ECE 310 - Lecture 33

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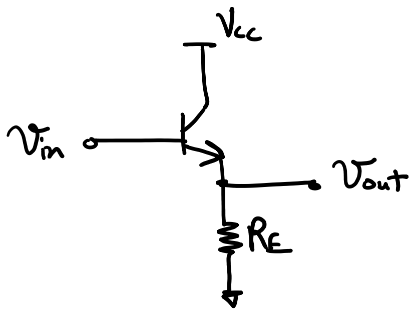
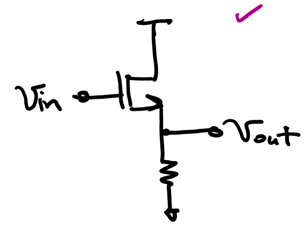
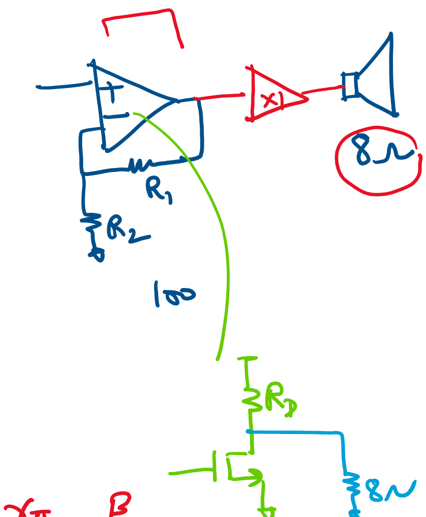
Emitter follower (Common Collector)







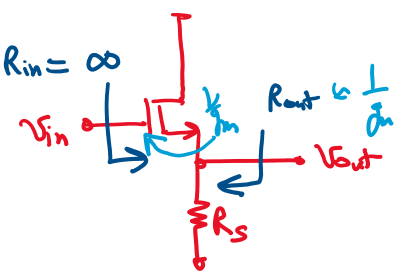
$$\frac{v_{out}}{v_{in}} = \frac{1}{1 + \frac{r_\pi}{(\beta+1)} \cdot \frac{1}{R_E}}$$

$$\approx \frac{R_E}{R_E + \frac{1}{g_m}}$$

$$\frac{r_\pi}{\beta+1} \approx \frac{r_\pi}{\beta} = \frac{1}{g_m}$$

$$\therefore r_\pi = \frac{\beta}{g_m}$$

$R_{in} = \infty$

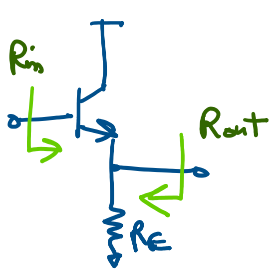


$R_{out} \approx \frac{1}{g_m} \| R_S \approx \frac{1}{g_m}$

$R_{in} \to \infty$

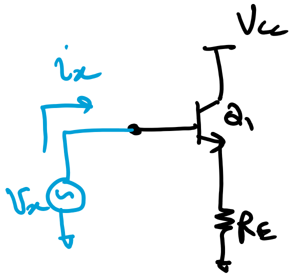
$R_{out} \approx \frac{1}{g_m} \to 0$

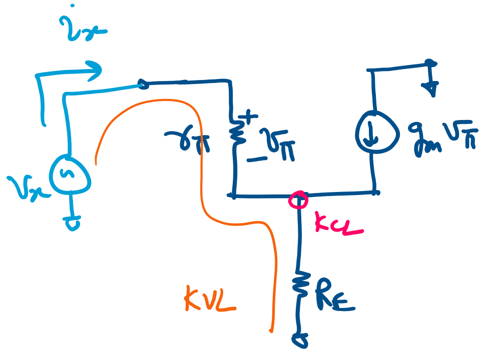
Need to derive R_{in} & R_{out} of Emitter follower Circuit



$V_A \to \infty$

$r_o \to \infty$





$$v_x = v_\pi + (i_x + g_m v_\pi) R_E \longrightarrow (1)$$

$$v_\pi = i_x r_\pi \longrightarrow (2)$$

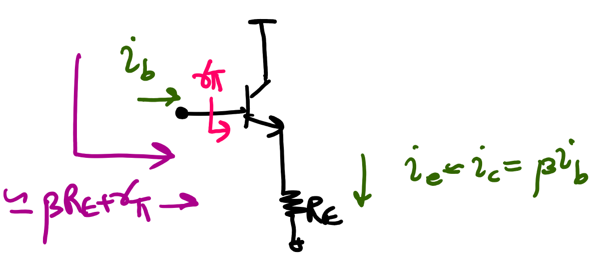
$$\because r_\pi = \frac{\beta}{g_m}$$

$$\Rightarrow g_m r_\pi = \beta$$

$$\Rightarrow \quad v_x = i_x r_\pi + (i_x + \underbrace{g_m r_\pi}_{\beta} i_x) R_E$$

$$\Rightarrow v_x = i_x r_\pi + (\beta+1) i_x R_E$$

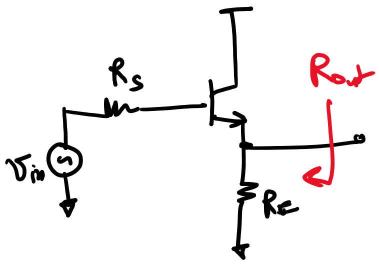
$$\Rightarrow \boxed{R_{in} = \frac{v_x}{i_x} = r_\pi + (\beta+1) R_E}$$



Emitter follower "transforms" the load resistor, R_E, to a much larger value $(\beta+1)R_E + r_\pi$

↳ forms an efficient voltage buffer by driving $R_{in} \to \infty$

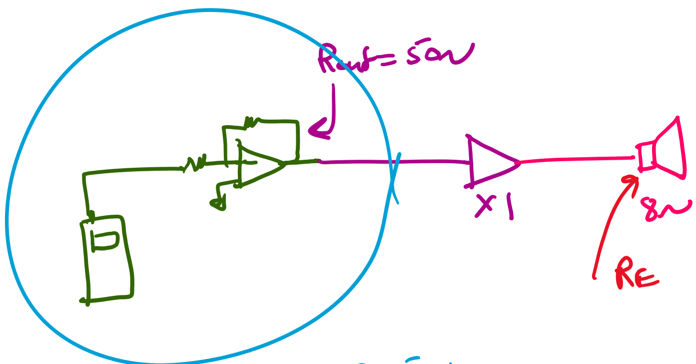
by driving $R_{in} \to \infty$

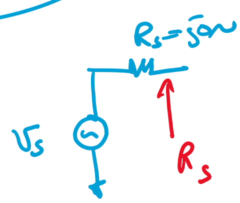


R_s / β

$$R_{out} = \left(\frac{R_s}{\beta+1} + \frac{1}{g_m}\right) \| R_E \simeq \frac{R_s}{\beta+1} + \frac{1}{g_m}$$

Does a good job of providing a low R_{out} ⟶ good voltage buffer.

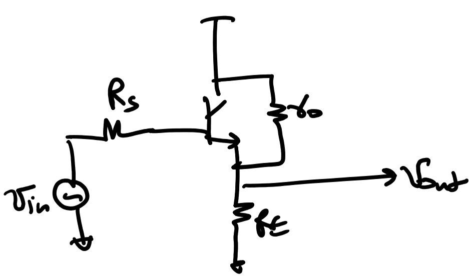




$$A_v = \frac{R_E \| r_o}{R_E \| r_o + \frac{R_s}{\beta+1} + \frac{1}{g_m}}$$

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

$$R_{out} = \left(\frac{R_s}{\beta+1} + \frac{1}{g_m}\right) \| R_E \| r_o$$



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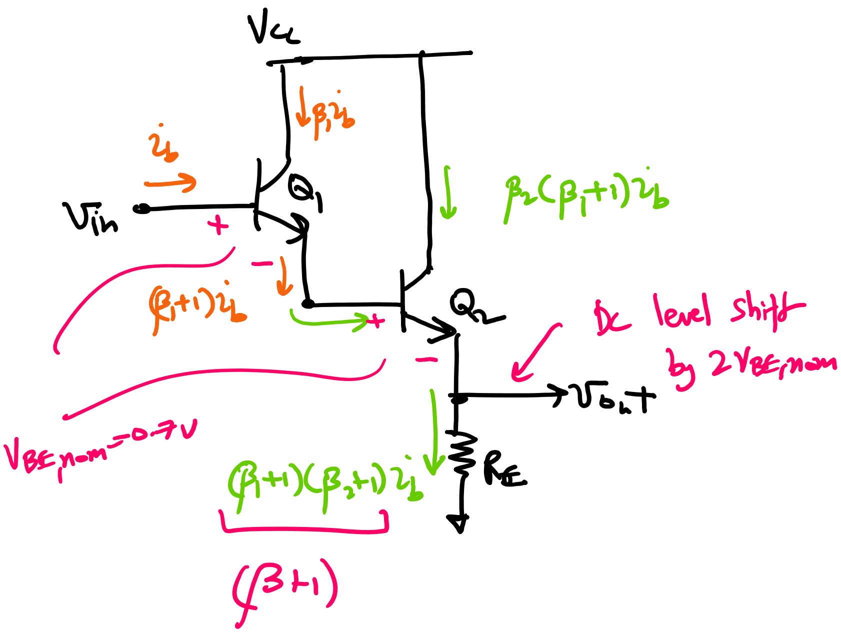
Darlington Pair $\equiv$ Two Emitter Followers in Cascade



$\beta + 1 = (\beta_1+1)(\beta_2+1)$

$\beta \simeq \beta_1\beta_2 = \beta_o^2$

if $\beta_1 = \beta_2 = \beta_o$

Current gain $= \beta_1\beta_2$

$I_B \ll I_E$

Excellent Voltage Buffer

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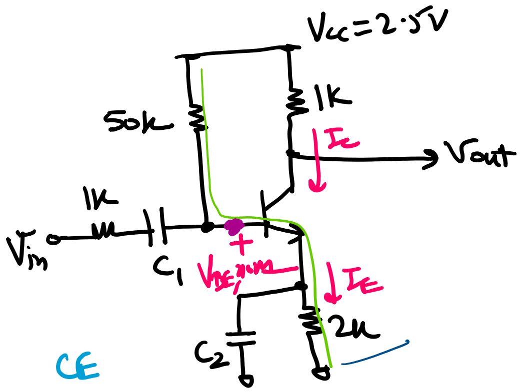
Example 5.52:

$I_S = 8\times10^{-16}\,A$, $\beta = 100$, $V_A = \infty$, $r_o \to \infty$, Caps are very large

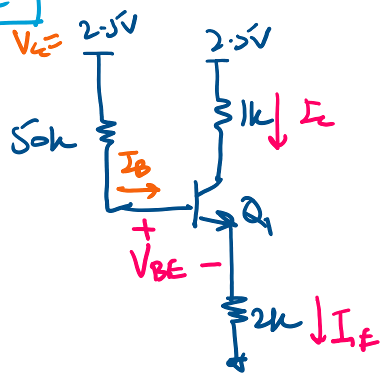
(Do not ignore base current)



CE

g_m, r_π

DC picture



$$I_B = \frac{V_{CC} - V_{BE} - I_E \times 2k}{50k} \qquad I_E \simeq I_C$$

$$I_C = \beta I_B = \frac{\beta\,(V_{CC} - V_{BE} - I_E \times 2k)}{50k}$$

$$I_C = \frac{100\,(2.5 - V_{BE})}{50k + \underbrace{(\beta+1)}_{101}\,2k}$$

$$I_C = \frac{100\,(2.5 - V_{BE})}{252k}$$

$$I_C \simeq I_S\, e^{V_{BE}/V_T}$$

Instead of iterative solution, use $V_{BE,nom} \simeq 0.7V$

(0.7V

$$0.7\,V$$

$$I_c = \frac{100 \times (2.5 - V_{BE,\,on})}{252k} = 0.714\,mA$$

$$g_m = \frac{I_c}{V_T} = \frac{0.714\,mA}{26\,mV} = 27.5\,\frac{mA}{V}$$

$$r_\pi = \frac{\beta}{g_m} = 3.64\,k\Omega$$

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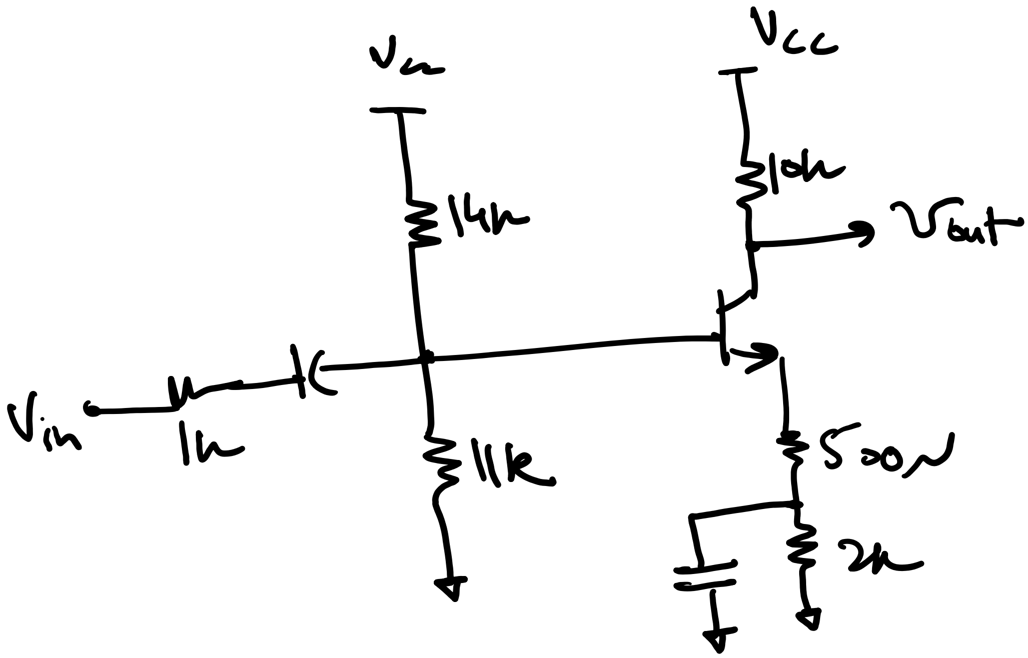
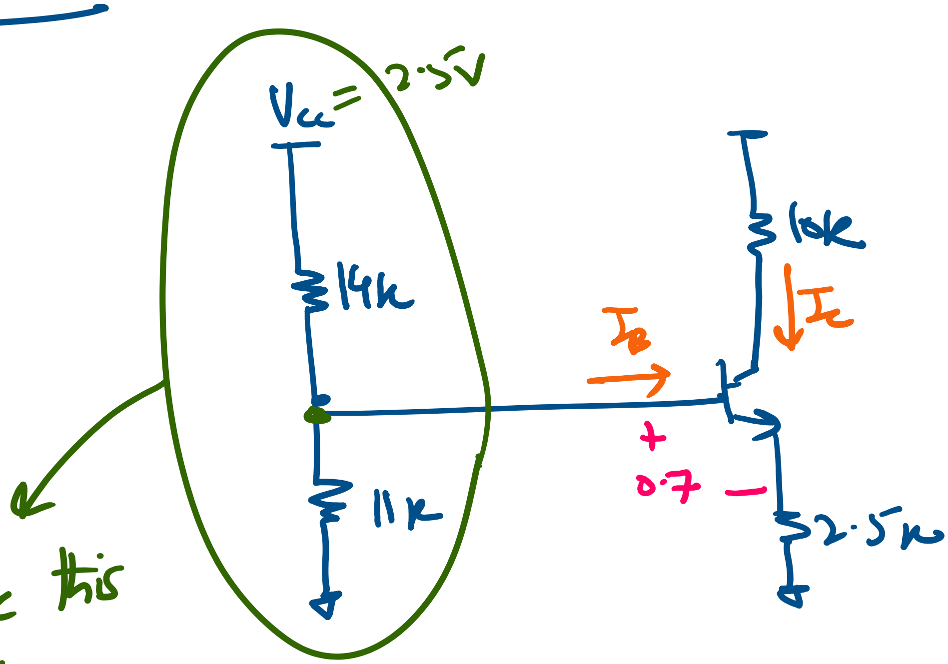
Problem 5.52 (c)



Dc picture:



Thevenize this part of the circuit

part of the circuit