Common-Base Amplifier Example

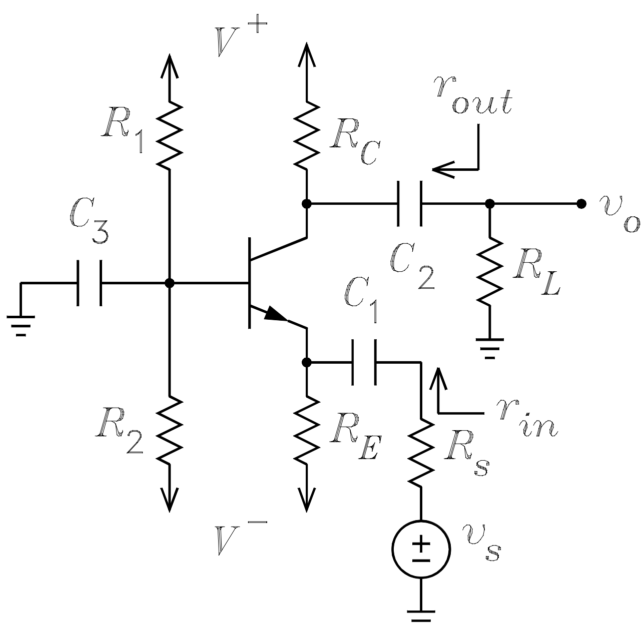
$R_P(x,y) := \frac{x \cdot y}{x+y}$ Function for calculating parallel resistors.

$R_1 := 100000$ $R_2 := 120000$ $R_C := 4300$ $R_E := 5600$ $R_S := 100$ $R_L := 10000$

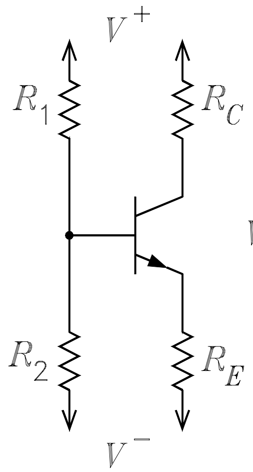
$V_{plus} := 15$ $V_{minus} := -15$ $V_{BE} := 0.65$ $V_T := 0.025$ $\beta := 99$ $\alpha := 0.99$

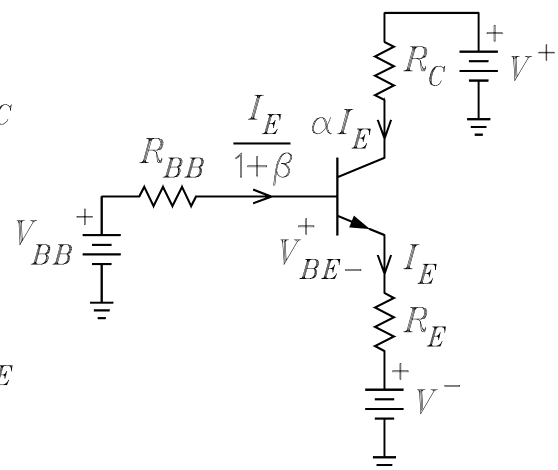
$r_x := 20$ $r_0 := 50000$

$v_s := 1$ With v_s = 1, the voltage gain is equal to v_o.



DC Bias Circuit





$V_{BB} := \frac{V_{plus} \cdot R_2 + V_{minus} \cdot R_1}{R_1 + R_2}$ $\quad V_{BB} = 1.364$

$R_{BB} := R_P(R_1, R_2)$ $\quad R_{BB} = 5.455 \cdot 10^4$

$I_E := \frac{V_{BB} - V_{BE} - V_{minus}}{\frac{R_{BB}}{1+\beta} + R_E}$ $\quad I_E = 2.557 \cdot 10^{-3}$

$r_e := \frac{V_T}{I_E}$ $\quad r_e = 9.777$

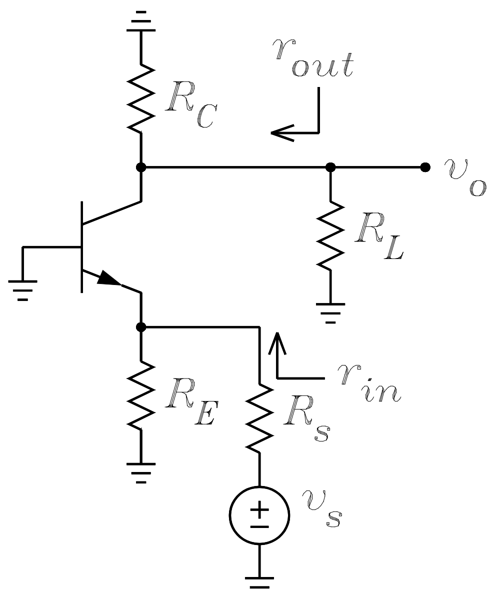
Test for Active Mode

$V_C := V_{plus} - \alpha \cdot I_E \cdot R_C$ $\quad V_C = 4.115$

$V_B := V_{minus} + I_E \cdot R_E + V_{BE}$ $\quad V_B = -0.031$

$V_{CB} := V_C - V_B$ $\quad V_{CB} = 4.146$ Thus active mode.

AC Signal Circuit



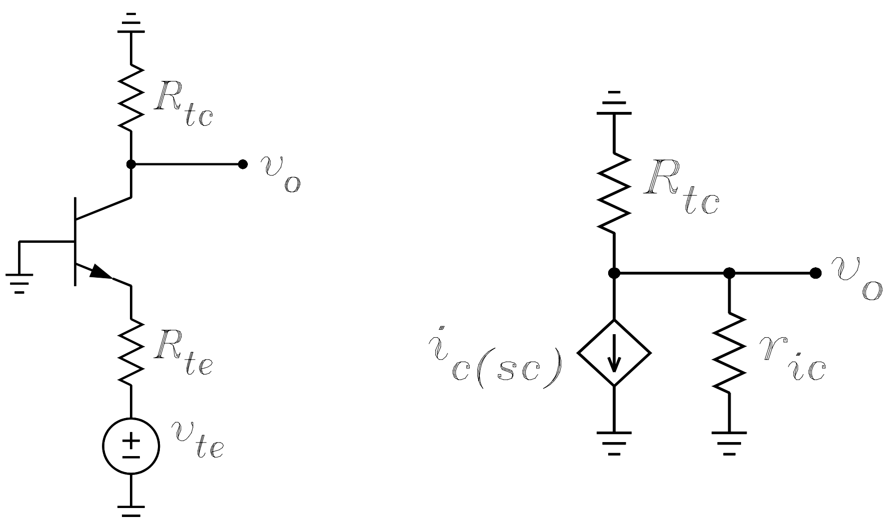
$$v_{te} := v_s \cdot \frac{R_E}{R_S + R_E} \qquad v_{te} = 0.982$$

$$R_{te} := R_P(R_E, R_S) \qquad R_{te} = 98.246$$

$$R_{tb} := 0$$

$$r'_e := \frac{R_{tb} + r_x}{1 + \beta} + r_e \qquad r'_e = 9.977$$

Circuit for v_o



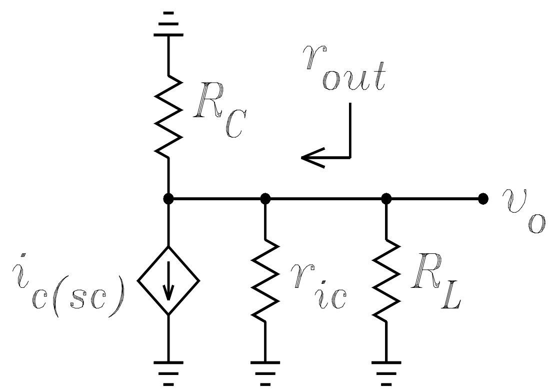
$R_{tc} := R_P(R_C, R_L)$ $\qquad R_{tc} = 3.007 \cdot 10^3$

$$r_{ic} := \frac{r_0 + R_P(r'_e, R_{te})}{1 - \frac{\alpha \cdot R_{te}}{r'_e + R_{te}}} \qquad r_{ic} = 4.938 \cdot 10^5$$

$$i_{csc} := \frac{-v_{te}}{R_{te} + R_P(r'_e, r_0)} \cdot \frac{\alpha \cdot r_0 + r'_e}{r_0 + r'_e} \qquad i_{csc} = -8.987 \cdot 10^{-3}$$

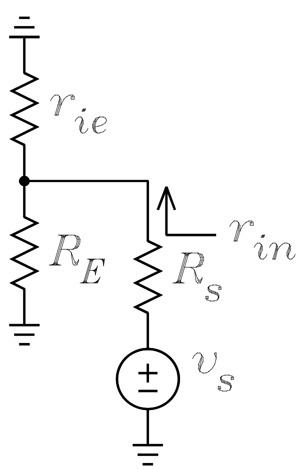
$v_o := -i_{csc} \cdot R_P(R_{tc}, r_{ic})$ $\qquad v_o = 26.862$ $\qquad$ This is the voltage gain.

Circuit for r_{out}



$r_{out} := R_P(R_C, r_{ic})$ $\quad$ $r_{out} = 4.263 \cdot 10^3$

Circuit for r_{in}



$$r_{ie} := r'_e \cdot \frac{r_0 + R_{tc}}{r'_e + r_0 + \frac{R_{tc}}{1+\beta}}$$ $\quad$ $r_{ie} = 10.569$

$r_{in} := R_P(r_{ie}, R_E)$ $\quad r_{in} = 10.549$

The following solution is based on the r_0 approximations where r_0 is neglected in calculating i_{csc} but not neglected in calculating r_{ic}.

$$G_{me} := \frac{\alpha}{r'_e + R_{te}}$$

$i_{csc} := -v_{te} \cdot G_{me}$ $\quad i_{csc} = -8.987 \cdot 10^{-3}$

$v_c := -i_{csc} \cdot R_P(R_{tc}, r_{ic})$ $\quad v_c = 26.861$ $\quad$ This is the voltage gain.

$$\text{Percent} := \frac{v_c - 26.862}{26.862} \cdot 100 \qquad \text{Percent} = -3.028 \cdot 10^{-3}$$

This is the percent change from the exact value.

$r_{out} := R_P(r_{ic}, R_C)$ $\quad r_{out} = 4.263 \cdot 10^3$

$r_{in} := R_P(r_{ie}, R_E)$ $\quad r_{in} = 10.549$

Approximate solution 1 using the equation $i_c = g_m \cdot (v_b - v_e)$ and neglecting r_x and r_0.

$$g_m := \frac{\alpha \cdot I_E}{V_T} \qquad g_m = 0.101$$

$r_{ie} := r_e$ $\quad r_{ie} = 9.777$

$$A_v := \frac{R_E}{R_S + R_E} \cdot \frac{r_{ie}}{r_{ie} + R_{te}} \cdot g_m \cdot R_P(R_C, R_L) \qquad A_v = 27.075$$

$r_{in} := R_P(R_E, r_{ie})$ $\quad r_{in} = 9.76$

$r_{out} := R_C$ $\quad r_{out} = 4.3 \cdot 10^3$

Approximate solution 2 using the equation $i_c = \alpha \cdot i_e$ and neglecting r_x and r_0.

$$A_v := \frac{R_E}{R_S + R_E} \cdot \frac{\alpha \cdot R_P(R_C, R_L)}{r_{ie} + R_{te}} \qquad A_v = 27.075$$

$$r_{in} := R_P(R_E, r_{ie}) \qquad r_{in} = 9.76$$

$$r_{out} := R_C \qquad r_{out} = 4.3 \cdot 10^3$$