EE112 - Fall 2016
Analog Integrated Circuits I

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I-V Characteristics of BJT

- The I-V looks similar to MOSFET's I-V, though the physical equations governing the saturation (triode for MOSFET) and active (saturation for MOSFET) are different.
- i_C has a finite slope in the active region, due to **base width modulation** (called **Early Effect**).
  - » Similar to channel length modulation in MOSFET

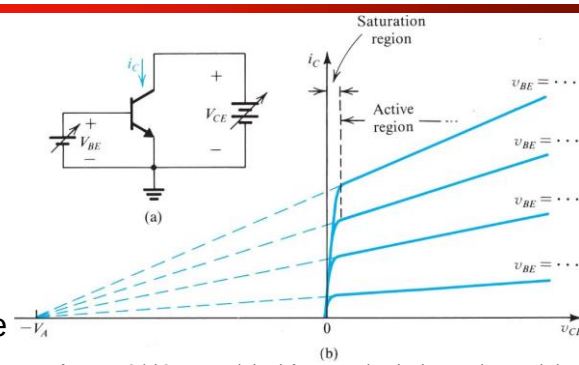


Figure 4.18 (a)Conceptual circuit for measuring the i_C - v_{CE} characteristics of the BJT. (b) The i_C -v_{CE} characteristics of a practical BJT.

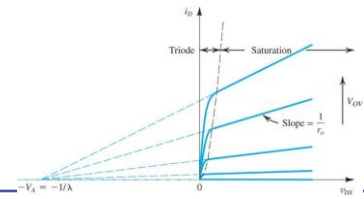
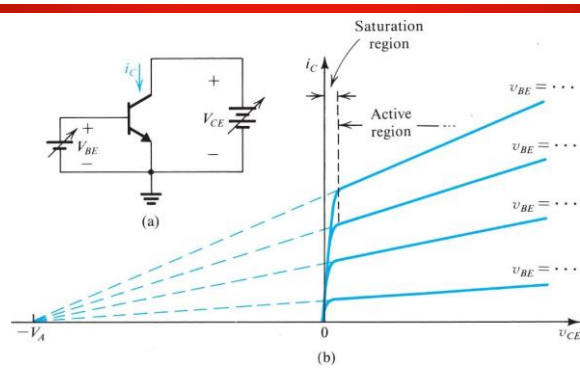


Figure 5.17

Early Effect



Large-Signal Model of BJT in Active Mode

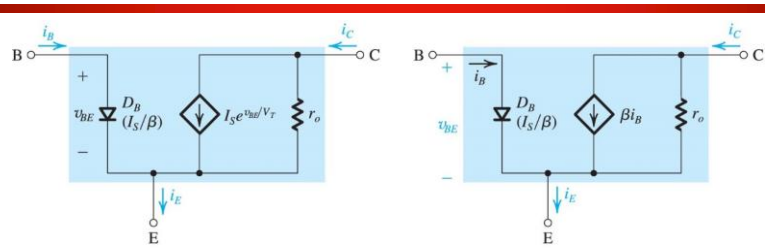


Figure 4.19 Large-signal, equivalent-circuit models of an *npn* BJT operating in the active mode in the common-emitter configuration with the output resistance r_o included.

BJT I-V using Base Current as Parameter

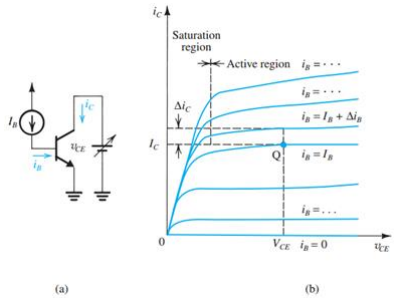


Figure 4.20 Common-emitter characteristics. (**a**) Basic CE circuit; note that in (**b**) the horizontal scale is expanded around the origin to show the saturation region in some detail.

- Usually the I-V curves are plotted with i_B as parameter rather than v_{BE} so the family of curves are roughly equally spaced.
- The current gain can be simply measured by

$$\beta = \frac{\Delta i_C}{\Delta i_B}$$

Saturated BJT

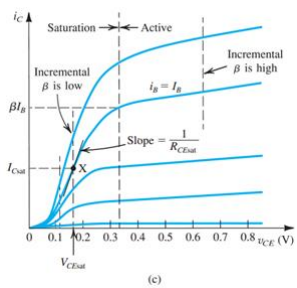


Fig 4.20 (c) A much greater expansion of the saturation region.

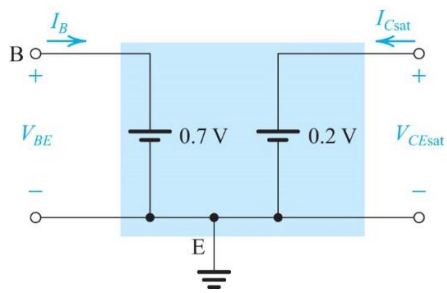


Figure 4.21 A simplified equivalent-circuit model of the saturated transistor.

Discussion: Circuit Modeling

Question: why do we use simplified models in hand calculation?

1. Better models can be used to obtain more accurate results.
2. However, at the expense of speed of analysis：the attendant complexity could impede the circuit designer's ability to gain **insight** regarding circuit behavior.
3. Accurate results using high level models can be obtained using circuit simulation with SPICE: done as the final stages of a design and certainly before circuit fabrication.
4. However, computer simulation is ***not*** a substitute for quick pencil-and-paper circuit analysis, an essential ability that aspiring circuit designers must master.

Example: BJT Bias Point (偏置点)

- β = 100, Find the bias point of the BJT circuit (i.e., i_C and all nodal voltages)

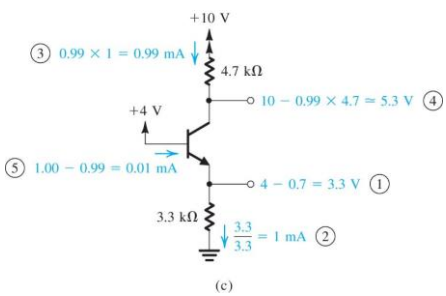
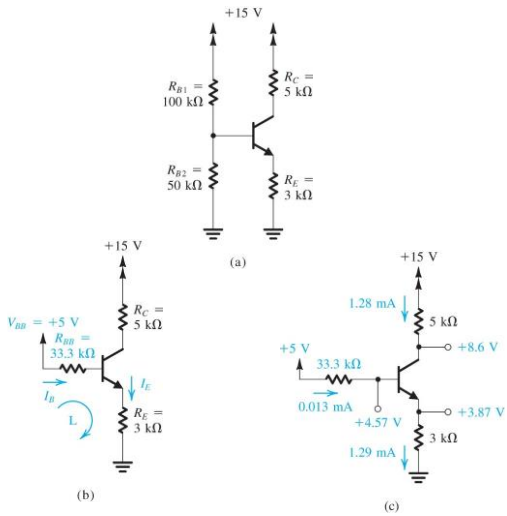


Figure 4.23 Analysis of the circuit for Example 4.4:

Note: in DC analysis, we can usually approximate $I_C \approx I_E$

BJT Bias Example



- β = 100, find the bias point.

Figure 4.29 Circuits for Example 4.10.

BJT Bias Example

- β = 100, find the bias point.

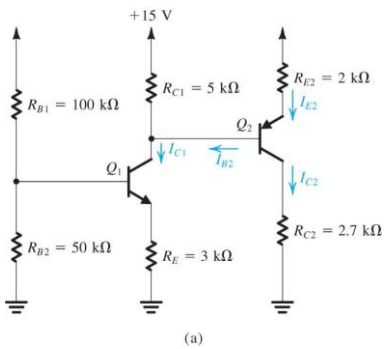


Figure 4.30 Circuits for Example 4.11.

“Digital” Circuit Example

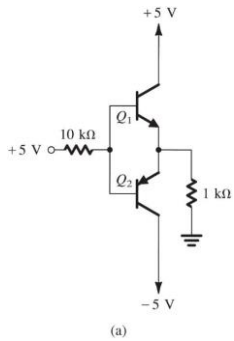


Figure 4.31 Example 4.12: (**a**) circuit;

- β = 100, find the bias point.