

Single stage diff pair w/ current mirror load

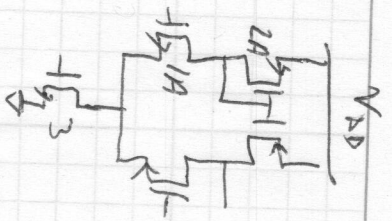
input common mode range

output swing

problems: input swing

gain

current mirror op-amp



Input common mode range

$$V_{gs1} + V_{thL,min}$$

$$V_{ov3}$$

$$V_{IC,min}$$

$$V_{th} + V_{ov1} + V_{ov3}$$

$$V_{G-2}$$

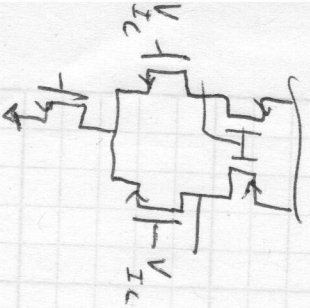
$$V_{DD} - |V_{tp1}| - |V_{ov2}|$$

$$V_{D,max}$$

$$V_{G-2}$$

$$V_{IC,max}$$

$$V_{G-2} + V_{th}$$

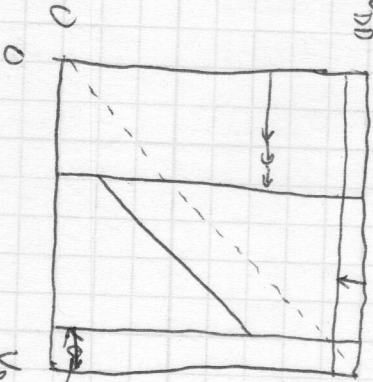


output swing

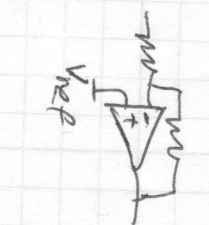
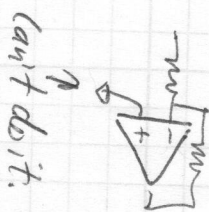
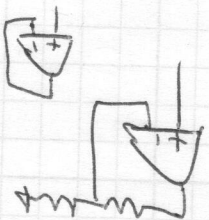
$$V_{ov,max} = V_{DD} - |V_{ov2}|$$

$$V_{ov,min} = V_{IC} - V_{th}$$

$$V_{out}$$



$$V_{IC}$$



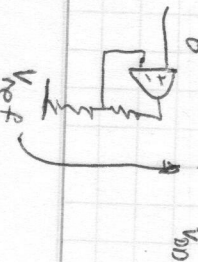
can't do it.

$$V_{DD}$$

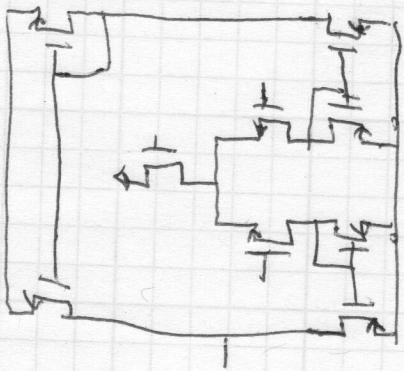
$$V_{DD}$$

$$V_{ref}$$

$$V_{ref}$$



fix output swing



- + easy bias
- + good output swing
- still low gain
- still restricted input

more gain: cascode output devices

restricts output swing

2nd stage pole

$$\omega_{p2} = \frac{1}{R_{o2} C_2}$$

$$R_{o2} = r_{d4} \parallel r_{d5}$$

1st stage pole

$$\omega_{p1} = \frac{1}{R_{o1} C_1}$$

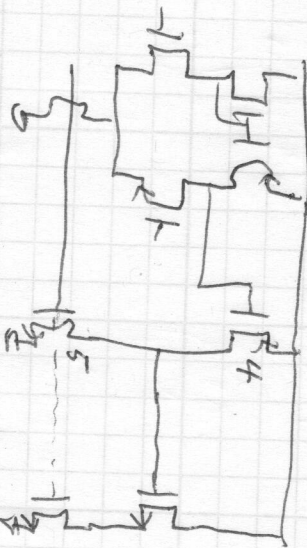
$$R_{o1} = r_{o1B} \parallel r_{o2B}$$

$$C_2 = C_{load} + C_{DB} + C_{GB}$$

...

$$C_1 = ?$$

more gain 2nd stage

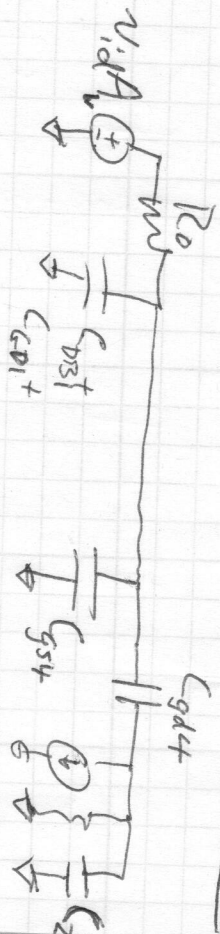


← vmos source follower

not so good w/ resistive feedback: $-A_{v2} R_{out} \parallel R_{FB}$

- FB current affects swing

50



assume small

$$C_1 = \begin{cases} C_{gs4} & \text{if gain of 2nd stage is small} \\ (1-A_{v2})C_{gs4} & \text{if } |A_{v2}| \text{ large} \end{cases}$$