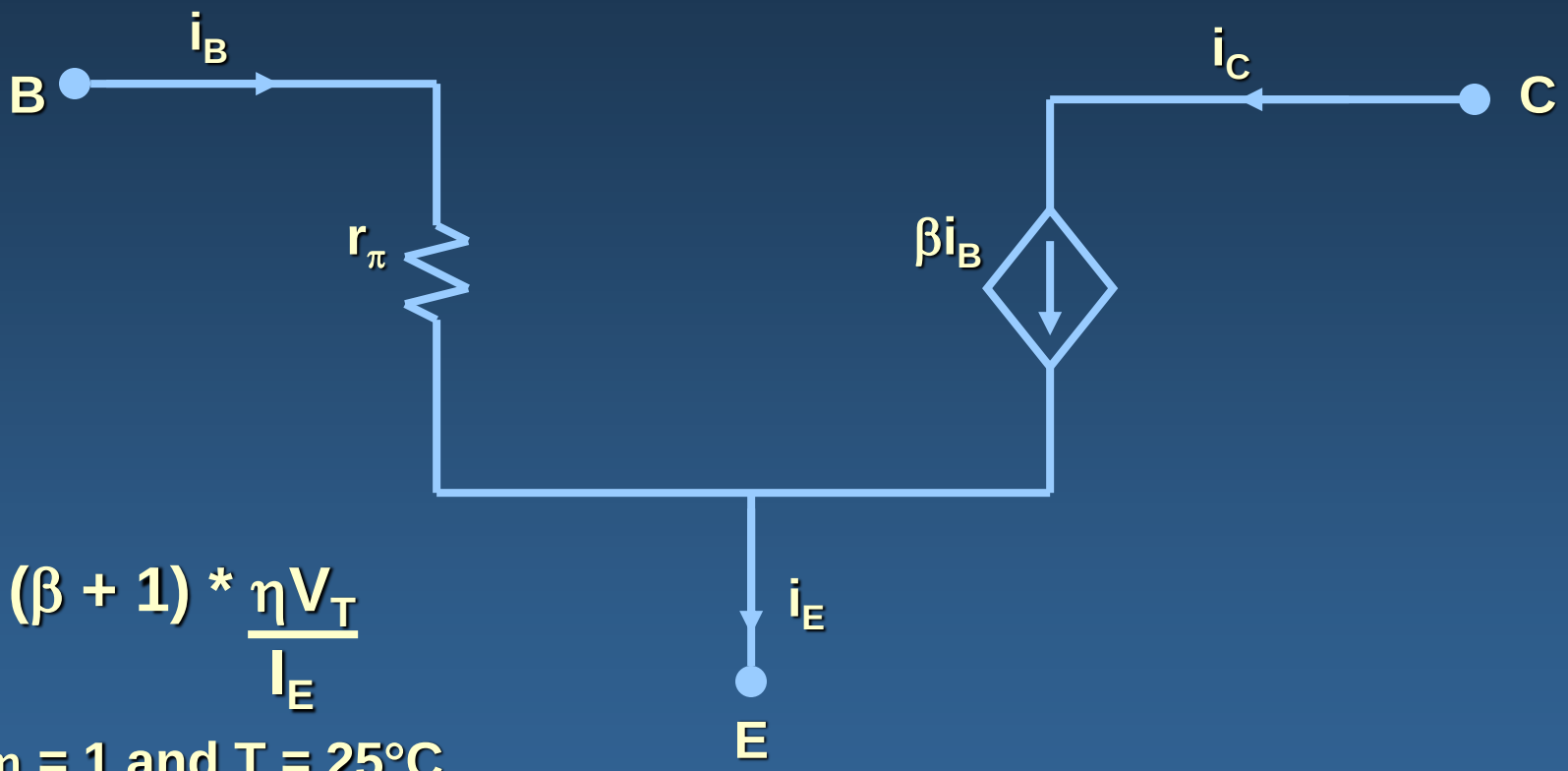
Small Signal BJT Equivalent Circuit

The small-signal model can be used when the BJT is in the active region. The small-signal active-region model for a CB circuit is shown below:



$$r_\pi = (\beta + 1) * \frac{\eta V_T}{I_E}$$

@ $\eta = 1$ and $T = 25°C$

$$r_\pi = (\beta + 1) * \frac{0.026}{I_E}$$

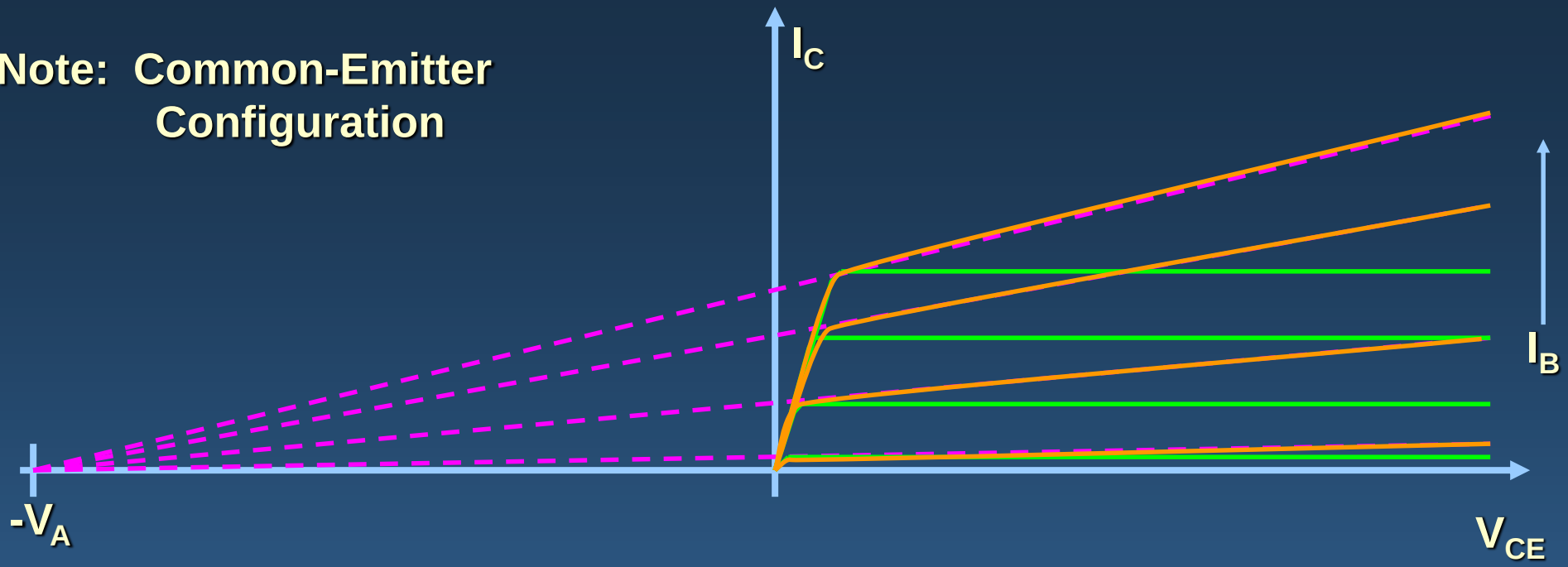
Recall:

$$\beta = I_C / I_B$$

Kristin Ackerson, Virginia Tech EE
Spring 2002

The Early Effect (Early Voltage)

Note: Common-Emitter Configuration



Green = Ideal I_C

Orange = Actual I_C (I_C')

$$I_C' = I_C \left(\frac{V_{CE}}{V_A} + 1 \right)$$

Kristin Ackerson, Virginia Tech EE
Spring 2002

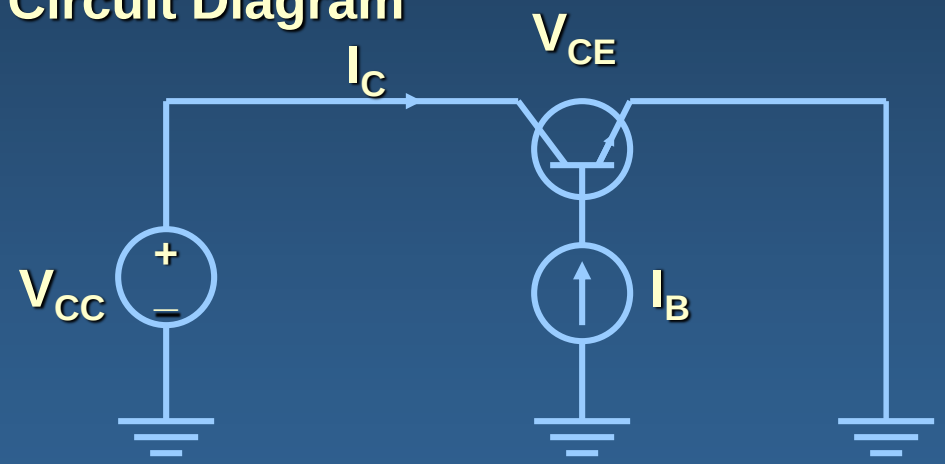
Early Effect Example

Given: The common-emitter circuit below with $I_B = 25\mu A$, $V_{CC} = 15V$, $\beta = 100$ and $V_A = 80$.

Find: a) The ideal collector current

b) The actual collector current

Circuit Diagram



$\beta = 100 = I_C/I_B$

a)

$I_C = 100 * I_B = 100 * (25x10^{-6}\ A)$

$I_C = 2.5\ mA$

b) $I_C' = I_C \left(\frac{V_{CE}}{V_A} + 1 \right) = 2.5x10^{-3} \left(\frac{15}{80} + 1 \right) = 2.96\ mA$

$I_C' = 2.96\ mA$

Kristin Ackerson, Virginia Tech EE
Spring 2002

Breakdown Voltage

The maximum voltage that the BJT can withstand.

BV_{CEO} = The breakdown voltage for a common-emitter biased circuit. This breakdown voltage usually ranges from ~20-1000 Volts.

BV_{CBO} = The breakdown voltage for a common-base biased circuit. This breakdown voltage is usually much higher than BV_{CEO} and has a minimum value of ~60 Volts.

Breakdown Voltage is Determined By:

- The Base Width
- Material Being Used
- Doping Levels
- Biasing Voltage

Kristin Ackerson, Virginia Tech EE
Spring 2002

Kristin Ackerson, Virginia Tech EE
Spring 2002