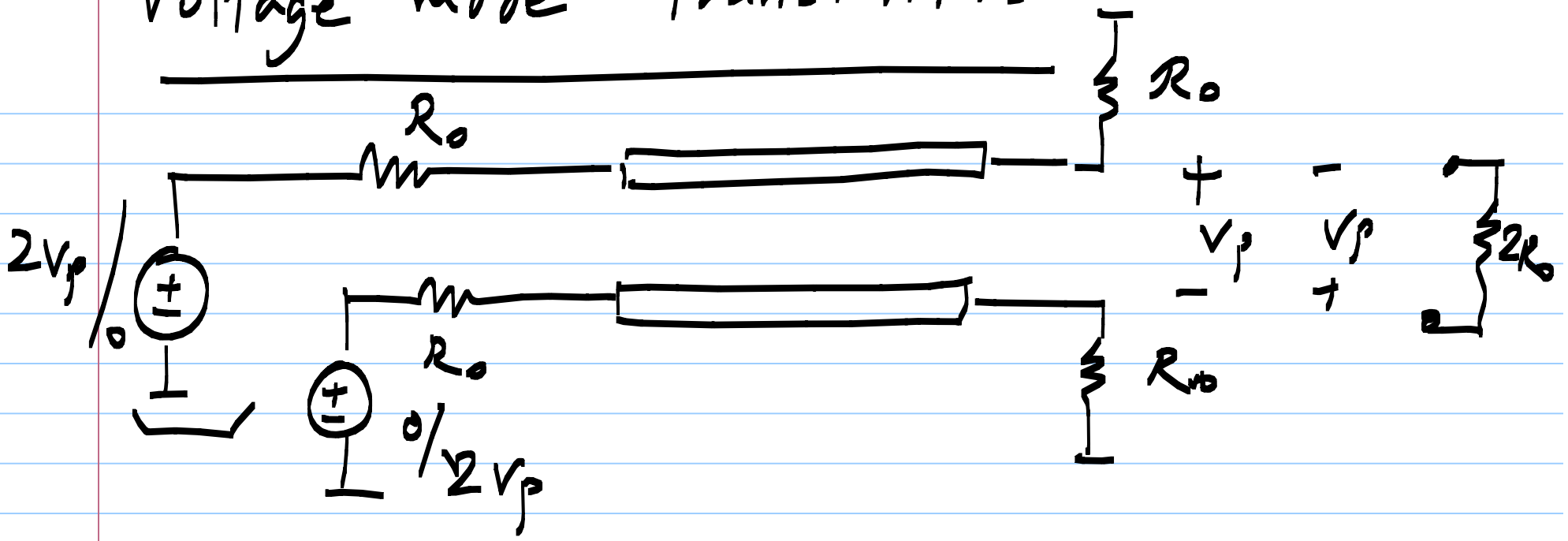
Current mode transmitters

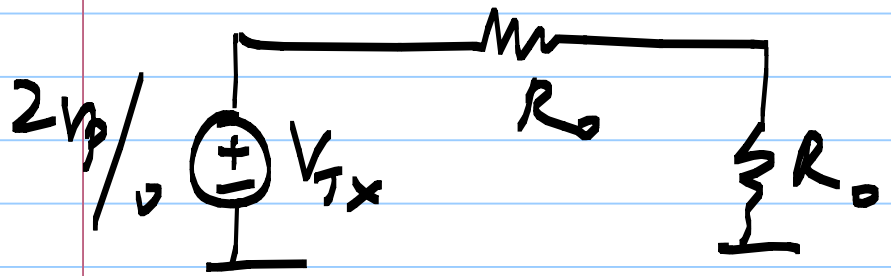
Fixed equalizer

- Diff pairs in parallel - tap values by size/currents — More flexible
- Separate diff pairs for each tap, or form a single DAC (eg: digital)
- pMOS + nMOS ⟹ higher efficiency, but higher parasitics of CMOS
- Many taps : large Common mode current ⟹ pMOS sources to raise the CM level

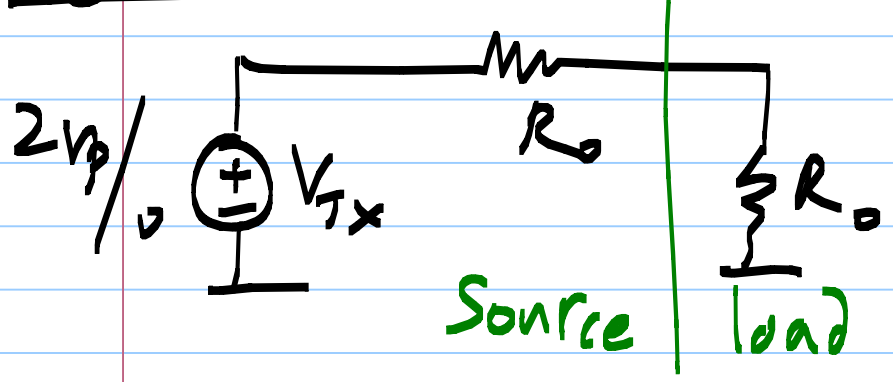
Voltage mode transmitters

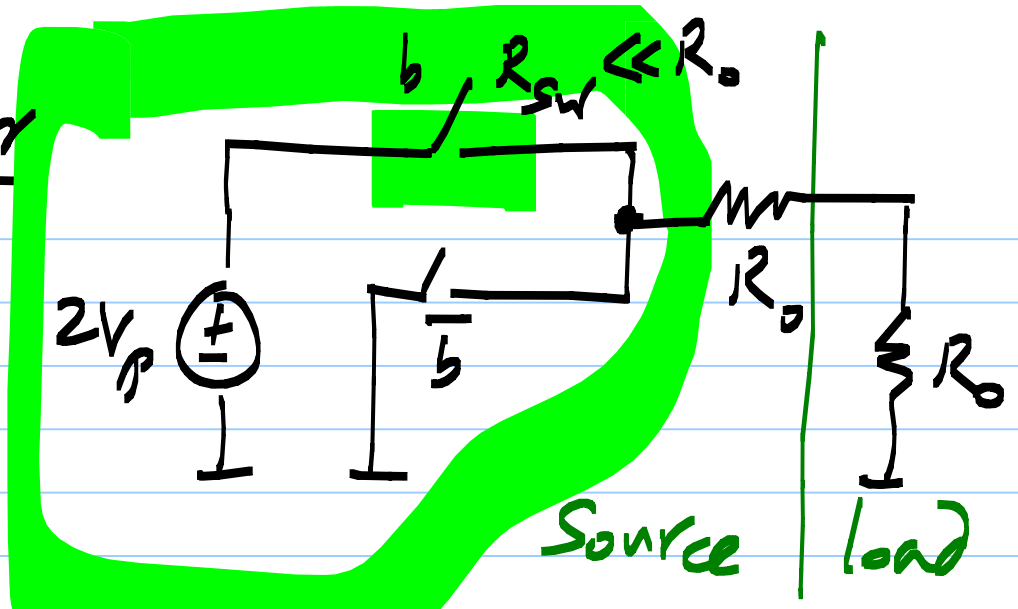


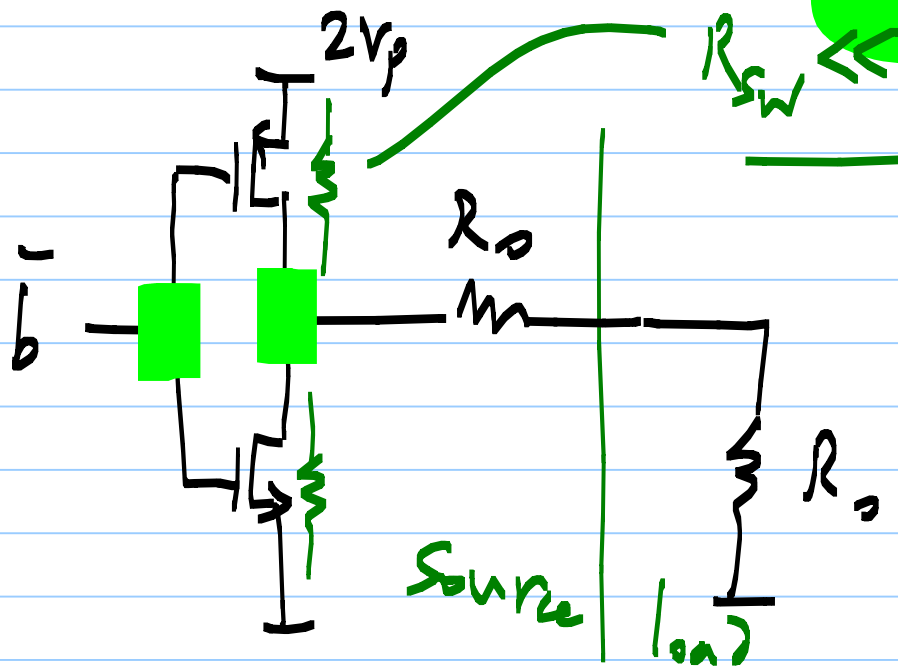
Single-ended transmitter



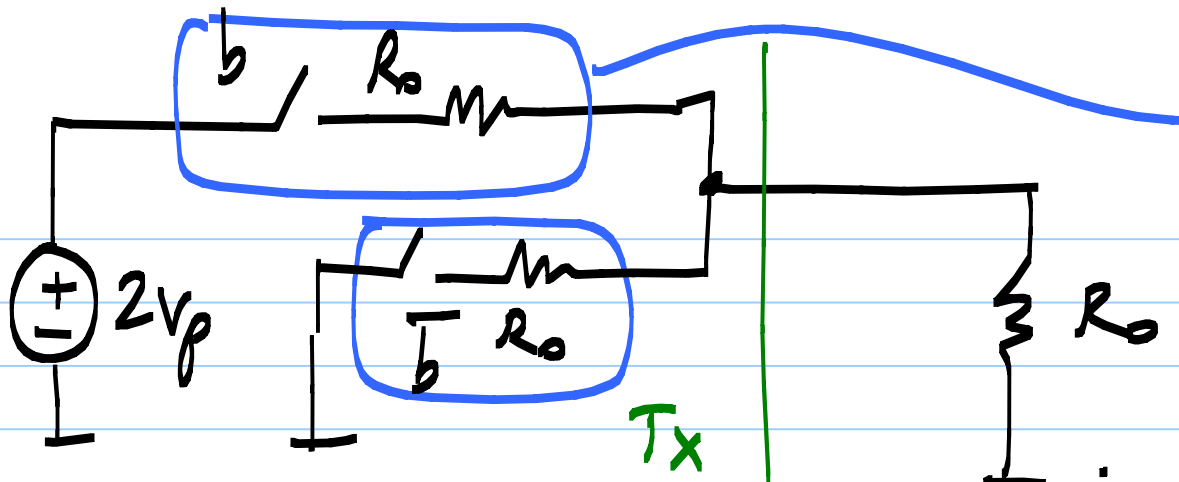
Single-ended transmitter



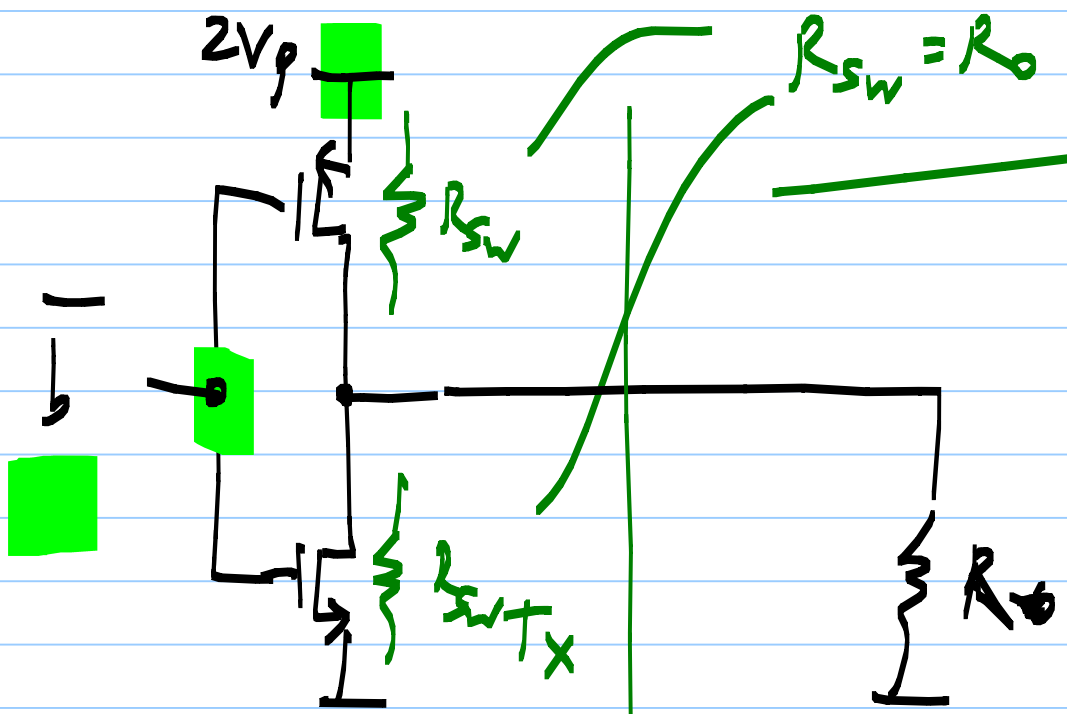




- very wide transistors
- large parasitics
- Increased switching power



Switch w/ resistance R_0

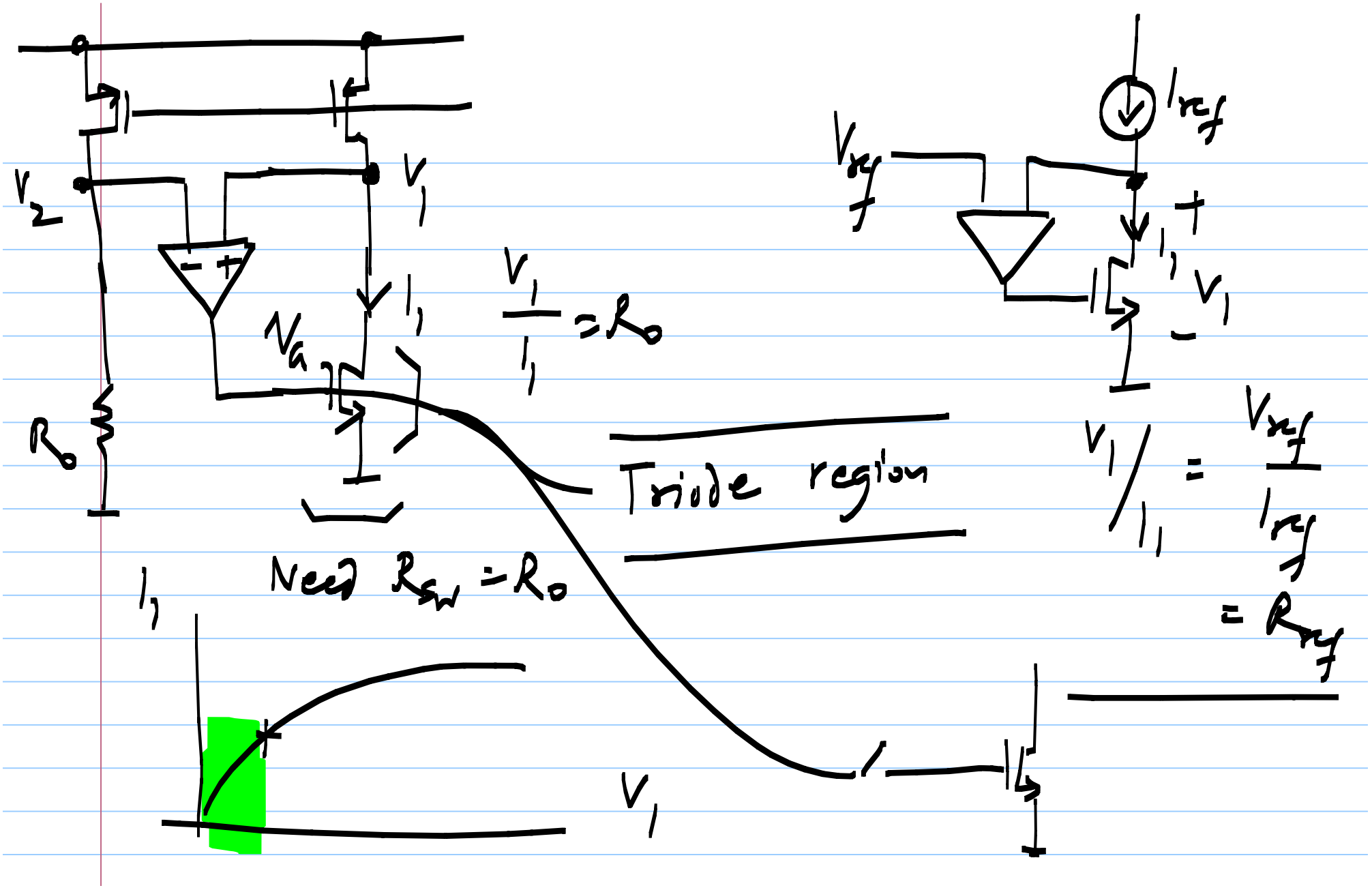


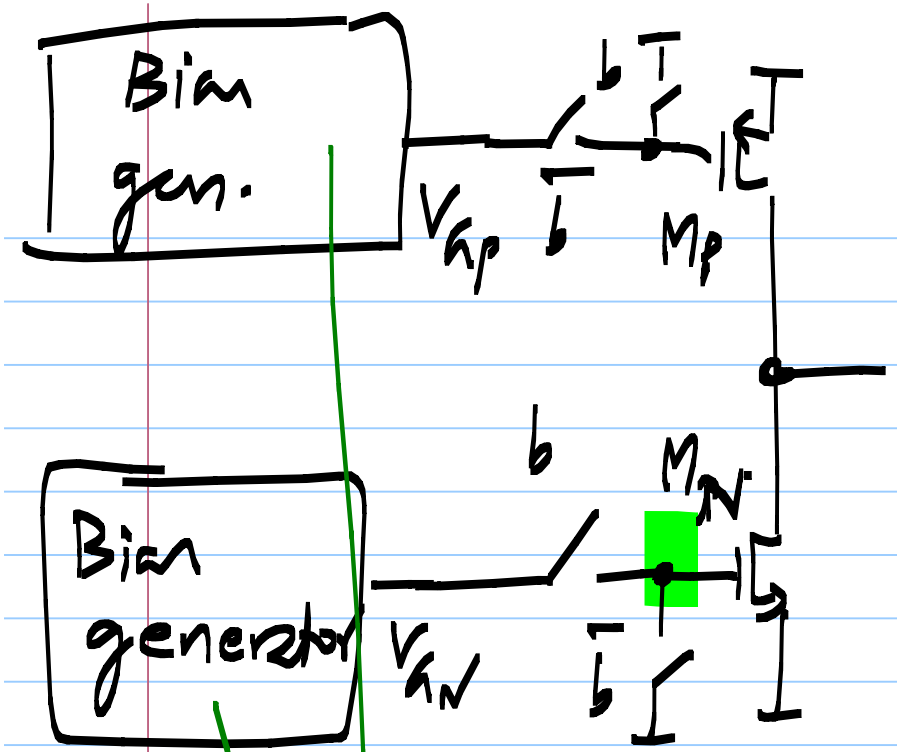
$R_{sw} = R_0$ (in the on state)

PVT variations

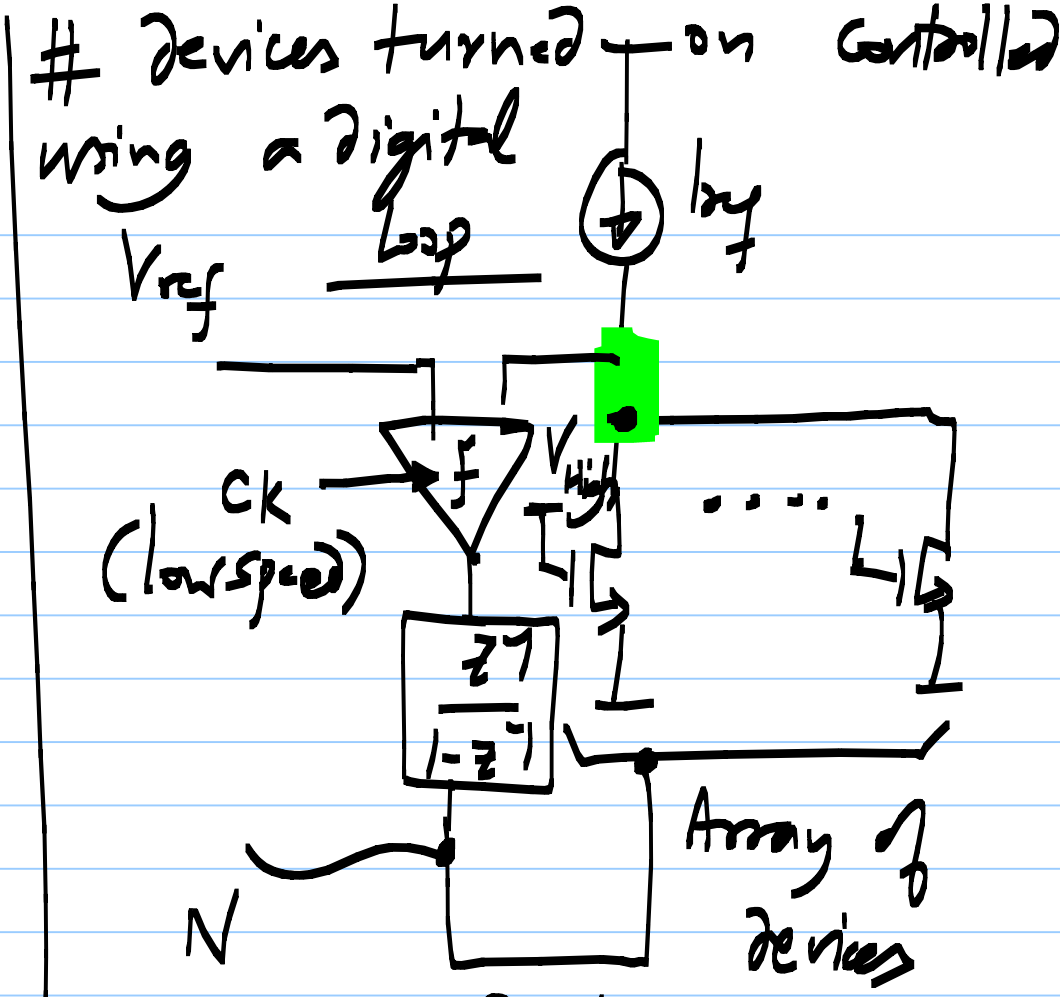
Mos: T, P, ($2V_p$, V_t in on state)

Control R_{sw} using a negative fb Loop.


V_2
V_1
R_0
V_G
I_1
$\frac{V_1}{I_1} = R_0$
Triode region
Need $R_{sw} = R_0$
I_1
V_1
I_{ref}
V_{ref}
V_1
I_1
$\frac{V_1}{I_1} = \frac{V_{ref}}{I_{ref}} = R_{ref}$

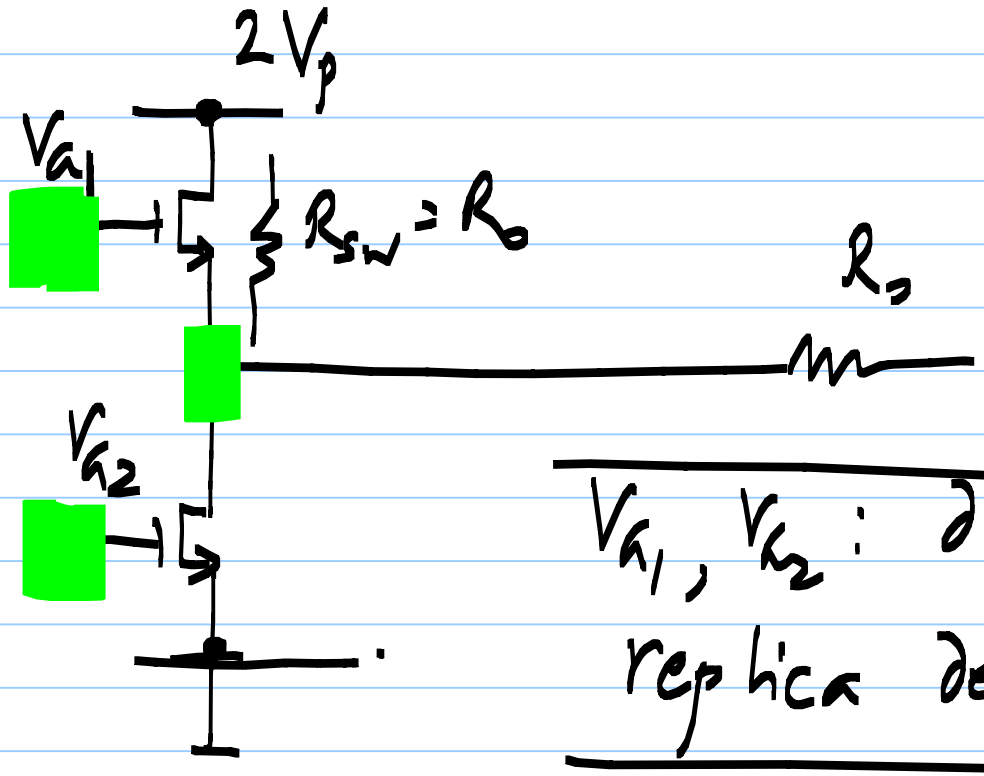


M_P, M_N: $R_{SW} = R$



Feedback to ensure $R_{SW} = R$

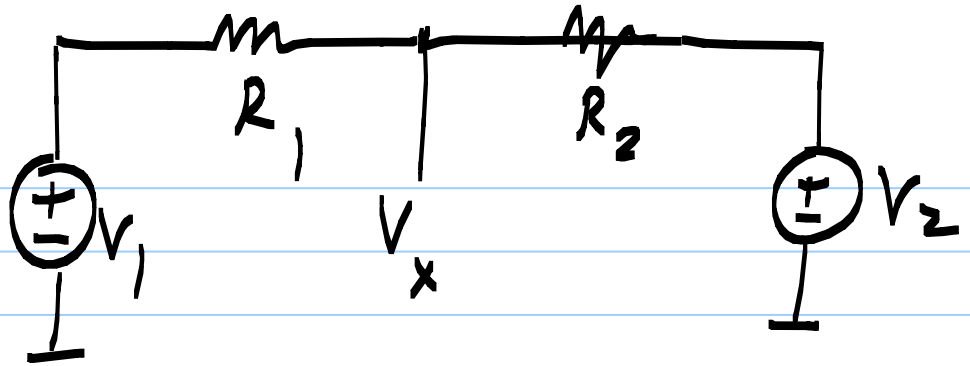
$V_{G1} > 2V_p + V_T$ $\qquad$ $2V_p < V_{DD}$

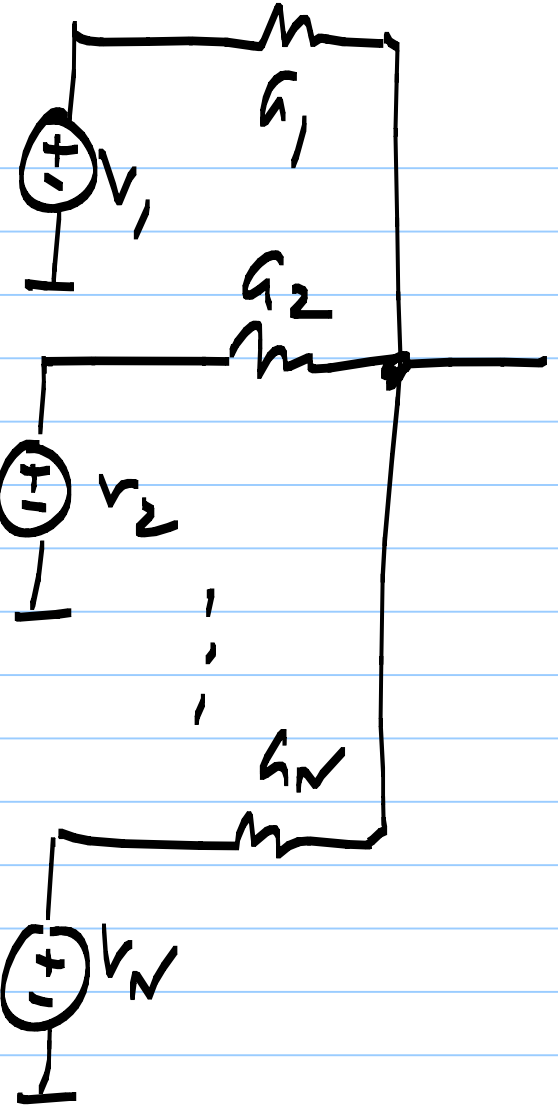


V_{G1}, V_{G2}: derive using replica devices in feedback

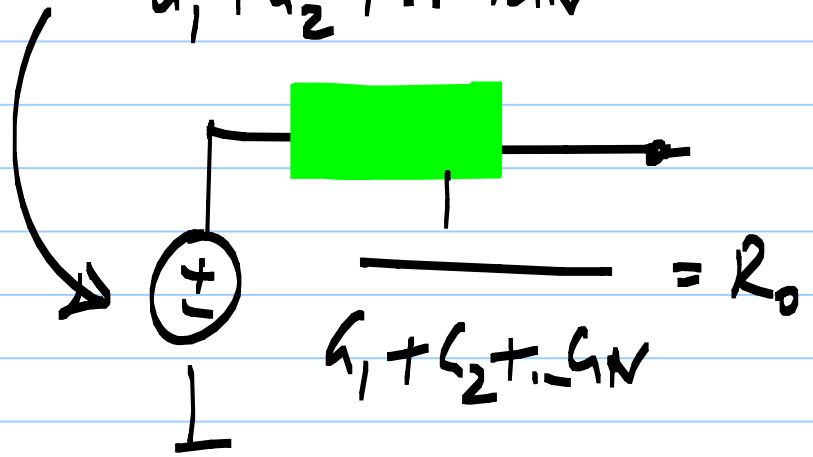
N-over-N driver; works when $2V_p < V_{DD}$

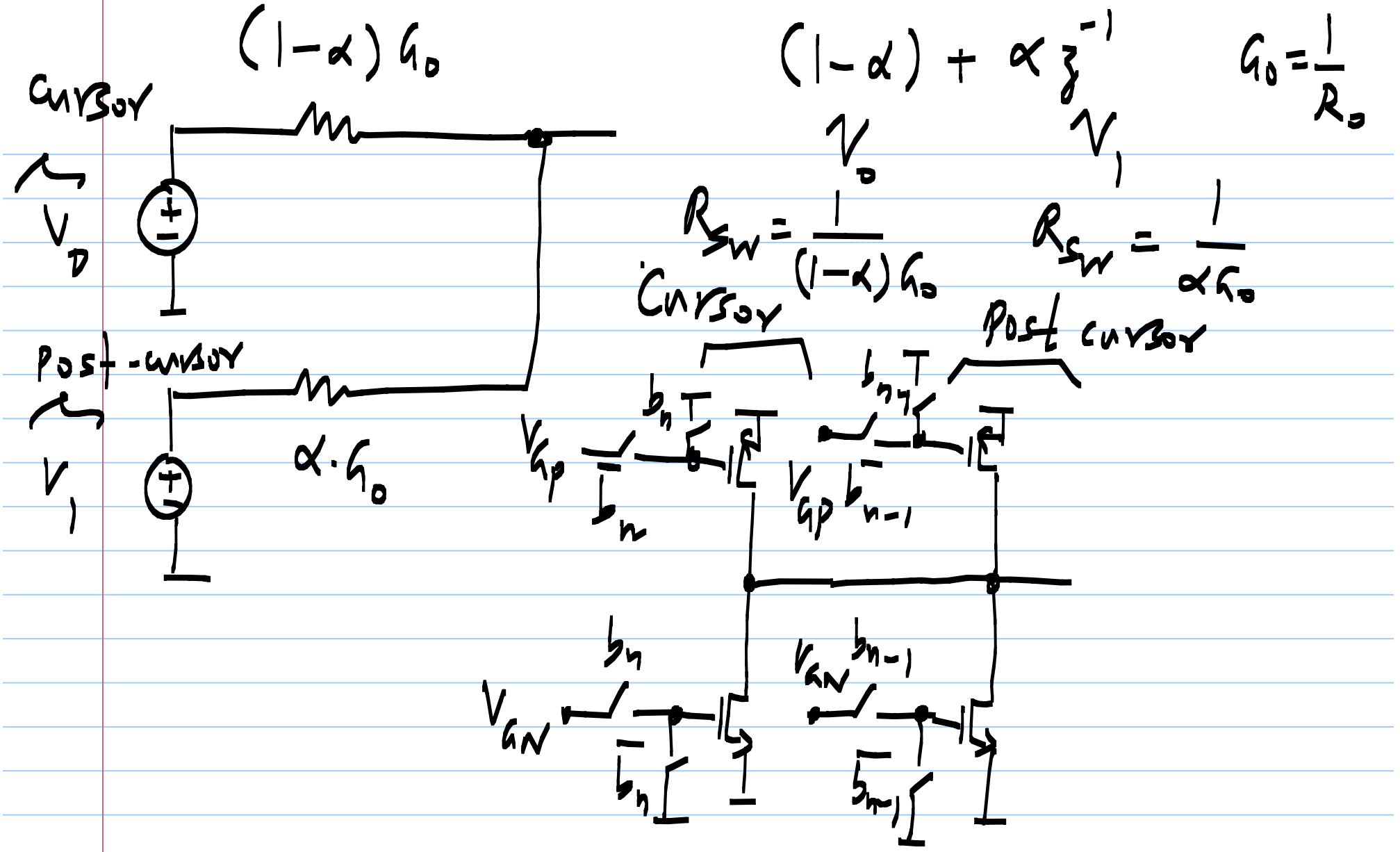
Smaller nMOS than pMOS for the same R_{sw}.

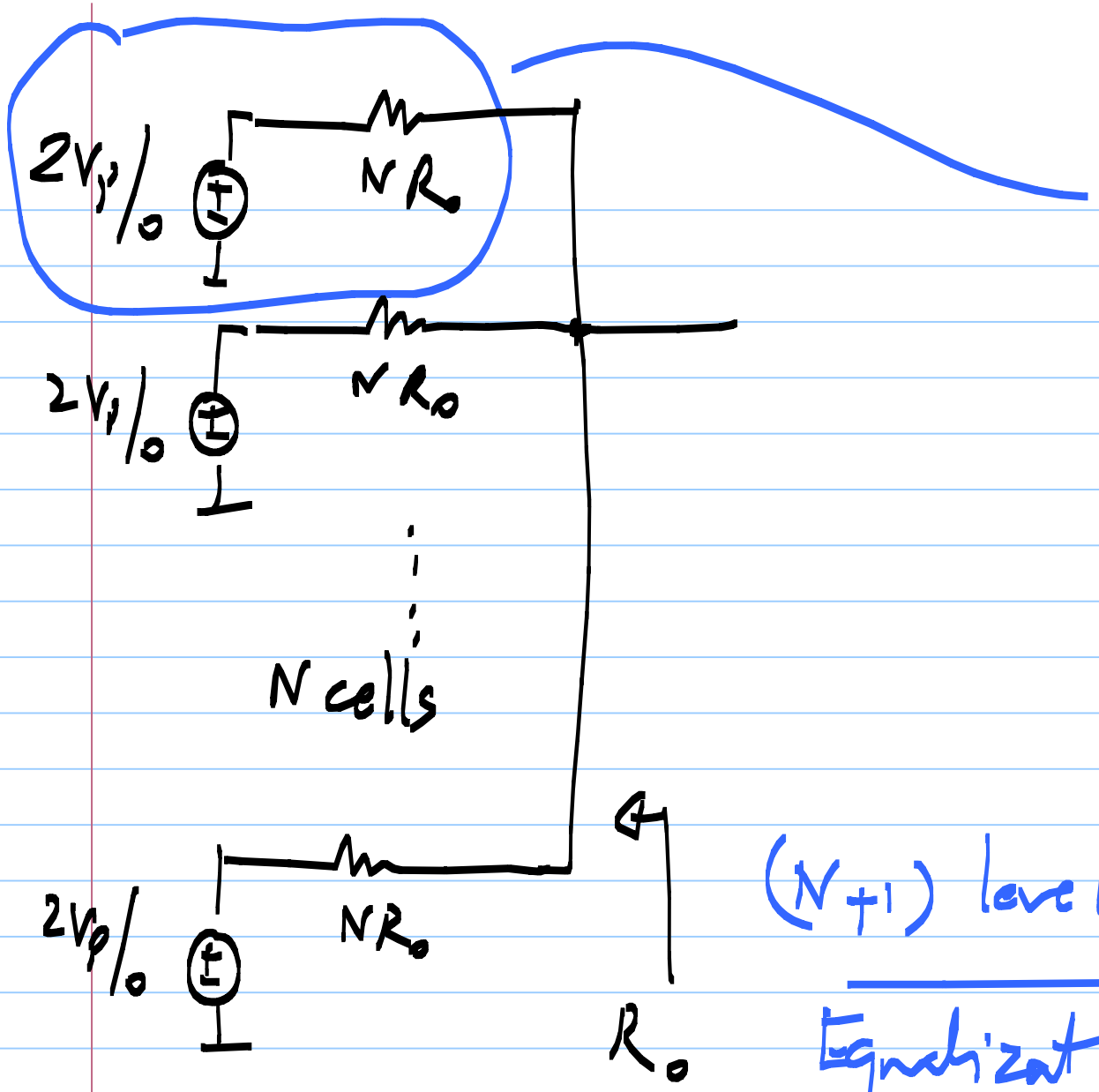


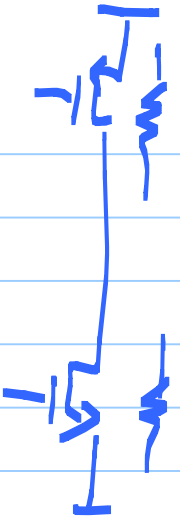


$$\frac{V_1 G_1 + V_2 G_2 + \dots V_N G_N}{G_1 + G_2 + \dots + G_N}$$




$(1-\alpha)\,G_0$
$(1-\alpha)+\alpha z^{-1}$
$G_0 = \frac{1}{R_0}$
Cursor
V_0
V_D
$R_{SW} = \frac{1}{(1-\alpha)G_0}$
V_1
$R_{SW} = \frac{1}{\alpha G_0}$
Post-cursor
$\alpha \cdot G_0$
Cursor
Post cursor
b_n
b_{n-1}
V_{GP}
$\overline{b_n}$
V_{GP}
$\overline{b_{n-1}}$
b_n
b_{n-1}
V_{GN}
V_{GN}
$\overline{b_n}$
$\overline{b_{n-1}}$





$R_{sw} = NR_0$

$(N+1)$ level DAC

Equalization in the 2^{y} domain

Voltage mode transmitters:

- More efficient than current-mode tx
- Switch resistance = desired termination
  - Replica in feedback
    - Analog (control V_R)
    - Digital (control # transistor)
- P-over-N or N-over-N (smaller swings, smaller devices)
- Equalization — Mutiple parallel units (taps) or (DAC)