ECE 342
Electronic Circuits

Lecture 19
CB and Emitter Follower

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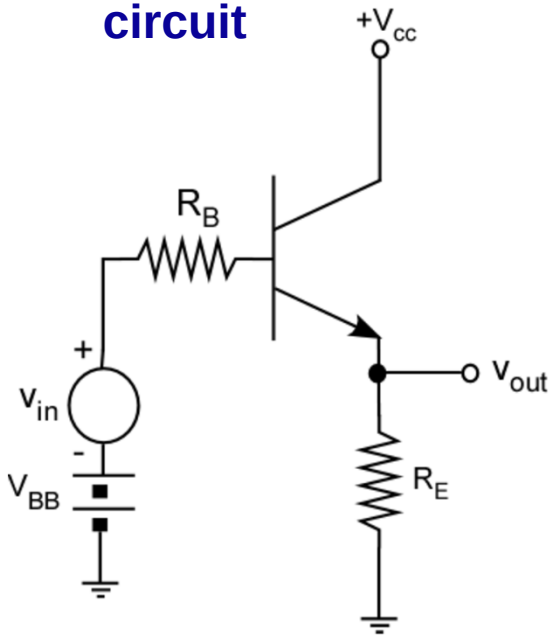
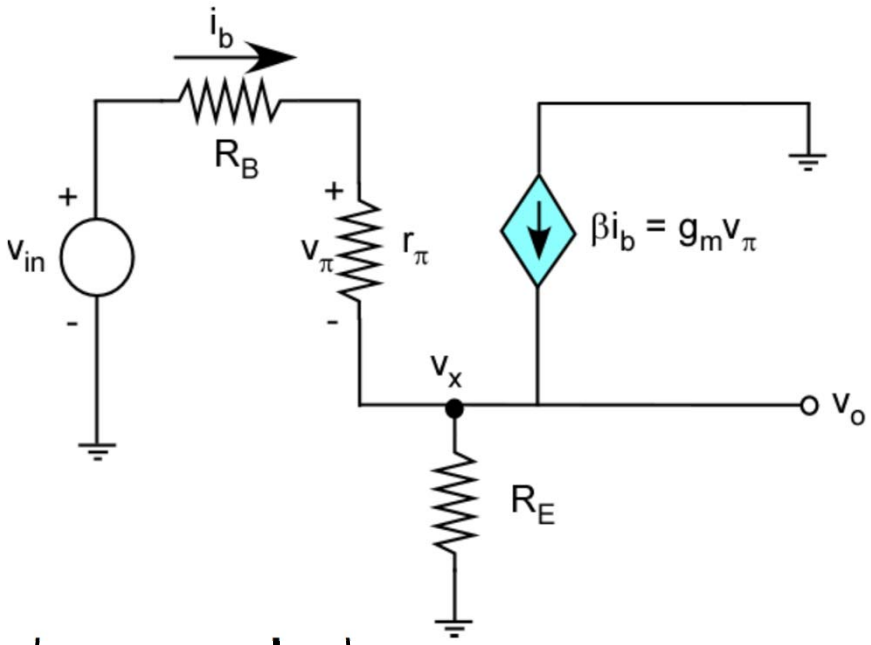
Emitter Follower

circuit



Incremental model



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

$$v_{in} = v_\pi + R_B i_b + v_o = v_\pi + v_\pi R_E \left(g_m + \frac{1}{r_\pi} \right) + \frac{v_\pi}{r_\pi} R_B$$

Emitter Follower

$$v_{in} = v_\pi \left[1 + \frac{R_B}{r_\pi} + R_E \left(g_m + \frac{1}{r_\pi} \right) \right]$$

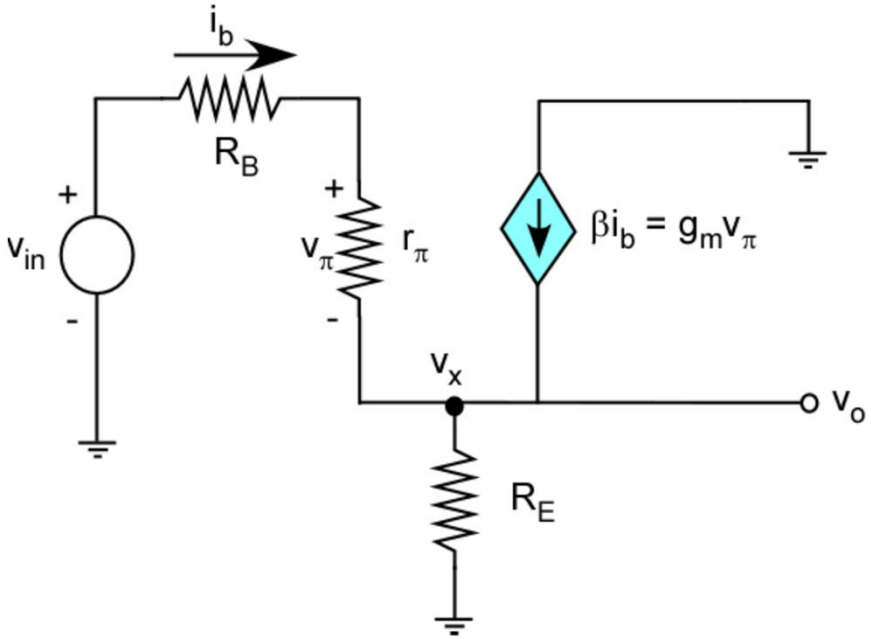
$$\frac{v_o}{v_{in}} = \frac{\left(g_m + \frac{1}{r_\pi} \right) R_E}{\left(g_m + \frac{1}{r_\pi} \right) R_E + 1 + \frac{R_B}{r_\pi}} = \frac{\left(g_m r_\pi + 1 \right) R_E}{\left(g_m r_\pi + 1 \right) R_E + r_\pi + R_B}$$

Using $g_m r_\pi = \beta$

$$\frac{v_o}{v_{in}} = \frac{\left(\beta + 1 \right) R_E}{\left(\beta + 1 \right) R_E + r_\pi + R_B} \simeq 1$$

Emitter follower has unity voltage gain

Emitter Follower – Input Impedance

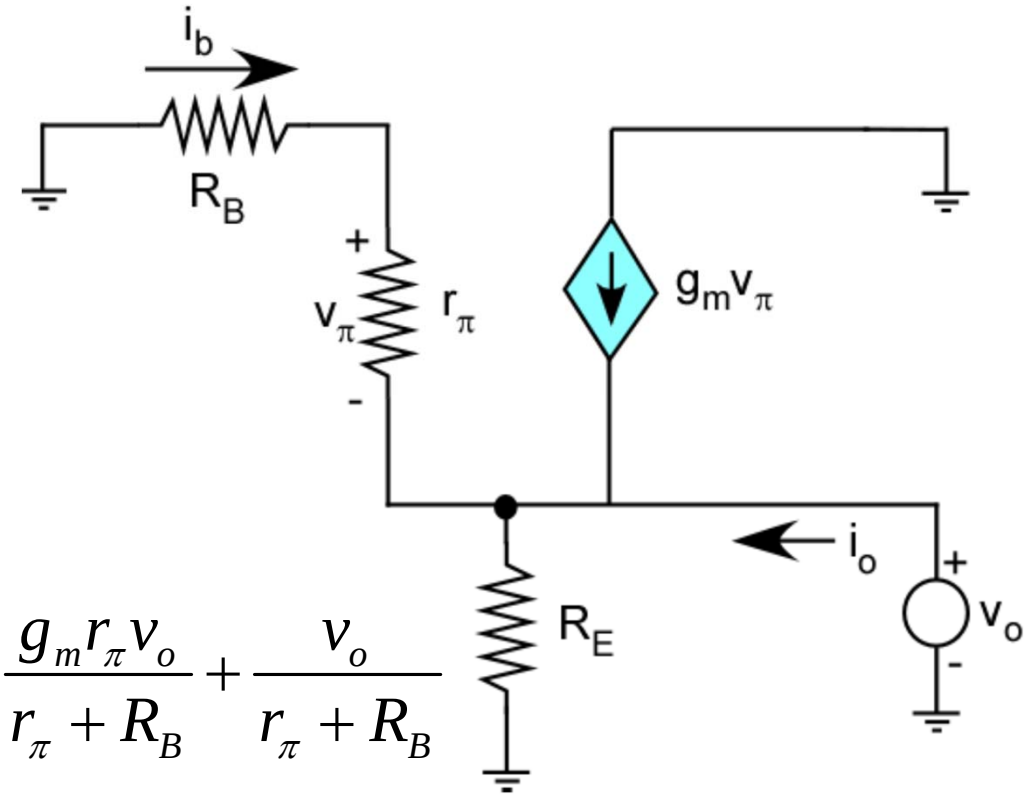


$$r_{in} = \frac{v_{in}}{i_b} = \frac{v_\pi \left[1 + R_B / r_\pi + R_E \left(g_m + 1/r_\pi \right) \right]}{v_\pi / r_\pi}$$

$$r_{in} = r_\pi + R_B + R_E \left(\beta + 1 \right)$$

Emitter Follower – Output Impedance

$$i_B = -\frac{v_o}{r_\pi + R_B}$$



$$i_o = \frac{v_o}{R_E} - g_m v_\pi + \frac{v_o}{r_\pi + R_B} = \frac{v_o}{R_E} + \frac{g_m r_\pi v_o}{r_\pi + R_B} + \frac{v_o}{r_\pi + R_B}$$

$$i_o = v_o \left[\frac{1}{R_E} + \frac{g_m}{r_\pi + R_B} + \frac{1}{r_\pi + R_B} \right] = v_o \left[r_\pi + R_B + R_E(\beta + 1) \right] \frac{1}{R_E \left(r_\pi + R_B \right)}$$

Output Impedance (cont')

Using $g_m r_\pi = \beta$

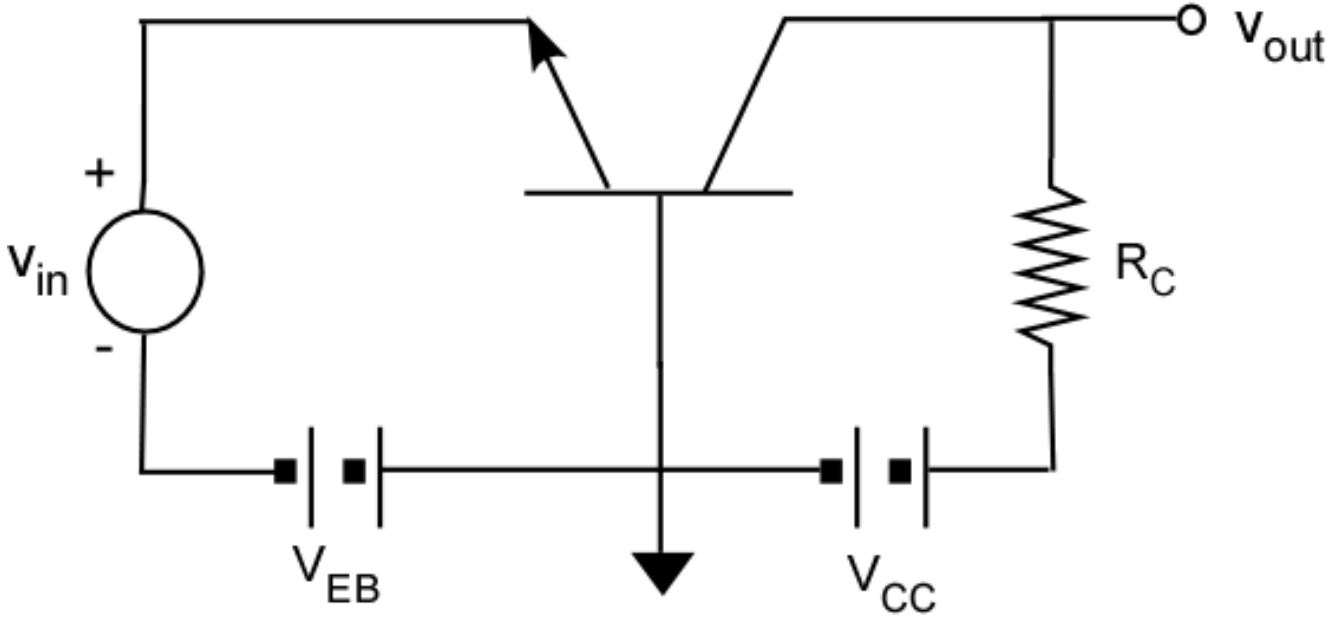
$$\frac{v_o}{i_o} = R_{out} = \frac{R_E\left(r_\pi + R_B\right)}{r_\pi + R_B + R_E(\beta+1)} = \frac{R_E\left(r_\pi + R_B\right)/(\beta+1)}{R_E + \left(r_\pi + R_B\right)/(\beta+1)}$$

$$R_{out} = R_E \,||\left(r_\pi + R_B\right)/(\beta+1)$$

If we neglect R_B

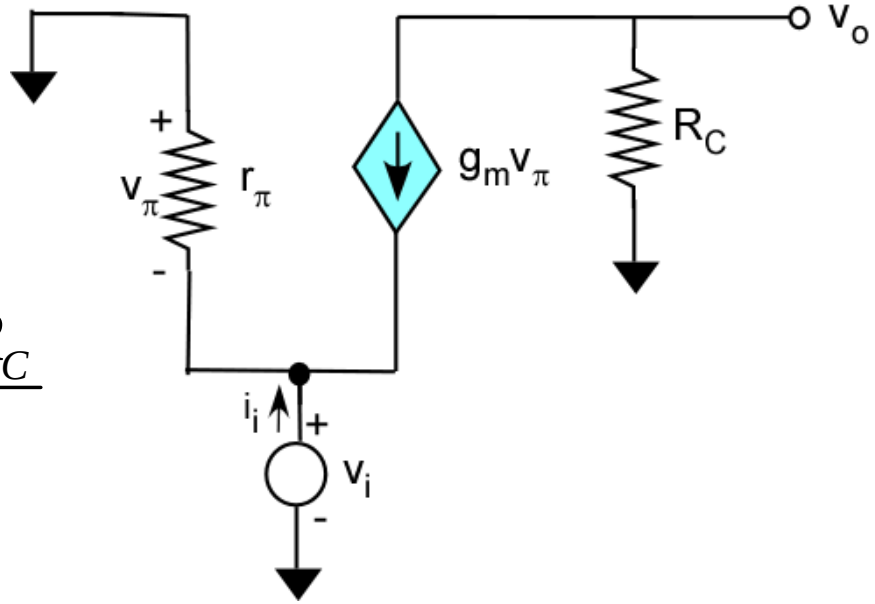
$$A_{MB}^{'} = \frac{(\beta+1)R_E}{r_\pi + (\beta+1)R_E} \quad and \quad R_{out}^{'} = R_E \,||\, \frac{r_\pi}{\beta+1}$$

Common Base Configuration



Common Base Configuration

$$v_i = -v_\pi, \quad v_o = -g_m v_\pi R_C = g_m v_i R_C$$



$$Voltage\ \ gain = \frac{v_o}{v_i} = g_m R_C = \frac{\alpha R_C}{r_e}$$

$$Current\ gain = \frac{i_o}{i_i} = \frac{g_m v_\pi}{i_i} = \frac{-g_m v_\pi}{\left(g_m + \frac{1}{r_\pi}\right)(-v_\pi)} = \frac{\beta}{\beta+1} = \alpha$$

$$R_{out} = R_C$$

$$r_{in} = \frac{r_\pi}{\beta+1}$$

BJT Topologies - Summary

	CE	CB	EF
A_{vo}	$-g_m R_C$	$g_m R_C$	1
R_{in}	r_π	$\frac{r_\pi}{\beta+1}$	$r_\pi + R_E(\beta+1)$
R_{out}	R_C	R_C	$R_E \parallel r_\pi/(\beta+1)$