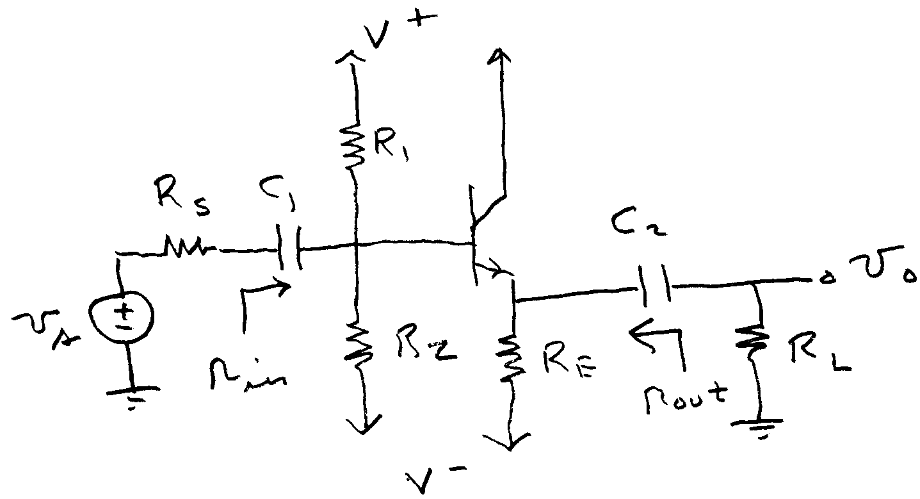
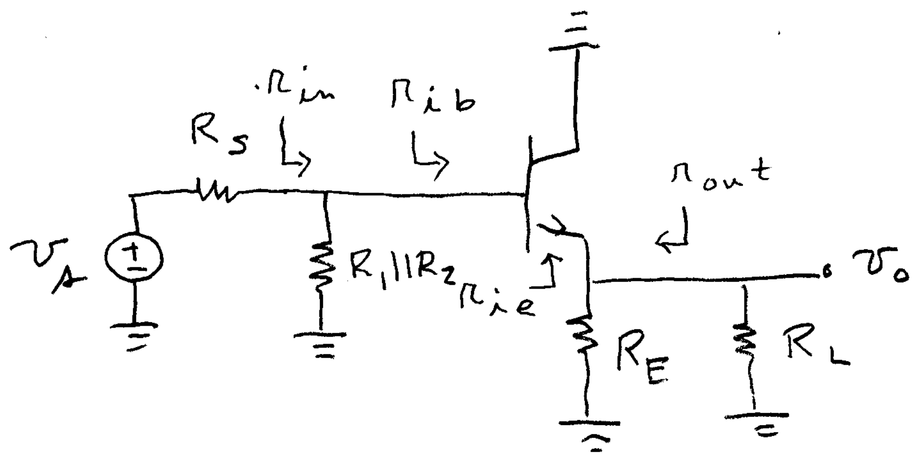
# The Common Collector (CC) Amplifier

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




The dc bias currents and voltages are solved for in the same way as for the CE and CB amplifiers. For the ac small-signal solution, set $V^+ = V^- = 0$ and assume the capacitors are ac short circuits. The circuit reduces to




The input and output resistances are given by

$$r_{in} = R_1 \| R_2 \| r_{ib}$$

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

where

$$r_{ib} = r_x + (1+\beta)(r_e + R_E \| R_L) \quad (R_{tc}=0)$$

$$r_{ie} = r_e' \frac{r_o}{r_e' + r_o} = r_e' \| r_o \quad (R_{tc} = 0)$$

$$r_e' = \frac{R_S \| R_1 \| R_2 + r_x}{1+\beta} + r_e$$

$$r_e = \frac{V_T}{I_E}$$

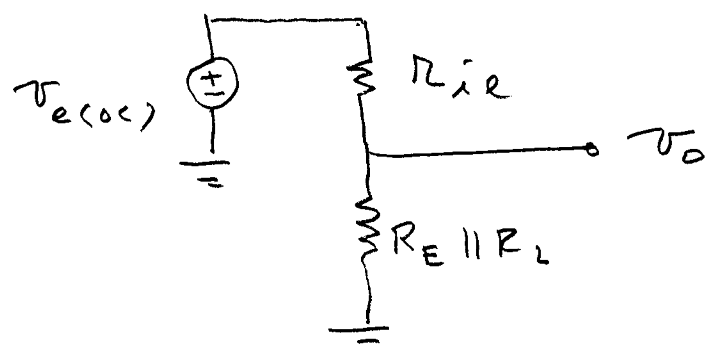
3 - 06/09/03

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

$$v_{tb} = v_s \frac{R_1 \| R_2}{R_S + R_1 \| R_2}$$

$$R_{tb} = R_S \| R_1 \| R_2$$

To solve for $v_o$, we replace the BJT with the Thévenin emitter circuit.




By voltage division

$$v_o = v_{e(oc)} \frac{R_E \| R_L}{r_{ie} + R_E \| R_L}$$

$$= v_{tb} \frac{r_o}{r_e' + r_o} \frac{R_E \| R_L}{r_{ie} + R_E \| R_L} \quad (R_{tb} = 0)$$

$$\Rightarrow \quad v_o = v_s \frac{R_1 \| R_2}{R_S + R_1 \| R_2} \frac{r_o}{r_e' + r_o} \frac{R_E \| R_L}{r_{ie} + R_E \| R_L}$$

Thus the voltage gain is given by

$$A_v = \frac{v_o}{v_s} = \frac{R_1 \| R_2}{R_S + R_1 \| R_2} \frac{r_o}{r_e' + r_o} \frac{R_E \| R_L}{r_{ie} + R_E \| R_L}$$

If $R_S \ll R_1 \| R_2$, $r_e' \ll r_o$, and $r_{ie} \ll R_E \| R_L$, it follows that $A_v \approx 1$. In no case can $A_v$ be greater than 1. The circuit is mainly used for current gain. It is often called an emitter follower or a buffer amplifier.

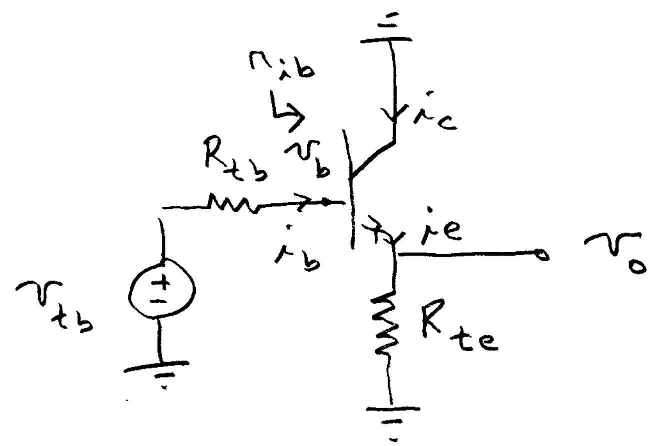
The above solution is exact. Often, an approximate solution is made for rough calculations. Assume that $r_x = 0$ and $r_o = \infty$ for the approximations. In this case

$r_{ie} = r_e' \qquad r_{ib} = (1+\beta)(r_e + R_{te})$

$i_c = \beta i_b = g_m v_{be} = g_m(v_b - v_e)$

$\quad = \alpha i_e$

The signal equivalent circuit is




$$v_o = i_e R_{te} = \frac{i_c}{\alpha} R_{te} = g_m(v_b - v_o)\frac{R_{te}}{\alpha}$$

$$\Rightarrow \quad v_o\left[1 + \frac{g_m R_{te}}{\alpha}\right] = v_b \frac{g_m R_{te}}{\alpha}$$

$$\Rightarrow \quad v_o = v_b \frac{\frac{g_m R_{te}}{\alpha}}{1 + \frac{g_m R_{te}}{\alpha}}$$

But $\quad v_b = v_{tb} \dfrac{r_{ib}}{R_{tb} + r_{ib}}$

$$\Rightarrow \quad v_o = v_{tb} \frac{r_{ib}}{R_{tb} + r_{ib}} \frac{\frac{g_m R_{te}}{\alpha}}{1 + \frac{g_m R_{te}}{\alpha}}$$

$$= v_s \frac{R_1 \| R_2}{R_s + R_1 \| R_2} \frac{r_{ib}}{R_{tb} + r_{ib}} \frac{\frac{g_m R_{te}}{\alpha}}{1 + \frac{g_m R_{te}}{\alpha}}$$

$$\Rightarrow A_v = \frac{v_o}{v_s} = \frac{R_1 \| R_2}{R_s + R_1 \| R_2} \frac{r_{ib}}{R_{tb} + r_{ib}} \frac{\frac{g_m R_{te}}{\alpha}}{1 + \frac{g_m R_{te}}{\alpha}}$$

Note that this solution is exact if $r_x$ is included in the expression for $r_{ib}$ and $r_o$ is combined in parallel with $R_{te}$. The latter can be done because $R_{tc} = 0$. For $R_{tc} \neq 0$, $r_o$ complicates the solution if it is to be included. The exact solution above should be used in this case if node equations are to be avoided.

A second and simpler approximate solution is as follows:

$$v_o = i_e R_{te} = (1+\beta) i_b R_{te}$$

$$= (1+\beta) \frac{v_{tb}}{R_{tb} + r_{ib}} R_{te}$$

$$= v_s \frac{R_1 \| R_2}{R_s + R_1 \| R_2} \frac{(1+\beta) R_{te}}{R_{tb} + r_{ib}}$$

$$\Rightarrow A_v = \frac{v_o}{v_s} = \frac{R_1 \| R_2}{R_S + R_1 \| R_2} \, \frac{(1+\beta) R_{te}}{R_{tb} + r_{ib}}$$

This solution is far simpler than the one which uses the equation $i_c = g_m(v_b - v_o)$ to calculate the currents. Again, it can be made exact by adding $r_x$ to $r_{ib}$ and combining $r_o$ in parallel with $R_{te}$. The latter cannot be done if $R_{tc} \neq 0$.