E151 Lecture 13 – Active Loads and Current Mirrors

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ENGR151

Disclaimer

These are notes 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 attending lecture.

Midterm is Coming Up

- Lab on Friday, but stays in 3 hour lab time, gentle grading
- Practice problems and maybe solutions on Sakai
- In class, 1 hr 15 min, no calculator, book, notes
- Get 1 page cheat sheet, must make your own
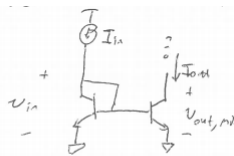- Note that tour through MOS physics & amplifiers is kind of a review

What's a Current Mirror and Why?

- Active loads are pretty cool, but tough to bias
- Amount to biasing w/ a current source ... ideal load (inf. Z, inf. Vsw)
- Fix biasing by using current mirrors
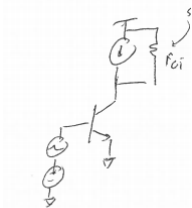
What do we care about w/ mirrors?

- Mirror design specifications – functions of Ic, compare @ same Ic
  - V_IN   V_BEON
  - V_MIN   V_CESAT
  - Error = ε = I_OUT/I_IN   beta/(beta+2)
  - rout   ro

$$I_{in} = I_{b1} + I_{c1} \overset{I_{b2}}{=} (\beta+1) I_{b1}$$

$$I_{out} = \beta I_{b1}$$
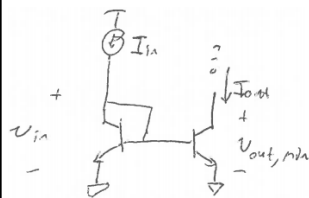
Note diode connected device is ~1/gm impedance

"simple mirror"
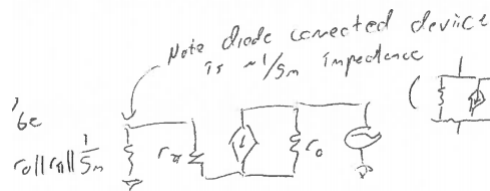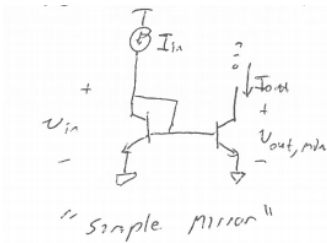
Use Mirrors to Make Active Loads

- av = gm*(ro1||ro2) – very high! (~1/2 of what we saw w/ isrc load)
- Need to pick V_B st we're in FAR, do w/ load line or another mirror

Load line Ic
① pick Ic here
Intersections define op. point, pick I_{c1} sb in middle
only have curve w/ I_c for Q_2

$V_{out} = V_{CE,Q1}$
$= V_{BC} - V_{CE,Q2}$

② loads to Vout here
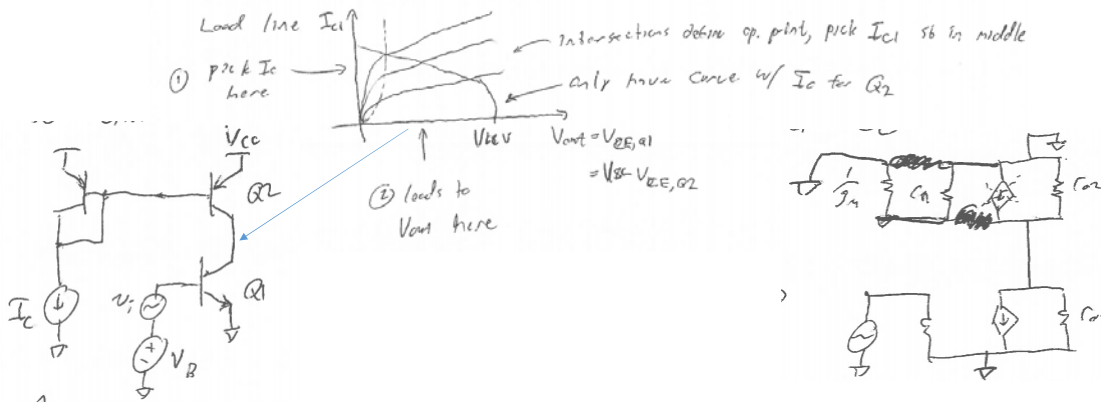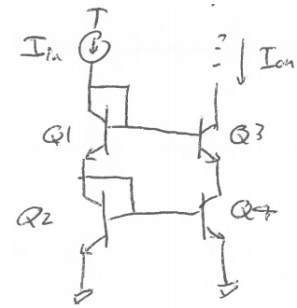
Current Mirror Reminder and Error

- Error example here, not commonly calculated b/c MOSFETs different
- Similarly, lots of cool types of mirrors ~ Widlar has feedback for low ε
- But cascode mirror commonly used in MOS b/c big rout
- Reminder: FOM are V_IN, V_MIN, ε, rout

$$I_{in} = I_{b1} + I_{c1} \approx (\beta+1) I_{b1}$$
$$I_{out} = \beta I_{b1}$$
$$\varepsilon = \frac{\beta}{\beta+2}$$

"Simple Mirror"

$$V_{in} = 2 \cdot V_{be,on}$$
$$V_{out,min} = 2 \cdot V_{CE,sat}$$