E151 Lecture 6 – Small Signal BJT Models and Regions of Operations in Circuits

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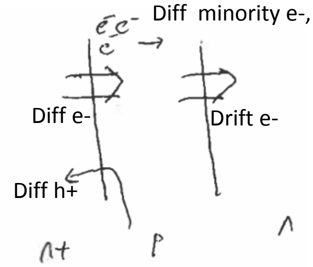
Disclaimer

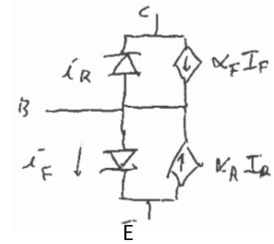
These are note for Prof. Spencer to give the lecture, they were not intended as a reference for students. Students asked for them anyway, so I'm putting them up as a courtesy. Remember that they are not intended as a substitute for lecture.

Introduced BJTs Last Time

More e- diff than h+ diff at n+/p b/c of doping imbalance
Diff minority e-, alpha=Ic/Ie make it

- Like two diodes, but short base region steals current sometimes.
- Started with device picture → Ebers-Moll (computer) model
- Now, go from Ebers-Moll to useful models:
  - Equivalent (large signal) circuits
  - Picture
  - Small signal models





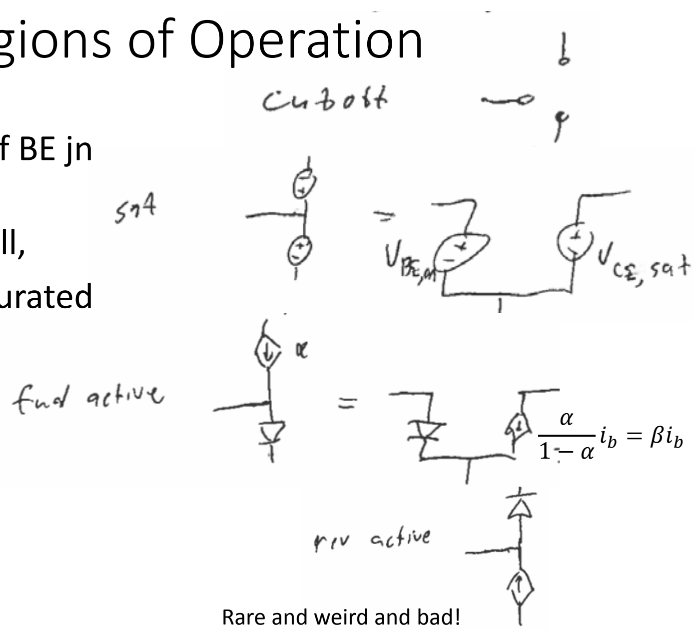
$$I_C = I_S\left(e^{v_{BE}/\phi_{TH}} - 1\right) - \frac{I_S}{\alpha_R}\left(e^{v_{BC}/\phi_{TH}} - 1\right)$$

$$I_E = I_S\left(e^{v_{BC}/\phi_{TH}} - 1\right) - \frac{I_S}{\alpha_F}\left(e^{v_{BE}/\phi_{TH}} - 1\right)$$

Notes: I_ES = alpha*I_CS, simplify to one I_S, 1/alpha terms represent carrier injection in model

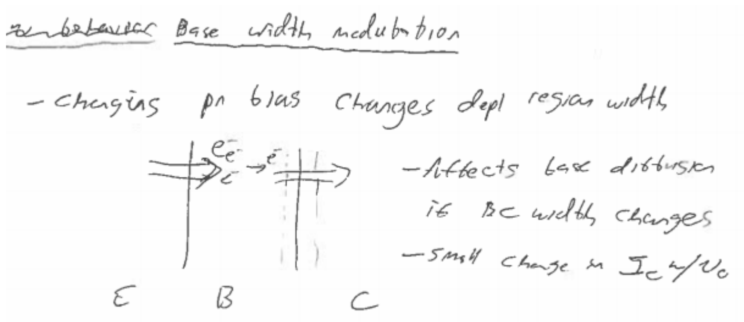
Circuit Models in Regions of Operation

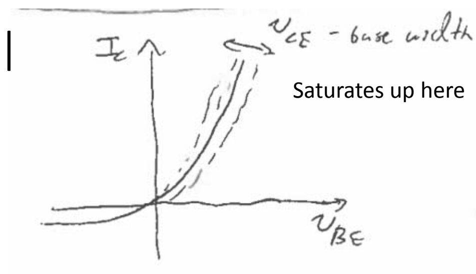
- Specify each region in terms of BE jn on/off and BC jn on/off
- Link to what is on in Ebers-Moll,
- Clarify hitting V_CE,SAT → saturated
- Point to U shape conversions
- Ignoring small I elements

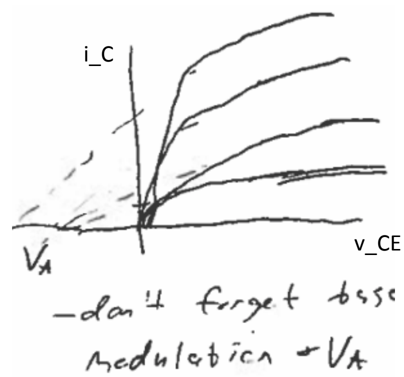


Two Ways to Draw Ebers-Moll →iC-vBE, iC-vCE

- i_B-v_BE is identical to i_C-v_BE
- Omitting breakdown
- Important Detail: Base Width Modulation







Small Signal in FAR Derivation

- Graphical, Ebers-Moll Equation Based, Diode argument, ic linear ib!

Don't forget to show gm*rp = beta