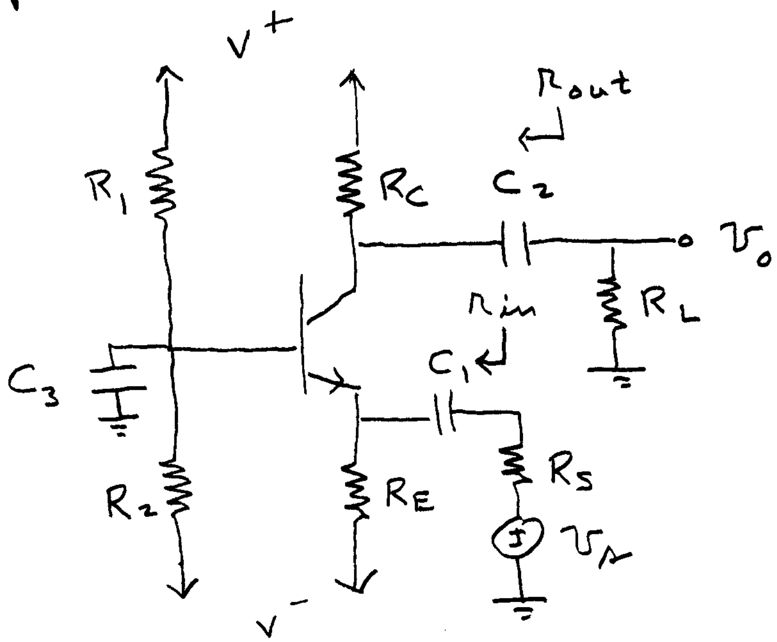
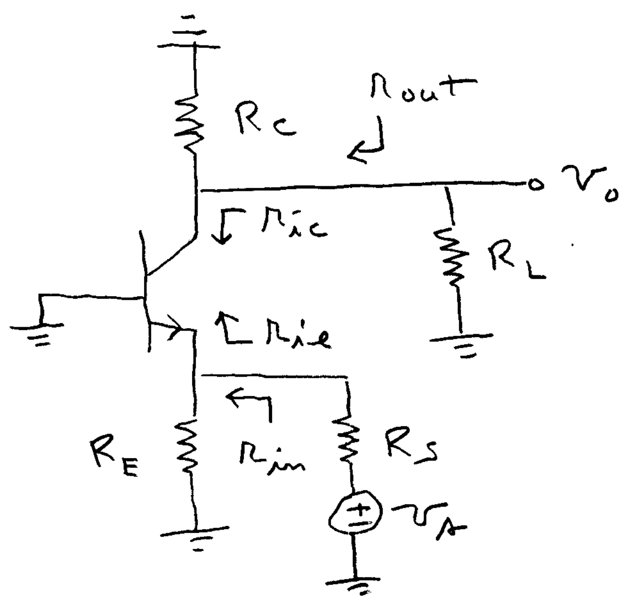
The Common Base (CB) Amplifier

For the CB amplifier, the signal is applied to the emitter and the output is taken from the collector. A typical capacitively coupled CB amplifier is shown.



The dc bias currents and voltages are solved for in the same way as for the CE amplifier. For the ac small-signal solution, set $V^+ = V^-$ and assume the capacitors are ac short circuits. The circuit reduces to.



The input and output resistances are given by

$$r_{in} = R_E \| r_{ie}$$

$$r_{out} = R_C \| r_{ic}$$

where

$$r_{ie} = r_e' \frac{r_o + R_{tc}}{r_e' + r_o + R_{tc}/(1+\beta)}$$

$$R_{tc} = R_C \| R_L \qquad R_{te} = R_E \| R_S$$

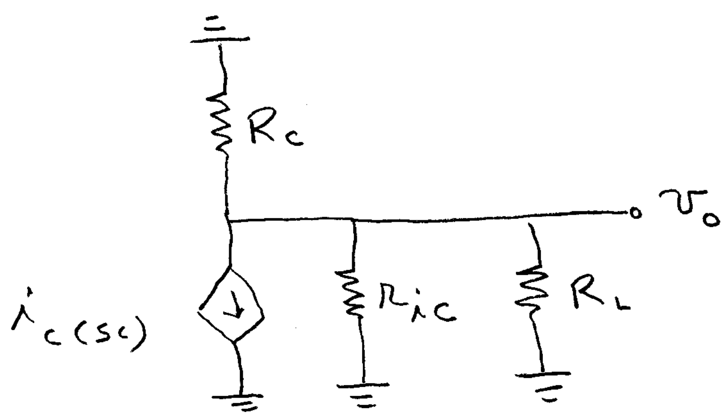
$$r_{ic} = \frac{r_o + r_e' \| R_{te}}{1 - \dfrac{\alpha R_{te}}{r_e' + R_{te}}}$$

$$r_e' = \frac{R_{tb} + r_x}{1+\beta} + r_e \qquad R_{tb} = 0$$

Looking out of the emitter, the Thévenin equivalent circuit has the values

$$v_{te} = v_A \frac{R_E}{R_S + R_E} \qquad R_{te} = R_E \| R_S$$

To solve for v_o, we replace the BJT with the Norton collector circuit.



$i_{c(sc)}$ is given by

$$i_{c(sc)} = -G_{me} v_{te}$$

where

$$G_{me} = \frac{1}{R_{te} + R_e' \| r_0} \frac{\alpha r_0 + R_e'}{r_0 + R_e'}$$

The output voltage is given by

$$v_o = -i_{c(sc)}\, r_{ic} \| R_c \| R_L$$

$$= +G_{me}\, v_{te}\, r_{ic} \| R_c \| R_L$$

$$= +G_{me}\, v_s \frac{R_E}{R_S + R_E}\, r_{ic} \| R_c \| R_L$$

Thus the voltage gain is given by

$$A_v = \frac{v_o}{v_s}$$

$$= +\frac{R_E}{R_S + R_E}\, G_{me}\, r_{ic} \| R_c \| R_L$$

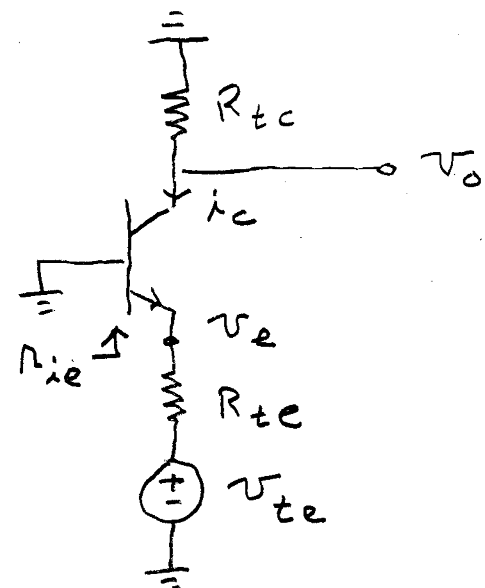
The above solution is exact. Often, an approximate solution is made for rough calculations. Assume that $r_x = 0$ and $r_o = \infty$ for the approximations. In this case

$$r_{ie} = r_e'$$

$$i_c = \alpha i_e = g_m v_{be} = g_m(\overset{0}{\cancel{v_b}} - v_e)$$

$$= -g_m v_e$$

The signal equivalent circuit is



$$v_e = v_{te} \frac{r_{ie}}{R_{te} + r_{ie}}$$

$$i_c = -g_m v_e$$

$$v_o = -i_c R_c = +g_m v_e R_{tc}$$

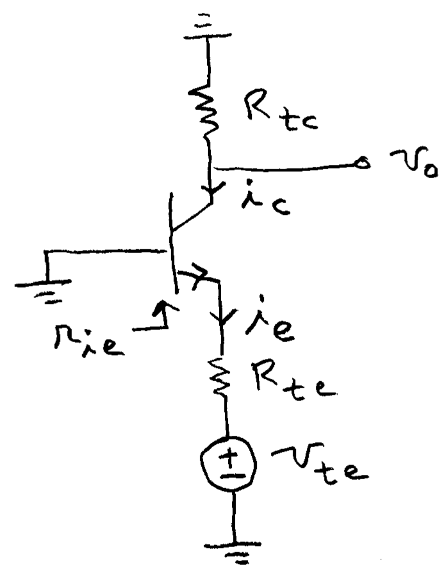
$$= +g_m v_{te} \frac{r_{ie}}{R_{te} + r_{ie}} R_{tc}$$

$$= +v_s \frac{R_E}{R_S + R_E} \frac{r_{ie}}{R_{te} + r_{ie}} g_m R_{tc}$$

$$\Rightarrow \quad A_v = \frac{v_o}{v_s}$$

$$= \frac{R_E}{R_S + R_E} \frac{r_{ie}}{R_{te} + r_{ie}} g_m R_{tc}$$

An Alternate Approximate Solution



For $r_x = 0$ and $r_o = \infty$, r_{ie} is given by

$$r_{ie} = \frac{R_{tb}}{1+\beta} + r_e' = r_e' \quad (R_{tb} = 0)$$

$$i_e = -\frac{v_{te}}{R_{te} + r_e'}$$

$$i_c = \alpha i_e = -v_{te} \frac{\alpha}{R_{te} + r_e'}$$

$$v_o = -i_c R_{tc} = +v_{te} \frac{\alpha R_{tc}}{R_{te} + r_e'}$$

$$= +v_A \frac{R_E}{R_S + R_E} \cdot \frac{\alpha R_{tc}}{R_{te} + r_e'}$$

$$\Rightarrow A_v = \frac{v_o}{v_A} = +\frac{R_E}{R_S + R_E} \frac{\alpha R_{tc}}{R_{te} + r_e'}$$