18-421/623

Recitation

for DPI (4:10~)

only 18-421/623 students in HH1305

DP1 Recitation

Ching-Yi Lin

Outline (starting from 4:10)

- Submission: Gradescope autograder
- Discussion
  - Bandwidth calculation
  - Resistive load options
  - Gm boosting
- Case study: Mohamed's presentation
- OH (~6:00) List at the whiteboard.

How to submit

- Gradescope autograder
- Templates are available on /afs/ece/class/ece623/F23



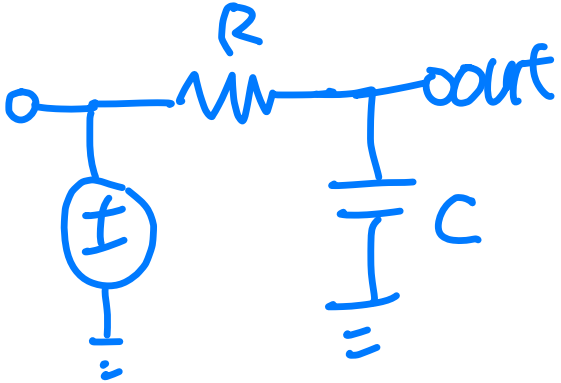
Rank	Submission Name	Area (um2)	BW (MHz)	Gain (kohm)	# of components	Power (uW)	Rin (ohm)
1	Template	44	29	29	9	403	1230

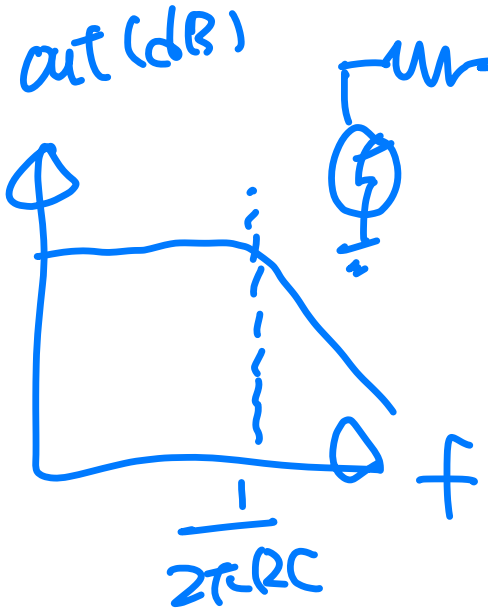
1

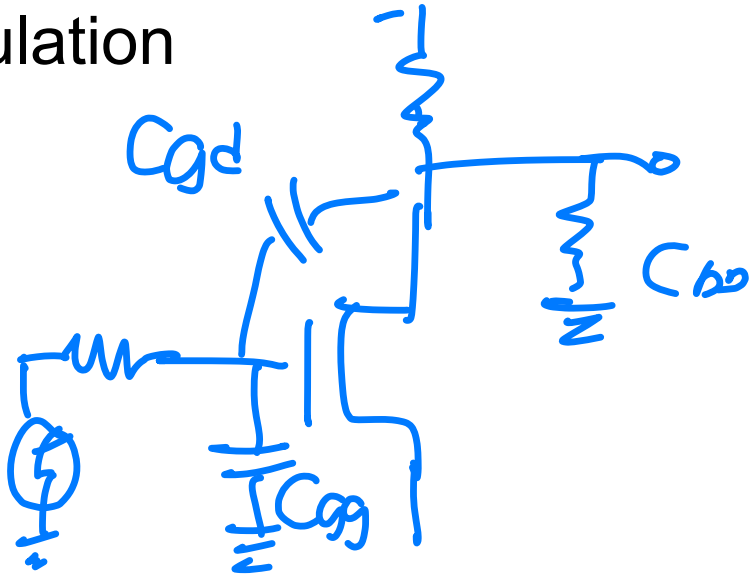
Discussion #1 – Bandwidth calculation

3db frequency = 1/2πRC

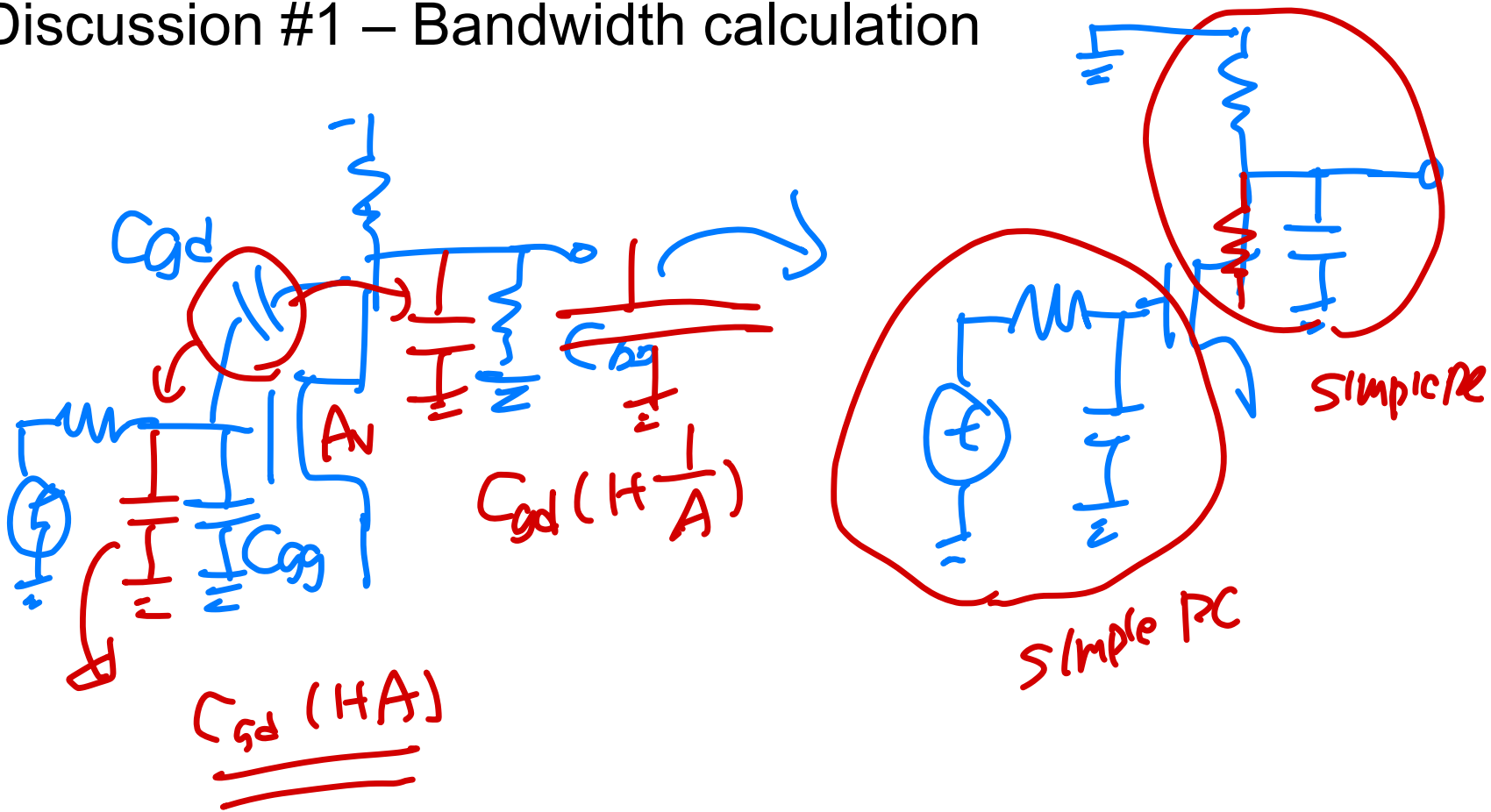
- R from your lecture notes
- C from your gm/ID script







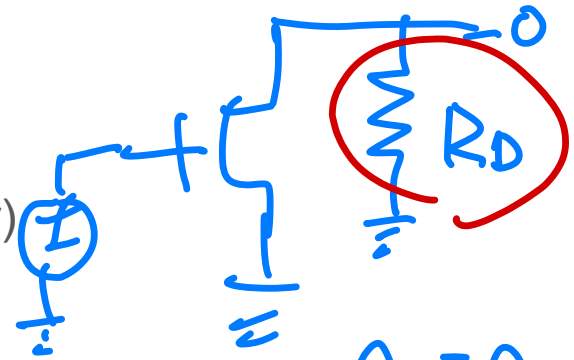
Discussion #1 – Bandwidth calculation



Discussion #2 – Resistive load option

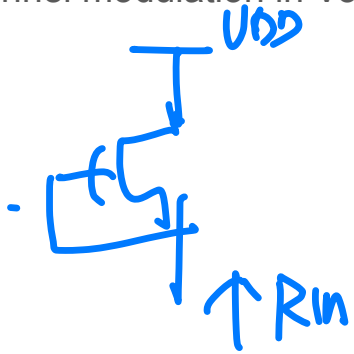
Three common resistive load options

- Resistor load
  - Cons: Value limited
- Active load (Diode-connected transistor)
  - Cons: Race between gm and 1/gm
- Current mirror
  - Cons: Rely on channel modulation in Vout



$\frac{1}{g_{m2}}$

$A_V = g_m (R_D /\!/ r_o)$



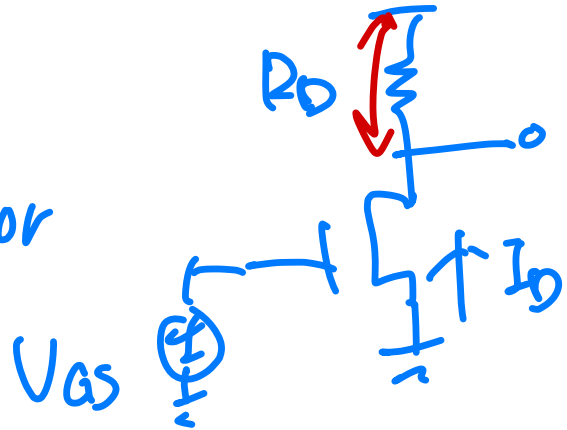
$\frac{1}{g_{m2}}$

$A = \frac{g_m}{g_{m2}} = \frac{2I_D / V_{OV}}{2I_D / V_{OV}}$

Discussion #2 – Resistive load option

Active load

- Resistor
- Current mirror



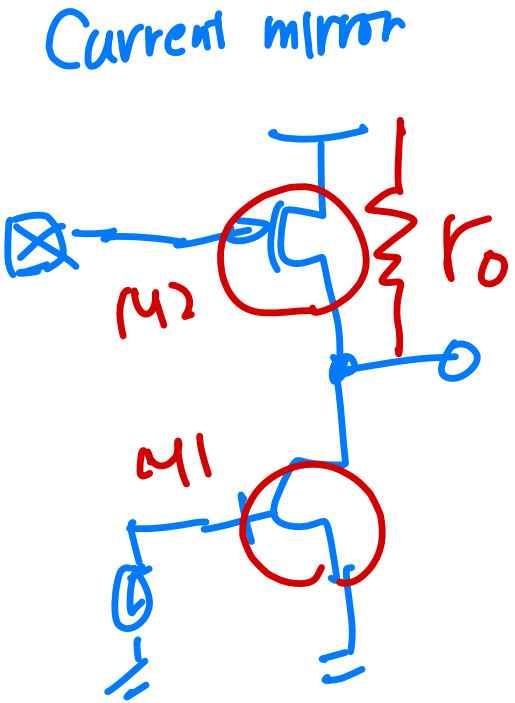
$V_{out} = V_{DD} - I_D R_D$

C

$=1$ $\quad > 0$

$$R_D = \frac{V_{DD} - V_{out}}{I_D}$$

Discussion #2 – Resistive load option



$I_{D1} = I_{D2}$

V_{G1}, V_{G2} given

$I_{D2} > I_{D1}$ – ~~V_{out}~~ ~~V_{DS}~~

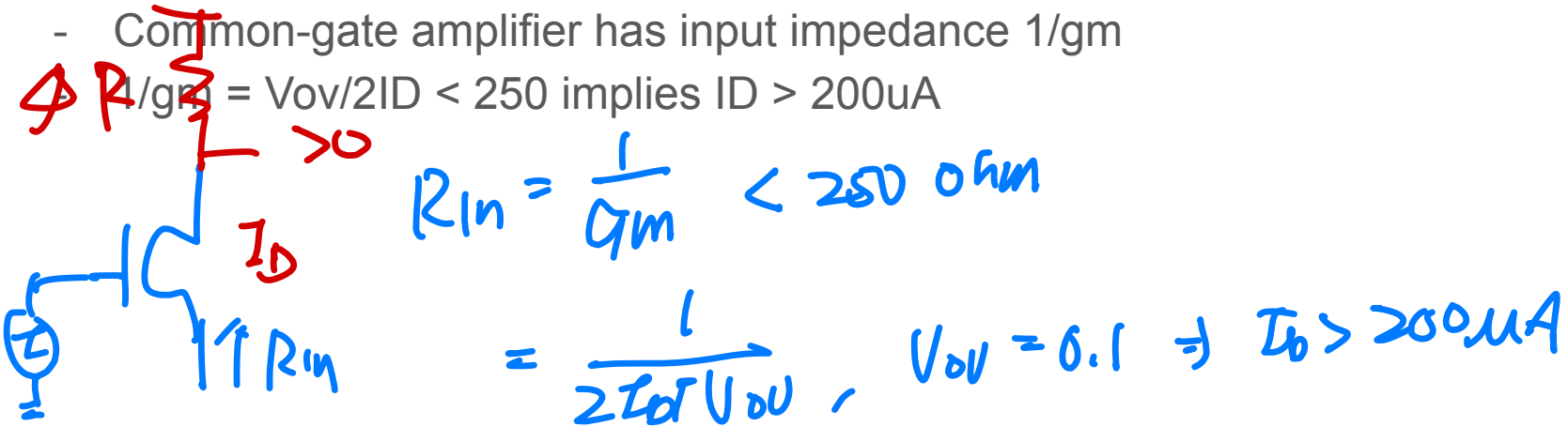
V_{DS1} ↓ I_{D1} ↓

$I_{D1} = I_{D2}$

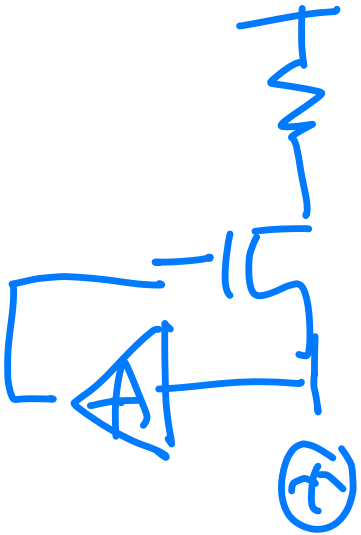
Discussion #3 – CG and gm boosting

Input impedance SPEC: 250 ohm

- Common-gate amplifier has input impedance 1/gm
- 1/gm = Vov/2ID < 250 implies ID > 200uA

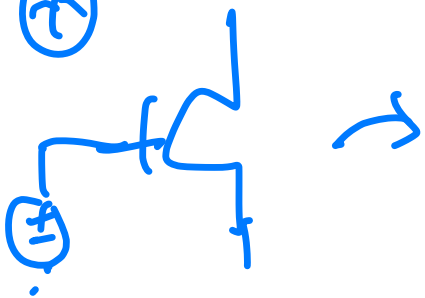


Discussion #3 – CG and gm boosting



$$V_{GS} = -A v_{in} - v_{in}$$

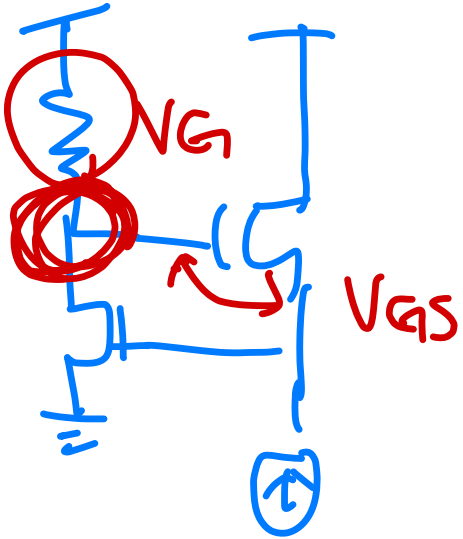
$$R_{in} = \frac{1}{g_m} \cdot g_m \Rightarrow R_{in} \to$$

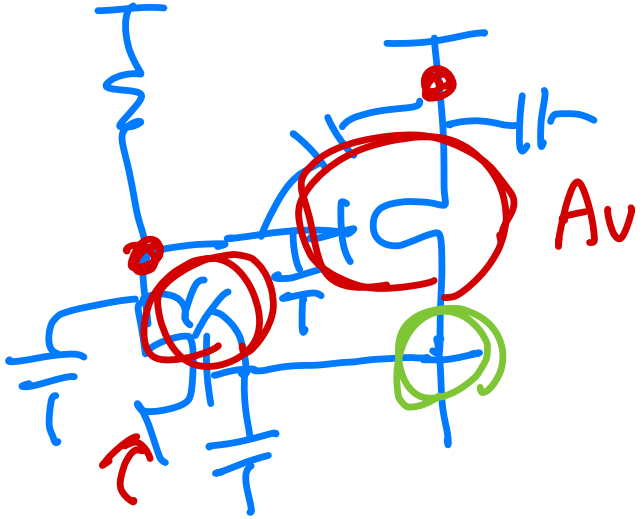


$$V_{GS} = V_G - V_{in}$$

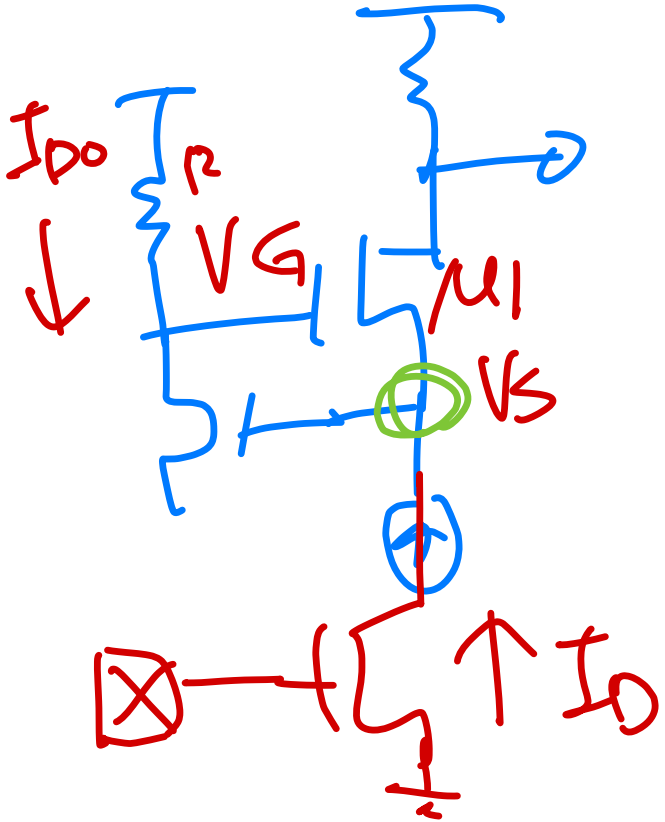
$$v_{GS} = \underline{0 - v_{in}}$$

Discussion #3 – CG and gm boosting





Discussion #3 – CG and gm boosting

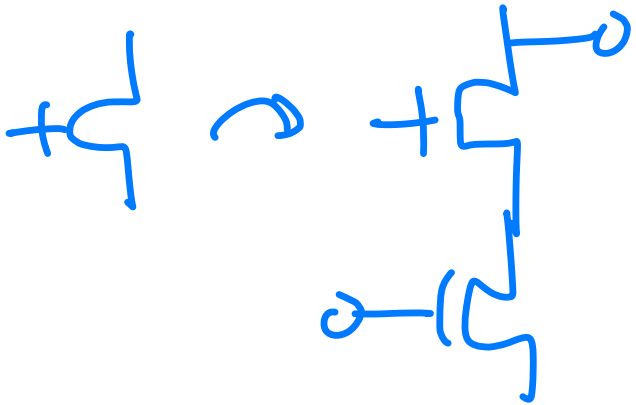


$V_S \rightarrow I_{DD} \rightarrow V_G$

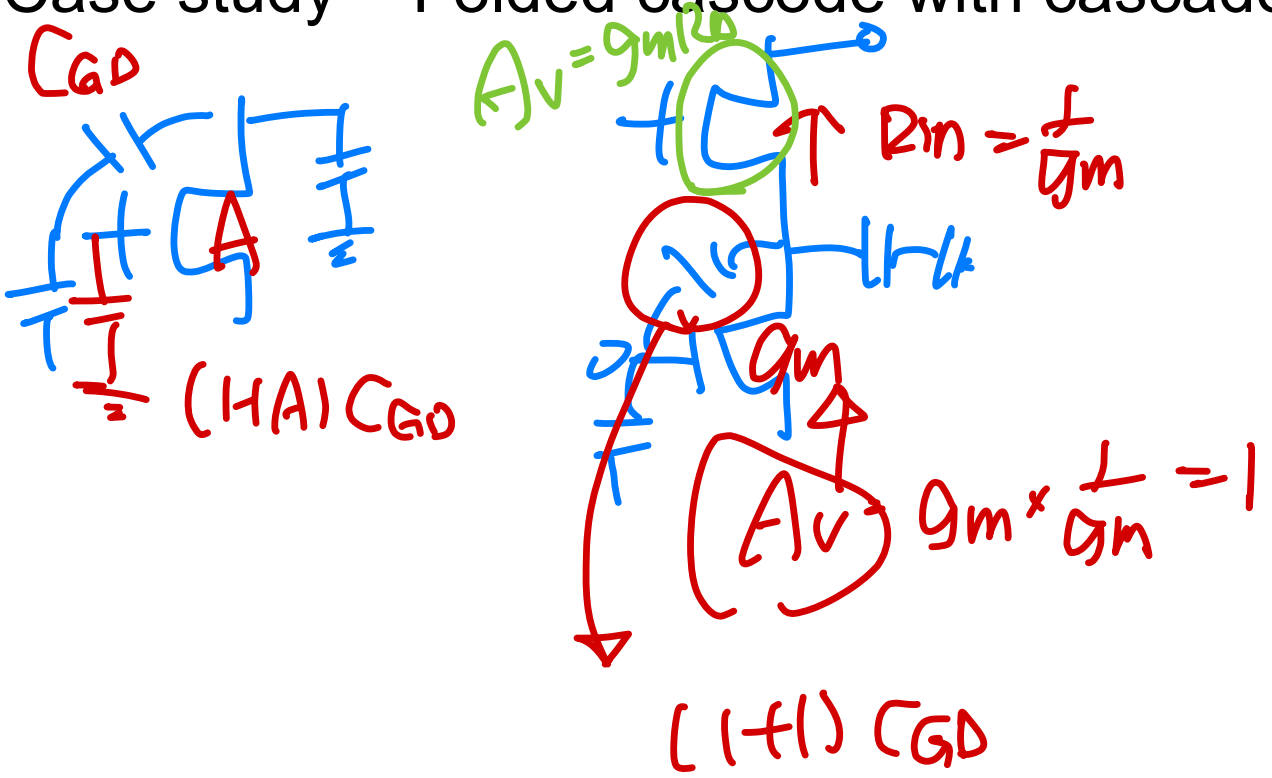
$I_D, V_G \rightarrow V_S$

Case study – Folded cascode with cascade current mirror

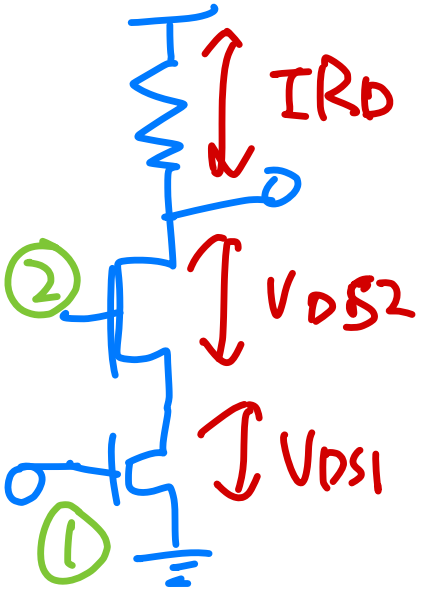
1. ~~Why cascode~~
2. ~~Why folded cascode~~
3. Why folded cascode + current mirror

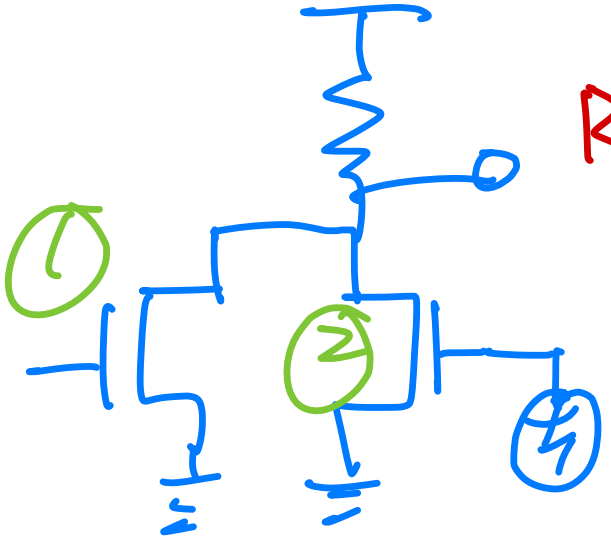


Case study – Folded cascode with cascade current mirror



Case study – Folded cascode with cascade current mirror





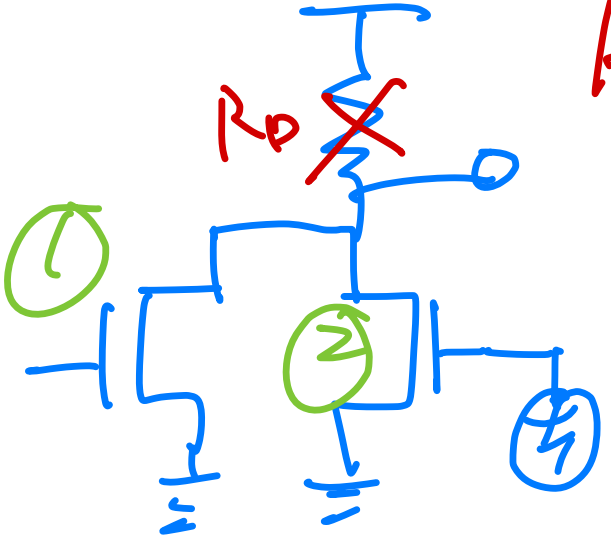
$R = \frac{V_{DD} - V_{DS2}}{I}$

$V_{DD} = IR_D + V_{DS2} + V_{DS1}$

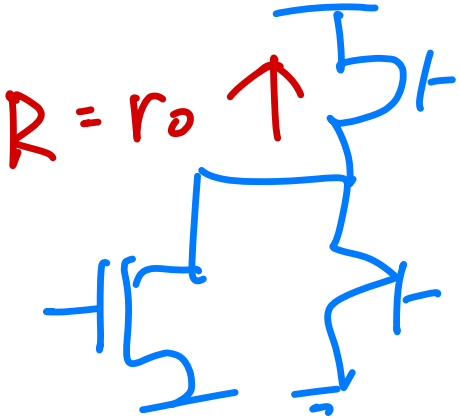
$\rightarrow R = \frac{V_{DD} - V_{DS2} - V_{DS1}}{I}$

$R = g_m r_o^2$

Case study – Folded cascode with cascade current mirror

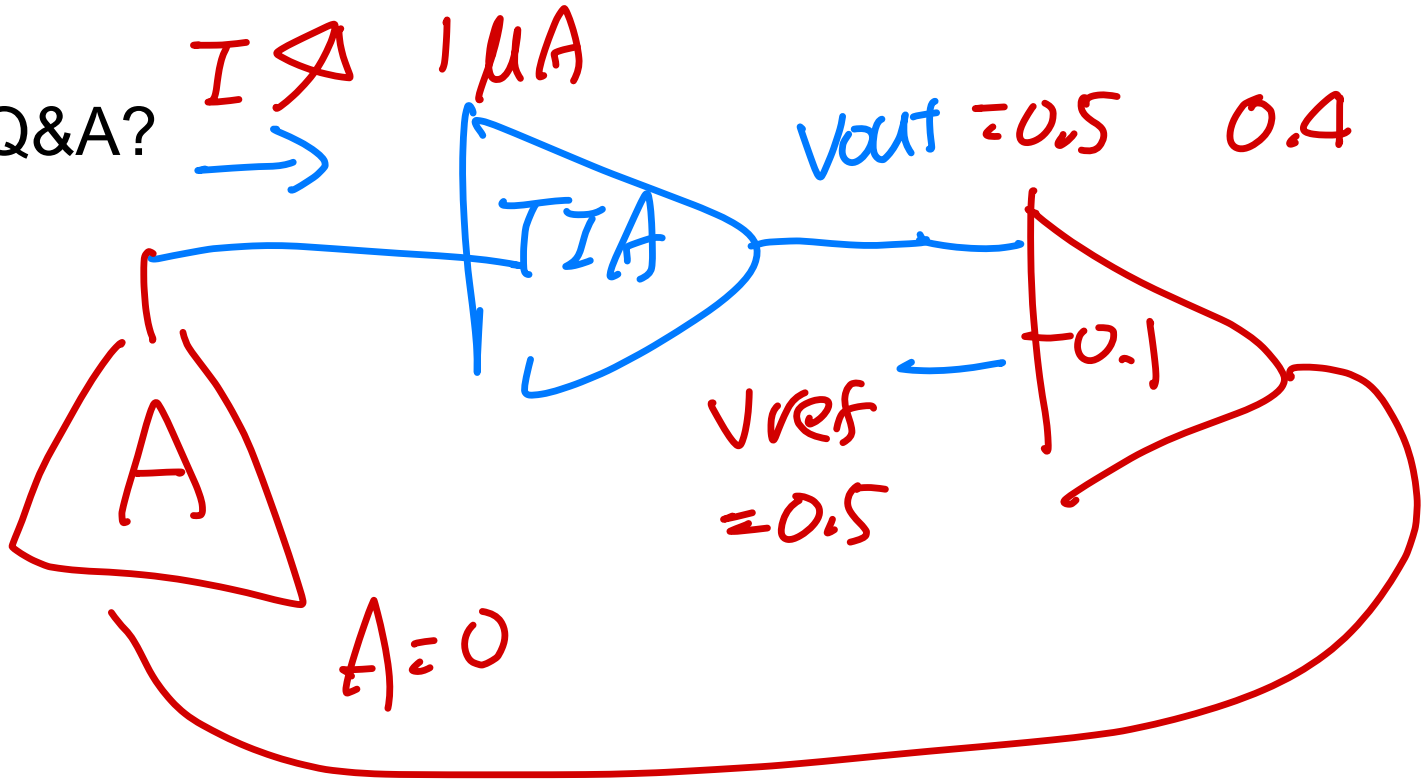


$A_v = g_m R_D$, $R_D \uparrow$, $A_v \uparrow$



$A_v = g_m (R_D \parallel r_o) \leq g_m r_o = \frac{g_m}{g_{ds}}$

Q&A?



$$A = \frac{1\,\mu A}{0.4 - 0.5} = 10\mu = BIAS_FB_GAIN$$

Office Hour (~6:00)

- No schematic debug, such as
  - Why my gain / Rin / bandwidth is lower than I expected
  - Why my Vout is at this level

- No KVL, KCL, algebra check

5 min

Office Hour (~6:00)

- No schematic debug, such as
  - Why my gain / Rin / bandwidth is lower than I expected
  - Why my Vout is at this level

- No KVL, KCL, algebra check