ECE 2100 Lecture Notes 3/14/03

Stuff

Interested in research at the "U"? Check out a series of talks in EMCB 112, Thursdays 2-3pm. These talks are geared for undergraduates.

HW #16, due: F, 3/14 Hw 15-16 handout

HW #17, due: W, 3/26 Hw 17 handout

HW #18, due: F, 3/28 Hw 18 handout

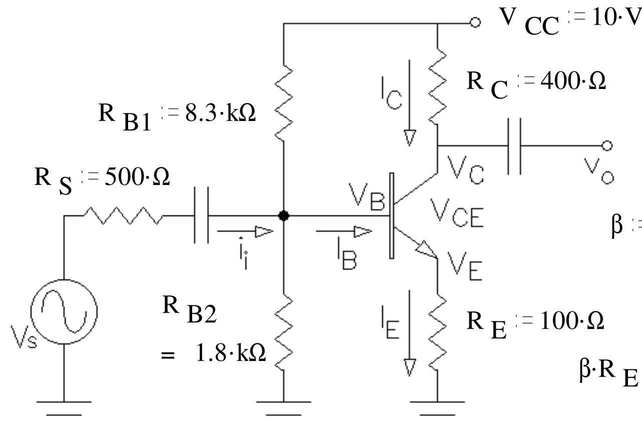
Spice #S2, due: F, 4/4 handout

Dr. Harrison will be here for a few minutes today to talk about ECE 3110 and IC design classes.

Finish up Common collector (CC)

Common emitter (CE)

Common Emitter amplifier, example:



$\beta := 180$

$\beta \cdot R_E = 18 \cdot k\Omega$

Bias:

$$V_{BB} := \frac{R_{B2}}{R_{B2} + R_{B1}} \cdot V_{CC} \qquad V_{BB} = 1.782 \cdot V$$

$$R_{BB} := \frac{1}{\left(\frac{1}{R_{B2}} + \frac{1}{R_{B1}}\right)} \qquad R_{BB} = 1.479 \cdot k\Omega$$

$$I_B := \frac{V_{BB} - 0.7 \cdot V}{R_{BB} + \beta \cdot R_E} \qquad I_B = 0.056 \cdot mA$$

$$I_E := \frac{V_E}{R_E} \qquad I_C := I_E \qquad I_C = 10 \cdot mA$$

$$V_E := I_B \cdot (\beta \cdot R_E) \qquad V_E = 1 \cdot V$$

$$V_B := V_E + 0.7 \cdot V \qquad V_B = 1.7 \cdot V$$

$$V_C := V_{CC} - I_C \cdot R_C \qquad V_C = 6 \cdot V$$

What if we put in an AC input signal: $v_B(t) := V_B + 0.5 \cdot V \cdot \cos\left(6280 \cdot \frac{rad}{sec} \cdot t\right)$ $\qquad v_E(t) := v_B(t) - 0.7 \cdot V$

$$i_C(t) := \frac{v_E(t)}{R_E} \qquad v_C(t) := V_{CC} - i_C(t) \cdot R_C$$

$$\frac{R_C}{R_E} = \frac{400 \cdot \Omega}{100 \cdot \Omega} = 4$$

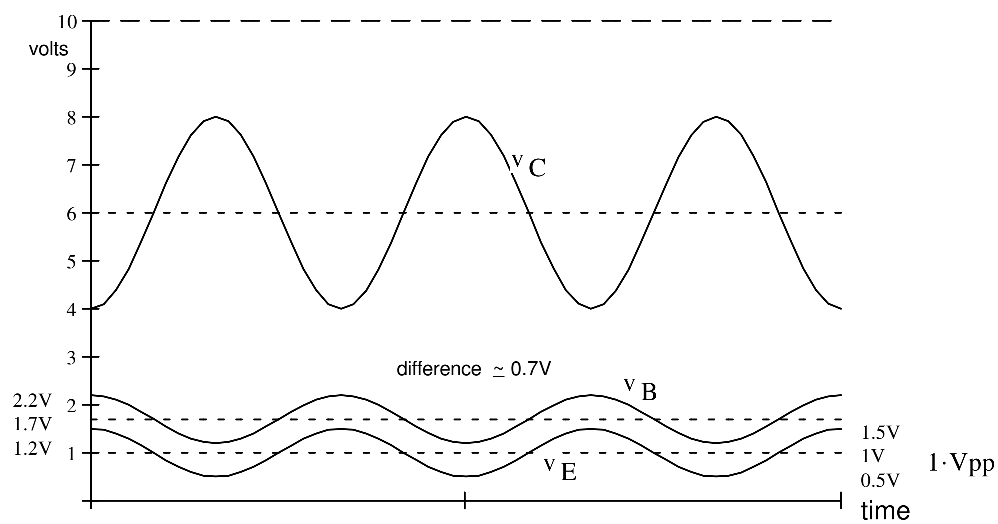
v_C is 4 times bigger and inverted

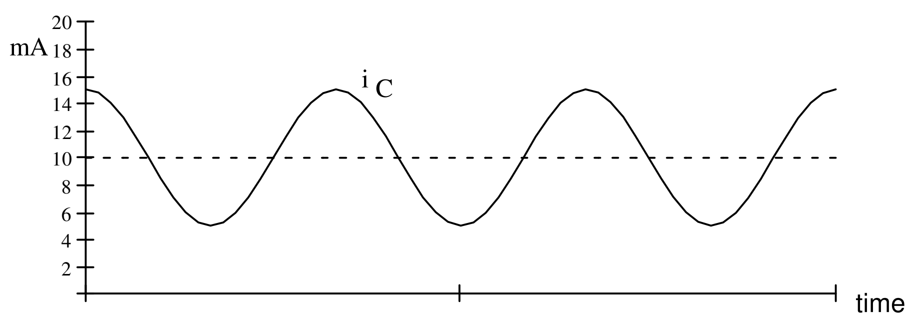
Actually, to be more correct, we should account for the small-signal resistance of the base-emitter junction.

$$r_e := \frac{V_T}{I_C} \qquad r_e = 2.5 \cdot \Omega$$

gain is really:

$$\frac{R_C}{R_E + r_e} = 3.902$$





Common emitter (CE), continued

Input impedance: $R_i = R_{B1} \| R_{B2} \| \beta \cdot (r_e + R_E)$

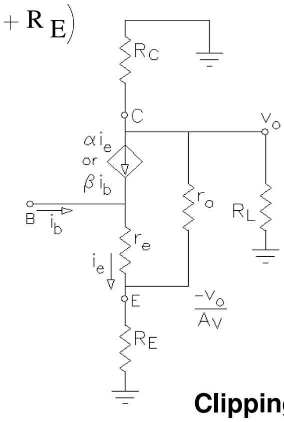
Output impedance: $R_o = R_C \| r_o$

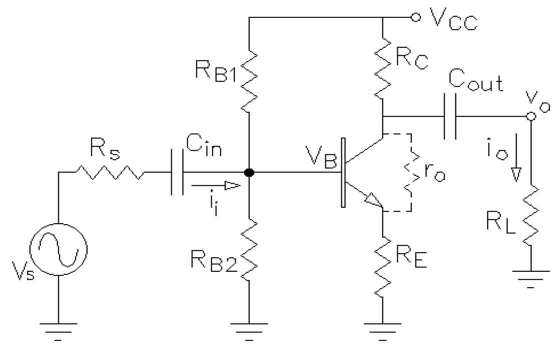
Often neglected $r_o = \dfrac{V_A}{I_C}$ Early voltage. (guess $V_A \simeq 100$ V if no data)

AC collector resistance: $r_c = R_C \| R_L \| r_o$

More correct, use: $r_o \cdot \dfrac{A_v}{A_v + 1}$

instead of r_o very rarely done.

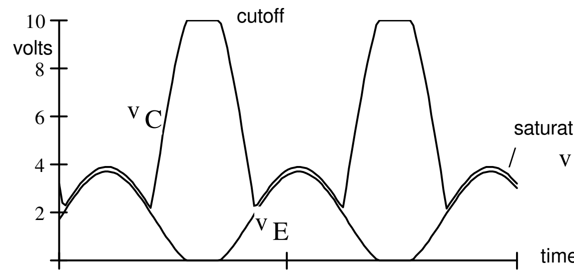




Voltage gain: $A_v = \dfrac{v_o}{v_b} = \dfrac{r_c}{r_e + R_E}$

Current gain: $A_i = \dfrac{i_o}{i_i} = \dfrac{r_c}{r_e + R_E} \cdot \dfrac{R_i}{R_L} = A_v \cdot \dfrac{R_i}{R_L}$

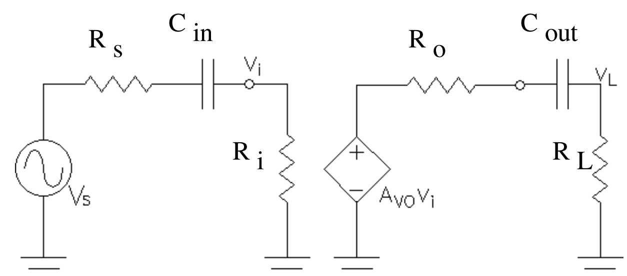
Clipping Cutoff clipping: $i_E = 0$



Low frequency corner frequencies

$$f_{CL1} = \frac{1}{2 \cdot \pi \cdot (R_S + R_i) \cdot C_{in}}$$

$$f_{CL2} = \frac{1}{2 \cdot \pi \cdot (R_L + R_o) \cdot C_{out}}$$



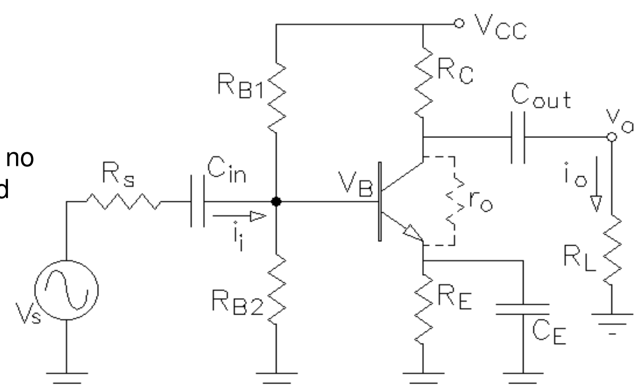
With bypass capacitor (C_E)

This basically makes the R_E dissapear at signal frequencies (If the cap is big enough).

Input impedance: $R_i = R_{B1} \| R_{B2} \| \beta \cdot r_e$ Much lower

Output impedance: $R_o = R_C \| r_o$ Same as above, but no r_o correction needed

AC collector resistance: $r_c = R_C \| R_L \| r_o$



Voltage gain: $A_v = \dfrac{v_o}{v_b} = \dfrac{r_c}{r_e}$

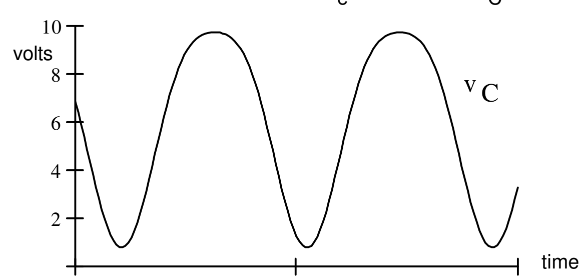
Current gain: $A_i = A_v \cdot \dfrac{R_i}{R_L}$

Another low frequency corner frequency:

$$f_{CL3} = \frac{1}{2 \cdot \pi \cdot C_E} \cdot \left(\frac{1}{r_e} + \frac{1}{R_E} \right)$$

Because r_e is so small, this will usually dominate, even when C_E is big.

If the output swing is too big you'll get distortion because r_e varies with i_C



Have a good & a safe Spring Break, see you in a week & a half. Go find some sun....