

Mittern

Lab 5

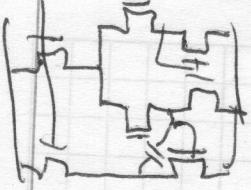
HW

Project

Cascade op-amps

telescopic

folded



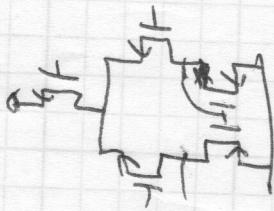
2 stage: increase gain
decrease in/out cm/swing

drive resistive loads (moderate)

problem: stability

Seen several op-amps now. All get used in practice

very common



limits:
- input common mode

- output swing

- low gain

- high impedance levels only

good: simple!

easy tuning
single pole, $\text{pm} \sim 90^\circ$

if we don't need resistive loads (i.e.

just capacitive)

there are other topologies that are

- single stage

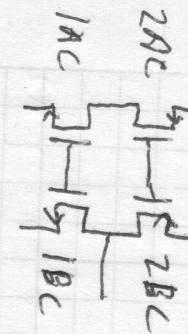
- high gain } telescopic cascode } foldy

- good-ish in/out cm/swing } cascode



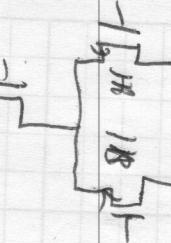
Add $\left\{ \begin{matrix} 1 \\ 2 \\ BC \end{matrix} \right\}$ to increase output resistance, gain

(doesn't work w/ resistive load)



Add $1AC$ } for symmetry

and to improve/cause biasing



telescopic cascode

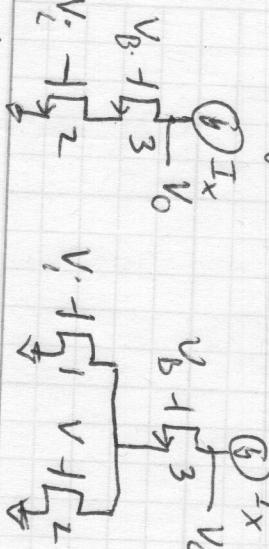
good: high gain

single pole \Rightarrow stable

not so good: in/out coupling

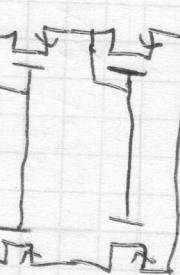
so... very popular solution: folded cascode

"folding"



$$g_{m2}(g_{m3}r_{o3}r_{o2}) - g_{m1}(g_{m3}r_{o3})(r_{o1}r_{o2}) \Rightarrow \text{some!}$$

Simplest



easy to

resists output

swing

letter: use b_n, b_p

size b_n st.

$V_{SBn} = V_t + 2V_{BE}$

$$V_{SBn} = V_t + 2V_{BE}$$

fig 9.12

$$G_m = -\frac{1}{2} g_m$$

$$R_o = ?$$

$\textcircled{1} I_X$

$\textcircled{2} I_{tail}$

$\textcircled{3} V_{tail}$

$\textcircled{4} V_{tail}$

$\textcircled{5} I_{tail}$

$\textcircled{6} V_o$

$\textcircled{7} V_o$

$\textcircled{8} V_o$

$\textcircled{9} V_o$

$\textcircled{10} V_o$

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$$R_o = R_{top} \parallel R_{DN} \quad R_{tp} \approx g_{m4} r_{o4} r_{o5}$$

typically

$$I_{D3,4,5} \approx I_{DIA,BIB}$$

$$R_{DN} = S_{m3} r_{o3} (r_{o2} \parallel r_{oIB})$$

$$\text{if } S_{m3} \approx 1 \quad I_{D2} = I_{D3} + I_{DIB} = 2 I_{DIB}$$

$$r_{o2} = \frac{1}{\lambda^2 I_{DIB}} \quad r_{oIB} = \frac{1}{\lambda_p I_{DIB}}$$

$$R_{tp} \parallel R_{DN} \approx \frac{1}{4} S_m r_o^2$$

$$R_t = -C_m R_v = +\frac{1}{8} (g_m r_o)^2$$

out of swing

$$V_{o,min} = V_{G3} - V_{th} \geq V_{ov2} + V_{ov3}$$

↑
depends on how you bias V_{G3}

topb corner mode

$$V_{im,max} = V_{D0} - |V_{ov3}| - |V_{tp}| - |V_{ov1}|$$

$$V_{im,min} = V_{S3} - |V_{tp}|$$

$$V_{ov,max} = V_{G4} + |V_{tp}| \leq V_{D0} - |V_{ov4}| - |V_{ov3}|$$

longest possible

$$V_{im,min} = V_{ov2} - |V_{tp}| < 0$$

short corner mode below ground!