Lecture 19

BJT Common Emitter (CE) Amplifier

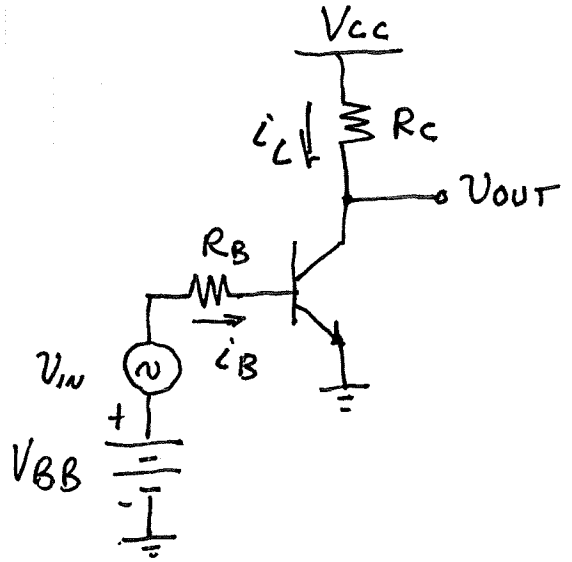
BJT Common Emitter (CE) Amplifier (w/ R_B)

- DC Bias Analysis
- Small-Signal (ac) Analysis
- Beta Dependency

BJT Common Emitter (CE) Amplifier (w/ R_E)

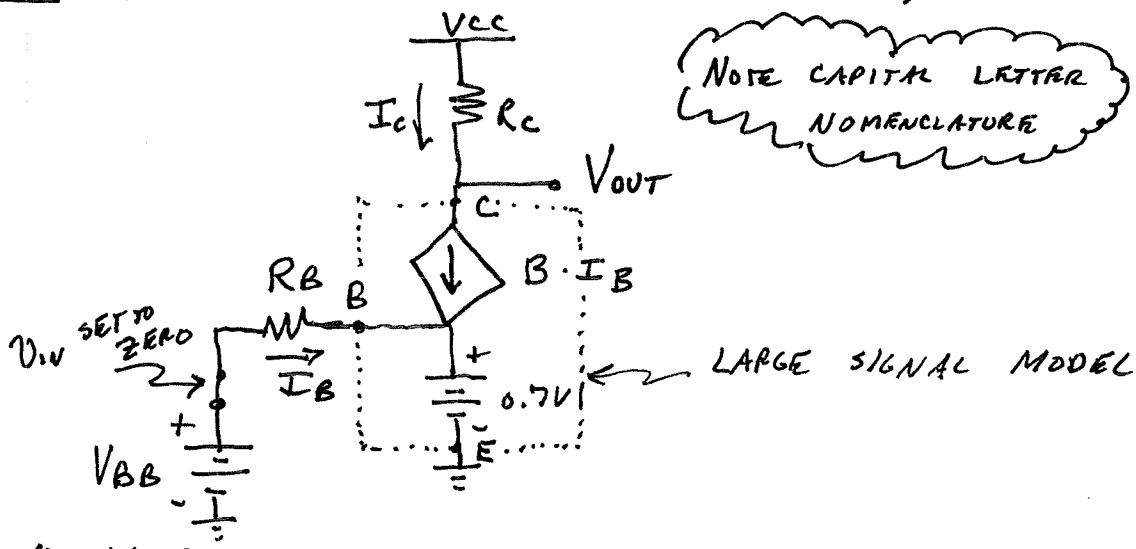
- DC Bias Analysis
- Small-Signal (ac) Analysis
- Beta Independency !

COMMON EMITTER BJT AMPLIFIER



- FIND DC BIAS
- FIND GAIN

DC BIAS (USE CONSTANT VOLTAGE DROP MODEL w/ CURRENT SOURCE)



NOTE CAPITAL LETTER NOMENCLATURE

KVL AT INPUT:

$$V_{BB} = R_B I_B + 0.7V$$

$$I_B = (V_{BB} - 0.7V) / R_B$$

NOW AT OUTPUT:

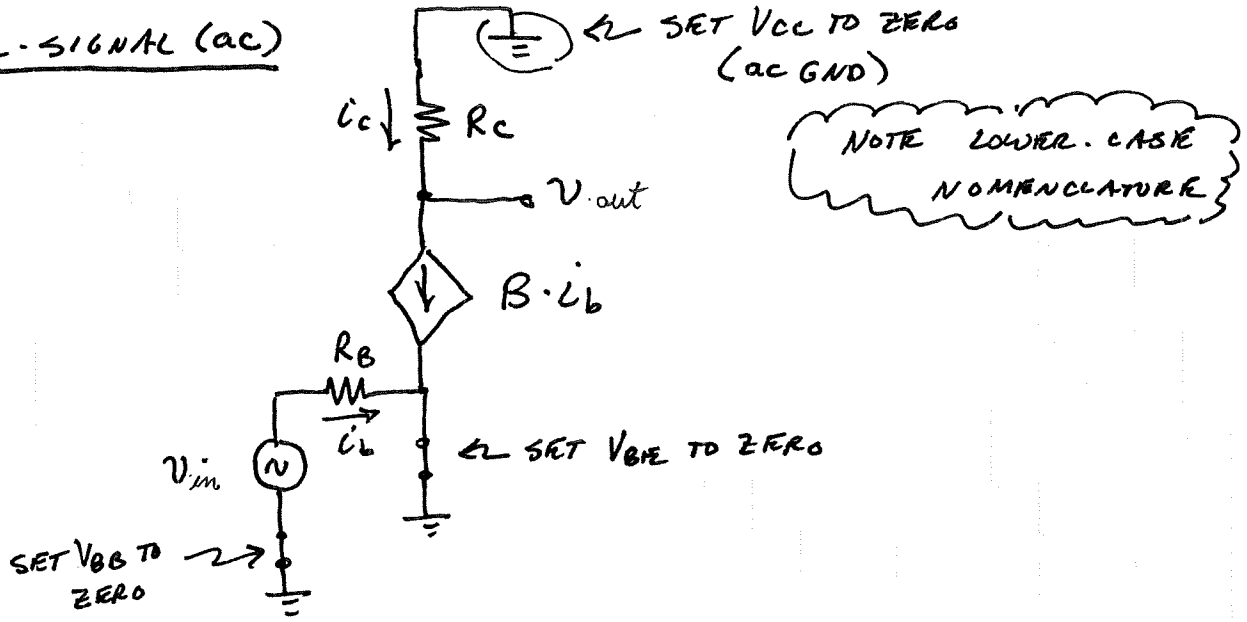
$$I_C = \beta \cdot I_B = \beta \left(\frac{1}{R_B}\right)(V_{BB} - 0.7\,V)$$

$$V_{OUT} = V_{CC} - I_C \cdot R_C = \boxed{V_{CC} - \beta \left(\frac{R_C}{R_B}\right)(V_{BB} - 0.7V)}$$

NOTE BETA DEPENDENCE (BAD)

NOW SMALL-SIGNAL AC ANALYSIS (SET DC SOURCES TO ZERO)

SMALL-SIGNAL (ac)



KVL AT INPUT:

$$v_{in} = R_B \cdot i_b$$

$$i_b = \frac{v_{IN}}{R_B}$$

AT OUTPUT:

$$i_C = \beta \cdot i_b = \beta \left(\frac{1}{R_B}\right) v_{in}$$

$$v_{out} = 0 - i_C \cdot R_C = -\beta \left(\frac{R_C}{R_B}\right) v_{in}$$

$$\boxed{v_{out} = -\beta \left(\frac{R_C}{R_B}\right) v_{in}}$$

A_v (VOLTAGE GAIN)

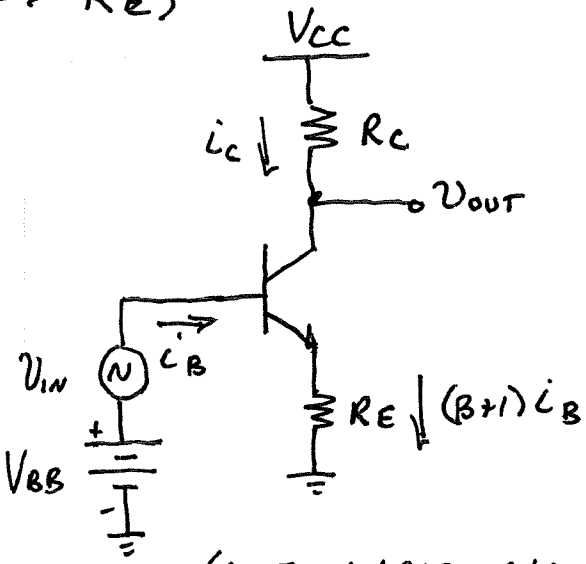
$$A_v = \frac{v_{out}}{v_{in}} = -\beta \left(\frac{R_C}{R_B}\right)$$

↑

NOTE BETA DEPENDENCE (BAD)

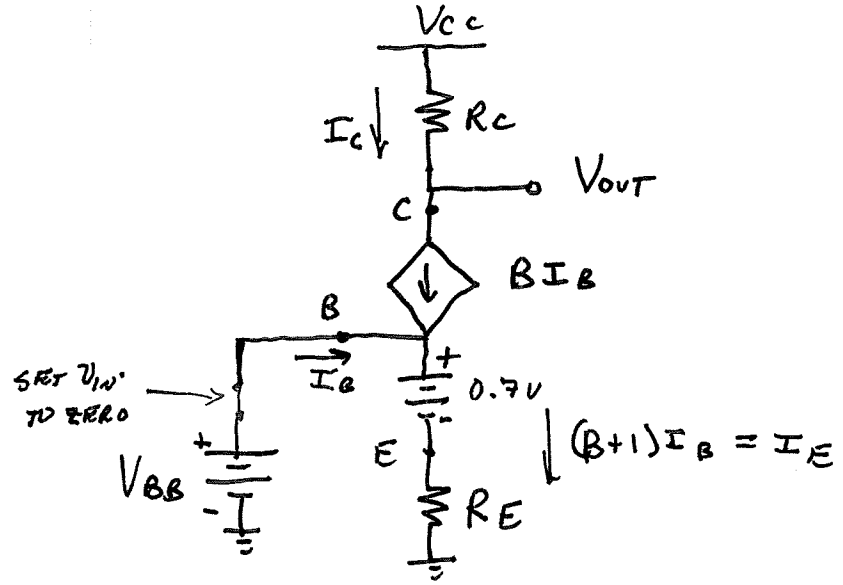
ELIMINATING BETA DEPENDENCE

(MOVE $R_B \rightarrow R_E$)



- FIND DC BIAS
- FIND GAIN

DC BIAS (USE LARGE SIGNAL MODEL)



KVL AT INPUT:

$$V_{BB} = R_E \overbrace{(\beta+1) I_B}^{I_E} + 0.7V$$

$$I_B = (V_{BB} - 0.7V) / (\beta+1) R_E$$

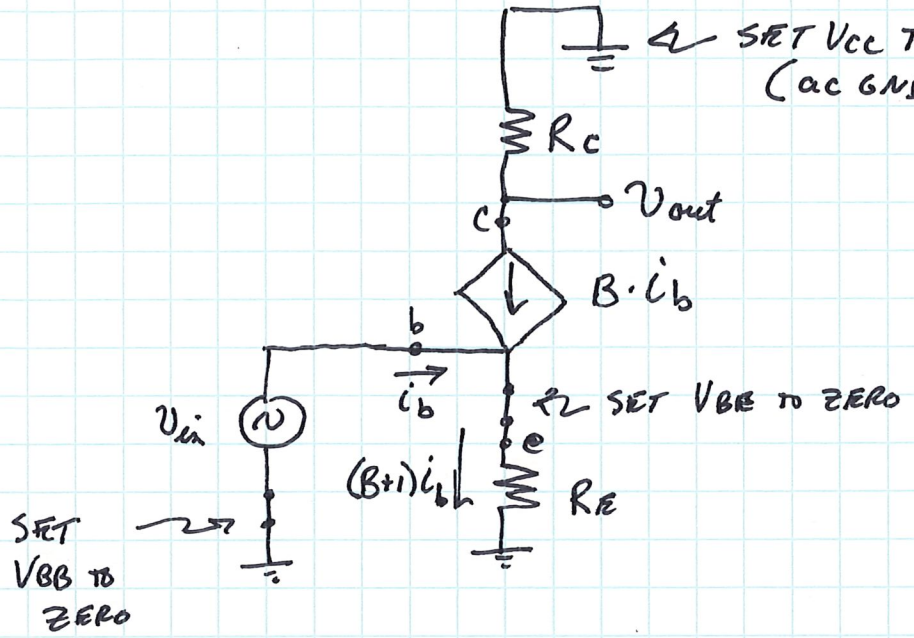
AT OUTPUT:

$$I_C = \beta \cdot I_B = \left(\frac{\beta}{\beta+1}\right)\left(\frac{1}{R_E}\right)(V_{BB} - 0.7V)$$

$$V_{OUT} = V_{CC} - I_C \cdot R_C = \boxed{V_{CC} - \left(\frac{\beta}{\beta+1}\right)\left(\frac{R_C}{R_E}\right)(V_{BB} - 0.7V)}$$

↑ BETA INDEPENDENCE ?
(GOOD!)

NOW SMALL SIGNAL AC (SET DC SOURCES TO ZERO) BITAR



KVL AT INPUT:

$$v_{in} = R_E \underbrace{(B+1) i_b}_{i_e}$$

$$i_b = \frac{v_{in}}{(B+1) R_E}$$

AT OUTPUT:

$$i_C = B i_b = \left(\frac{B}{B+1}\right)\left(\frac{1}{R_E}\right) v_{in}$$

$$v_{out} = 0 - R_C \cdot i_C = -\left(\frac{B}{B+1}\right)\left(\frac{R_C}{R_E}\right) v_{in}$$

$$v_{out} = \underbrace{-\left(\frac{B}{B+1}\right)\left(\frac{R_C}{R_E}\right)}_{A_V \text{ (VOLTAGE GAIN)}} v_{in}$$

$$\boxed{A_V = \frac{v_{out}}{v_{in}} = -\left(\frac{B}{B+1}\right)\left(\frac{R_C}{R_E}\right) \approx -\frac{R_C}{R_E}}$$

↑ NOTE BETA INDEPENDENCE (GOOD!)