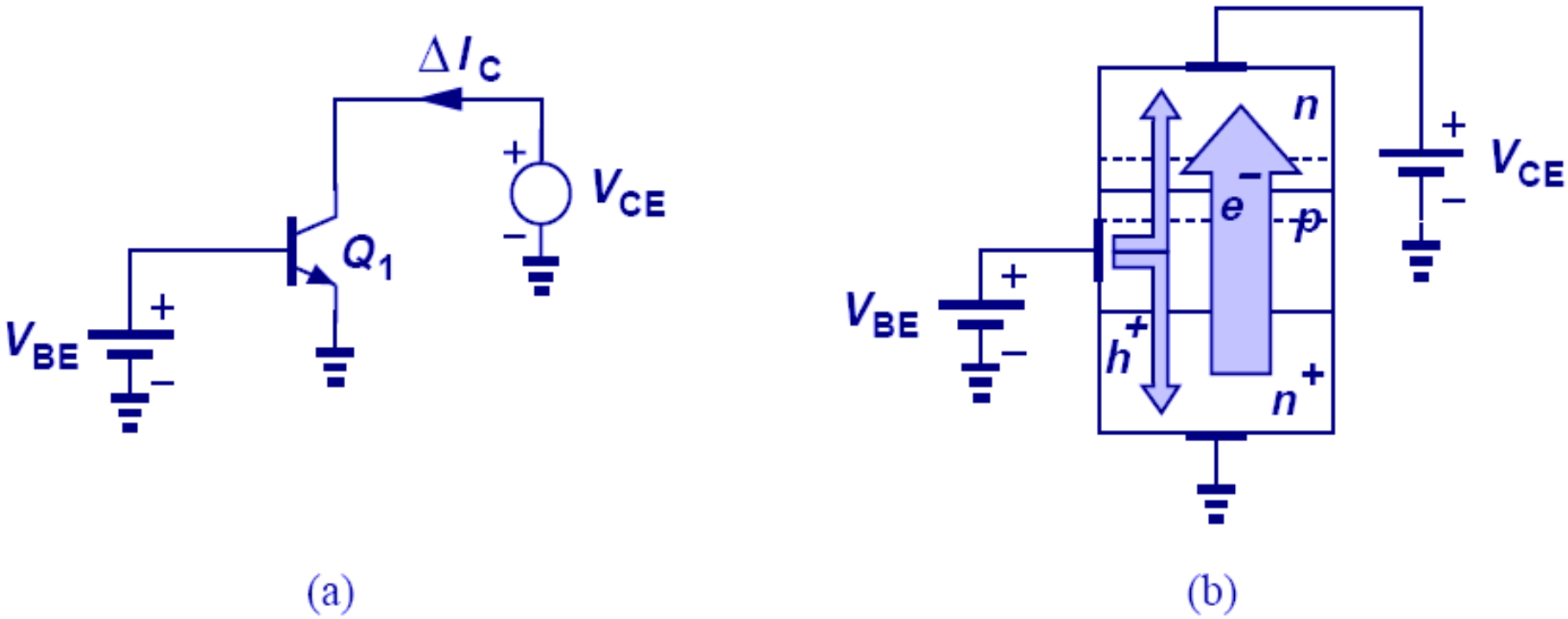
Lecture 5

OUTLINE

- Bipolar Junction Transistor (BJT) (Cont'd)
  - BJT operation in saturation mode
  - PNP BJT
  - Examples of small signal models

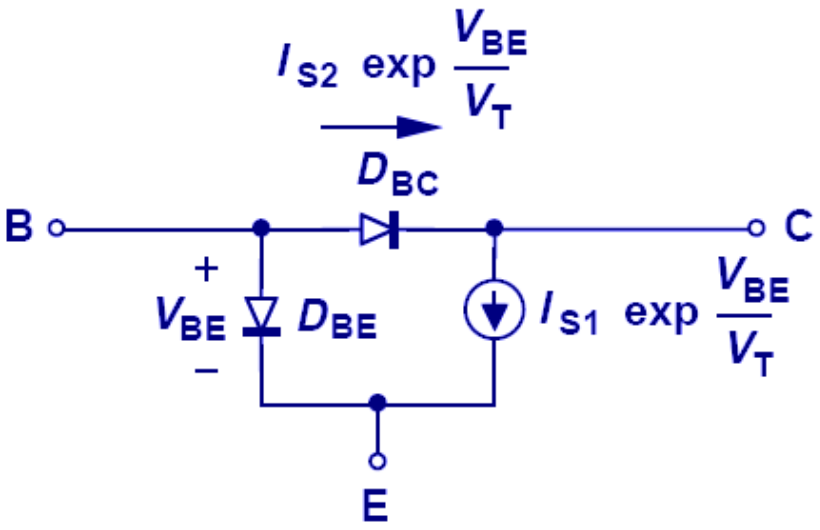
Reading: Chapter 4.5-4.6

Bipolar Transistor in Saturation

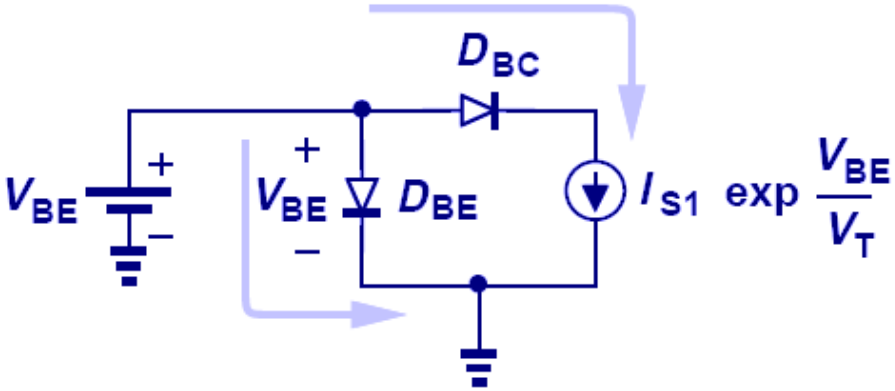


- When collector voltage drops below base voltage and forward biases the collector-base junction, base current increases and the current gain factor, β, decreases.

Large-Signal Model for Saturation Region

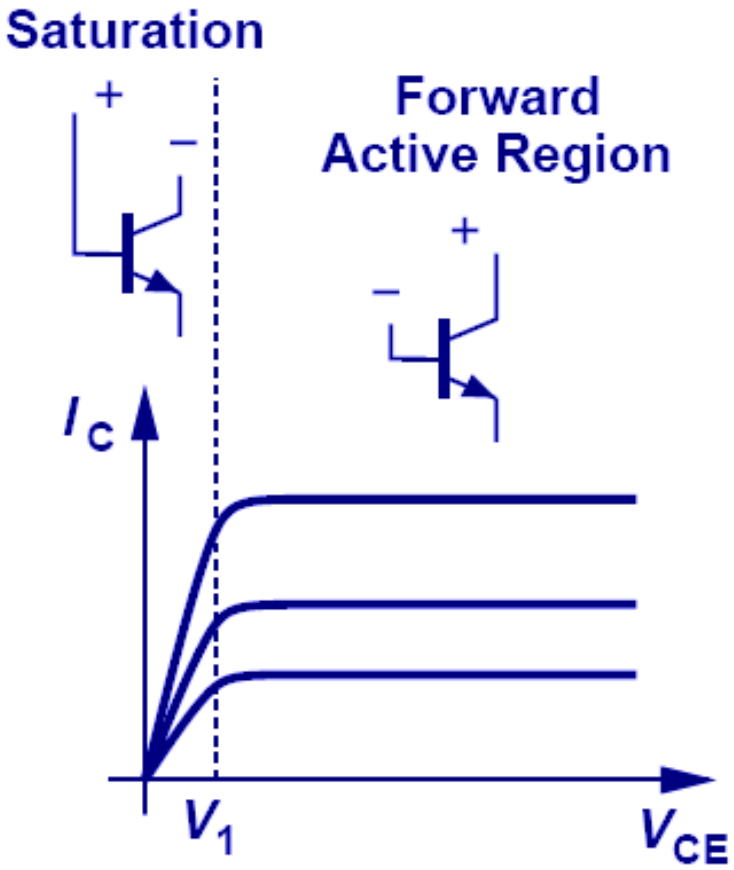


(a)



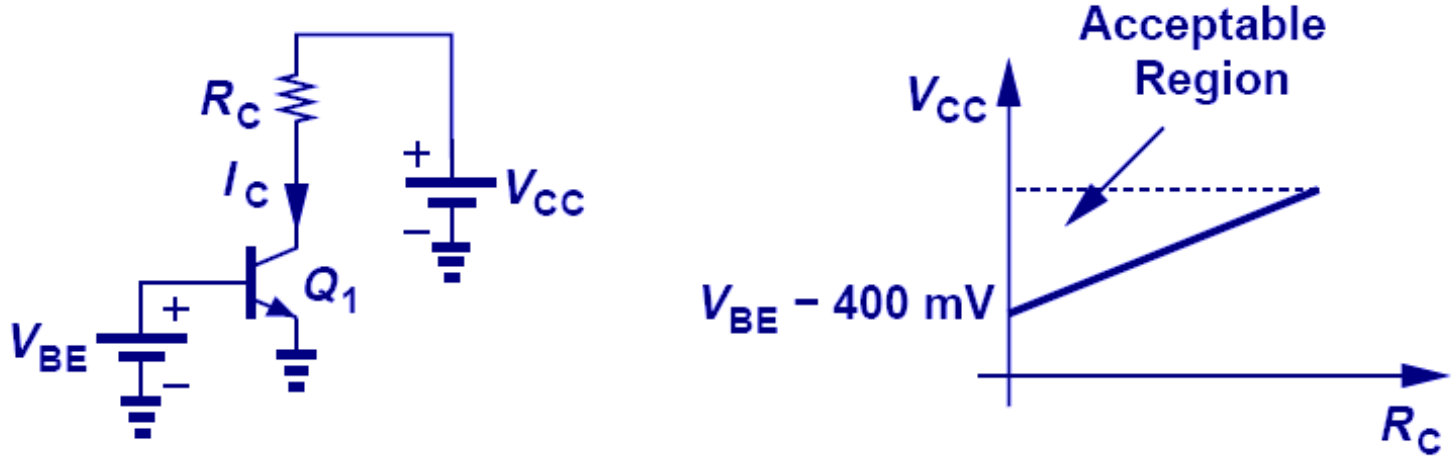
(b)

Overall I/V Characteristics



- The speed of the BJT also drops in saturation.

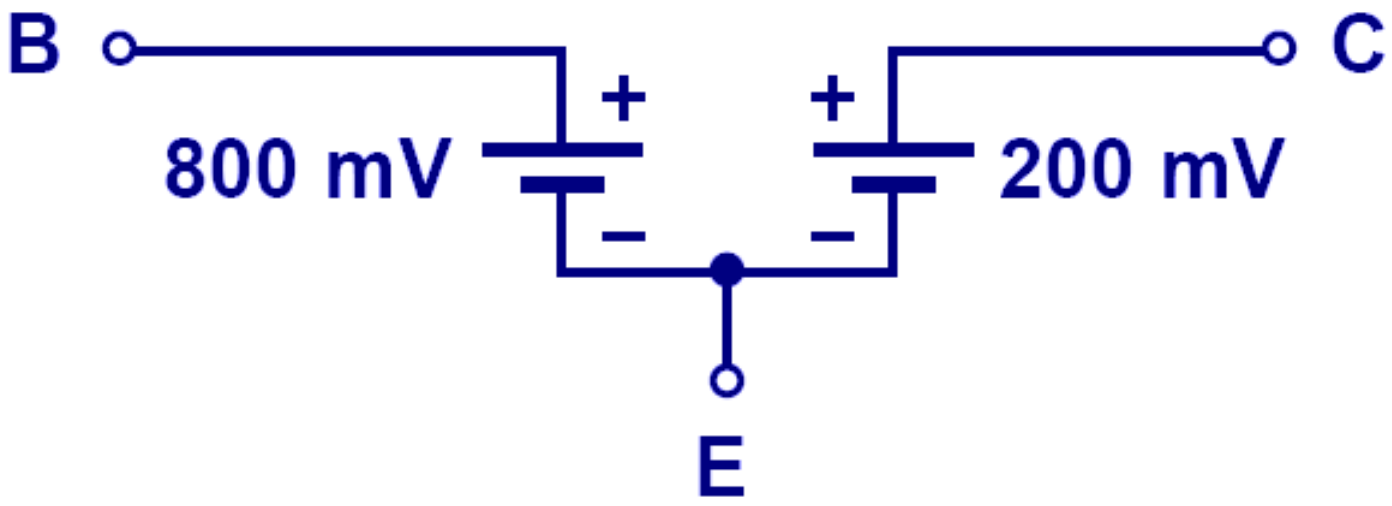
Example: Acceptable VCC Region



$$V_{CC} \geq I_C R_C + (V_{BE} - 400mV)$$

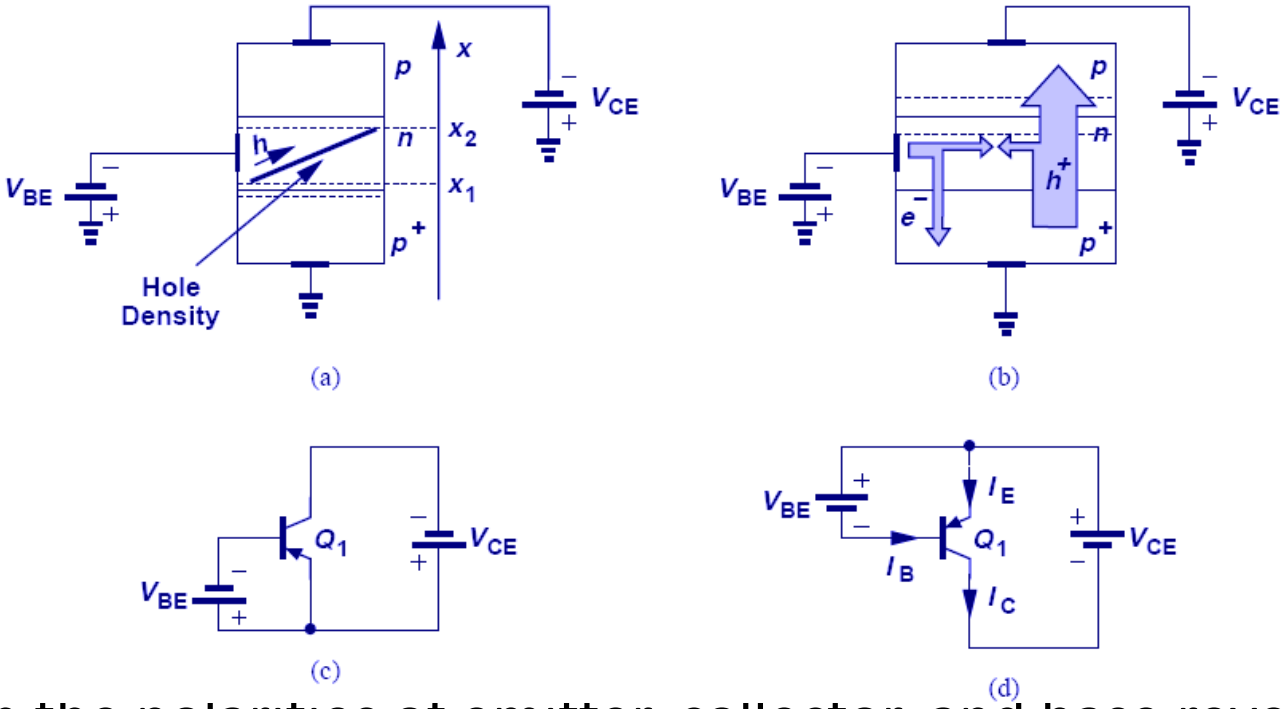
- In order to keep BJT at least in soft saturation region, the collector voltage must not fall below the base voltage by more than 400mV.
- A linear relationship can be derived for V_{CC} and R_C and an acceptable region can be chosen.

Deep Saturation



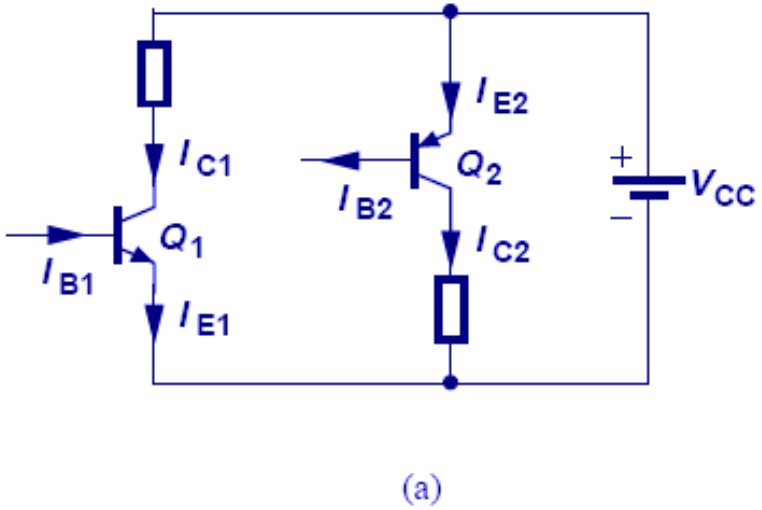
- In deep saturation region, the transistor loses its voltage-controlled current capability and V_{CE} becomes constant.

PNP Transistor

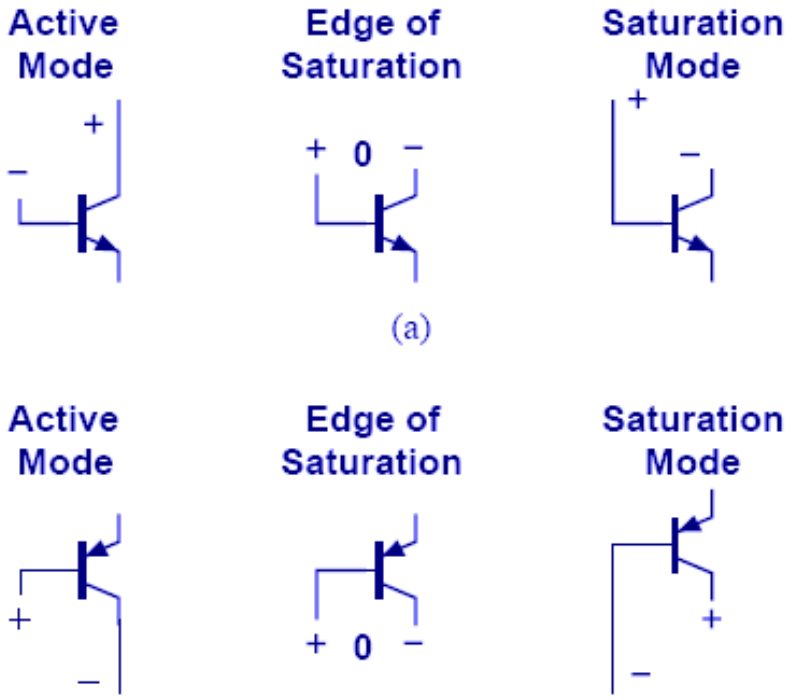


- With the polarities of emitter, collector, and base reversed, a PNP transistor is formed.
- All the principles that applied to NPN's also apply to PNP's, with the exception that emitter is at a higher potential than base and base at a higher potential than collector.

A Comparison between NPN and PNP Transistors



(a)



- The figure above summarizes the direction of current flow and operation regions for both the NPN and PNP BJT's.

PNP Equations with Early Effect

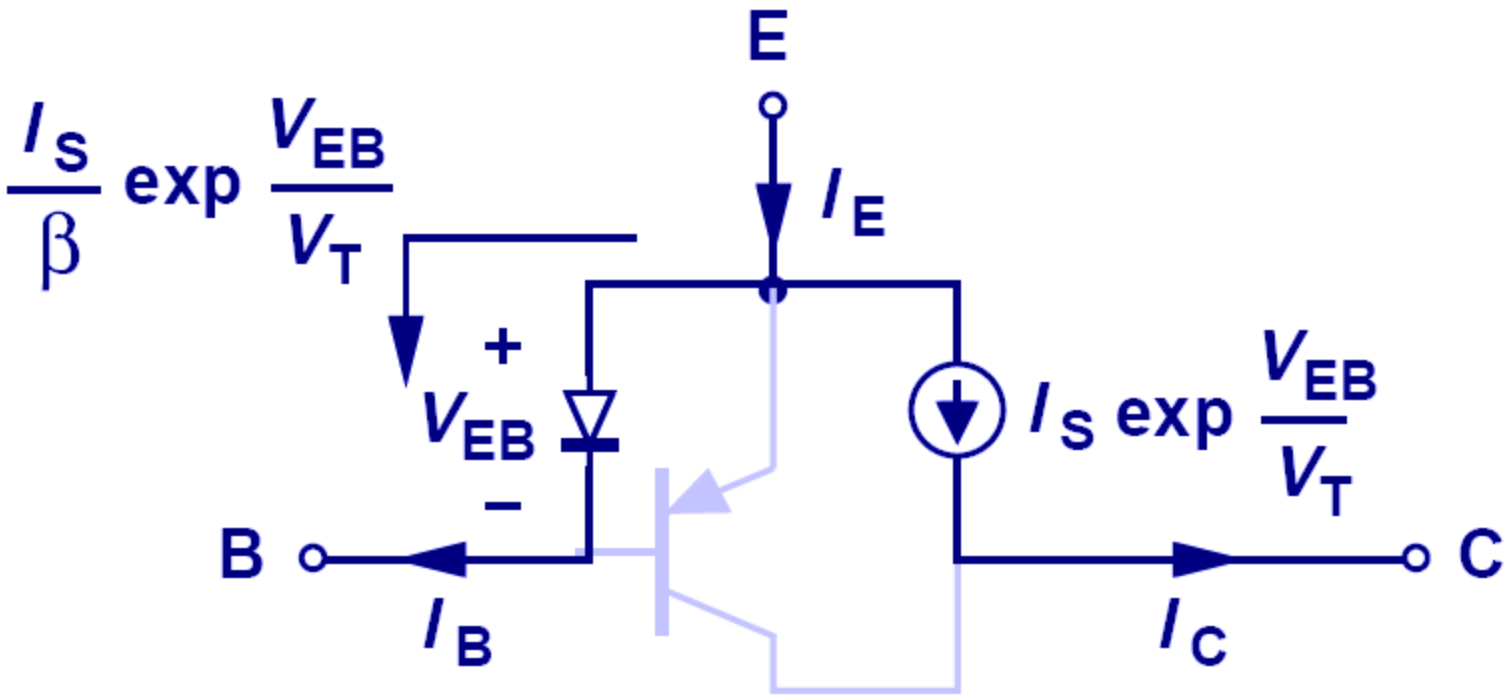
$$I_C = I_S \exp \frac{V_{EB}}{V_T}$$

$$I_B = \frac{I_S}{\beta} \exp \frac{V_{EB}}{V_T}$$

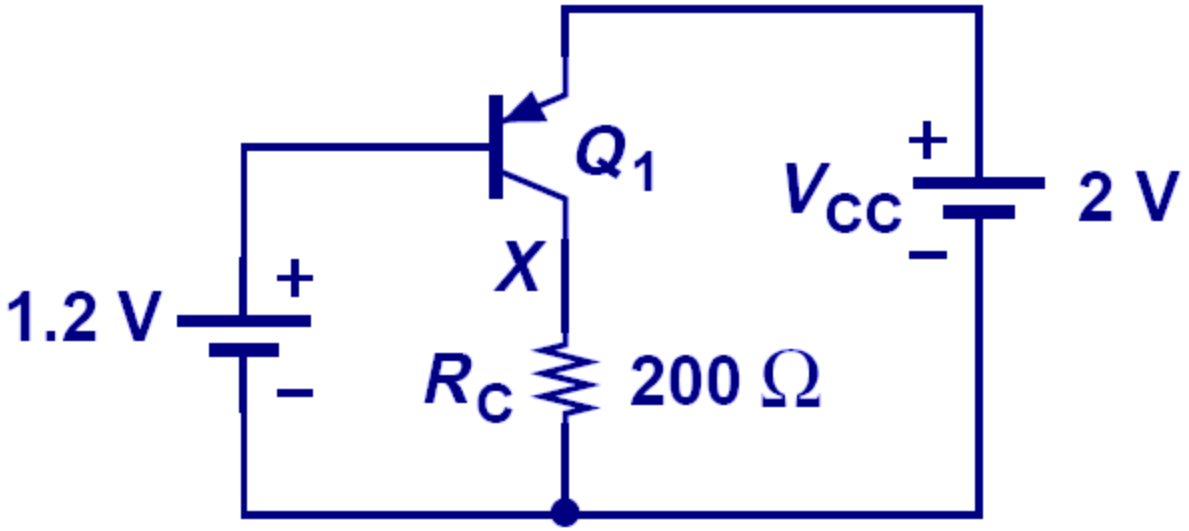
$$I_E = \frac{\beta + 1}{\beta} I_S \exp \frac{V_{EB}}{V_T}$$

$$I_C = \left(I_S \exp \frac{V_{EB}}{V_T} \right) \left(1 + \frac{V_{EC}}{V_A} \right)$$

Large Signal Model for PNP

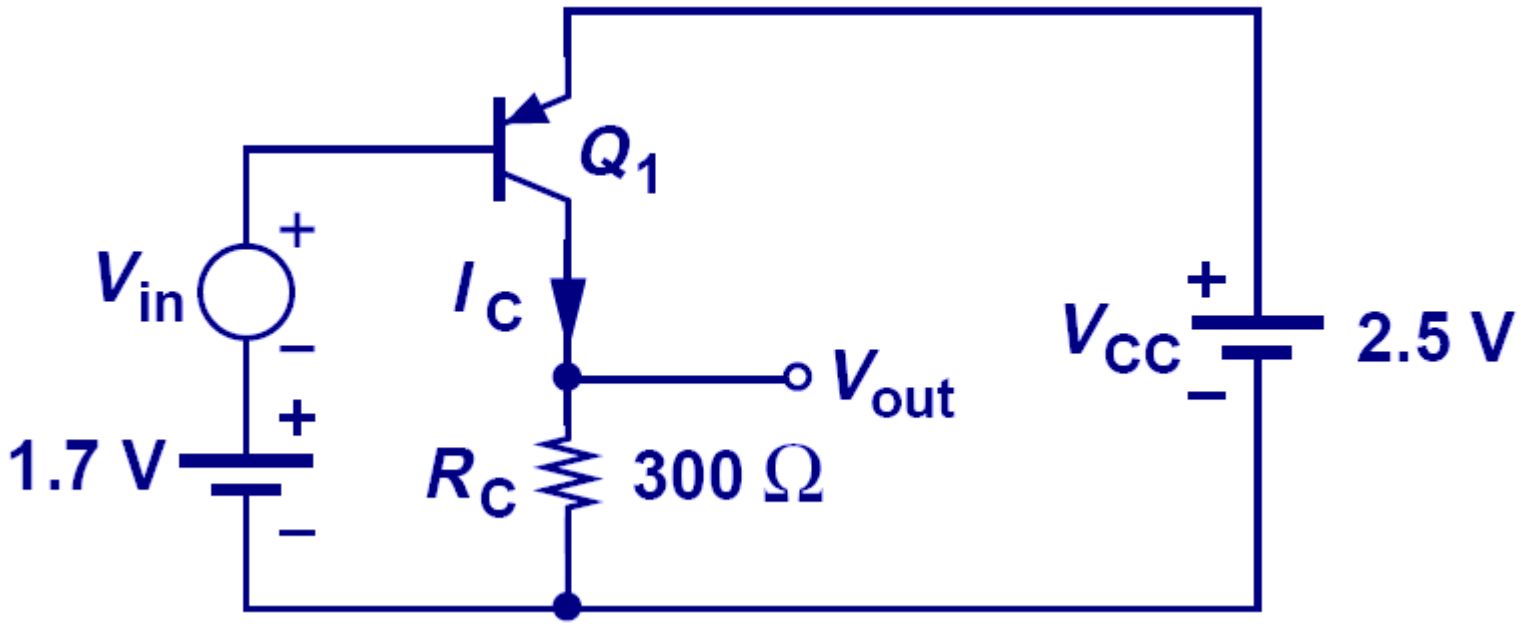


PNP Biasing

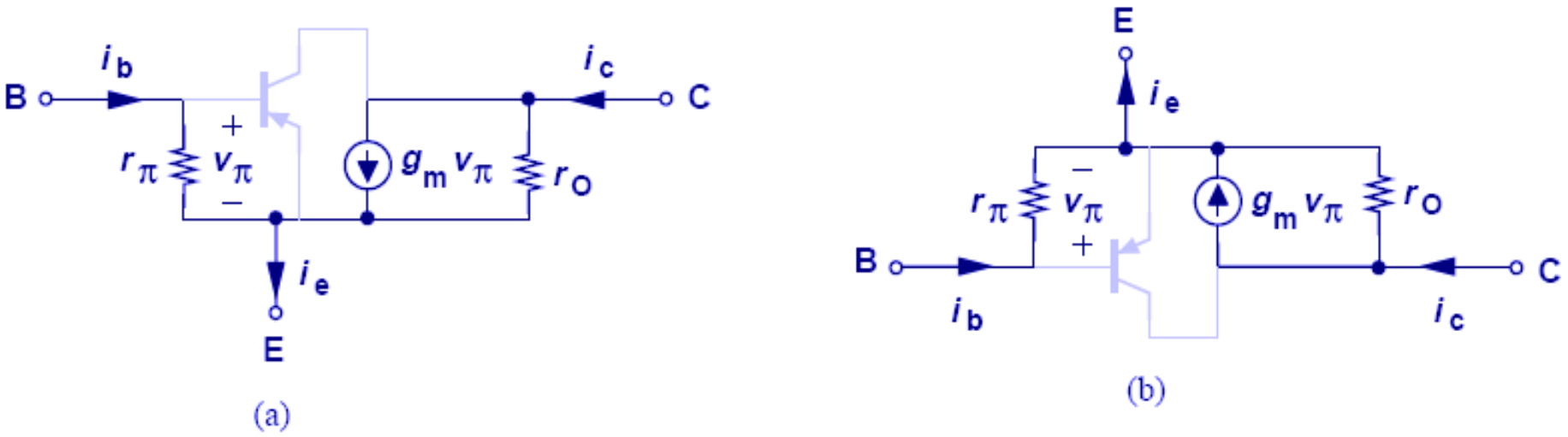


- Note that the emitter is at a higher potential than both the base and collector.

Small Signal Analysis

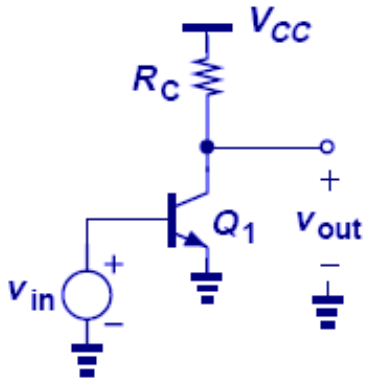


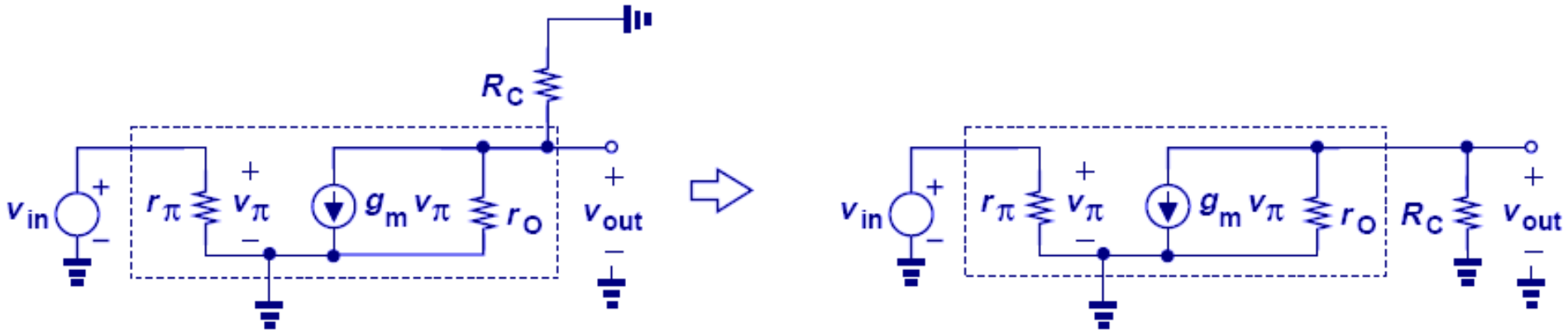
Small-Signal Model for PNP Transistor



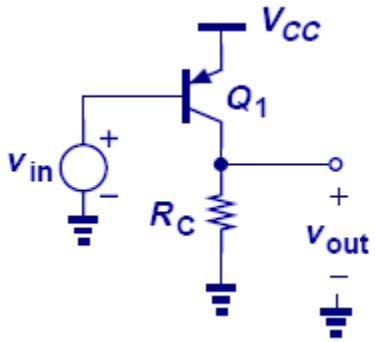
- The small signal model for PNP transistor is exactly IDENTICAL to that of NPN. This is not a mistake because the current direction is taken care of by the polarity of VBE.

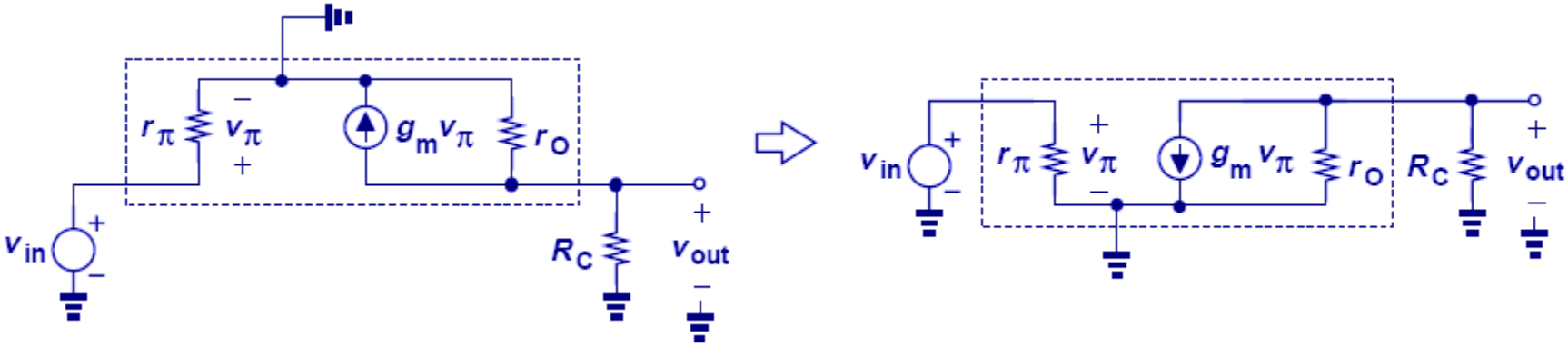
Small Signal Model Example I





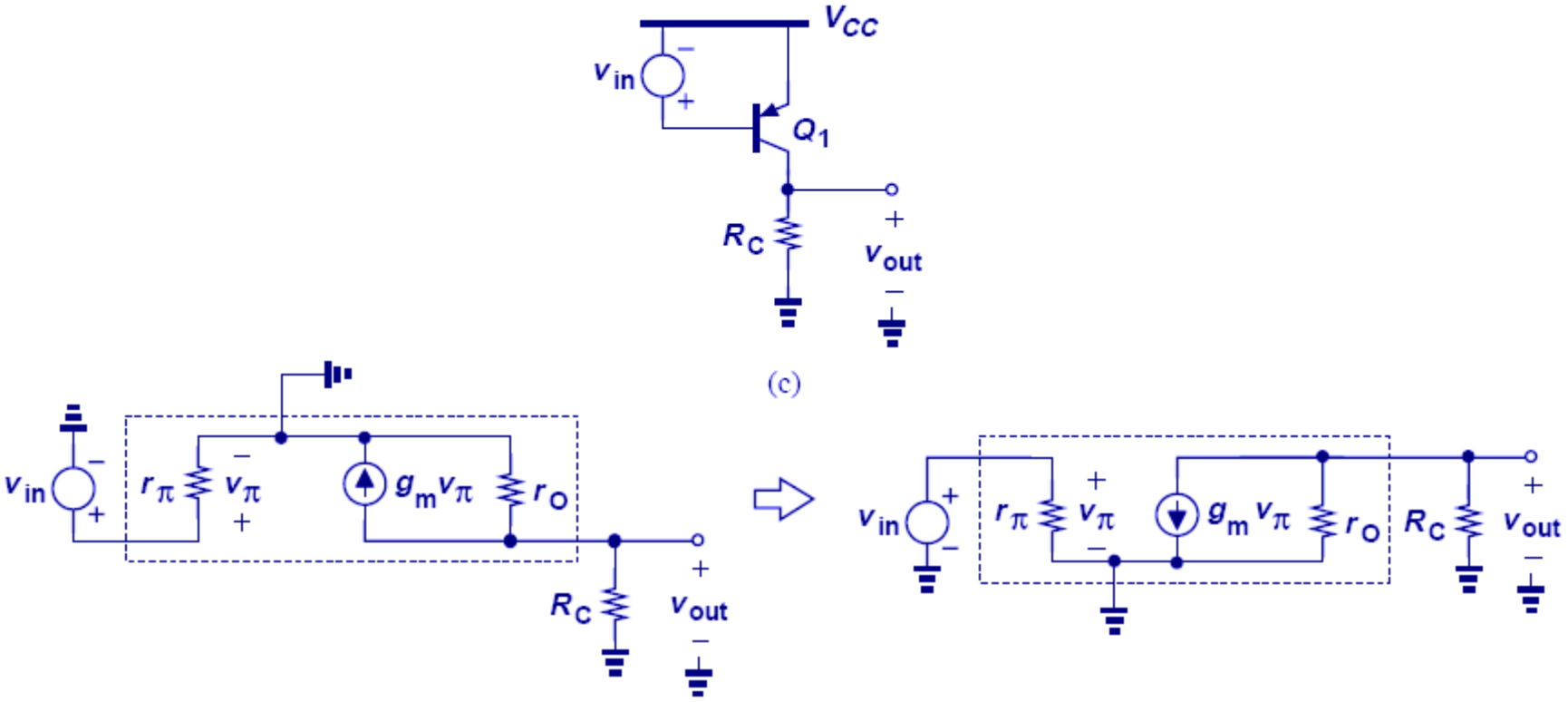
Small Signal Model Example II





- Small-signal model is identical to the previous ones.

Small Signal Model Example III



- Since during small-signal analysis, a constant voltage supply is considered to be AC ground, the final small-signal model is identical to the previous two.

Small Signal Model Example IV