2.6 Common Collector Amplifier (Emitter Follower)

The CC amplifier is typically used as the output stage of an amplifier cascade. It provides a comparatively high input resistance paired with a small output resistance and thus yields a high current gain.

**Basic Configuration**

![Basic Configuration Circuit]

**Assumption:**
The 2 coupling caps C2 and C0 act as AC shorts.

**Small Signal Equivalent Circuit**

![Small Signal Equivalent Circuit]

\[ V_{be} = \beta \cdot \frac{V_{in}}{I_{c}} \]

\[ V_{o} = \frac{V_{A}}{I_{c}} \]
Equations:

\[ V_{in} = i_b \left[ R_{be} + (1+\beta) \frac{\tilde{V}_e}{\tilde{I}_e} \right] \]  \hspace{1cm} (1)

\[ \dot{i}_i = i_b + \frac{V_{in}}{R_{IS}} \]  \hspace{1cm} (2)

\[ \frac{\tilde{V}_{in}}{\tilde{i}_i} = \frac{\tilde{V}_e}{\tilde{I}_e} \parallel \frac{V_{in}}{i_b} = \tilde{V}_e \parallel \left[ R_{be} + (1+\beta) \frac{\tilde{V}_e}{\tilde{I}_e} \right] \]  \hspace{1cm} (3)

\[ V_o = (1+\beta) i_b \tilde{V}_e \]  \hspace{1cm} (4)

\[ -i_o \tilde{R}_L = (1+\beta) i_b \tilde{V}_e \quad \text{or} \quad i_o = -(1+\beta) \frac{\tilde{V}_e}{\tilde{I}_e + \tilde{R}_L} i_b \]  \hspace{1cm} (5)

Internal Current Gain:

\[ A_I = \frac{i_o}{i_b} = -(1+\beta) \frac{\tilde{V}_e}{\tilde{I}_e + \tilde{R}_L} \]  \hspace{1cm} Note: \( A_I = \frac{i_o}{i_i} \) \( R_m = \infty \)  \hspace{1cm} (6)

Voltage Gain:

\[ A_v = \frac{V_o}{V_{in}} = \frac{(1+\beta) \tilde{V}_e}{R_{be} + (1+\beta) \tilde{V}_e} = \frac{\tilde{V}_e}{\tilde{V}_e \parallel \frac{1}{R_{be} + (1+\beta) \tilde{V}_e}} \]  \hspace{1cm} (7)

Output Resistance:

\[ R_{out} = \frac{V_o}{i_o} \bigg|_{V_L=0} = \tilde{V}_e \parallel \frac{V_o}{i_o} = \tilde{V}_e \parallel \frac{1}{\frac{1}{R_{be} + (1+\beta) \tilde{V}_e}} \]  \hspace{1cm} (8)
CC Amplifier Design Example

Realize a CC gain stage that can drive an 8Ω speaker and yield an output voltage swing of at least 1V. \( V_{cc} = 10\text{V}; \beta = 150; V_A = 60\text{V}\)

1. Select \( I_{c0} \) large enough to yield an output swing of 1V
   \[
   \text{Choice: } I_{c0} = 250\text{mA}
   \]

2. Select \( R_1, R_2 \) such that \( V_{c0} \approx 5\text{V} \) and \( \frac{V_{c0}}{\beta} \ll R_c \)
   \[
   \text{Select } R_1 = R_2 = 270\Omega \rightarrow R_3 = 175\Omega
   \]

3. From \( R_{c0} = \frac{V_{cc} \frac{R_2}{R_1 \beta} - V_{BE0}}{\frac{R_2}{R_1} + R_c} \) we obtain \( R_c = 16.5\Omega \)
   \[
   \text{Choose } R_c = 15\Omega \text{ (availability) } \rightarrow I_{c0} \approx 270\text{mA}
   \]

Performance Parameters:

\[
\begin{align*}
A_v &\approx 0.98 \\
A_I &\approx 72.7
\end{align*}
\]

\[
\begin{align*}
P_{in} &\approx 117.5\Omega \\
P_{out} &\approx 0.24\Omega
\end{align*}
\]

Note: \( P_{in} \) could be made significantly larger if we could increase \( R_3 \). Solution: Use bipolar supply voltages (see Lab 7, Fig. 1)