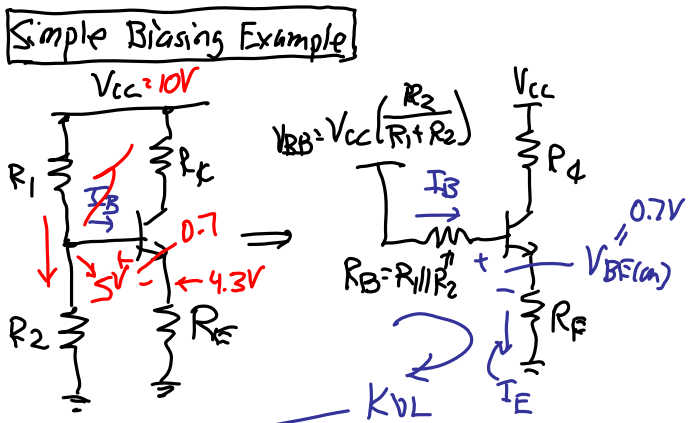
Lecture 2: Device Models I (Bipolar Review)

- Announcements:
- The course website was up and running last week
  - Just google ee140 to get to it
- HW#1 online last week … due next week Wednesday, at 8 a.m., in the 140/240A box on 1st floor (near the TI lab)
- My Monday Office Hours updated to 2-3 p.m.
- ----------
- Lecture Topics:
  - Review (fast)
  - Bipolar Junction Transistor Modeling
    - —Basic Structure & Physics
    - —Large Signal Models
    - —DC Operating Point
    - —Small Signal Models
    - —Frequency Shaping Elements
    - —Layout
    - —Unity Gain Frequency
- ----------
- Last Time: Reviewed op amps and started into BJT modeling using the module handout
- Continue with the handout

over



$V_{BB} = I_B R_B + V_{BE(on)} + I_E R_E$

$$I_C = \frac{V_{BB} - V_{BE(on)}}{\frac{R_E}{\alpha} + \frac{R_B}{\beta}}$$

Ex. $V_{CC} = 10V$, $V_{BE(on)} = 0.7V$, $R_E = 5k\Omega$, $R_1 = R_2 = 20k\Omega$

$\beta = 200 \rightarrow \alpha = \frac{200}{201} = 0.995$

$V_{BB} = 5V$

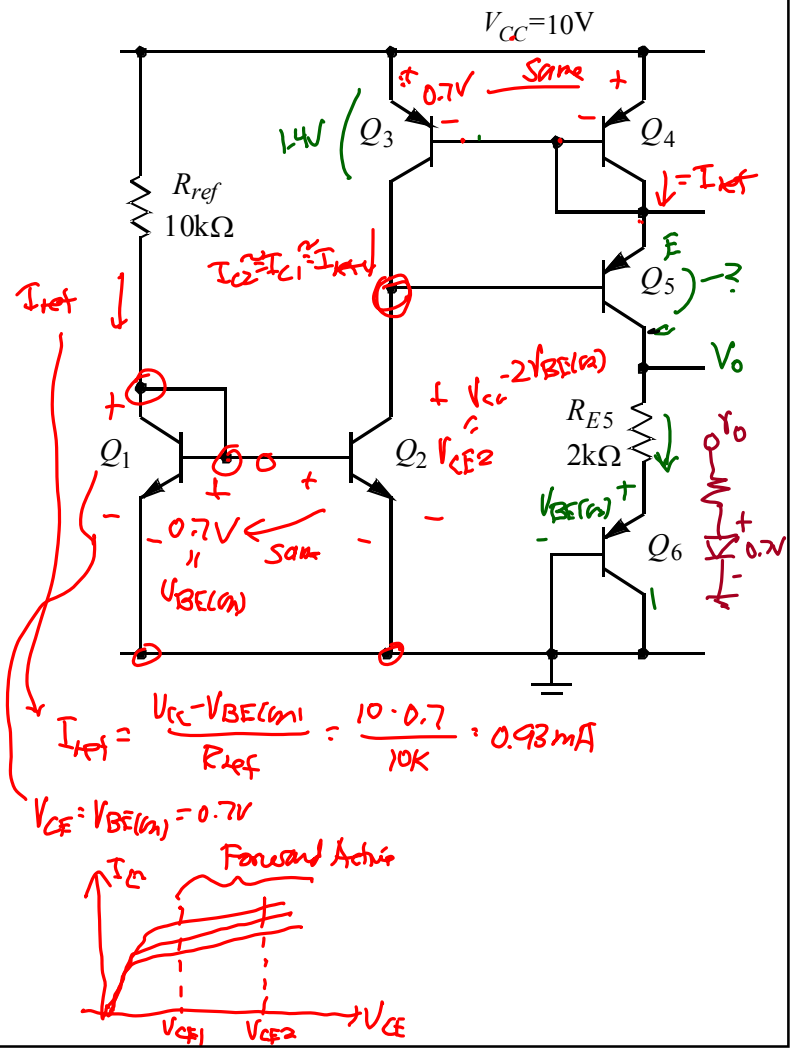
$$\therefore I_C = \frac{5 - 0.7}{\frac{5K}{0.995} + \frac{10K}{200}} = 0.85mA$$

→ Same!

Ignore I_B: $I_C \approx I_E = \frac{4.3}{5K} = 0.86mA$

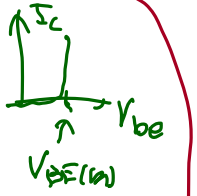
Example: Find the DC operating pt.

⇒ want the I_C's of all transistors → $g_m, r_o, \ldots$ small-signal elements

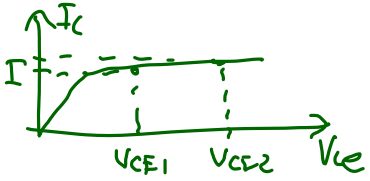


$V_o = V_{BE6(on)} + I_{ref} R_{E5} = 0.7 + (0.93m)(2K) = 2.56V$

In biasing: ① V_{BE}'s are well-defined $\approx V_{BE(on)}$



② V_{CE}'s not well-defined



FA

For Q_5 to be FA, need: ~ need $|V_{CE5}| > 0.2V$

$V_o < V_{CC} - V_{BEC(on)4} - V_{CE(sat)5}$

$10 - 0.7 - 0.2 = 9.1V$

What if $R_{E5} = 20k\Omega$?

$V_o = 0.7V + (0.93m)(20k) = 19.3V$ → X

Q_5 is saturated!

$V_o = V_{CC} - V_{BE4(on)} - V_{CE(sat)} = 9.1V$

$I_{E5} = \frac{V_o - V_{BE6(on)}}{R_{E5}} = \frac{9.1 - 0.7}{20K} = 0.42mA$