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

\[ R_{\text{in}} = R_E \parallel R_{ie} \]
\[ R_{\text{out}} = R_C \parallel R_{ic} \]

where

\[ R_{ie} = R_e' \frac{R_0 + R_{te}}{R_e' + R_0 + R_{te} / (1 + \beta)} \]
\[ R_{te} = R_c \parallel R_L \quad R_{te} = R_E \parallel R_s \]

\[ R_{ic} = \frac{R_0 + R_e' \parallel R_{te}}{1 - \frac{\alpha R_{te}}{R_e' + R_{te}}} \]
\[ R_e' = \frac{R_{tb} + R_e}{1 + \beta} + R_e \quad R_{tb} = 0 \]
Looking out of the emitter, the Thévenin equivalent circuit has the values

\[ V_{te} = V_A \frac{R_E}{R_S + R_E} \quad R_{te} = R_E \parallel R_S \]

To solve for \( V_0 \), we replace the BJT with the Norton collector circuit.

\[ V_0 \]

\[ R_c \]

\[ \lambda_c(s_c) \]

\[ \dot{V}_{te} \]

\[ \dot{V}_{c(s_c)} = -Gme \dot{V}_{te} \]

Where

\[ Gme = \frac{1}{R_{te} + R'_E \parallel R_o} \quad \frac{dR_0 + R'_e}{R_0 + R_e} \]
The output voltage is given by

\[ V_o = -I_c(s) \, R_c \parallel R_L \]

\[ = +G_m \, V_{te} \, R_c \parallel R_L \]

\[ = +G_m \, V_{te} \frac{R_E}{R_s + R_E} \, R_c \parallel R_L \]

Thus the voltage gain is given by

\[ A_v = \frac{V_o}{V_{in}} \]

\[ = + \frac{R_E}{R_s + R_E} \, G_m \, R_c \parallel R_L \]

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

\[ R_c = R \]

\[ I_c = \alpha I_e = g_m V_{be} = g_m (V_b - V_e) \]

\[ = -g_m V_e \]
The signal equivalent circuit is

\[ V_e = V_{te} \frac{R_{ie}}{R_{te} + R_{ie}} \]

\[ I_c = -g_m V_e \]

\[ V_o = -I_c R_c = +g_m V_e R_{tc} \]

\[ = +g_m V_{te} \frac{R_{ie}}{R_{te} + R_{ie}} R_{tc} \]

\[ = +V_A \frac{R_E}{R_s + R_E} \frac{R_{ie}}{R_{te} + R_{ie}} g_m R_{tc} \]

\[ \Rightarrow A_V = \frac{V_o}{V_i} = \frac{R_E}{R_s + R_E} \frac{R_{ie}}{R_{te} + R_{ie}} g_m R_{tc} \]
An Alternate Approximate Solution

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

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

$$\lambda = -\frac{v_{te}}{r_{te} + r_e'}$$

$$\lambda_c = \lambda v_e = -v_{te} \frac{\lambda}{r_{te} + r_e'}$$

$$v_o = -\lambda_c r_{tc} = +v_{te} \frac{d r_{tc}}{r_{te} + r_e'}$$

$$= +V_h \frac{R_E}{R_s + R_E} \frac{\lambda}{r_{te} + r_e'}$$

$$\Rightarrow A_v = \frac{v_o}{v_h} = + \frac{R_E}{R_s + R_E} \frac{\lambda}{r_{te} + r_e'}$$