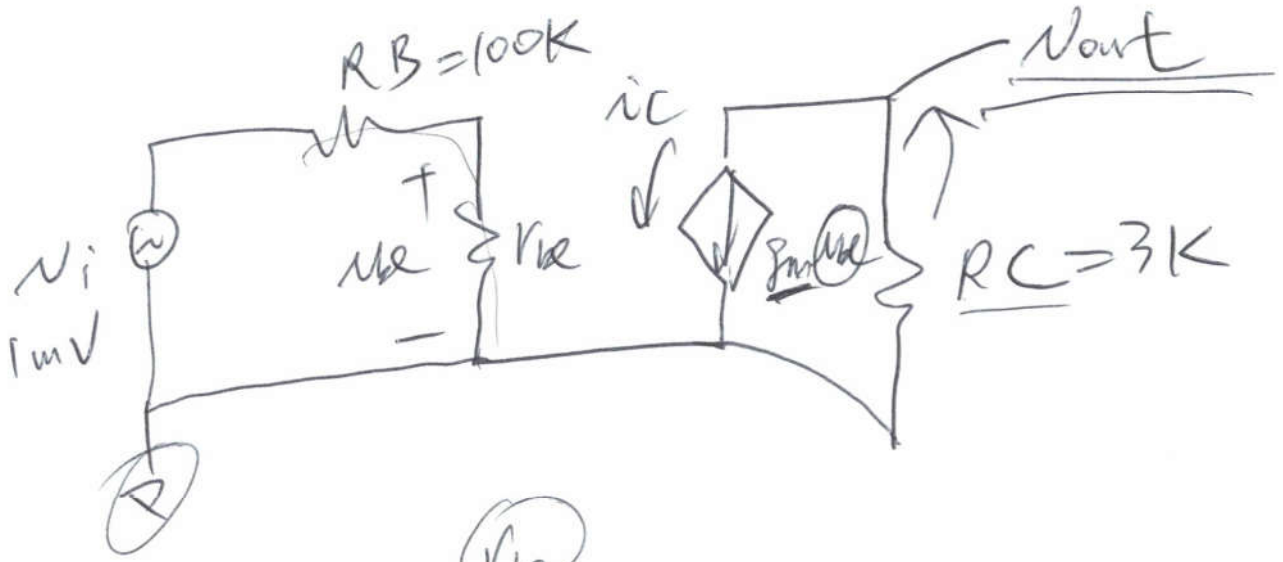
$$I_B = \frac{3-0.7}{100K} = 23\,\mu A$$

$$I_C = I_B \cdot \beta = 2.3\,mA$$

$$\begin{cases} I_E = \frac{I_C}{\alpha} \\ \alpha = \frac{\beta}{1+\beta} \end{cases}$$

$$I_E = I_B + I_C = 23\,\mu A + 2.3\,mA = 2323\,\mu A.$$

$$g_m = \frac{I_C}{V_T} = \frac{2.3\,mA}{25\,mV} = 0.09\ A/V$$



$$\begin{cases} V_{be} = V_i \cdot \dfrac{r_{be}}{r_{be}+R_B} \\ r_{be} = \dfrac{V_T}{I_B} = \dfrac{25mV}{23\mu A} = 1.1\,K\Omega \end{cases}$$

$$V_{be} = V_i \cdot \frac{1.1K}{101.1K} \simeq 0.01 \cdot V_i$$

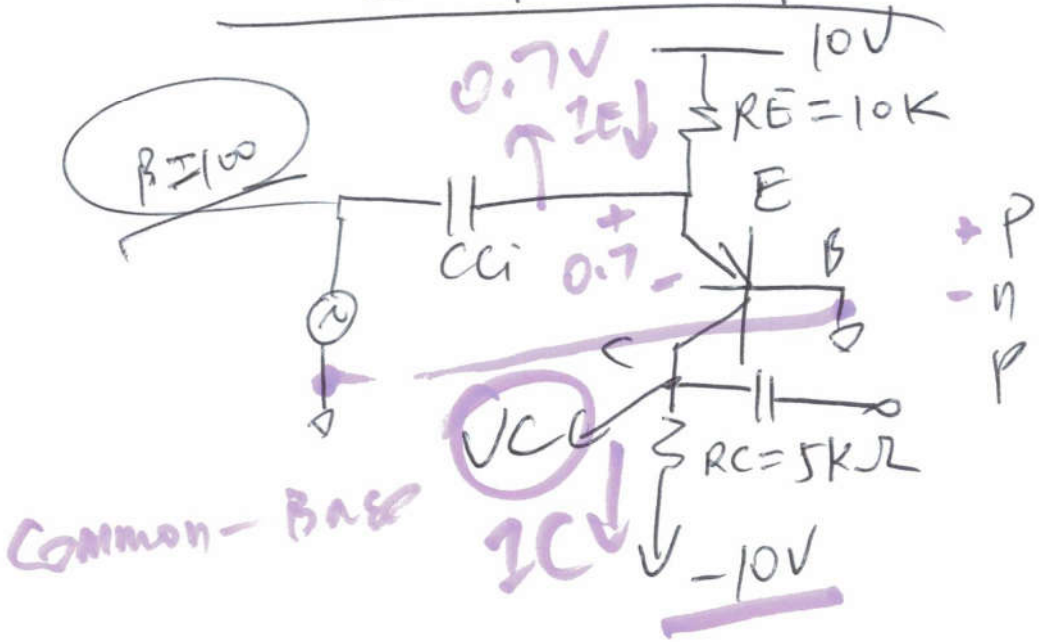
$$V_c = g_m V_{be} = 0.09\,V \times 0.01\,V_i$$

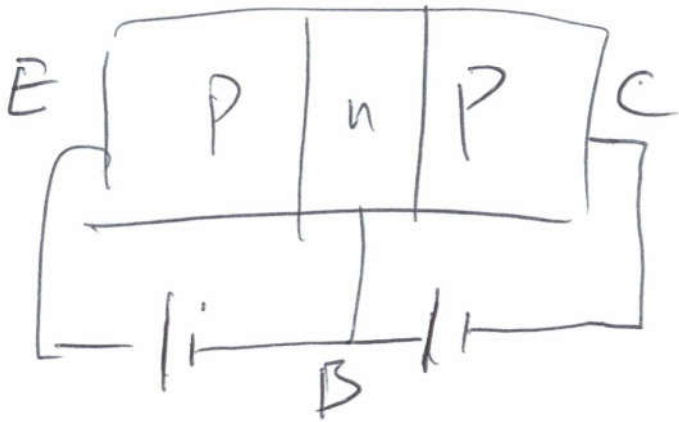
$$V_{out} = -i_c \cdot R_C = -0.09 \times 0.01\,V_i \cdot R_C, \quad R_C = 3K\Omega$$

$$\frac{V_{out}}{V_i} = -2.7\ V/V$$

(4)

Example 7.7 P415





DC operating point:

$$I_E = \frac{10 - 0.7}{10K} = \frac{9.3}{10K} = 0.93\,mA$$

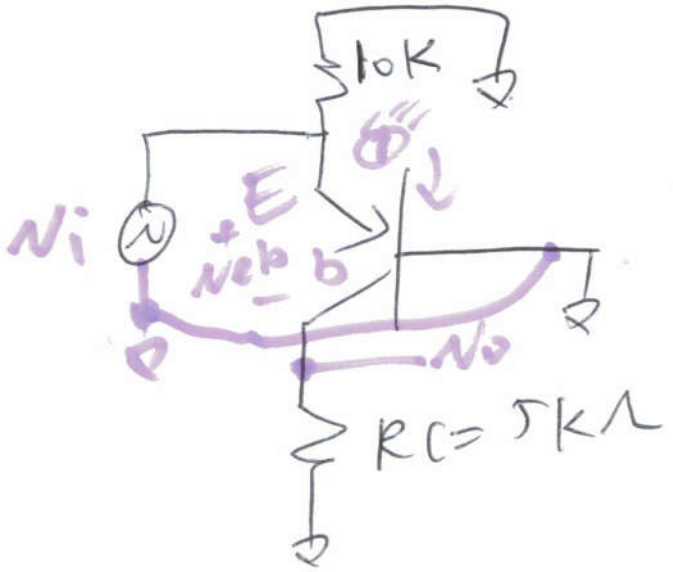
$$I_C = \alpha I_E = \frac{\beta}{H_P} \cdot I_E = \frac{100}{10} \cdot 0.93mA = 0.92mA$$

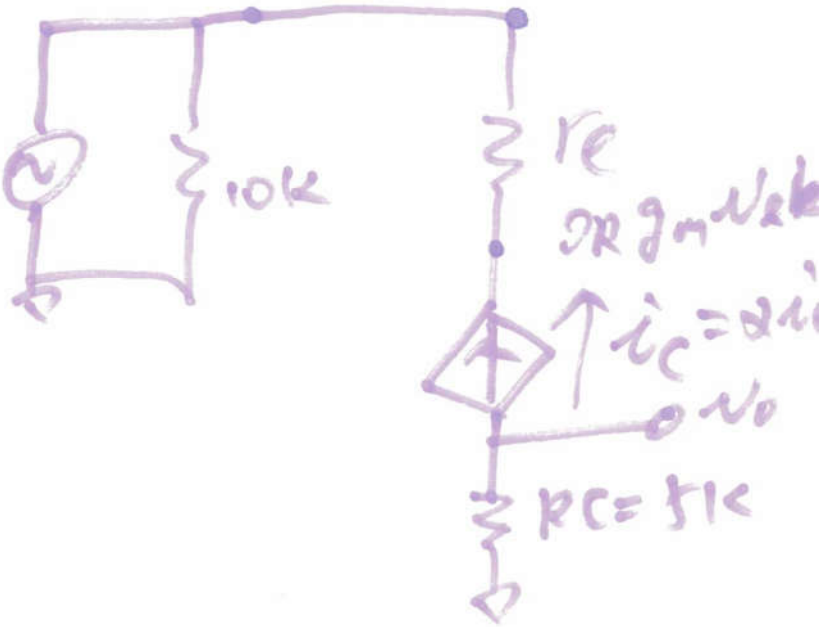
$$I_B = \frac{I_C}{100} = \frac{0.92mA}{100} = 9.2\mu A$$

$$V_C = -10 + I_C \cdot R_C = -10 + 0.92mA \cdot 5K = -5.4V$$

$$g_m = \frac{I_C}{V_T} = \frac{0.92mA}{25mV} = 36.8mA/V$$

AC analysis



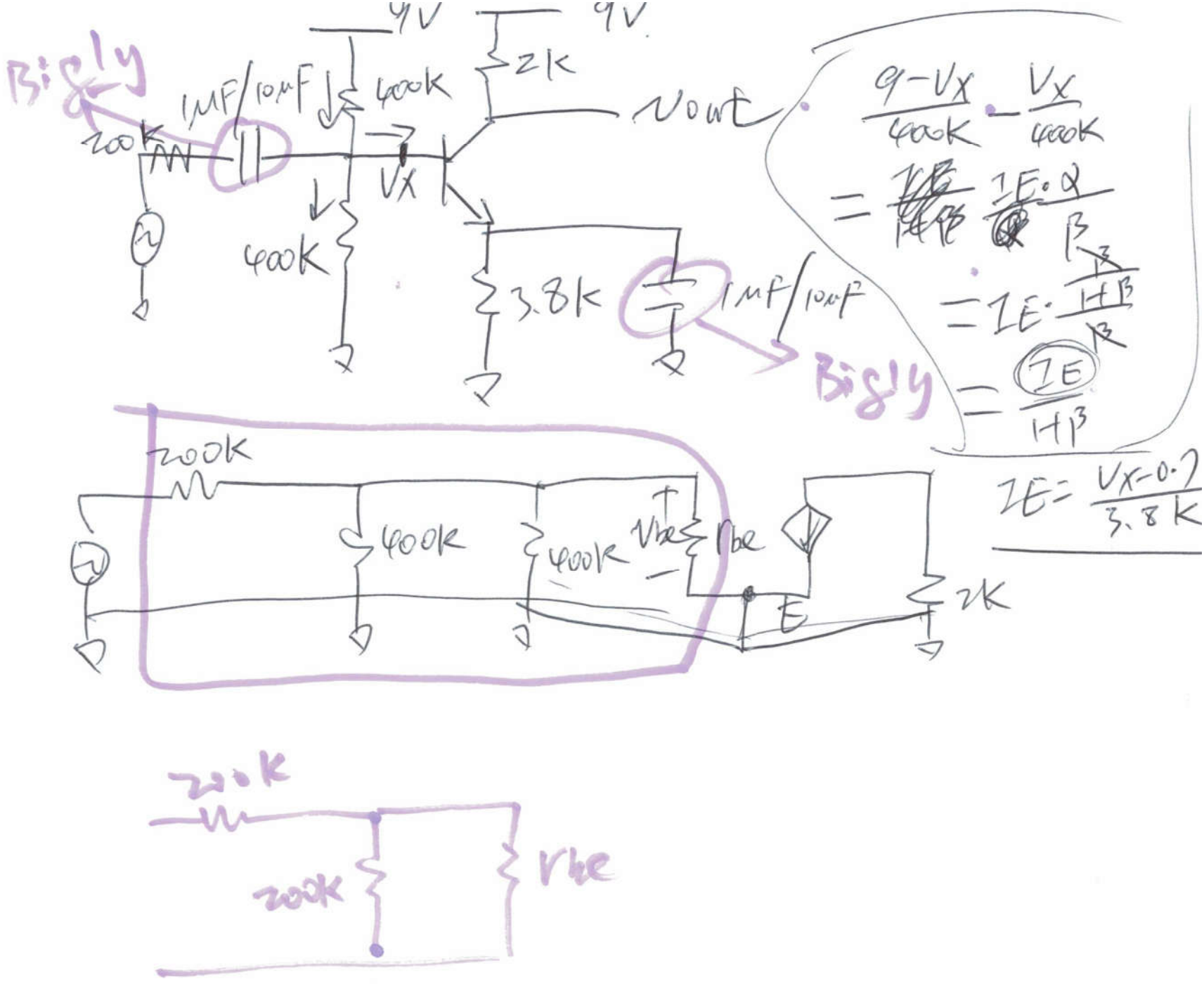


$$V_i = V_{eb}$$

$$i_c = g_m \cdot V_{eb} = g_m \cdot V_i$$

$$V_o = -i_c \cdot R_C = -g_m V_i \cdot R_C$$

$$\frac{V_o}{V_i} = -g_m R_C .$$



$$\frac{9-V_x}{400k} = \frac{V_x}{400k}$$

$$= \frac{I_E \cdot \alpha}{\beta} \cdot \frac{\beta}{1+\beta}$$

$$= I_E \cdot \frac{1}{1+\beta}$$

$$= \frac{I_E}{1+\beta}$$

$$I_E = \frac{V_x - 0.7}{3.8k}$$