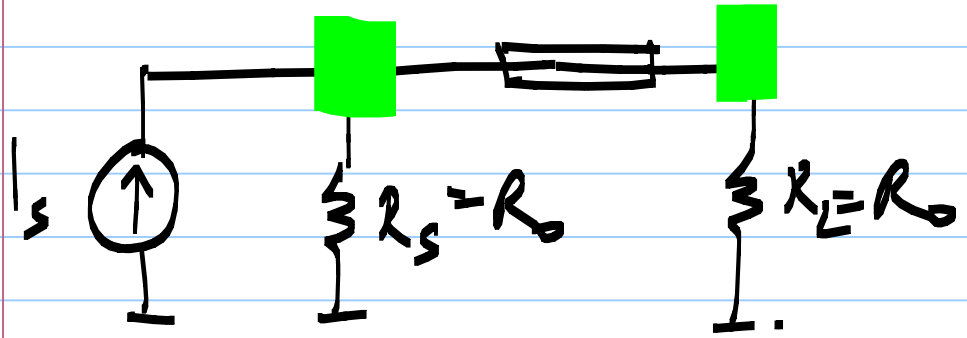
Small swings ~ 100s mV Voltage mode Tx is more efficient

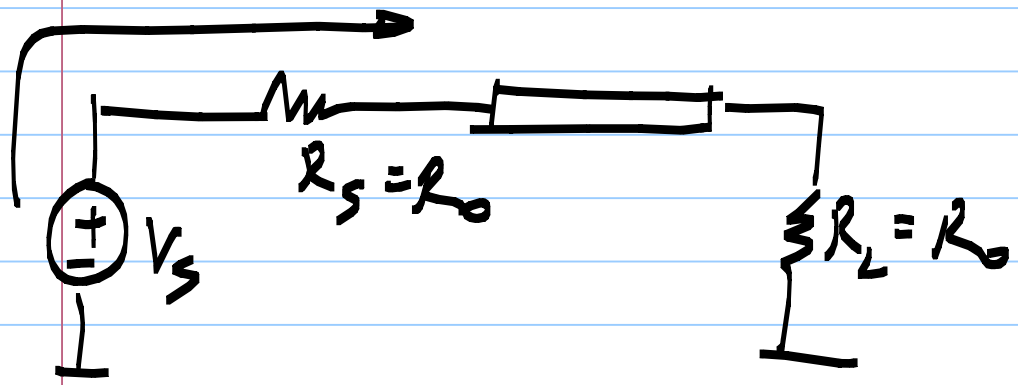
Current and voltage mode transmit drivers



Current driver

$\Rightarrow$ current division

$V_{Rx} = V_{Tx}$



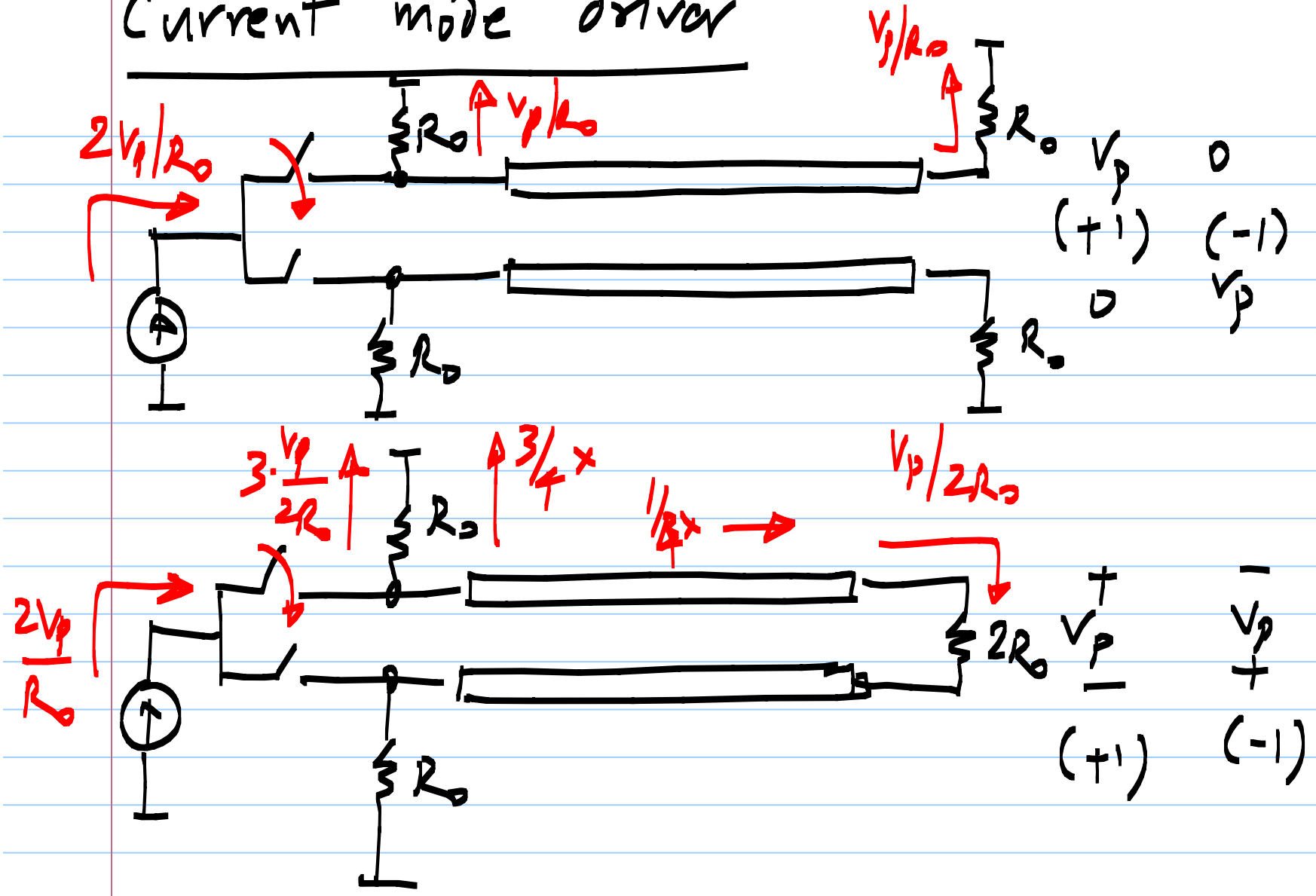
Voltage driver

All of Tx current goes to the receiver

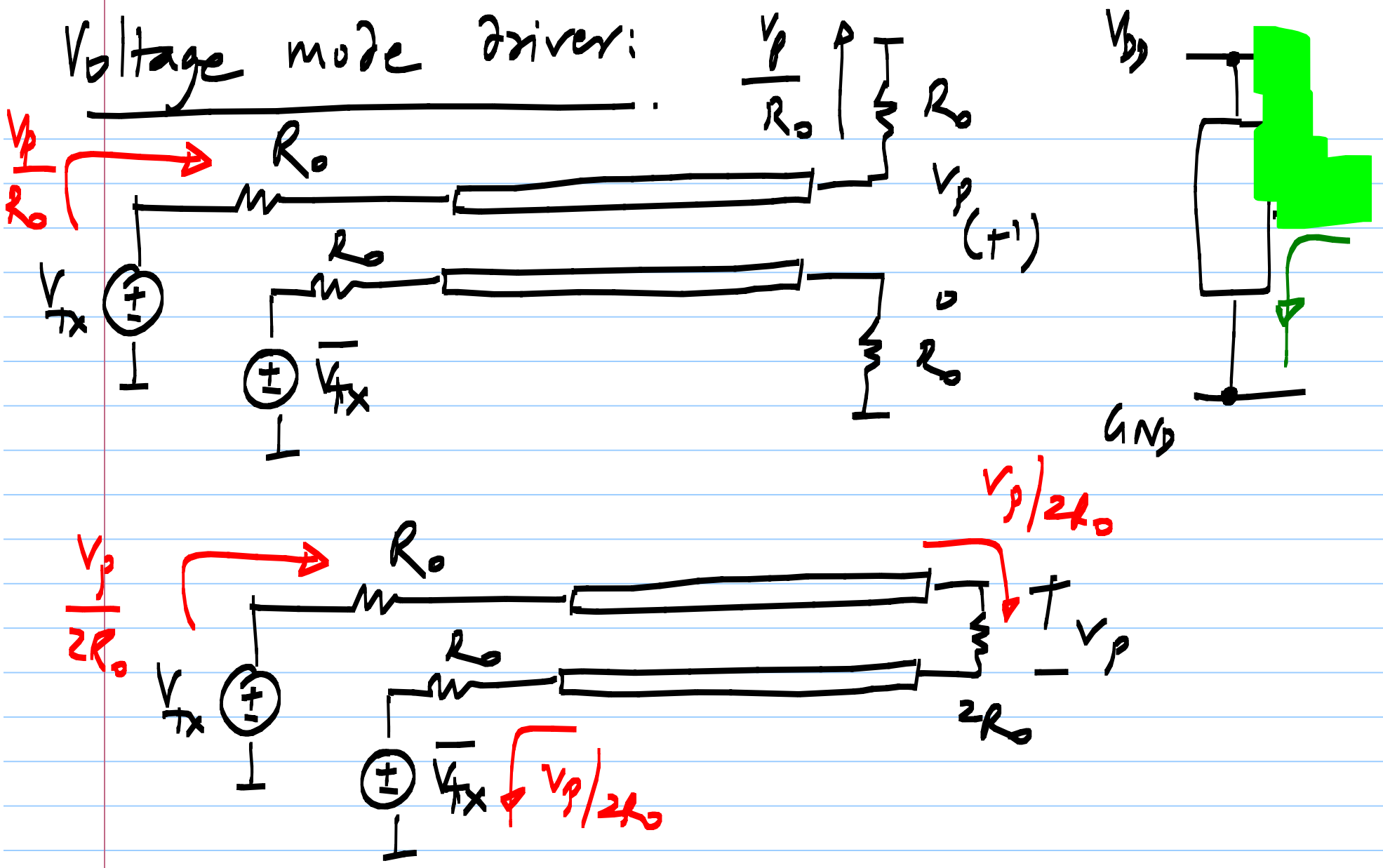
Voltage division

Smaller Tx current

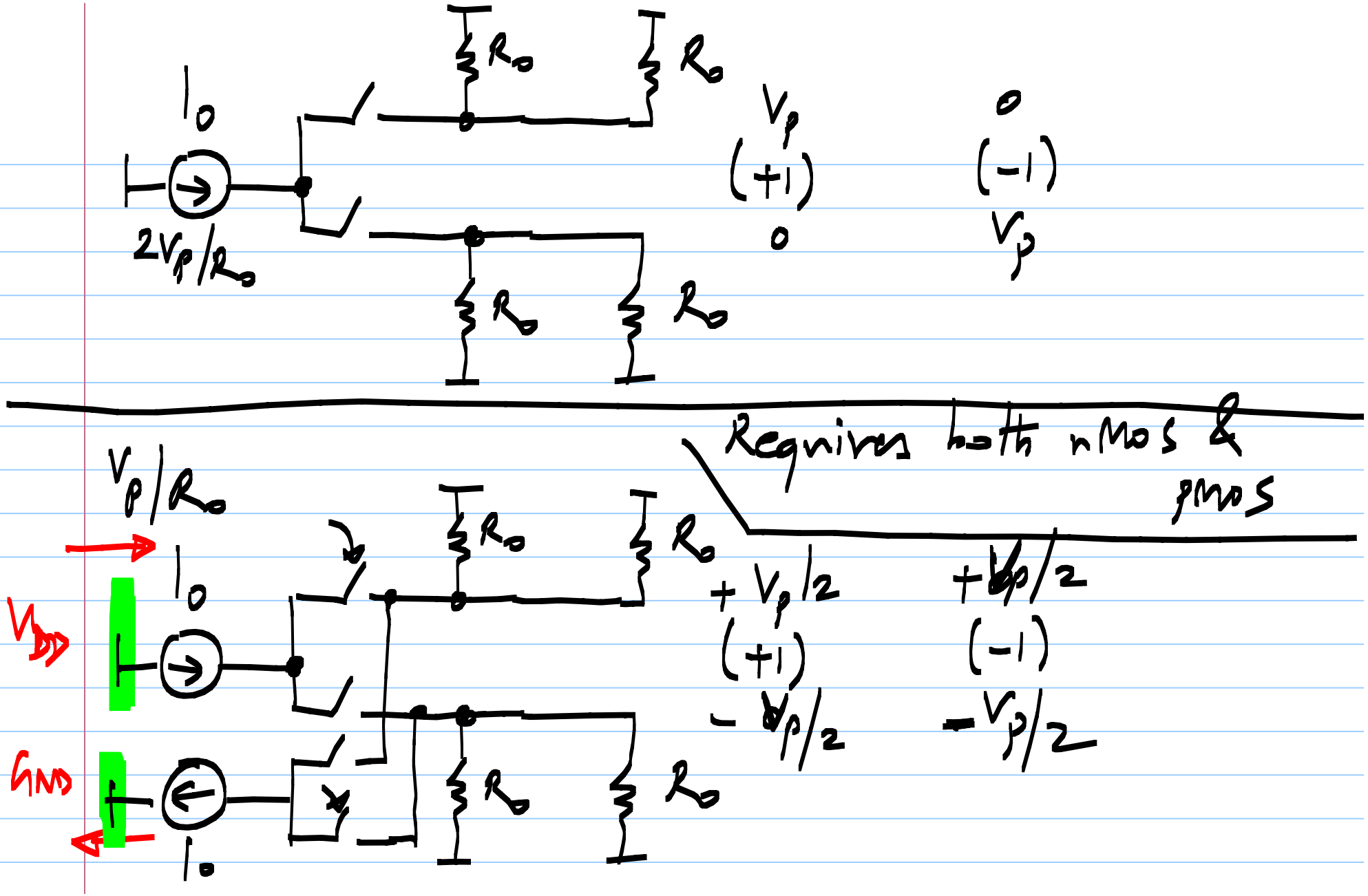
Current mode driver



Voltage mode driver:



	Pseudo-diff termination	Diff termination
V. mode	$V_p/2R$	$V_p/2R$
I. mode	$2V_p/R$	$2V_p/R$


R_0
R_0
I_0
$2V_p/R_0$
R_0
R_0
V_p
(+1)
0
0
(-1)
V_p
Requires both nMOS & pMOS
V_p/R_0
I_0
R_0
R_0
V_{DD}
GND
R_0
R_0
I_0
$+V_p/2$
(+1)
$-V_p/2$
$+V_p/2$
(-1)
$-V_p/2$

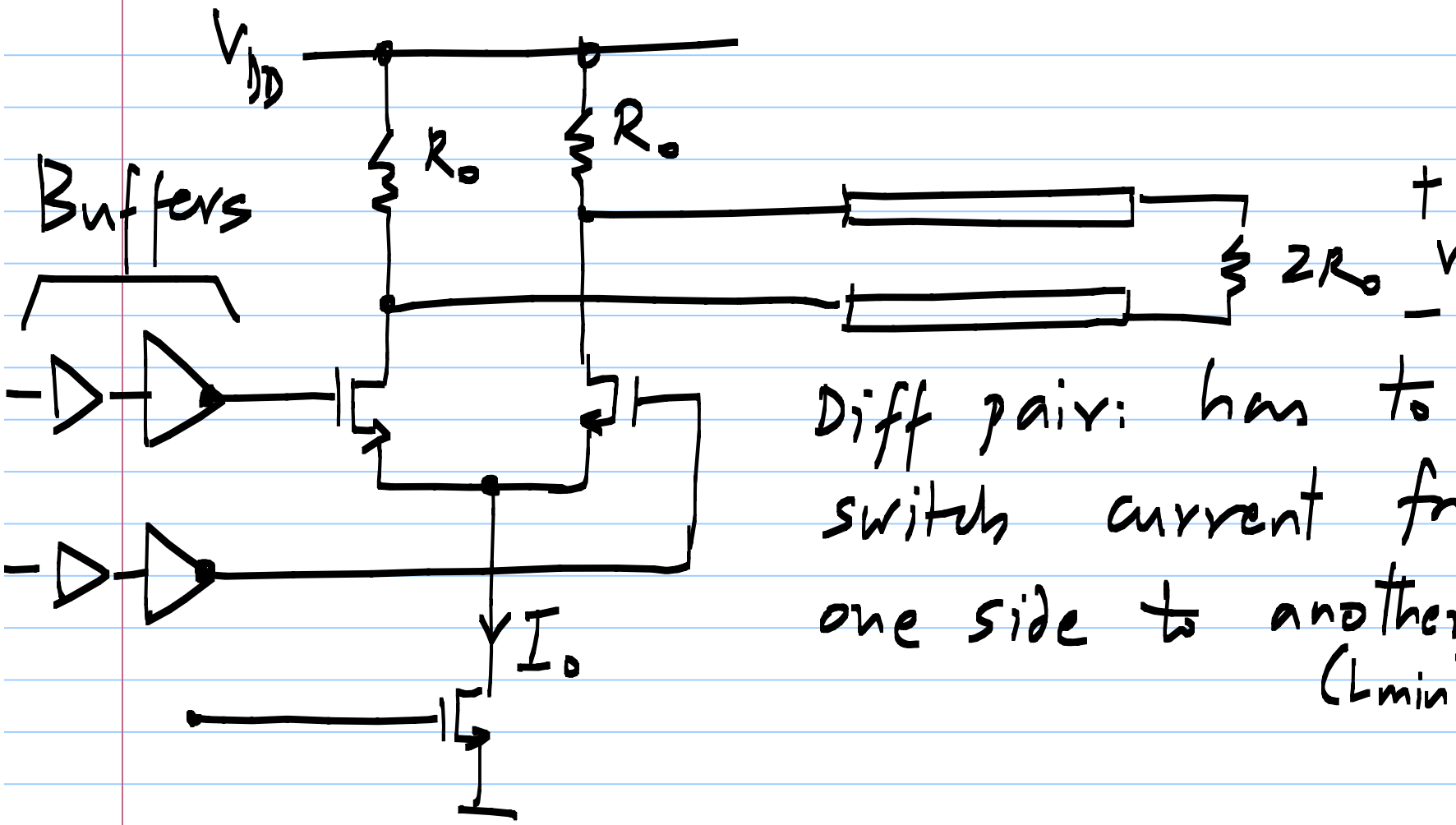
Power efficiency : $\frac{\text{Power dissipated (TRx) (W)}}{\text{Data rate (b/s)}}$

: $\frac{\text{Energy}}{\text{bit}}$

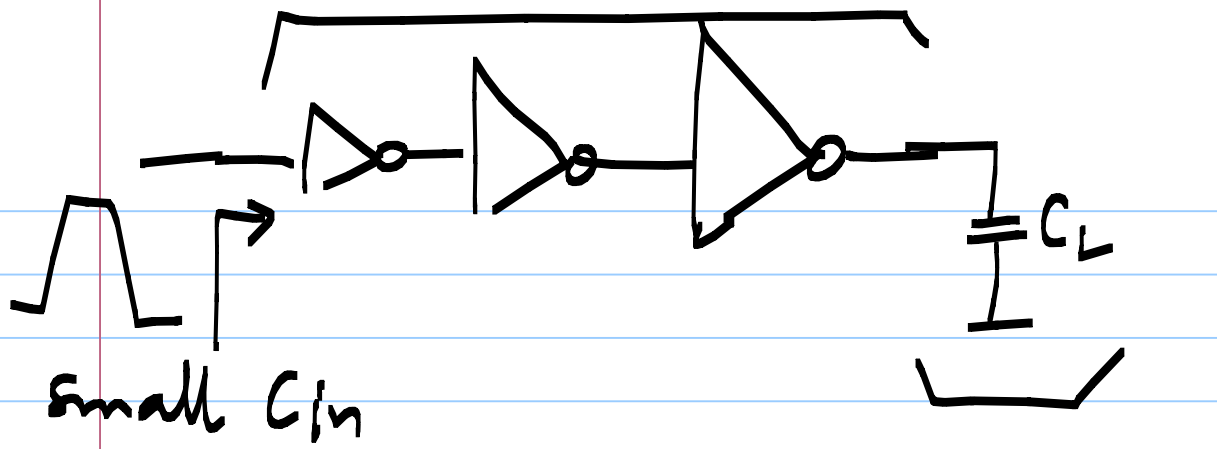
State of the art : $< 4\ pJ/bit$

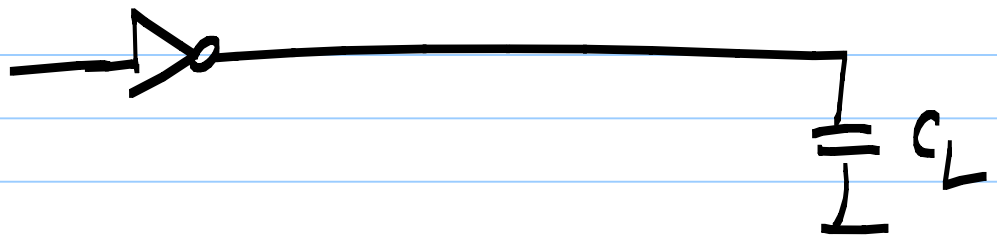
$1\ pJ/bit = \frac{1\ mW}{GHz}$

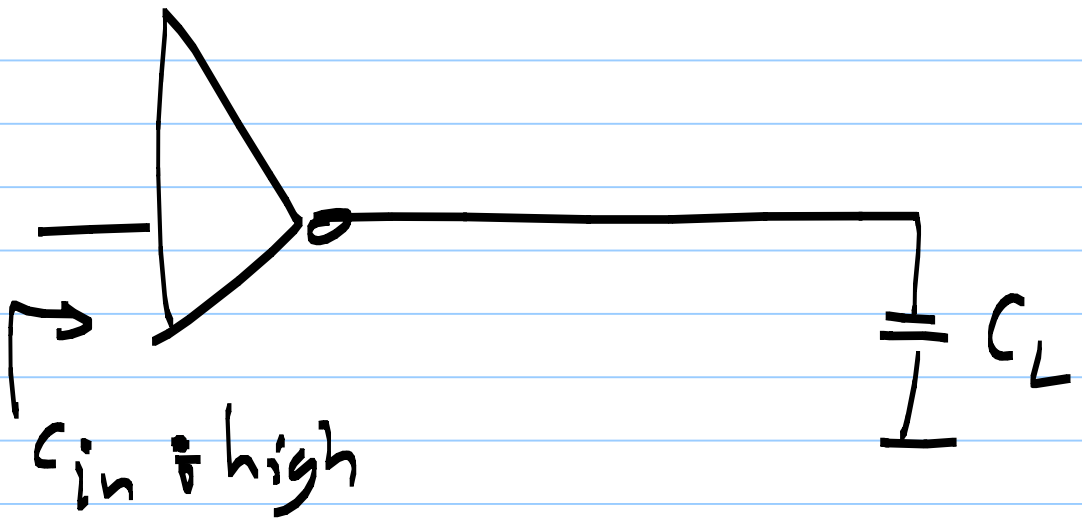
Current mode driver: (No equalization)

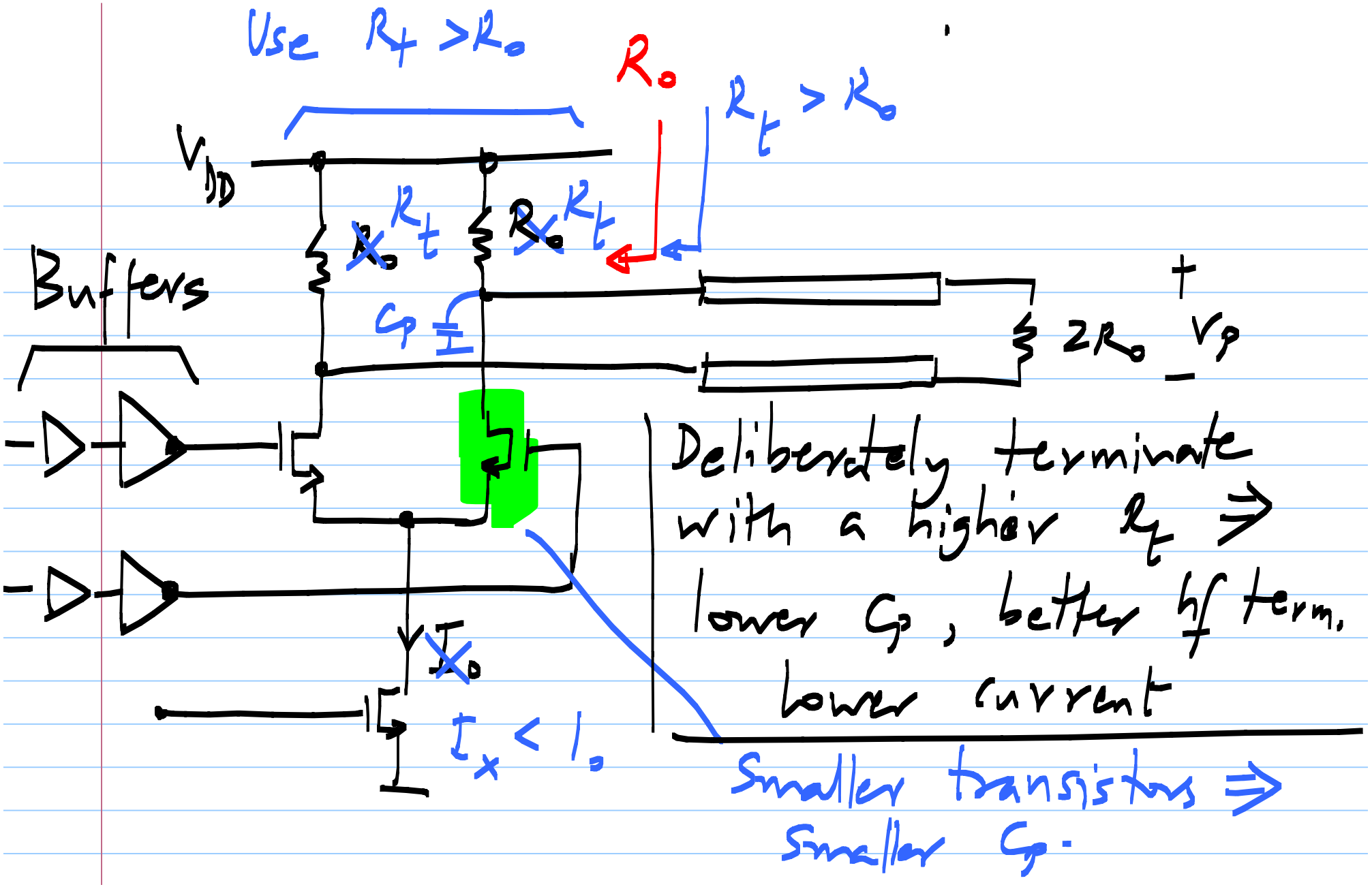


Diff pair: has to switch current from one side to another $\Rightarrow \frac{W}{L}$ (Lmin)


C_L
small C_{in}

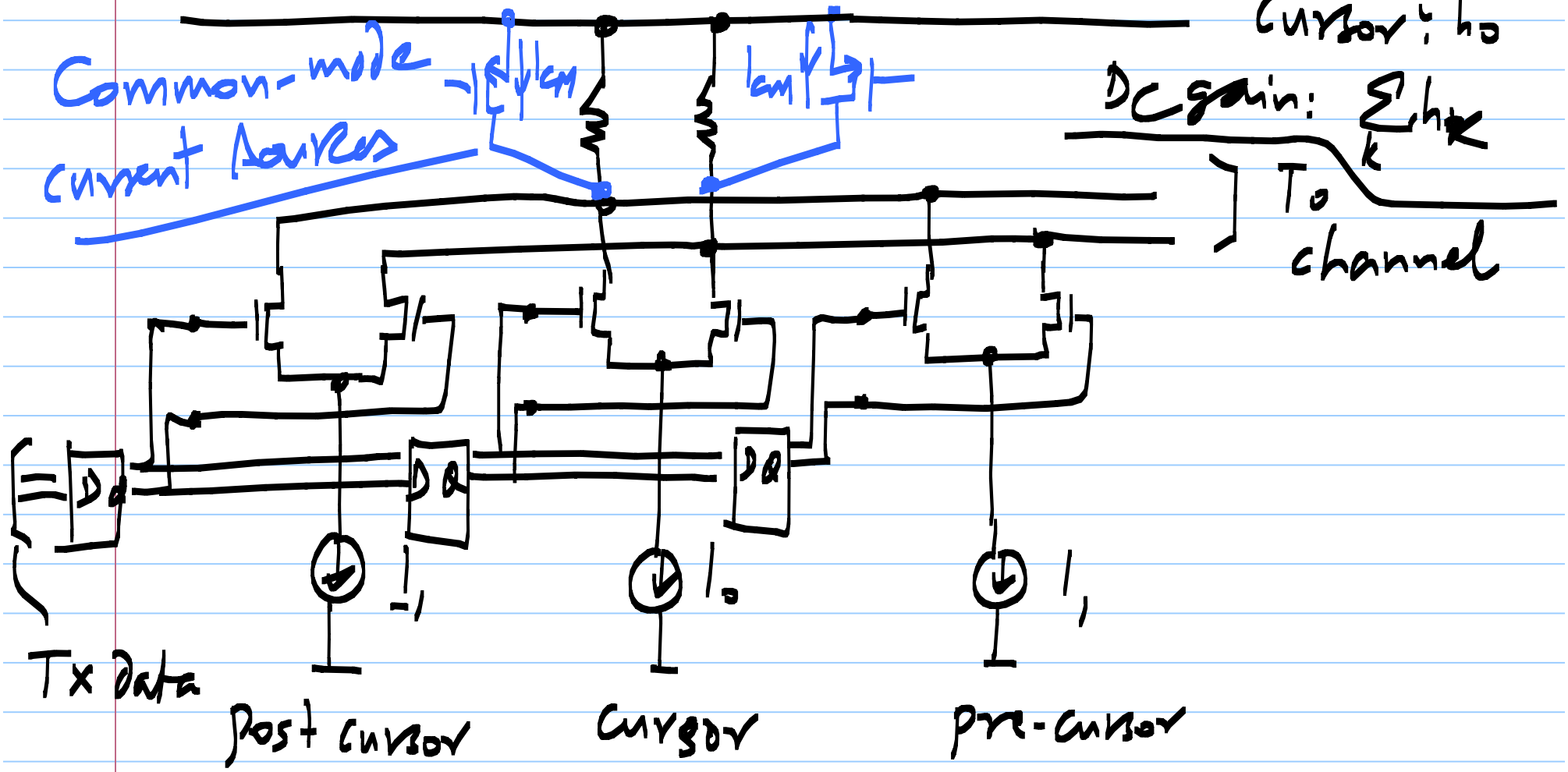

C_L


C_L
C_{in} = high


Use $R_t > R_o$
R_o
$R_t > R_o$
V_{DD}
R_t
R_o
Buffers
C_p
$2R_o$
V_p
V_{To}
$I_x < I_o$
Deliberately terminate with a higher R_t ⇒ lower C_p, better if term. lower current
Smaller transistors ⇒ smaller C_p.

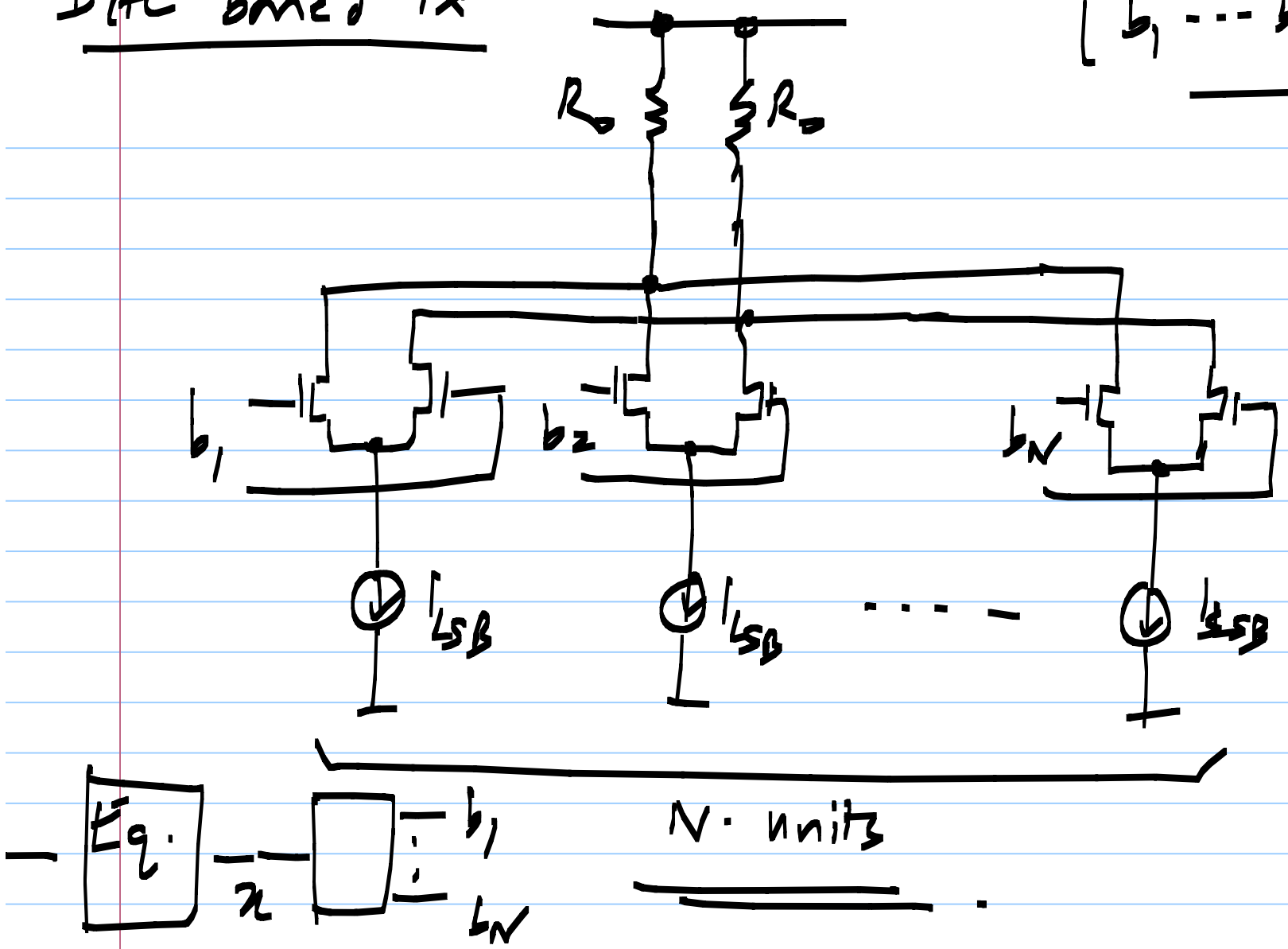
Equalization:

Peak: $h_0 + \sum_{k \neq 0} |h_k|$

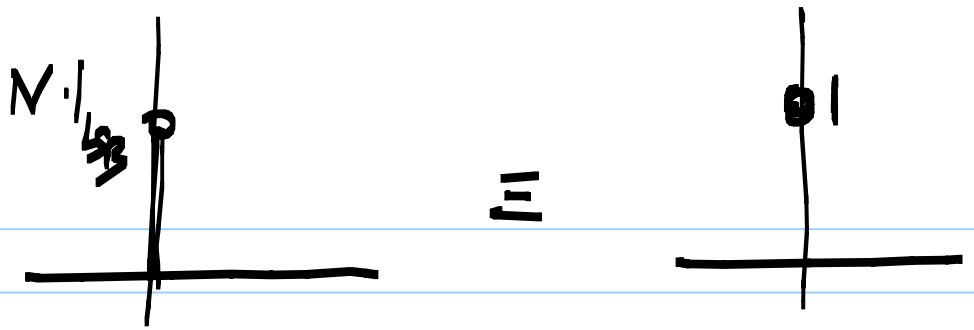


DAC based Tx

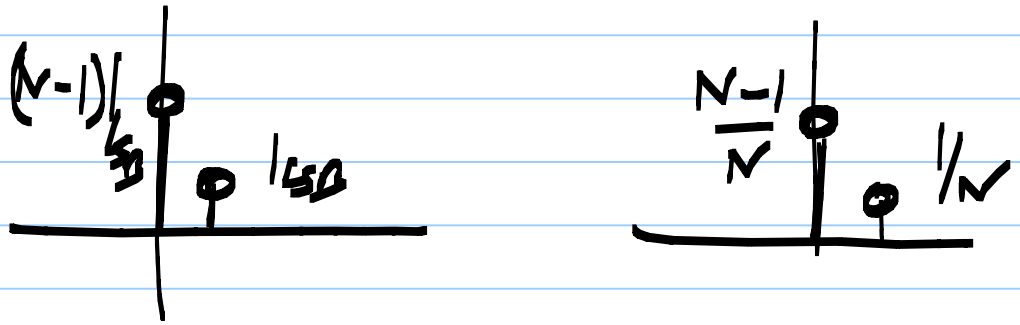
$[b_1 \cdots b_N] = x$



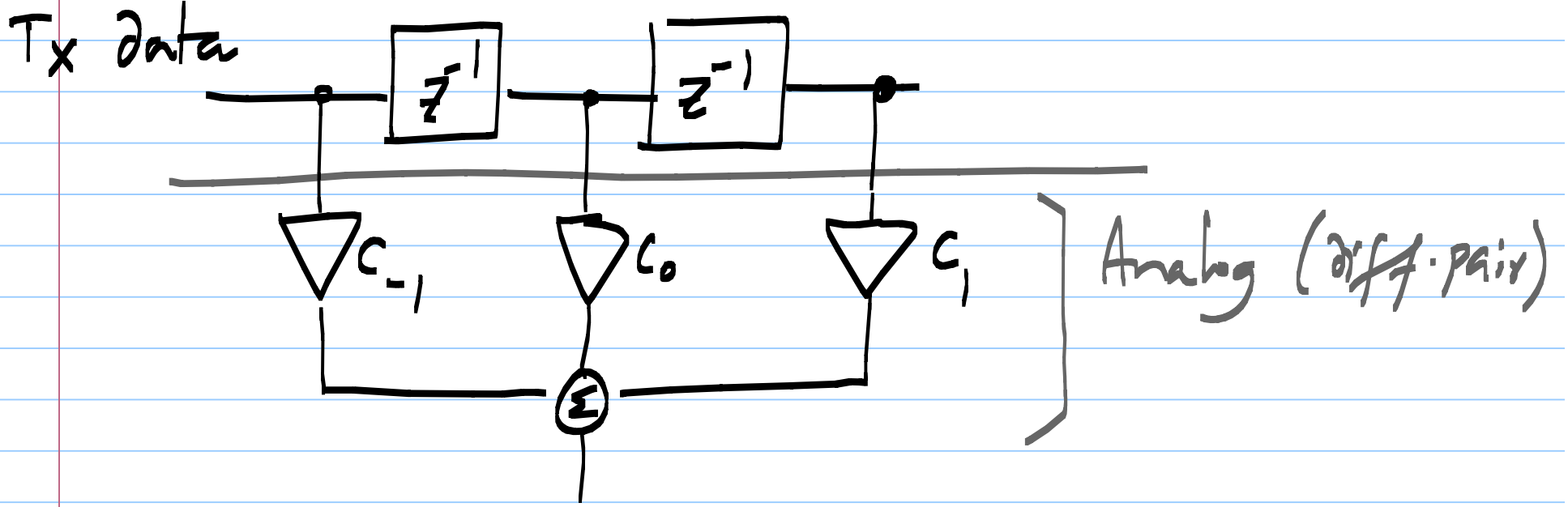
No equalization:



1 tap equalization:



Semi-digital :



Digital