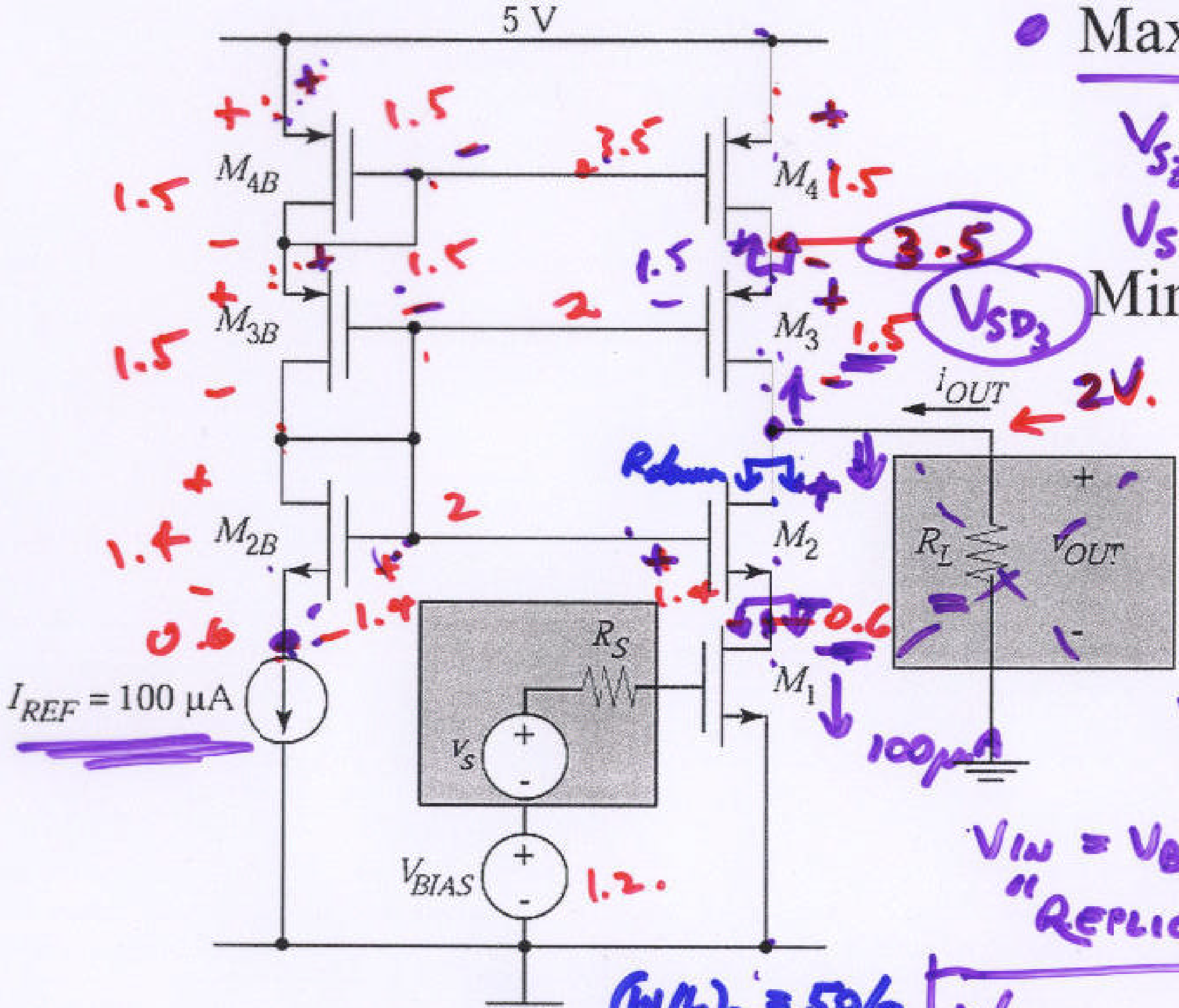
Lecture 38

- Last time:
  - LEC. 37 – CMOS cascode transconductance amplifier design example (FINISHING THIS TODAY)
- Today:
  - KILLER EXAMPLE
  - BiCMOS voltage amplifier: example of "dissection" technique for a complicated circuit

ANALYSIS VS. DESIGN.
(TOP → BOTTOM) (BOTTOM → TOP)

Output (Voltage) Swing

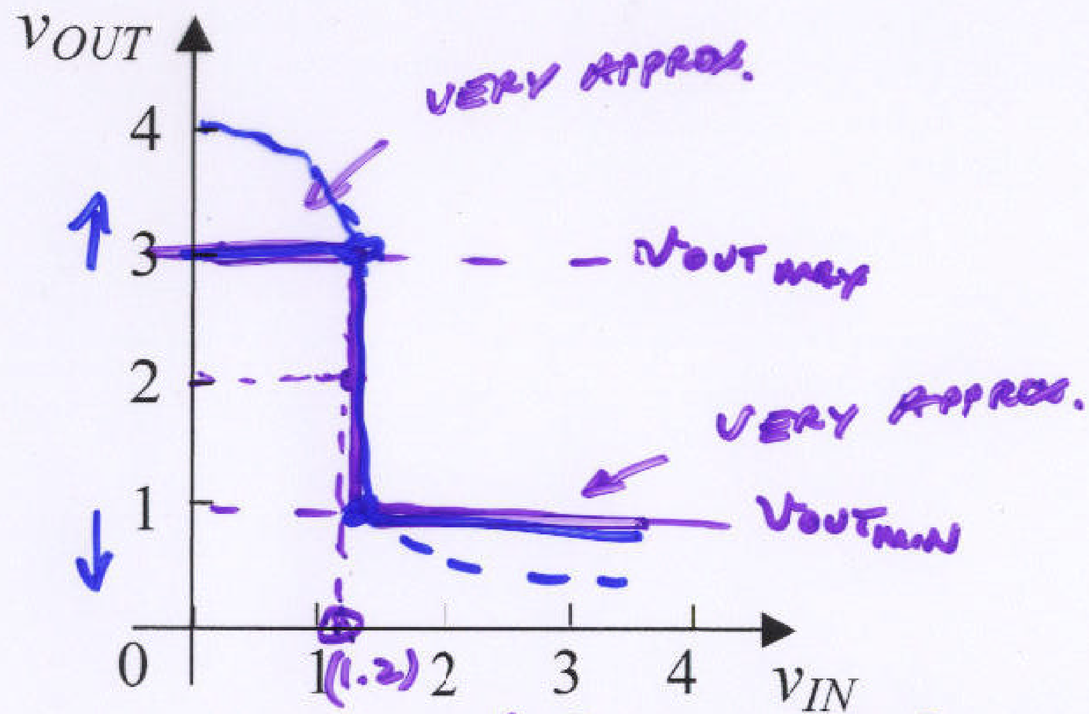


- Maximum V_{OUT}

- Minimum V_{OUT}

Voltage Transfer Curve

Open-circuit voltage gain: $A_v = v_{out} / v_{in} = - g_{m1} R_{out}$



CHECK THIS! → $A_v \big|_{unloaded} \cong -g_{m1} \cdot R_{out} = -10^{-3} \times 10^{7} = \frac{dv_{OUT}}{dv_{IN}} \Big|_Q$ (1 mS, 10 MΩ; $R_L \to \infty$, $R_S \to 0$)

$= -10{,}000$

R. T. Howe

Two-Port Model

Gm ↑
Rout ↑
Vout max − Vout min ↑

Find output resistance R_{out}

$\lambda_n = (1/20)\ V^{-1}$, $\lambda_n = (1/50)\ V^{-1}$ at $L = 2\ \mu m$ →

$r_{on} = (100\ \mu A\ /\ 20\ V^{-1})^{-1} = 200\ k\Omega$, $r_{op} = 500\ k\Omega$

$$g_{m2} = \frac{2I_{D2}}{V_{GS2} - V_{Tn}} = \frac{2(100\mu A)}{1.4V - 1V} = 500\mu S$$

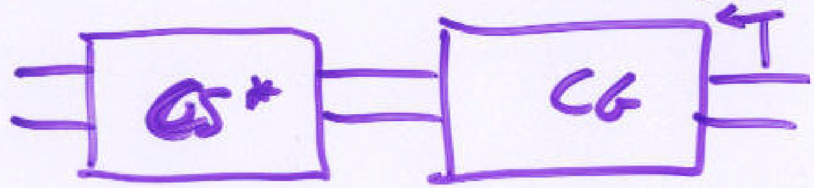
$$g_{m3} = \frac{2(-I_{D3})}{V_{SG3} + V_{Tp}} = \frac{2(100\mu A)}{1.5V - 1V} = 400\mu S$$

$g_{m2} r_{o1} =$ (0.5)(200) $= 100$

CASCODE I-SUPPLY

$$R_{out} = r_{oc} \,||\, r_{o2}\left(1 + g_{m2} R_{S2}\right) = r_{o3}\left(1 + g_{m3} R_{S3}\right) \,||\, r_{o2}\left(1 + g_{m2} r_{o1}\right)$$

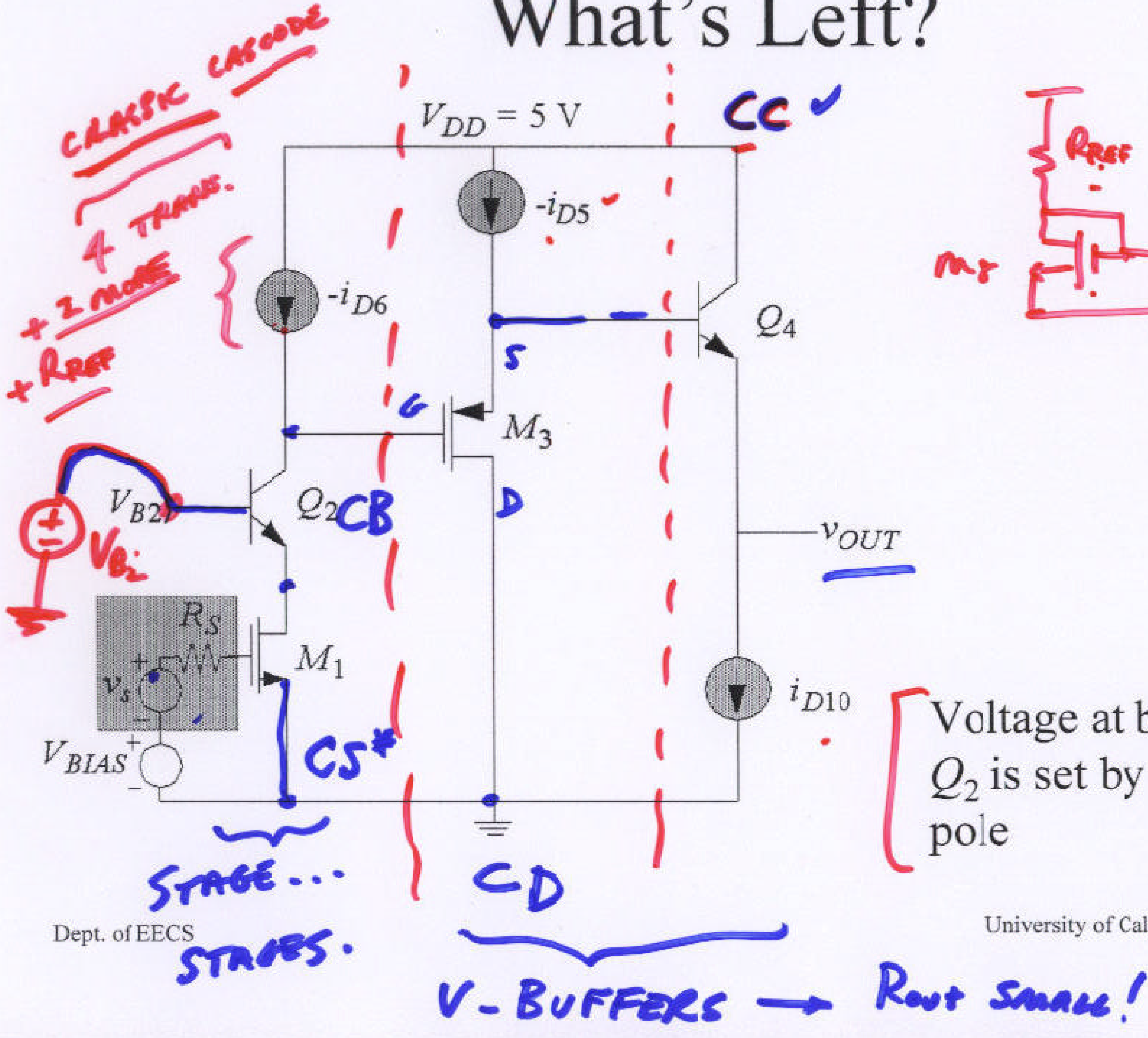
"Rdown"

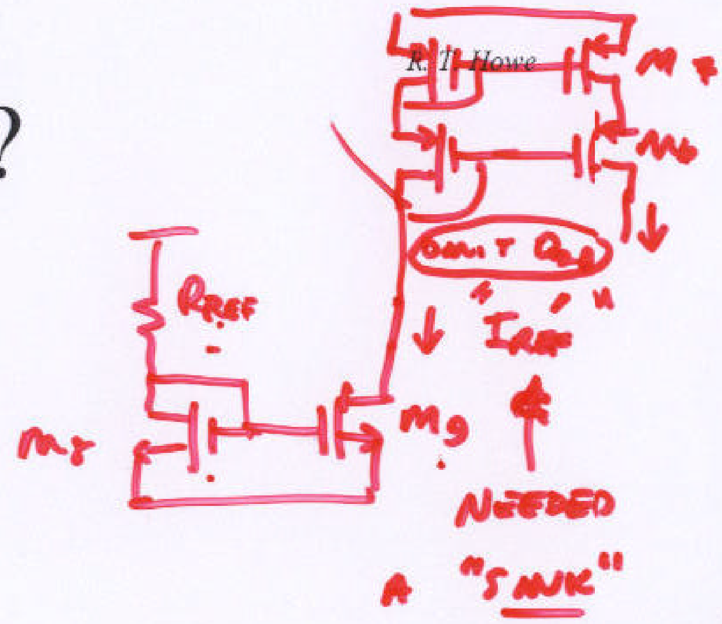


100 × 0.2 MΩ = 20 MΩ.

R. T. Howe

What's Left?





Voltage at base of Q_2 is set by totem pole

Cutting Through the Complexity

Two Approaches:

(HOWE) 1. Eliminate "background" transistors to reduce clutter

(SODINI) 2. Identify the "signal path" between the input and output

↑ v_s + other small-signals generated by v_s.

Multi-Stage Voltage Amplifier