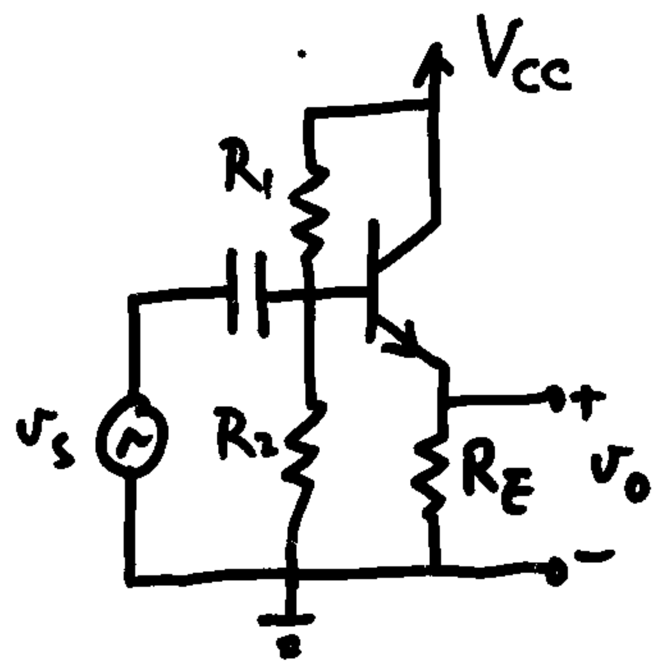
Common-Collector Amplifier

(Emitter-Follower)

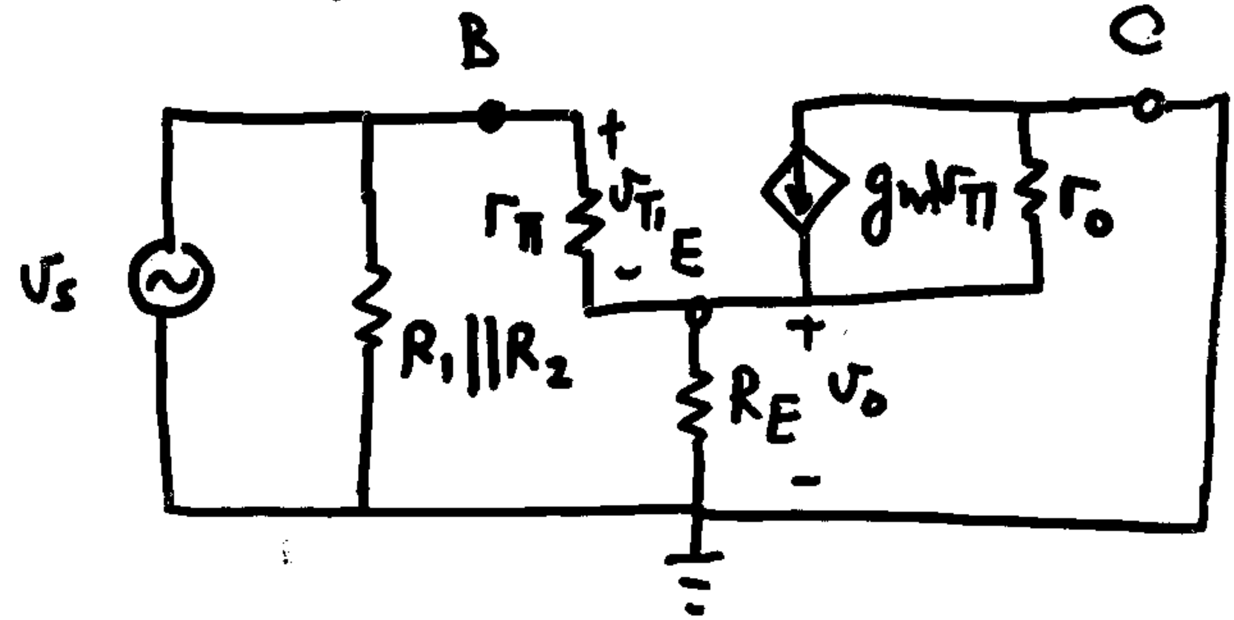
Emitter follows the base minus a diode drop.



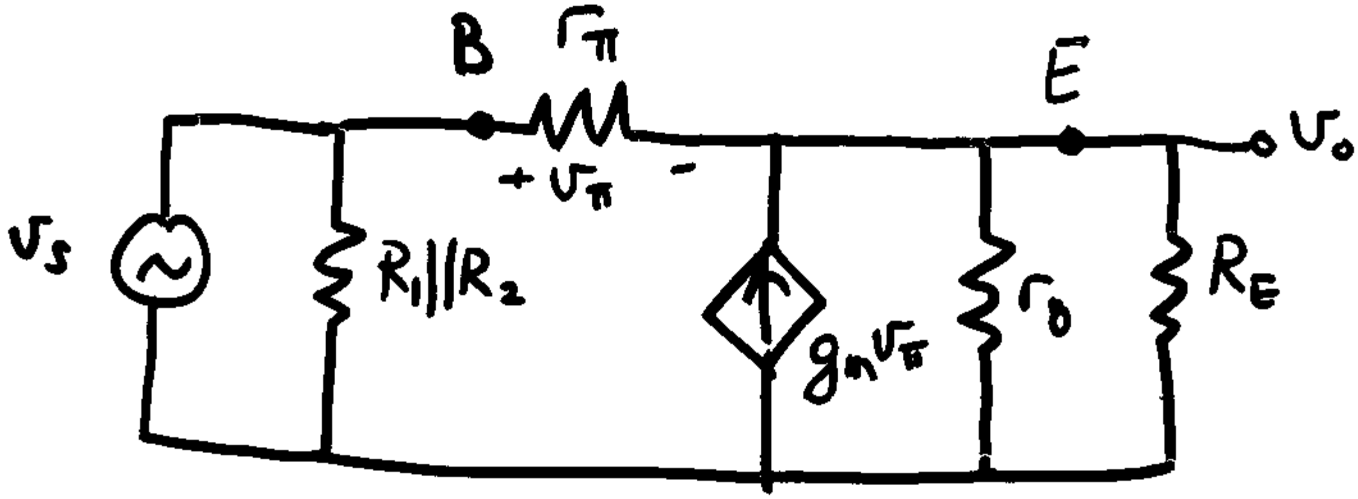
$R_s = 0$

$R_L = \infty$

A.C. eq. ckt



a.c. eq. ckt for CC Amplifier



Find $A_{v_s} = \frac{v_o}{v_s}$

$$v_s = v_\pi + v_o$$

$$v_o = \left(\frac{v_\pi}{r_\pi} + g_m v_\pi \right) (R_E \| r_o)$$

$$= \frac{v_\pi}{r_\pi} (1 + \beta)(R_E \| r_o)$$

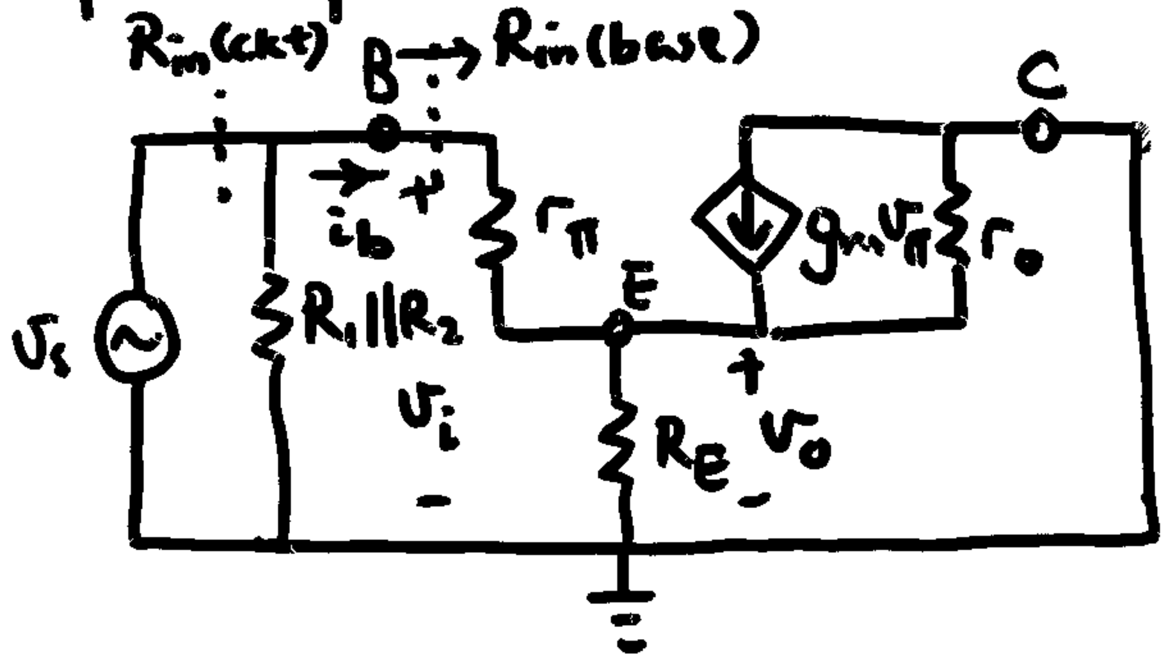
$$A_{v_s} = \frac{\frac{v_\pi}{r_\pi}(1+\beta)(R_E \| r_o)}{v_\pi + \frac{v_\pi}{r_\pi}(1+\beta)(R_E \| r_o)}$$

$$= \frac{(\beta+1)(R_E \| r_o)}{r_\pi + (\beta+1)(R_E \| r_o)}$$

Note: (1) No phase reversal

(2) $|A_{v_s}| < 1$

Input impedance



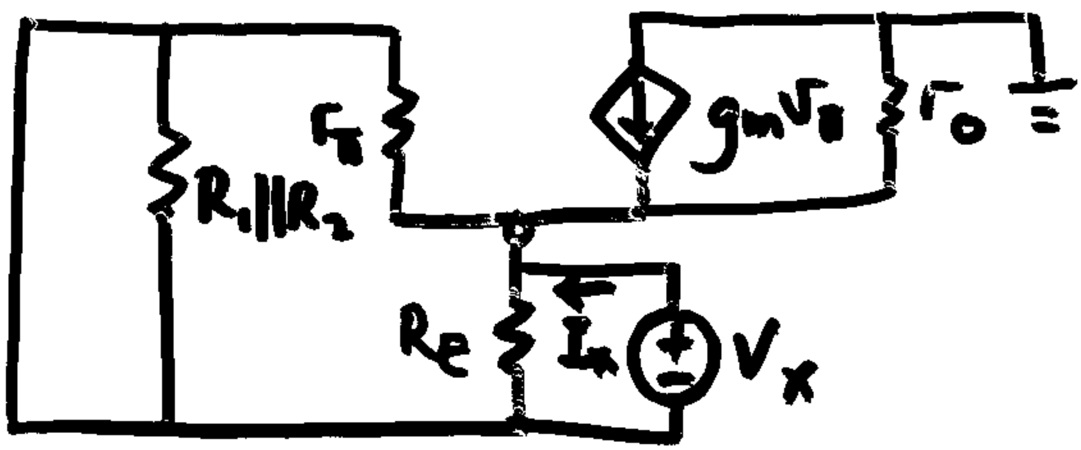
$$R_{in}(base) = \frac{v_i}{i_b} = \frac{v_i}{v_i/(r_\pi + (\beta+1)(R_E \| r_o))}$$

$$= r_\pi + (\beta+1)(R_E \| r_o)$$

$$R_{in}(ckt) = R_1 \| R_2 \| (r_\pi + (\beta+1)(R_E \| r_o))$$

Note: $R_{in}(base)$, $R_{in}(ckt)$ } can be large

Output impedance



$$R_{out} = \frac{V_x}{I_x}$$

$$I_x = \frac{V_x}{R_E} + \frac{V_x}{r_o} + \frac{V_x}{r_\pi} + \frac{\beta V_x}{r_\pi}$$

$$\frac{1}{R_{out}} = \frac{I_x}{V_x} = \frac{1}{R_E} + \frac{1}{r_o} + \frac{1}{r_\pi} + \frac{\beta}{r_\pi}$$

$$R_{out} = R_E || r_o || r_\pi || \frac{r_\pi}{\beta}$$

$$= R_E || r_o || \frac{r_\pi}{\beta+1}$$

Note: Output impedance can be very small. useful for delivering large current to a load

Current gain

$$A_i = \frac{v_o / R_E}{v_s / R_{in(ckt)}}$$

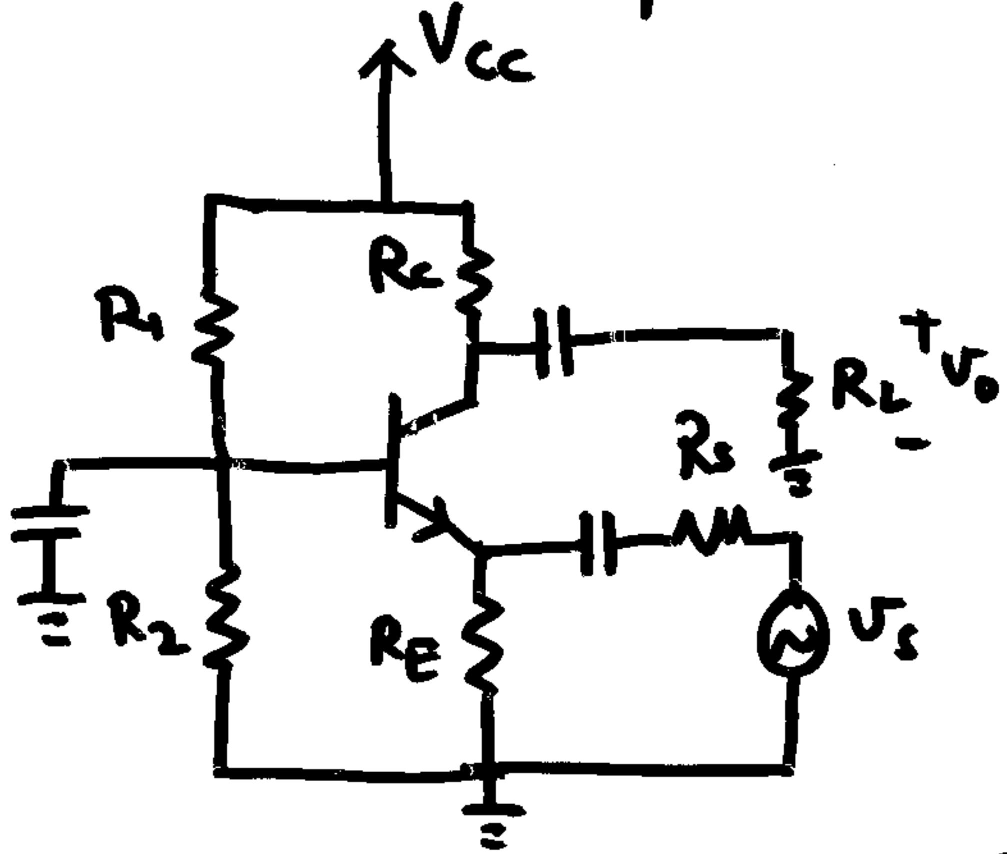
$$= \frac{(\beta+1)(R_E \| r_o)}{r_\pi + (\beta+1)(R_E \| r_o)} \frac{R_1 \| R_2 \| R_{in(base)}}{R_E}$$

$R_{in(base)} = r_\pi + (\beta+1)(R_E \| r_o)$

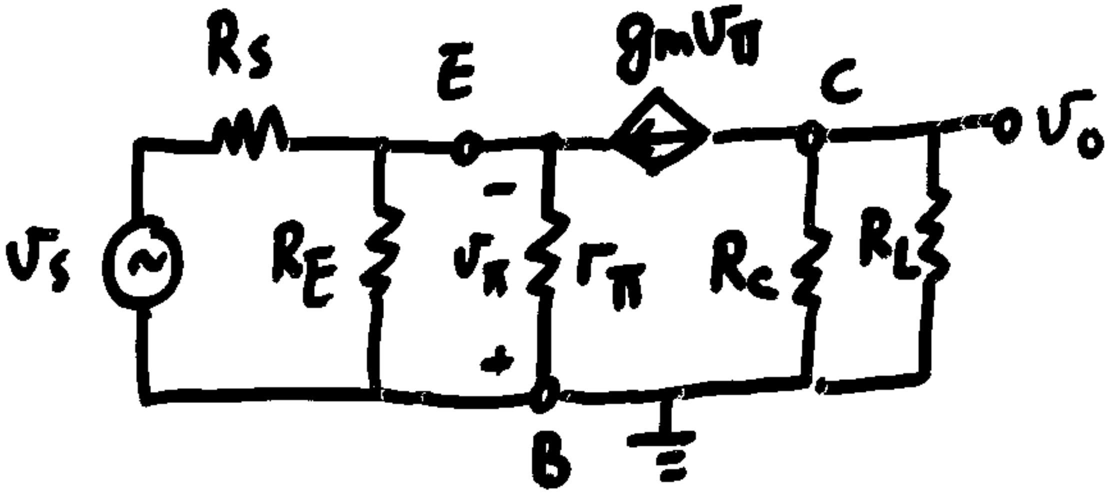
$$= (\beta+1) \frac{r_o}{R_E + r_o} \frac{R_1 \| R_2}{R_1 \| R_2 + R_{in(base)}}$$

$$\simeq (\beta+1)$$

Common Base Amplifier



a.c. equivalent (ignoring r_o)



$$v_o = -g_m v_\pi (R_C \| R_L)$$

Apply KCL,

$$g_m v_\pi + \frac{v_\pi}{r_\pi} + \frac{v_\pi}{R_E} + \frac{v_s - (-v_\pi)}{R_s} = 0$$

$$\frac{v_s}{R_s} = -v_\pi \left(g_m + \frac{1}{r_\pi} + \frac{1}{R_E} + \frac{1}{R_s} \right)$$

$$= -v_\pi \left(\frac{\beta+1}{r_\pi} + \frac{1}{R_E} + \frac{1}{R_s} \right)$$

$$v_\pi = -\frac{v_s}{R_s} \left(\frac{r_\pi}{\beta+1} \| R_E \| R_s \right)$$

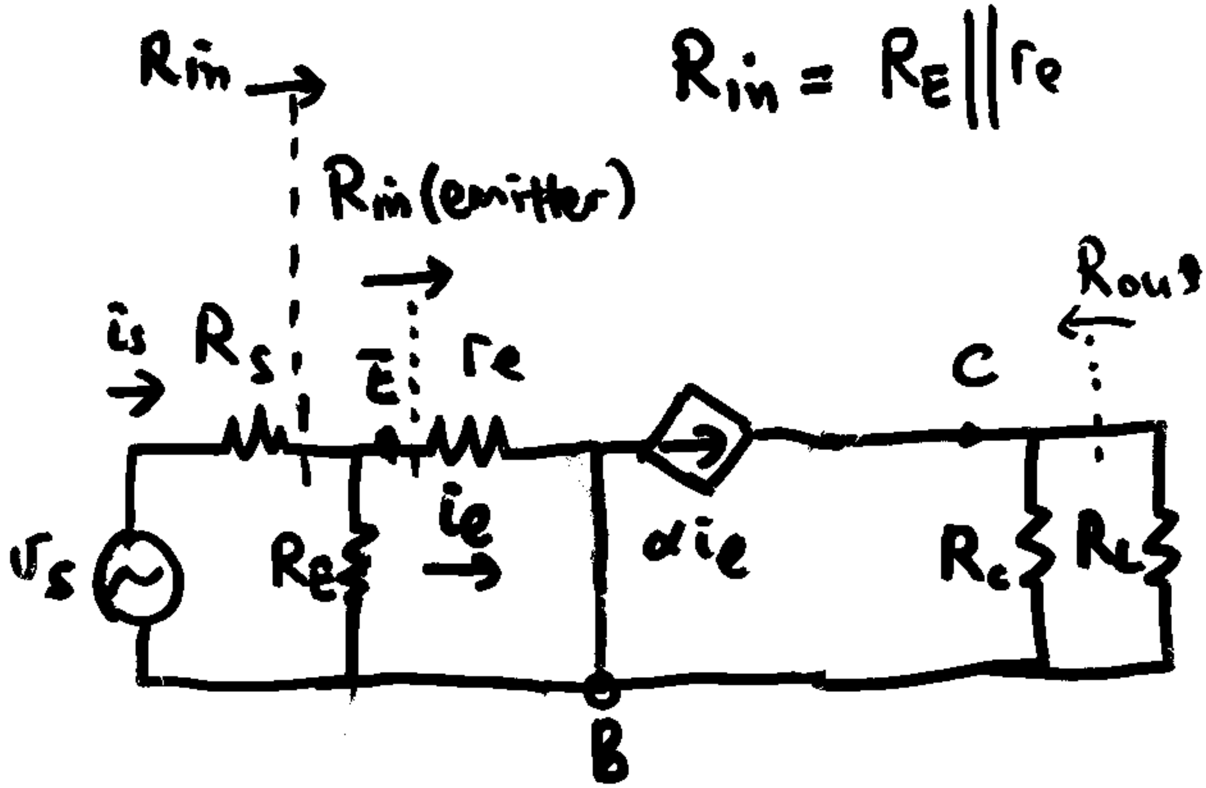
$$A_{v_s} = \frac{v_o}{v_s} = g_m (R_C \| R_L) \left(\frac{1}{R_s} \right) \left(\frac{r_\pi}{\beta+1} \| R_E \| R_s \right)$$

$$A_{v_s} = g_m (R_C \| R_L) \quad R_s = 0$$

Input impedance

$$R_{in(emitter)} = r_e = \frac{r_\pi}{\beta+1}$$

$$R_{in} = R_E \| r_e$$



Output impedance

$$R_{out} = R_C$$

Current gain

$$A_{i_s} = \frac{i_o}{i_s} = \frac{v_o/R_L}{v_s/R_{in(ckt)}}$$

$$= g_m \frac{R_C}{R_C+R_L}\left(\frac{r_\pi}{\beta+1} \| R_E\right)$$