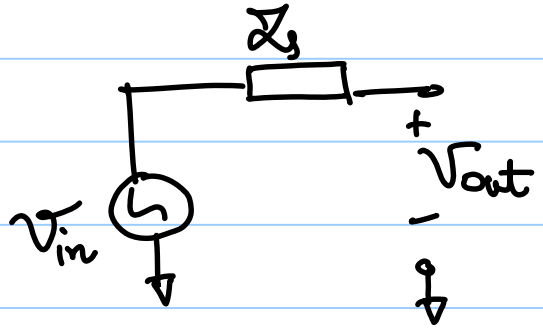
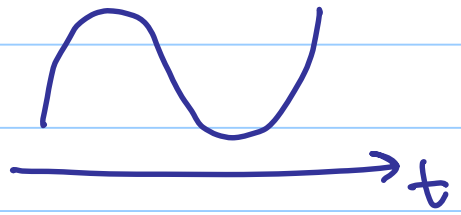
ECE 511 - Lecture 19

Note Title 4/3/2014

Differential Amplifiers

"Single-ended signaling"

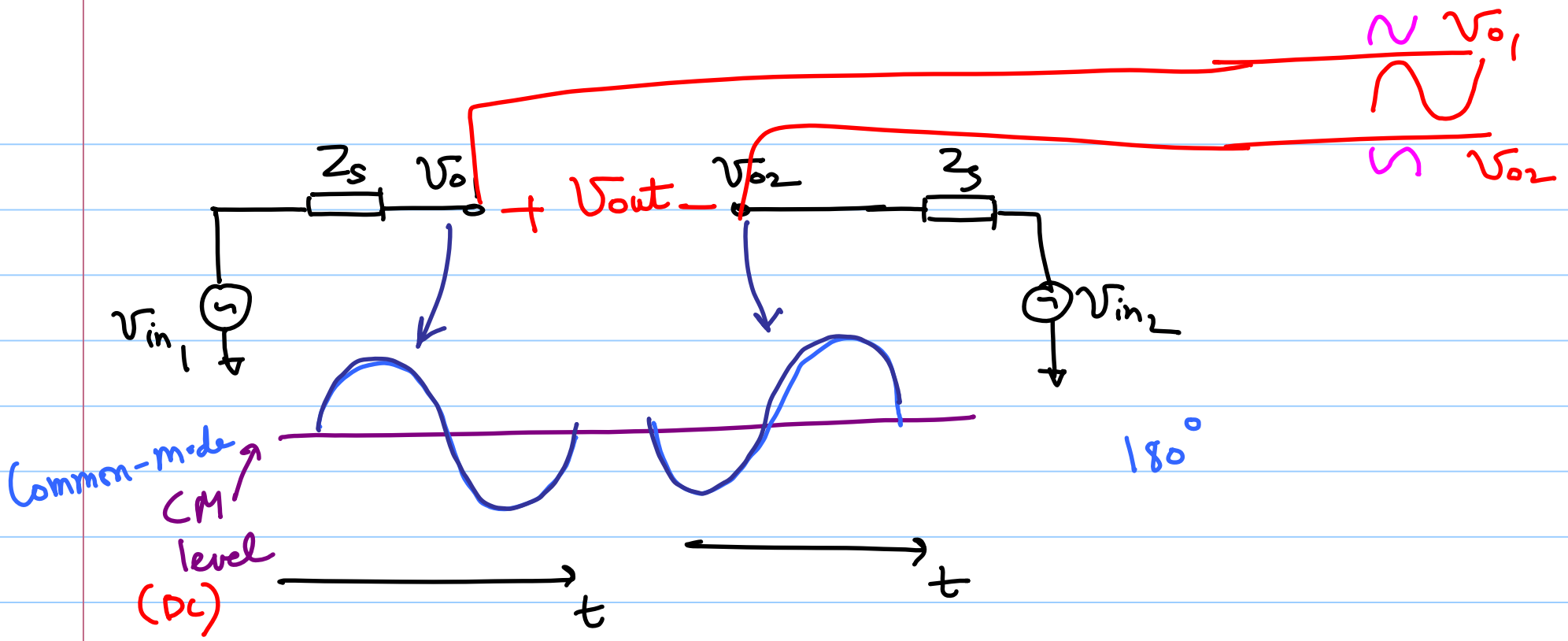




referred to ground

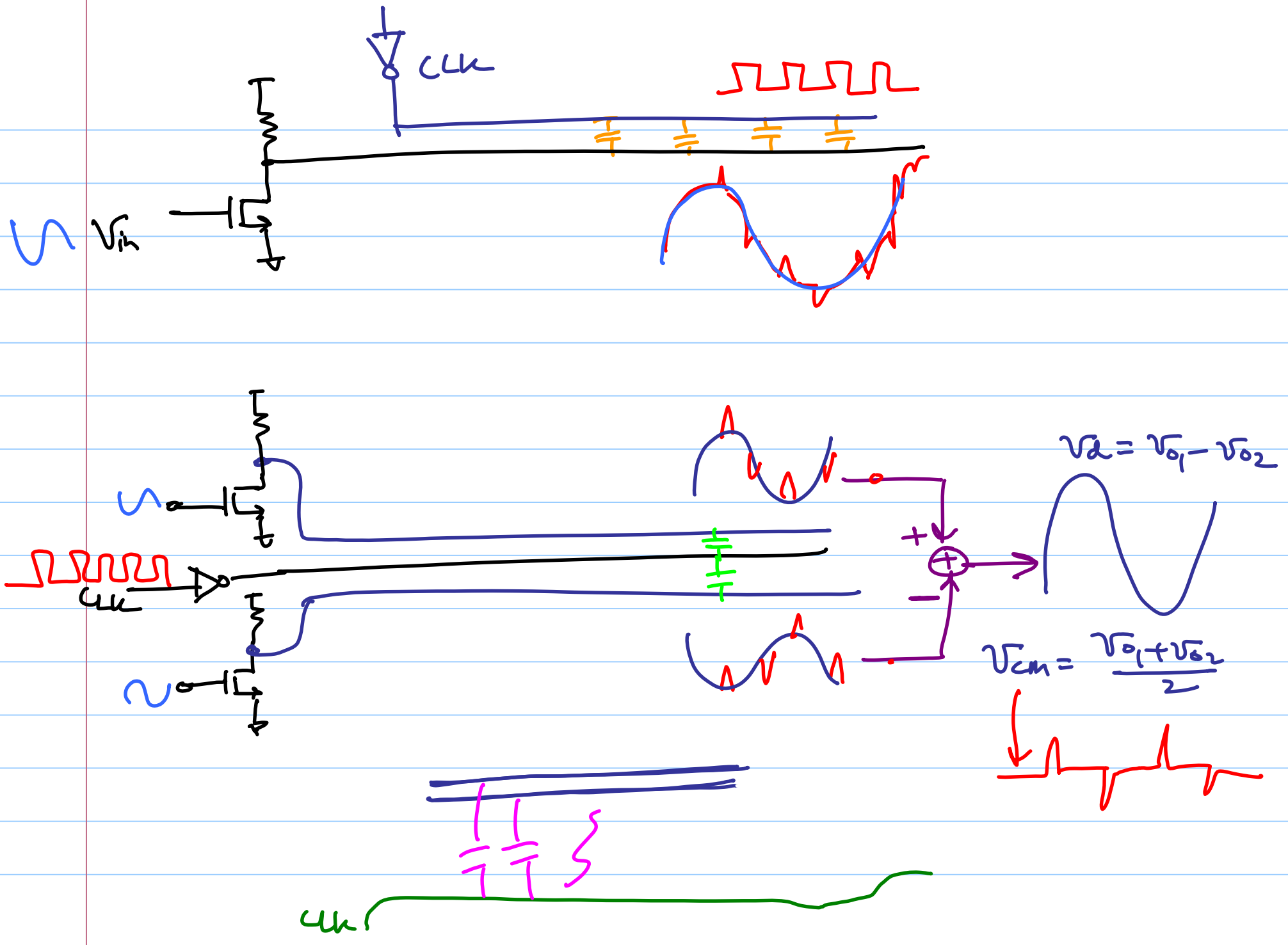
① Monday Apr/7, 3PM
SUB Barnes 157

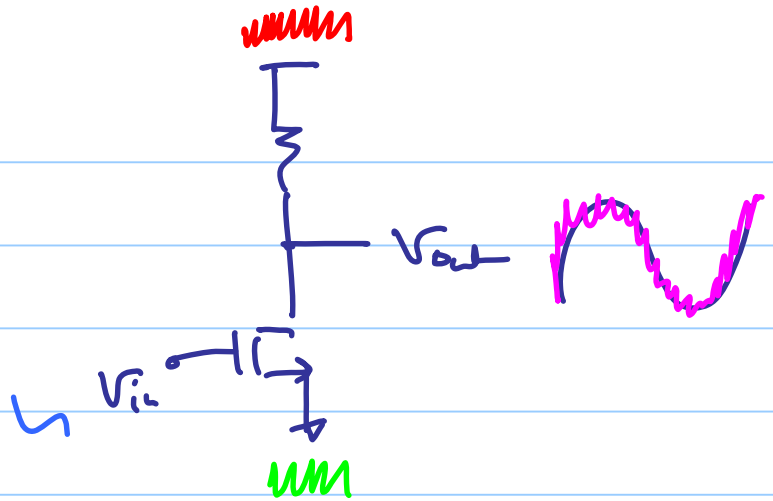
② Wednesday Apr/9, 4:30PM
Talk on Power Management Circuits
Dr. Paul Furth

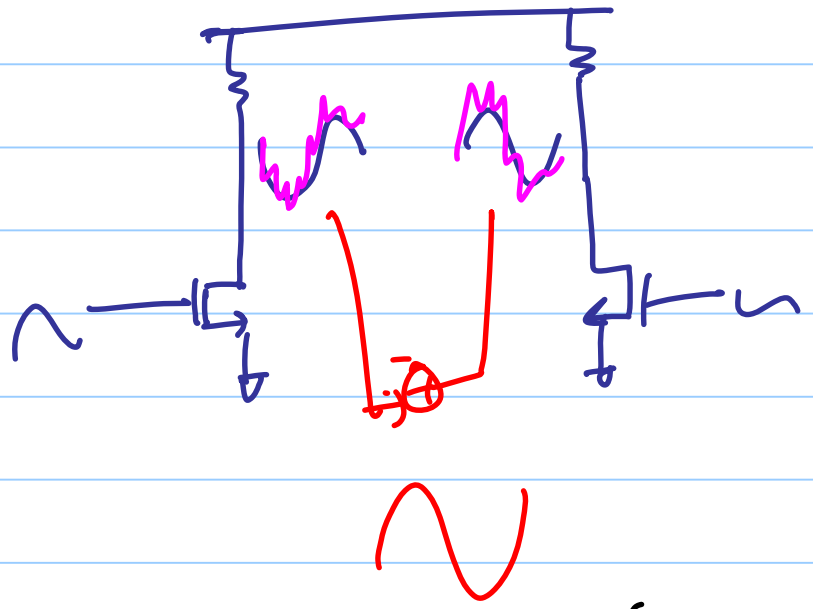


Differential signal $v_d = v_{o1} - v_{o2}$

$V_{cm} = \frac{v_{o1} + v_{o2}}{2}$ ← DC value (Ideally)

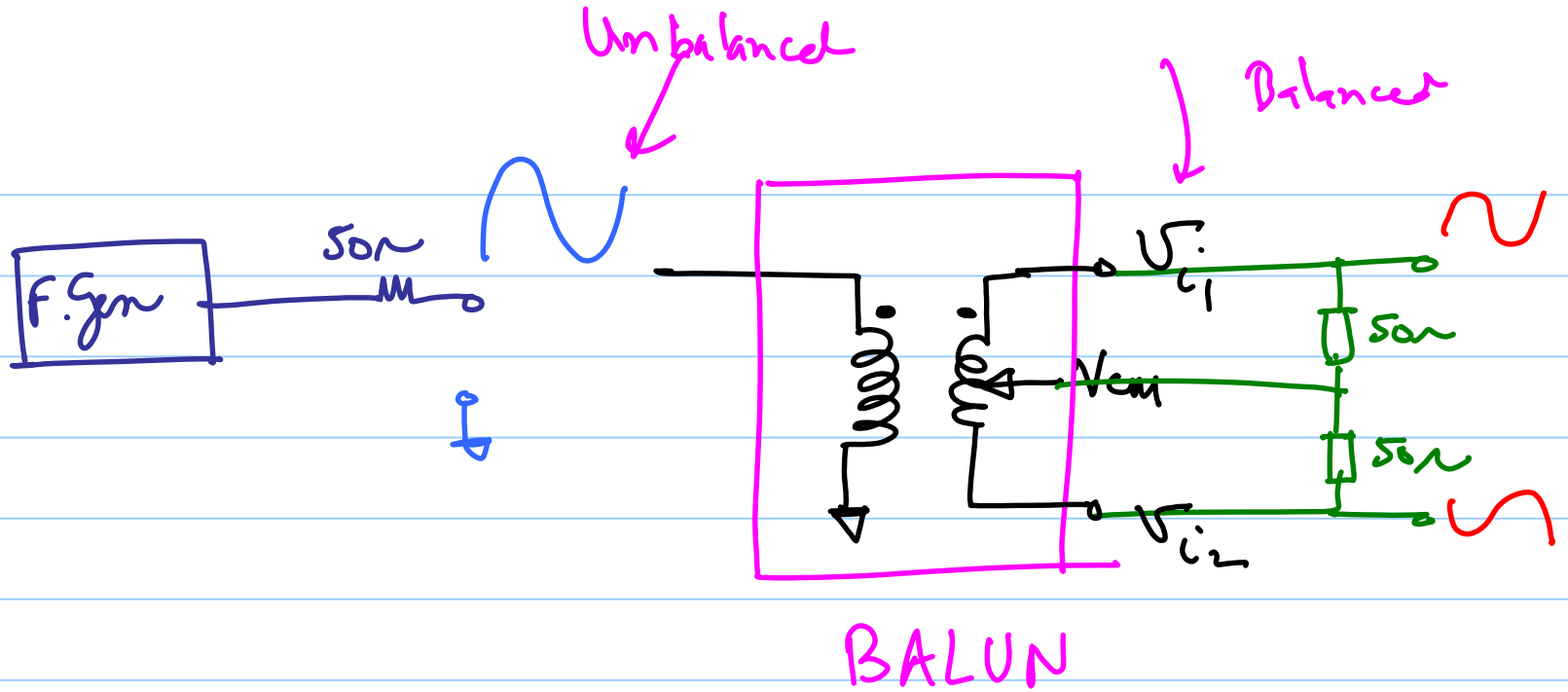

CLK
V_{in}
+
−
$V_d = V_{o1} - V_{o2}$
$V_{cm} = \frac{V_{o1}+V_{o2}}{2}$
CLK





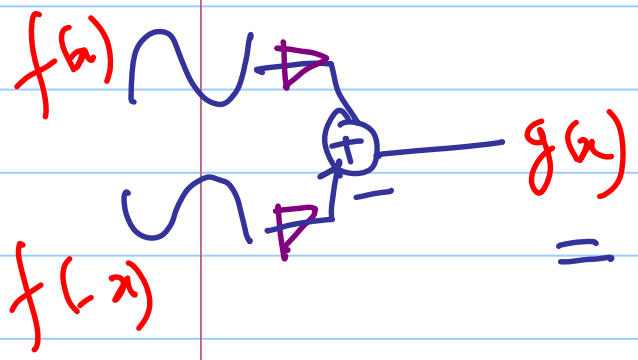
Diff. circuits reject any CM noise / disturbance

* Also cancel any even-order non-linearity


Unbalanced
Balanced
F.Gen
50Ω
50Ω
50Ω
Vcm
V_{i1}
V_{i2}
BALUN

$$g(x) = \frac{f(x) - f(-x)}{2}$$

Odd function



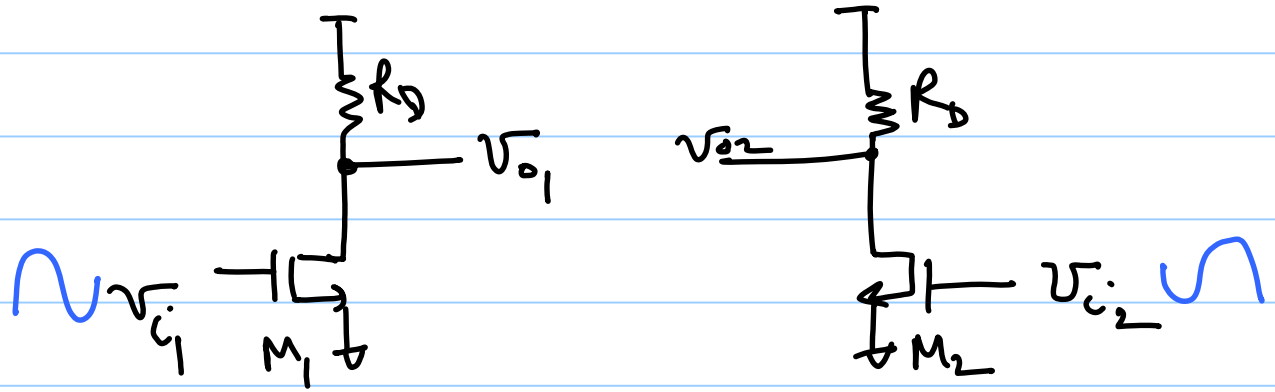
$=$

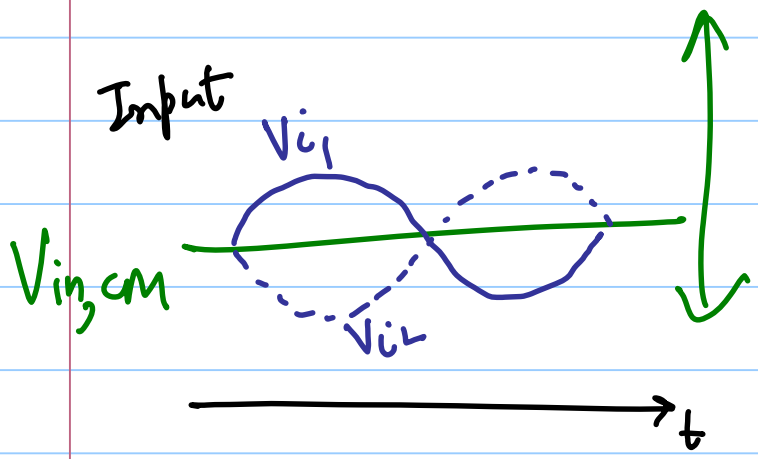
only has odd-order Taylor series

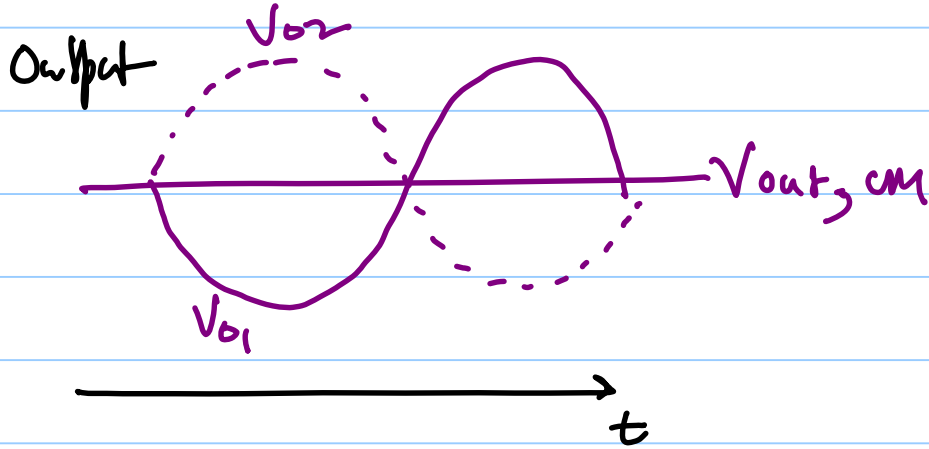
$$g_1 x + g_3 x^3 + g_5 x^5 + \cdots$$

$\times$ gets rid of Even-order nonlinearity terms

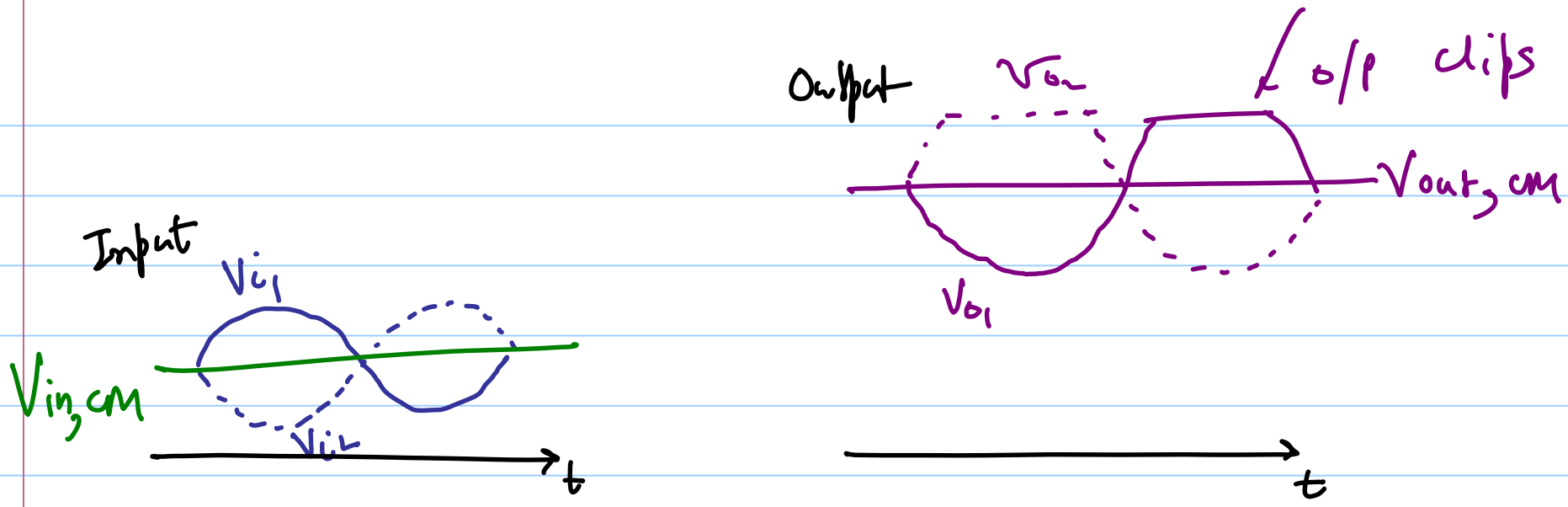
CS Amplifier





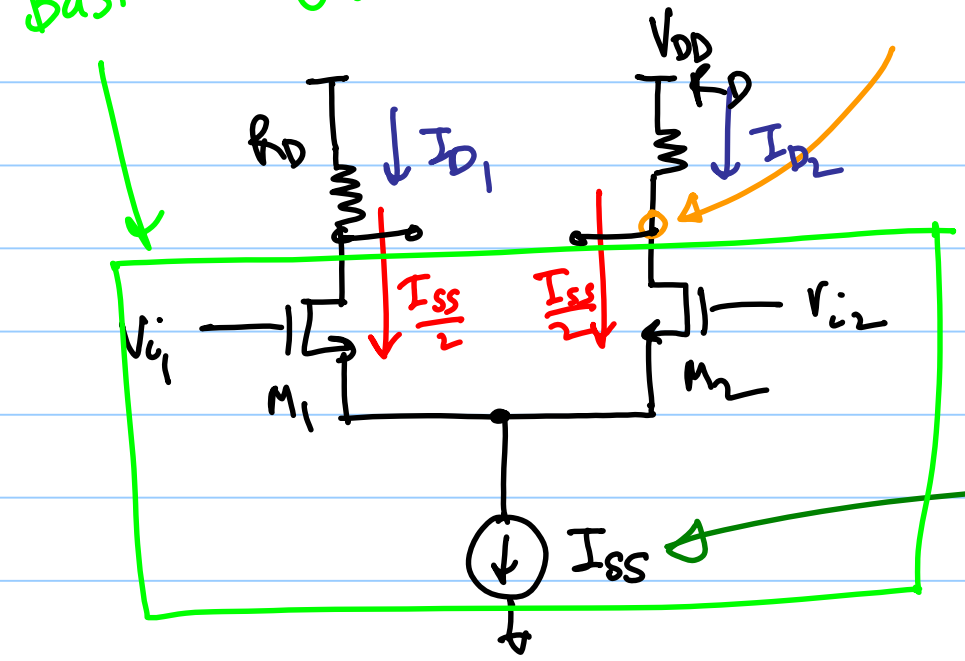


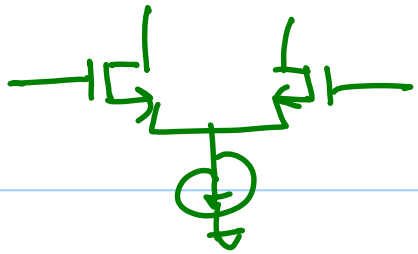
What happens if $V_{in,cm}$ is not well-defined



What we want is that DC biasing should be indep. of the $V_{in,cm}$ (input cm-level)

Basic Diff-Pair



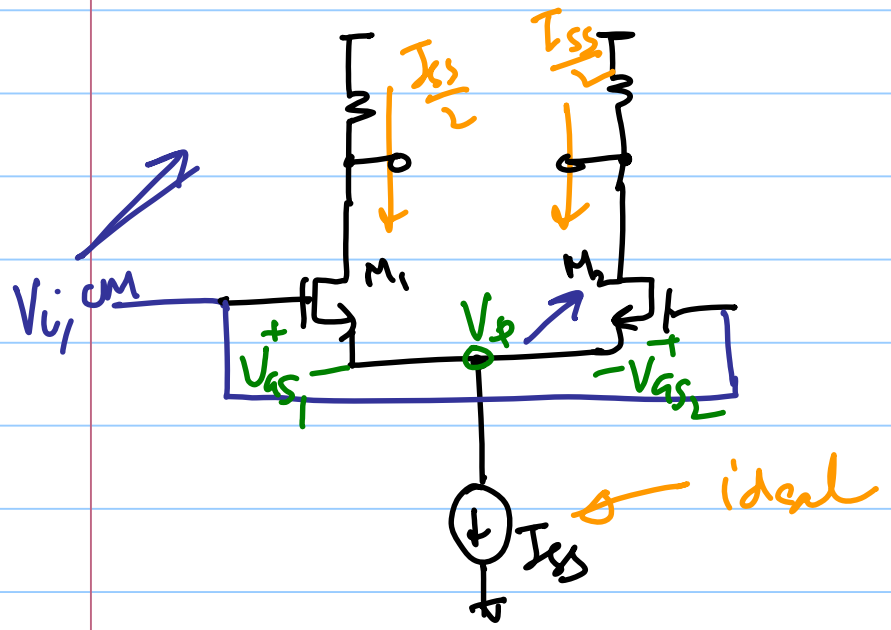


$$I_{D_1} + I_{D_2} = I_{SS}$$

tail current source

output common-level : $V_{out,cm} = V_{DD} - \frac{I_{SS}}{2} \cdot R_D$

Basic Diff amp

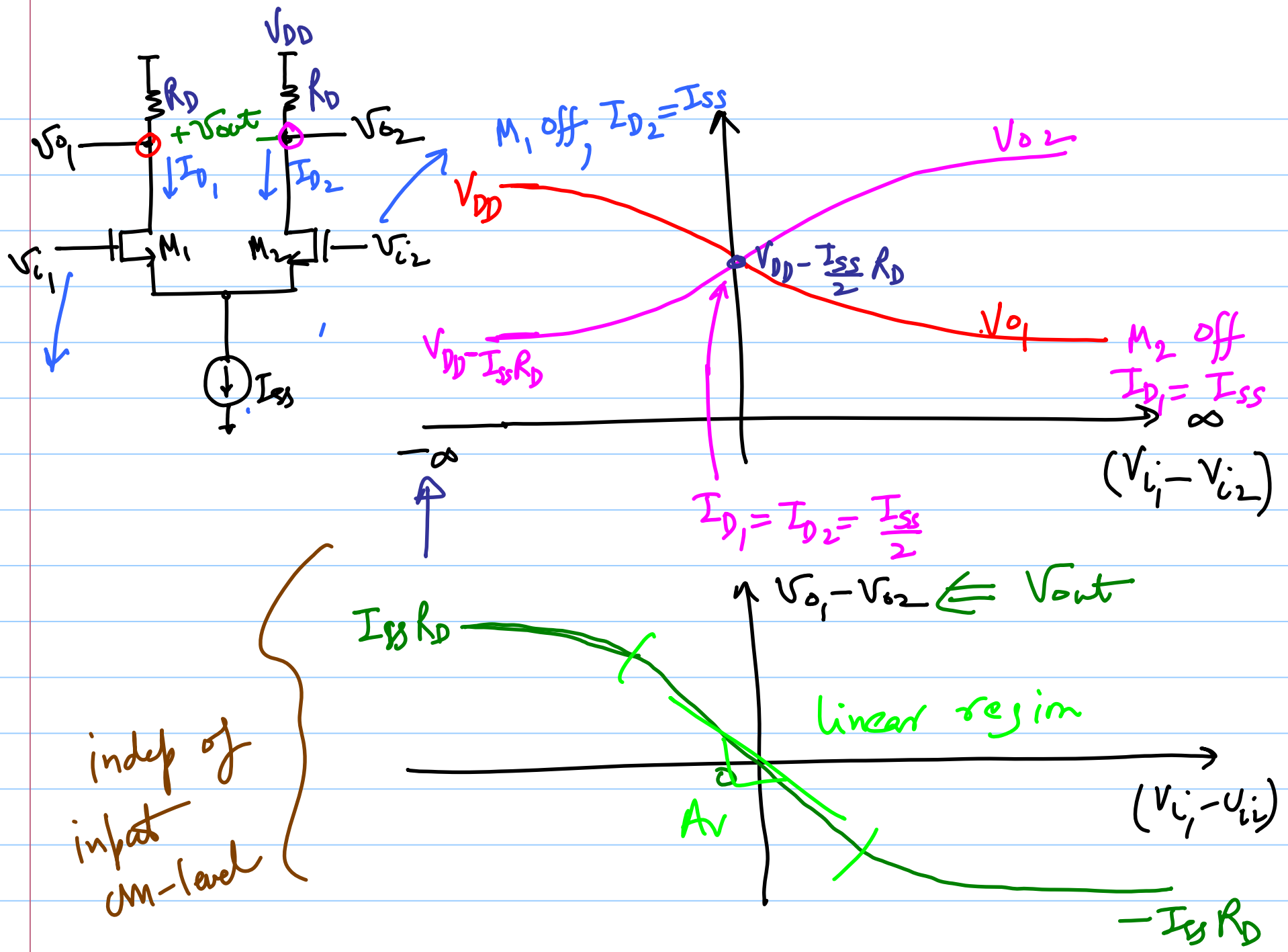


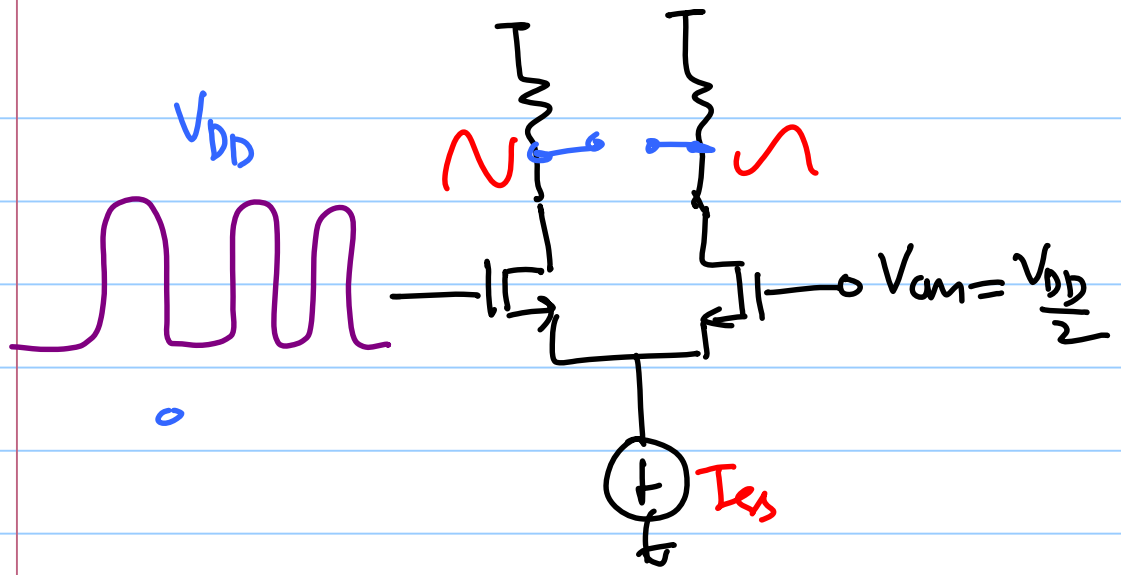
$$V_{GS_1} = \sqrt{\frac{I_{SS}}{\beta}} + V_{THN}$$

As long as $M_{1,2}$ & I_{SS} are in Saturation

$\Rightarrow$ Biasing (V_{GS}, I_D, V_{DS}) is indep of $V_{in,cm}$.

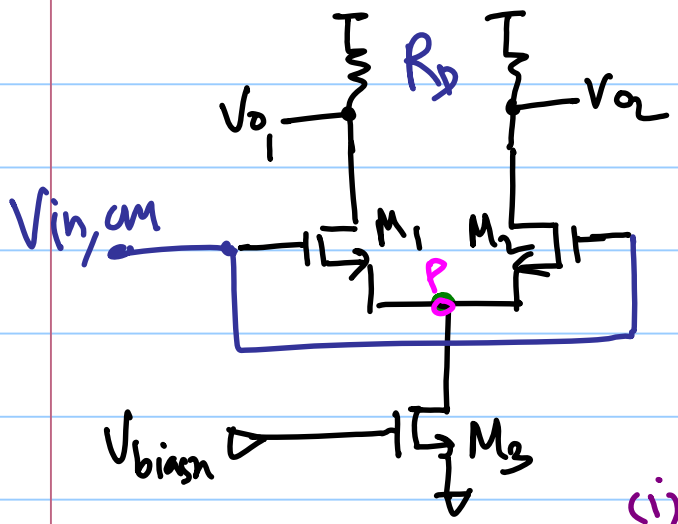
Greatly simplifies Biasing!

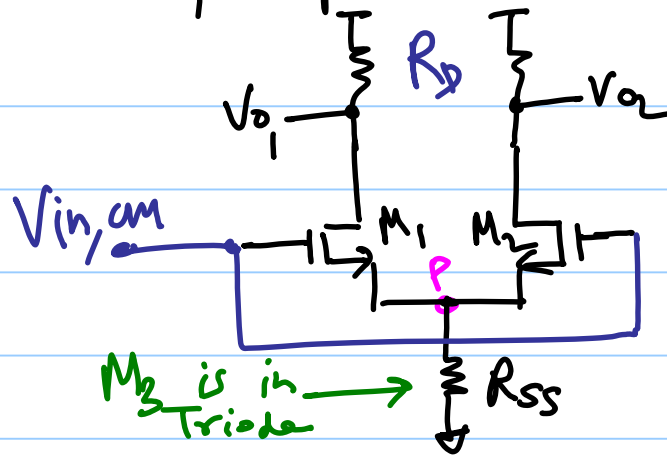

V_{DD}
R_D
R_D
V_{o1}
$+V_{out}$
V_{o2}
I_{D_1}
I_{D_2}
V_{i1}
M_1
M_2
V_{i2}
I_{SS}
M_1 off, $I_{D_2} = I_{SS}$
V_{DD}
V_{o2}
$V_{DD} - \frac{I_{SS}}{2} R_D$
V_{o1}
$V_{DD} - I_{SS} R_D$
M_2 off
$I_{D_1} = I_{SS}$
$-\infty$
∞
$(V_{i_1} - V_{i_2})$
$I_{D_1} = I_{D_2} = \frac{I_{SS}}{2}$
indep of input cm-level
$V_{o_1} - V_{o_2} \Leftarrow V_{out}$
$I_{SS} R_D$
linear regim
A_V
$(V_{i_1} - V_{i_2})$
$-I_{SS} R_D$



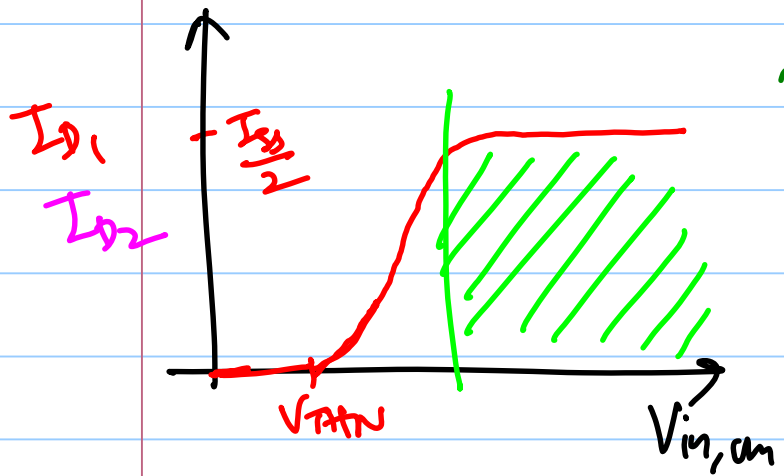
with caveats

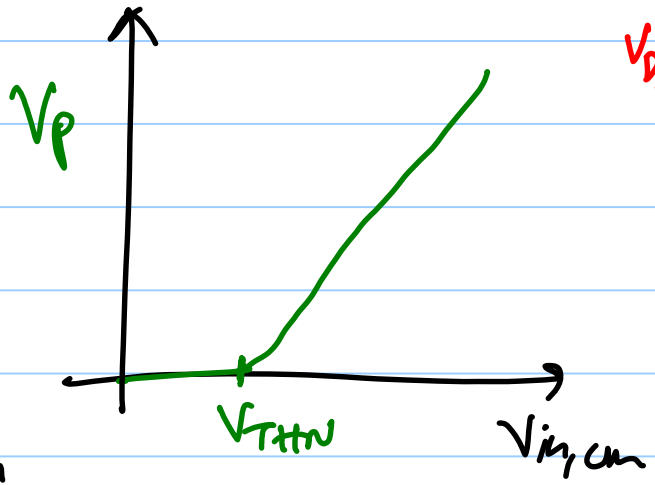
Common-Mode Behavior of a Diff-pair

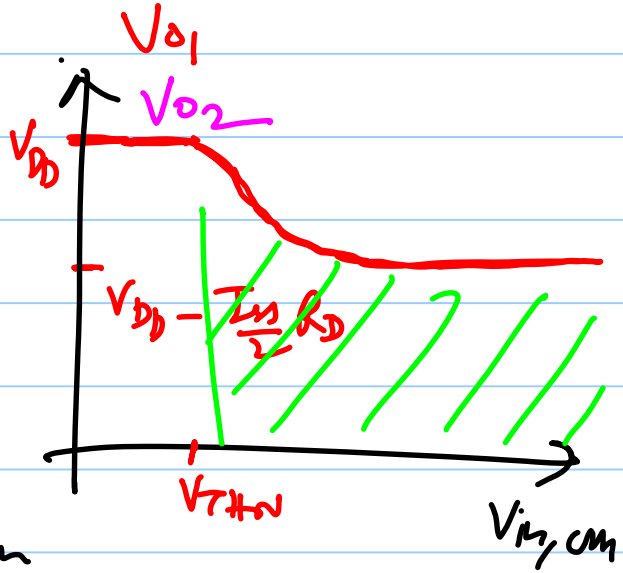




(i) $V_{in,cm} = 0$ (ii) $V_{in,cm} > V_{THN}$







INPUT CMR

Common-mode range