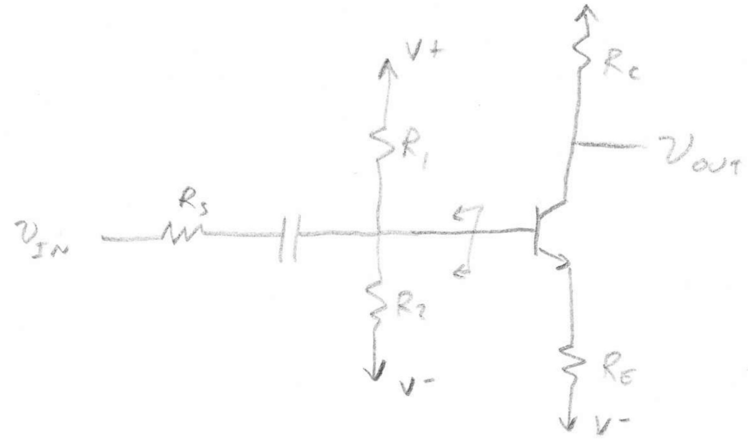
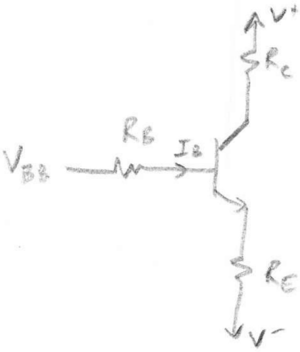


DC Bias Conditions

$$V_{BB} = V^+ \frac{R_2}{R_1+R_2} + V^- \frac{R_1}{R_1+R_2} = 0$$

$$R_B = R_1 \,//\, R_2 = 50\,k\Omega$$

DC Circuit



$$V_{BB} = I_B R_B + V_{BE,on} + (\beta+1) I_B R_E + V^-$$

$$I_B = \frac{V_{BB} - V_{BE,on} - V^-}{R_B + (1+\beta) R_E} = 28.5\,\mu A$$

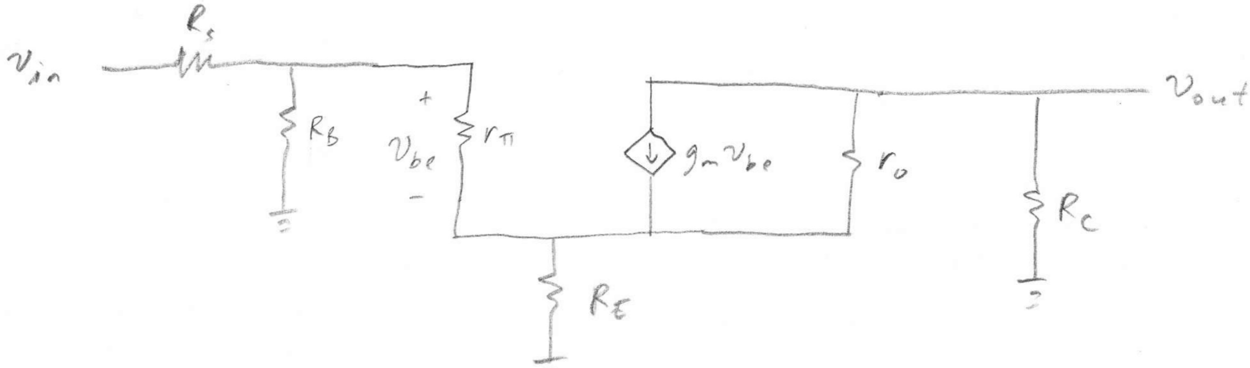
This transistor operates in forward active (as given by the problem statement)

$$\therefore\ I_C = \beta I_B = 2.85\,mA$$

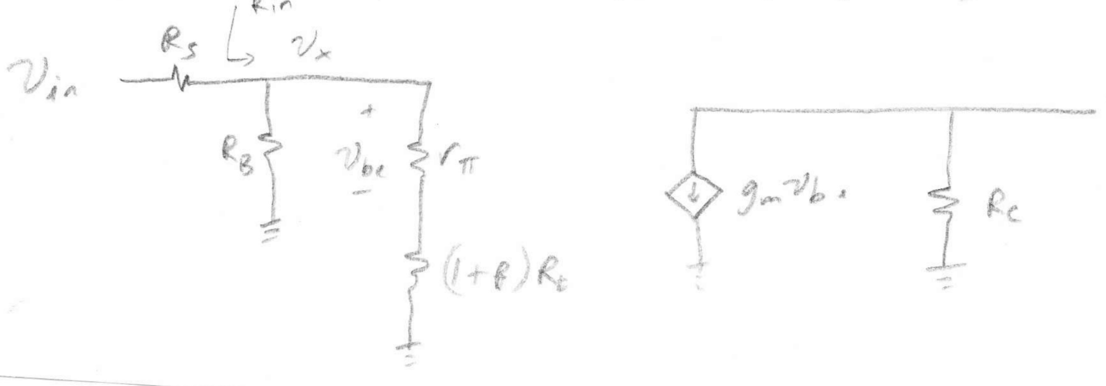
Small-Signal Parameters

$$r_\pi = \frac{\beta V_T}{I_C} = 912\,\Omega \qquad g_m = \frac{I_C}{V_T} = 0.1096\,S \qquad r_o = \frac{V_A}{I_C} = 17.5\,k\Omega$$

Small-Signal Model



For Part C, $V_A \to \infty \Rightarrow$ Redraw the small-signal model



Let $R_{in} = R_B // \left(r_\pi + (1+\beta) R_E\right) = 33.5 k\Omega$

$$\therefore v_x = v_{in} \frac{R_{in}}{R_{in} + R_s} = v_{in}(0.985)$$

$$v_{be} = v_x \frac{r_\pi}{r_\pi + (1+\beta) R_E} = v_{in} \left(\frac{R_{in}}{R_{in} + R_s}\right)\left(\frac{r_\pi}{r_\pi + (1+\beta) R_E}\right)$$

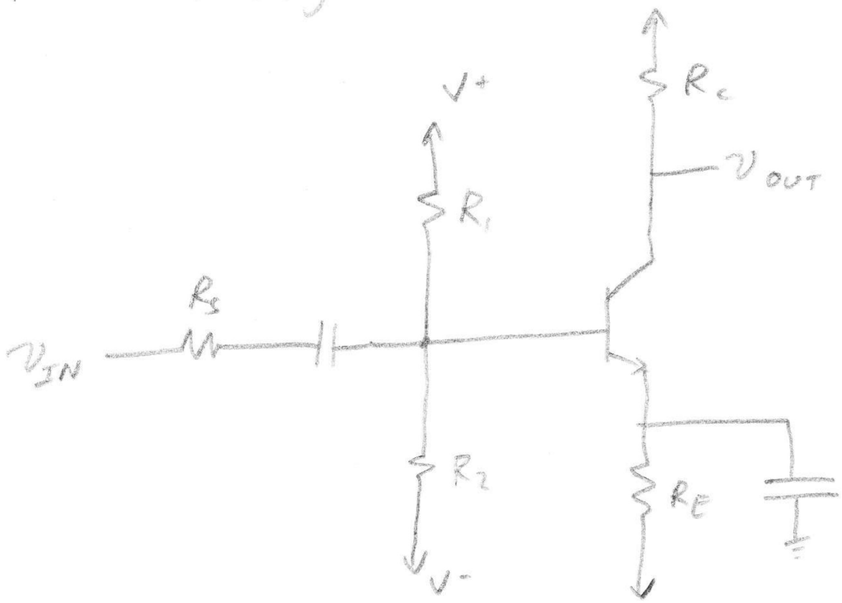
$$v_{out} = -g_m v_{be} R_C = -g_m v_{in} \left(\frac{R_{in}}{R_{in} + R_s}\right)\left(\frac{r_\pi}{r_\pi + (1+\beta) R_E}\right) R_C$$

$$a_v = \frac{v_{out}}{v_{in}} = -g_m R_C \left(\frac{R_{in}}{R_{in} + R_s}\right)\left(\frac{r_\pi}{r_\pi + (1+\beta) R_E}\right) = -1.93$$

Note, this is close to the approximation

$$a_v = -\frac{R_C}{R_E} = -2$$

How does the gain differ for the following circuit?

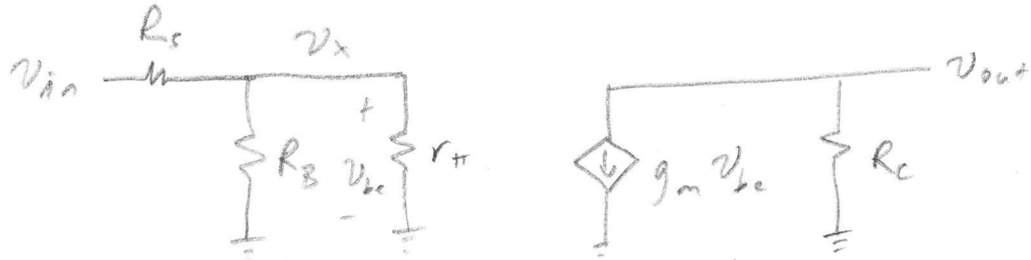


Note
The DC bias remains the same

$\therefore I_C = 2.85\,mA$

Also, r_π, g_m, r_o remain the same

Small-Signal Model (Assuming $V_A \to \infty$, like the previous problem)

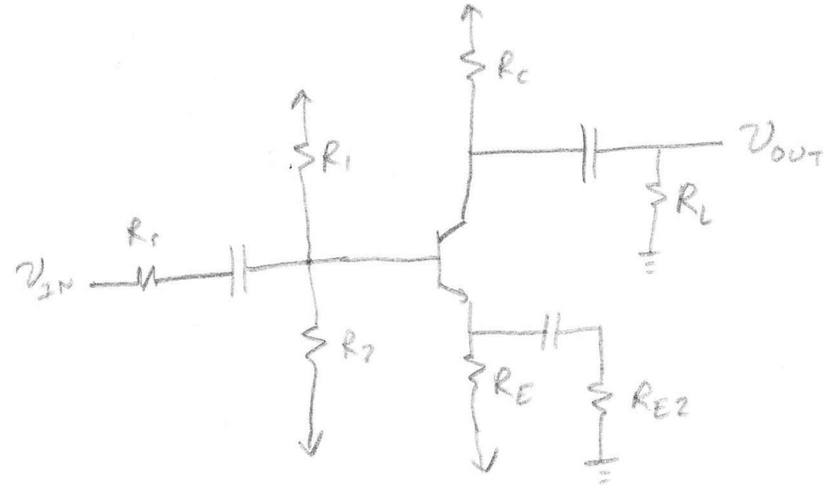


→ This looks just like a "standard" CE Amp

$$a_v = \frac{v_{out}}{v_{in}} = -g_m R_C \left(\frac{R_{in}}{R_s + R_{in}} \right) = -140.67$$

(Much larger than the previous version of the amplifier

Find the small signal gain

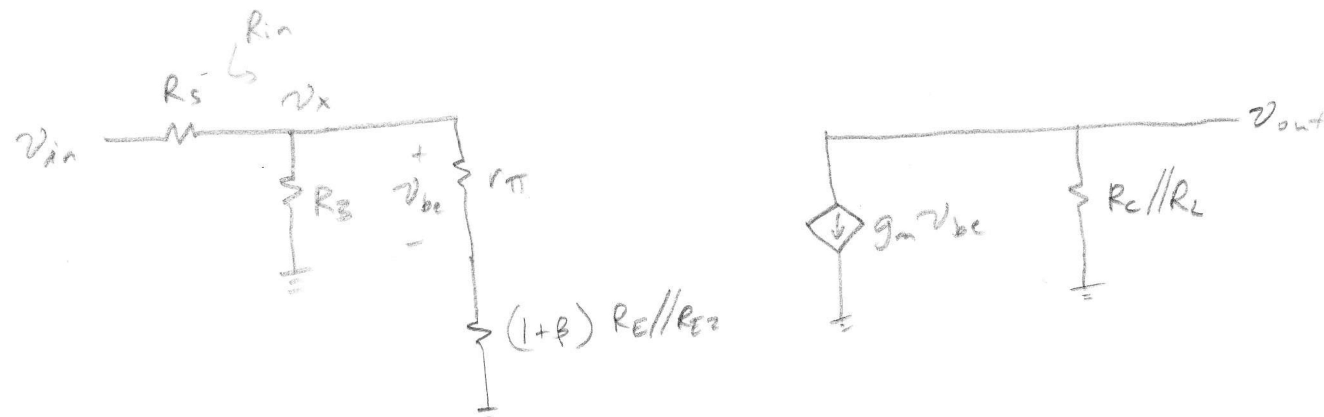


Note, the DC circuit is still the same

$\therefore I_C = 2.85 mA$

r_π, g_m, r_o remain the same

Small-signal model (assume $V_A \to \infty$)



$$R_{in} = (R_B) // \left(r_\pi + (1+\beta)\ R_E // R_{E2}\right) = 8.4 k\Omega$$

$$v_x = v_{in} \frac{R_{in}}{R_S + R_{in}} = v_{in}(0.944)$$

$$v_{be} = v_x \frac{r_\pi}{r_\pi + (1+\beta)\ R_E // R_{E2}} = v_x (0.09035)$$

$$a_v = \frac{v_{out}}{v_{in}} = -g_m v_{be}\ R_C // R_L = -18.3$$

This is slightly less than the approximate value of

$$\frac{v_{out}}{v_{in}} \approx -\frac{R_C}{R_{E2}}$$