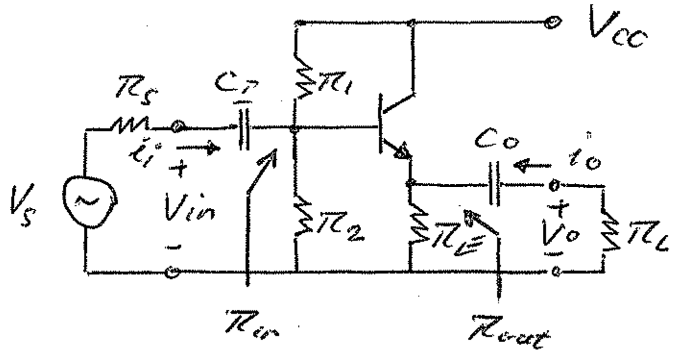
2.6 Common Collector Amplifier (Emitter Follower)

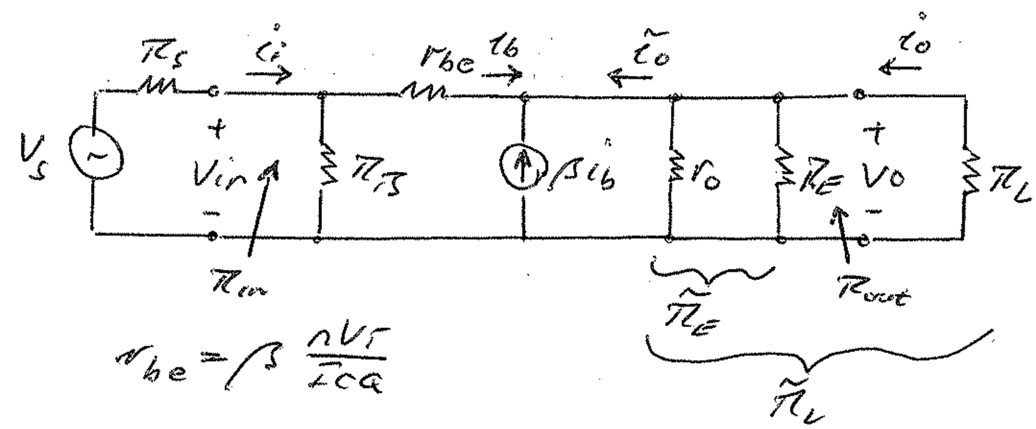
The CC amplifier is typically used as the output stage of an amplifier cascade. It provides a comparatively high input resistance paired with a small output resistance and thus yields a high current gain.

Basic Configuration



Assumption:
The 2 coupling caps C_I and C_o act as AC shorts

Small Signal equivalent Circuit



$$r_{be} = \beta \frac{n V_T}{I_{CQ}}$$

$$r_o = \frac{V_A}{I_{CQ}}$$

Equations:

$$v_{in} = i_b \left[r_{be} + (1+\beta)\tilde{R}_L \right] \qquad (1)$$

$$i_i = i_b + \frac{v_{in}}{R_B} \qquad (2)$$

$$\left\| R_{in} = \frac{v_{in}}{i_i} = R_B \,//\, \frac{v_{in}}{i_b} = R_B \,//\, \left[r_{be} + (1+\beta)\tilde{R}_L \right] \right\| \qquad (3)$$

$$v_o = (1+\beta)\, i_b \tilde{R}_L \qquad (4)$$

$$-i_o R_L = (1+\beta)\, i_b \tilde{R}_L \quad \text{or} \quad i_o = -(1+\beta)\frac{\tilde{R}_E}{\tilde{R}_E + R_L}\, i_b \qquad (5)$$

Internal Current Gain:

$$\left\| A_I = \frac{i_o}{i_b} = -(1+\beta)\frac{\tilde{R}_E}{\tilde{R}_E + R_L} \right\| \quad \text{Note: } A_I = \left.\frac{i_o}{i_i}\right|_{R_B = \infty} \qquad (6)$$

Voltage Gain:

$$\left\| A_V = \frac{v_o}{v_{in}} = \frac{(1+\beta)\tilde{R}_L}{r_{be} + (1+\beta)\tilde{R}_L} \cong \frac{\tilde{R}_L}{nV_T/I_{CQ} + \tilde{R}_L} \right\| \qquad (7)$$

Output Resistance:

$$\left\| R_{out} = \left.\frac{v_o}{i_o}\right|_{v_s = 0} = \tilde{R}_E \,//\, \frac{v_o}{\tilde{i}_o} = \tilde{R}_E \,//\, \frac{r_{be} + R_B // R_S}{1+\beta} \right\| \qquad (8)$$

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. $V_{CC} = 10V$, $\beta = 150$; $V_A = 60V$, $R_S = 50\Omega$;

1. Select I_{CQ} large enough to yield an output swing of 1V

   Choice: $I_{CQ} = 250mA$

2. Select R_1 & R_2 such that $V_{EQ} \cong 5V$ and $\frac{R_B}{\beta} \ll R_E$

   Select $R_1 = R_2 = 270\,\Omega$ → $R_B = 135\,\Omega$

3. From $I_{CQ} \cong \dfrac{V_{CC}\frac{R_2}{R_1+R_2} - V_{BEQ}}{\frac{R_B}{\beta} + R_E}$ we obtain $R_E = 16.3\Omega$

   Choose $R_E = 15\,\Omega$ (availability) → $I_{CQ} \cong 270mA$

Performance Parameters:

$A_V \cong 0.98$	$R_{in} \cong 117\,\Omega$
$A_I \cong -72.7$	$R_{out} \cong 0.24\,\Omega$

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