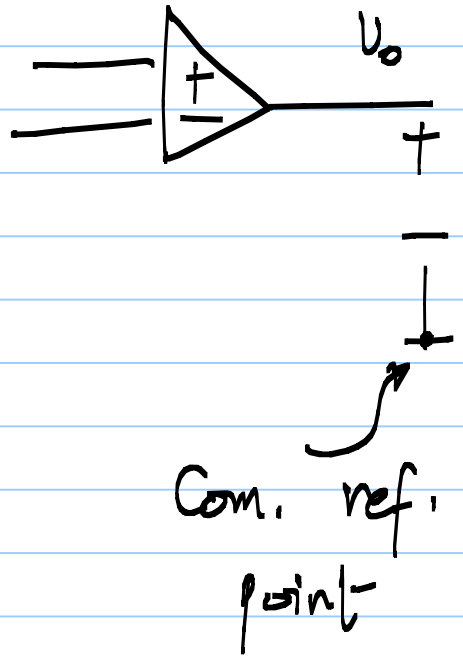
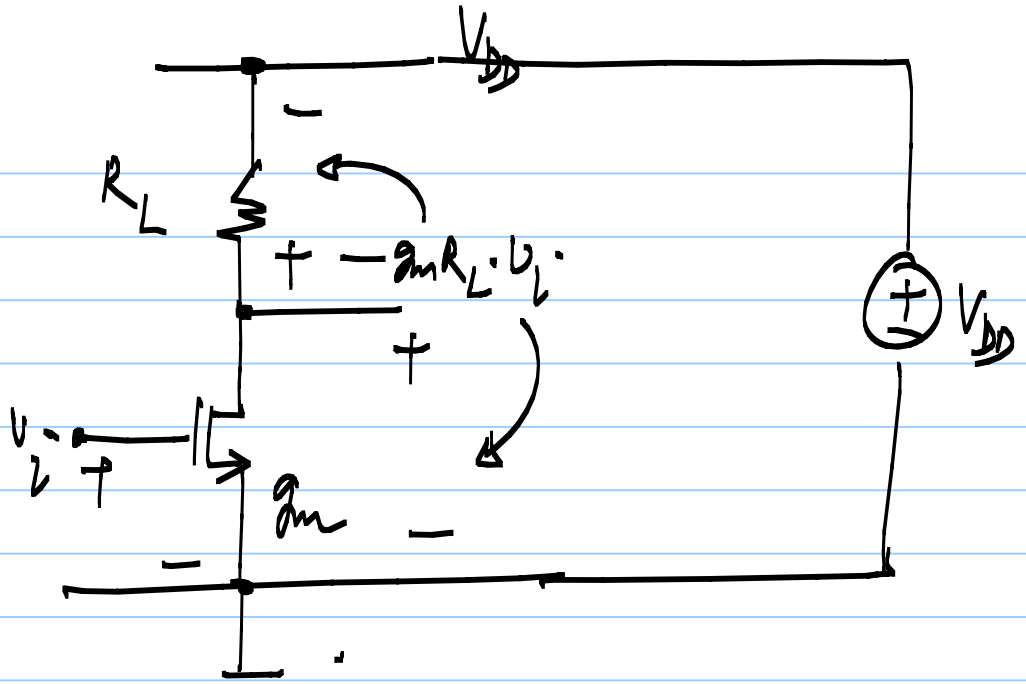
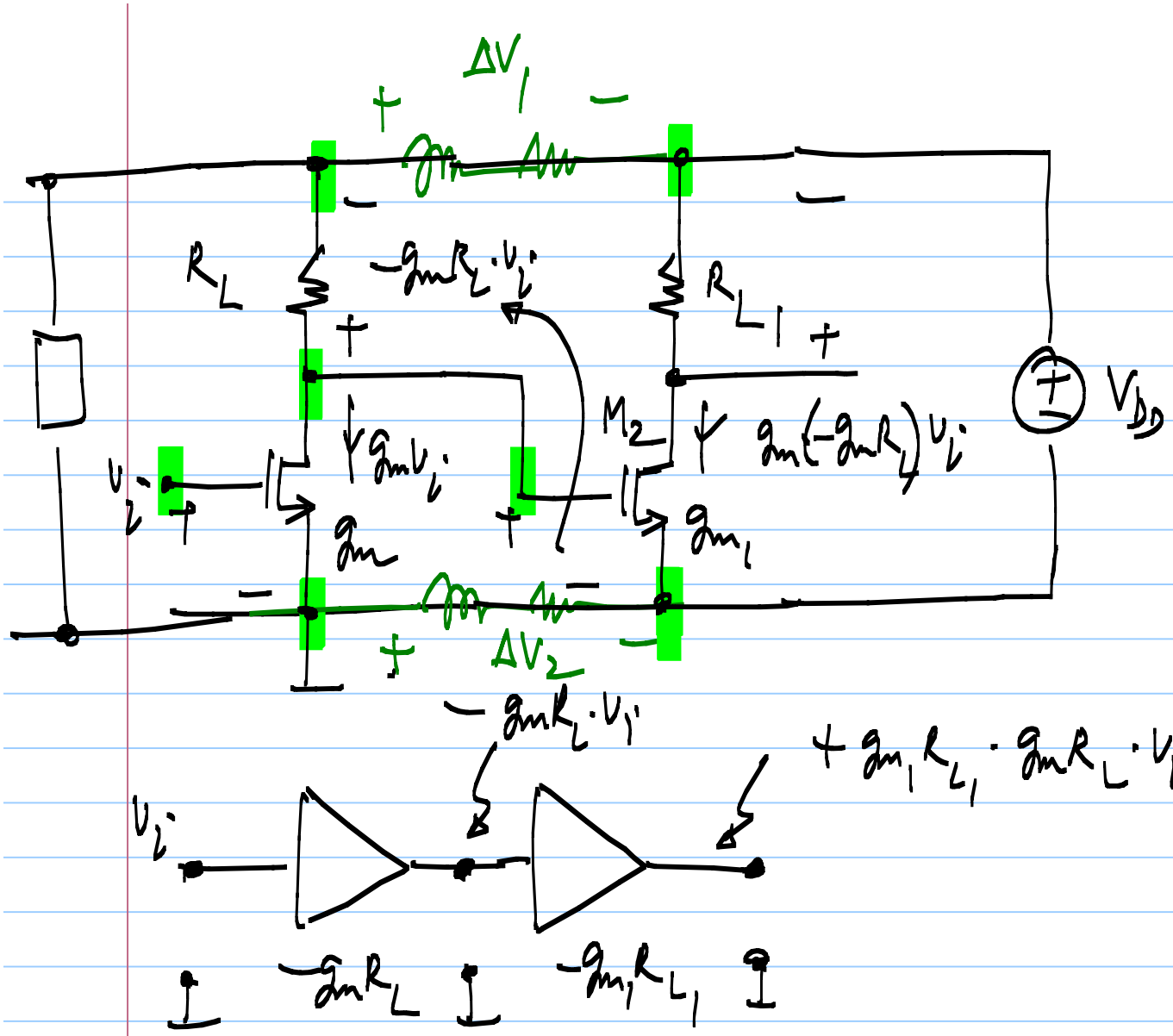
Lecture 39



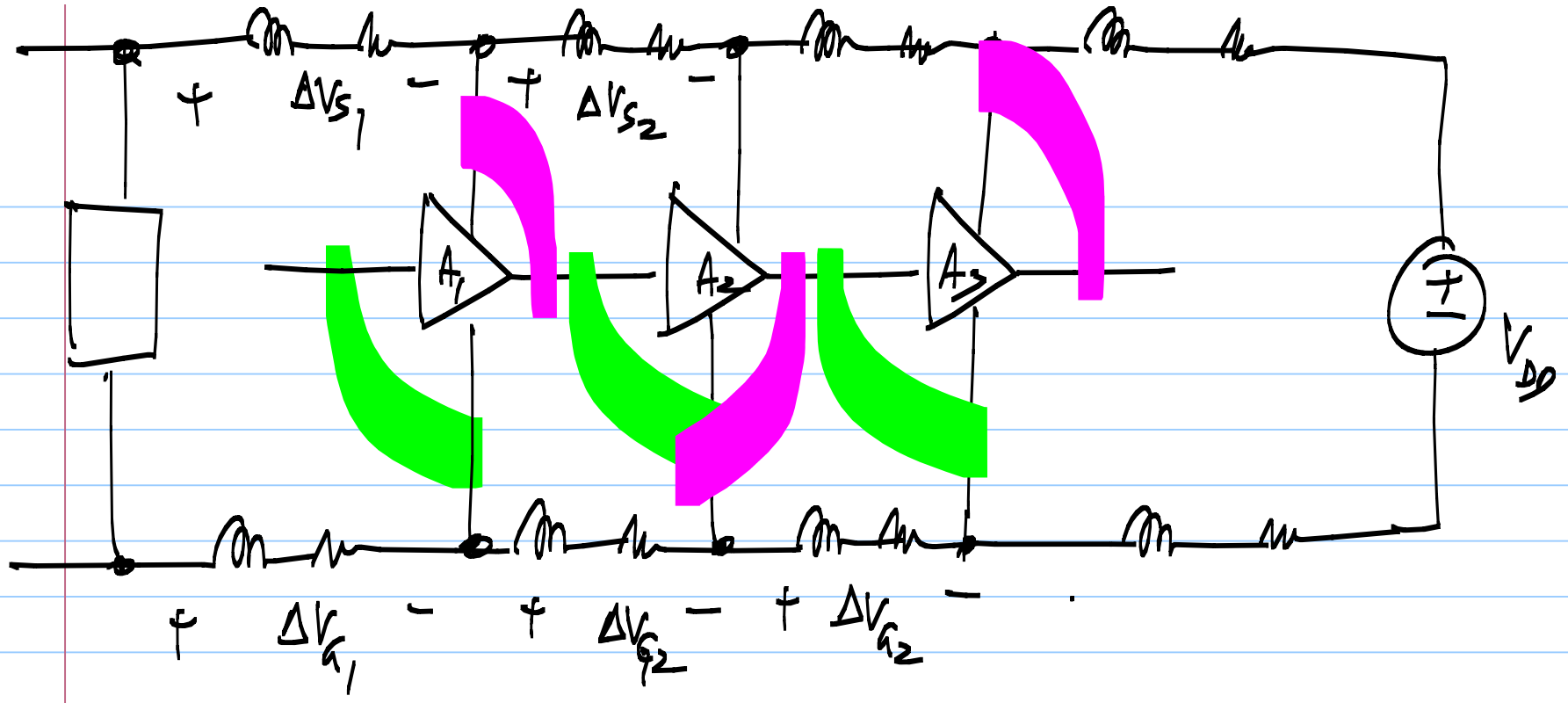




v_{gs} of M_2:

$-g_m R_L v_i + \Delta V_1$

depends on other circuits connected to the supply

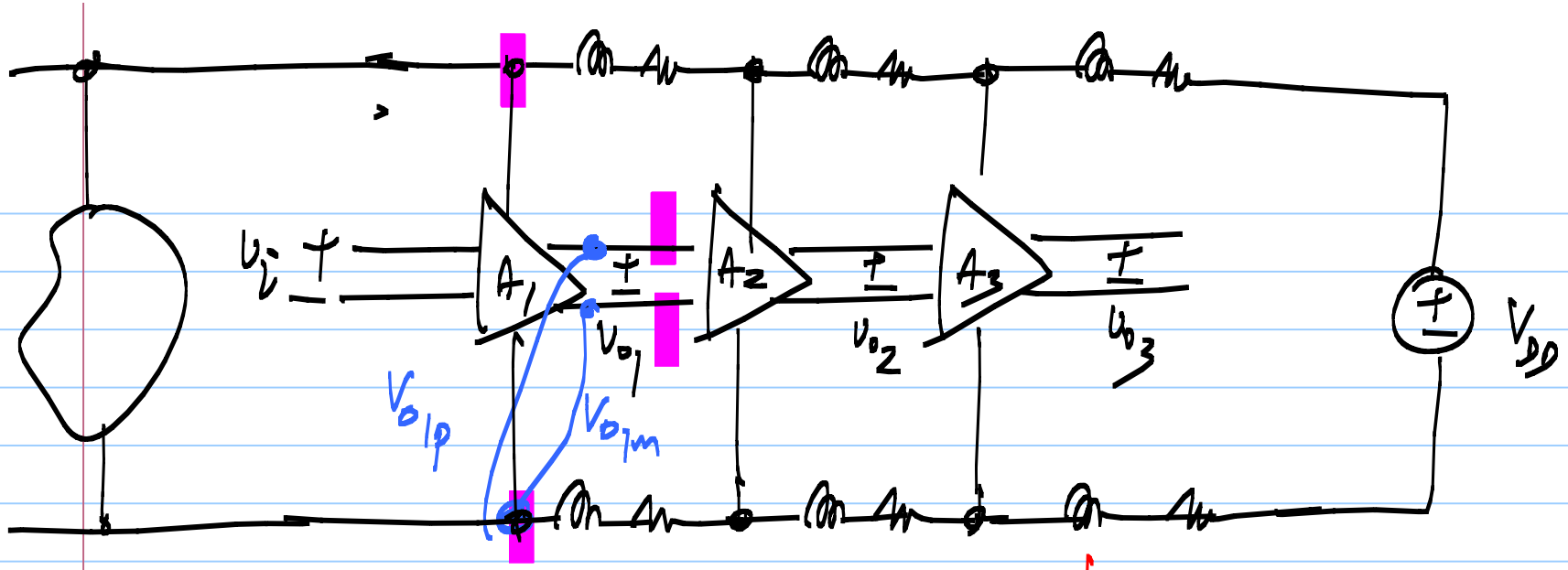

+ ΔVS1 −
+ ΔVS2 −
A1
A2
A3
VDD
+ ΔVG1 −
+ ΔVG2 −
+ ΔVG2 −

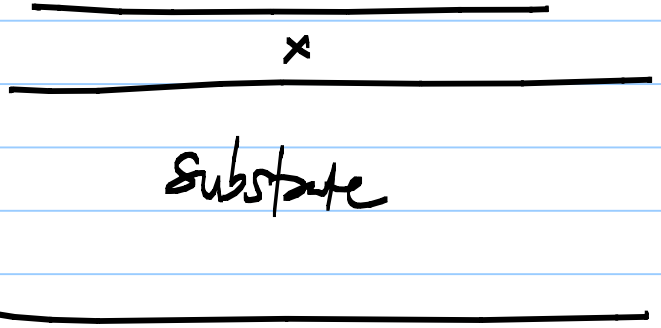
Problem: Voltages defined between some node x and Common ground

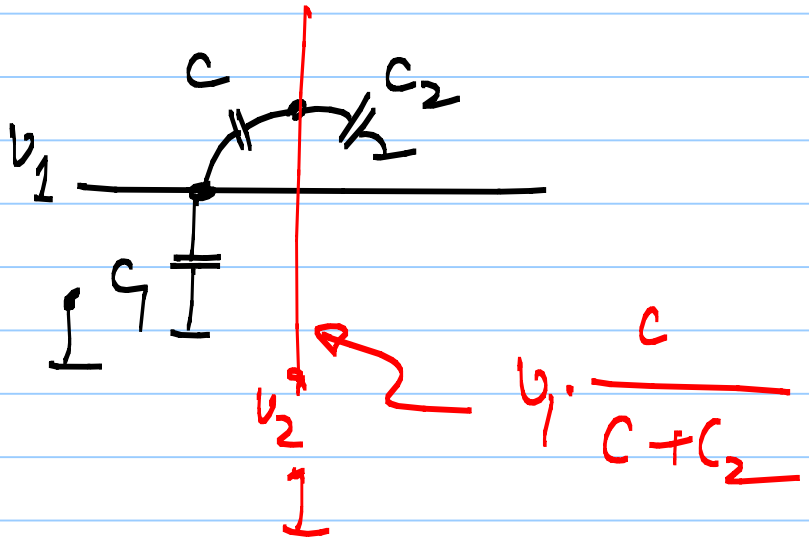
Use two wires to define any signal

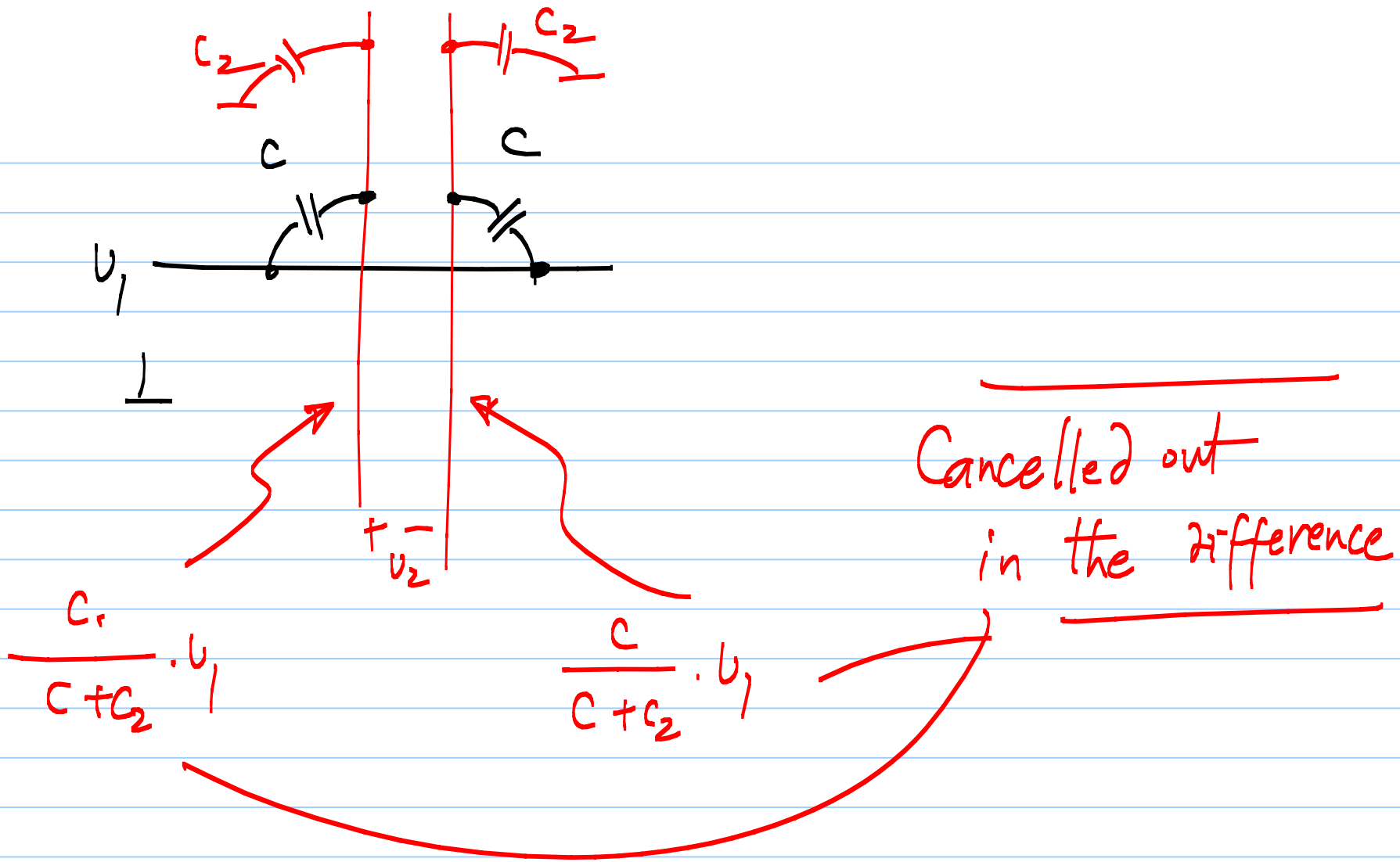
used only for the signal

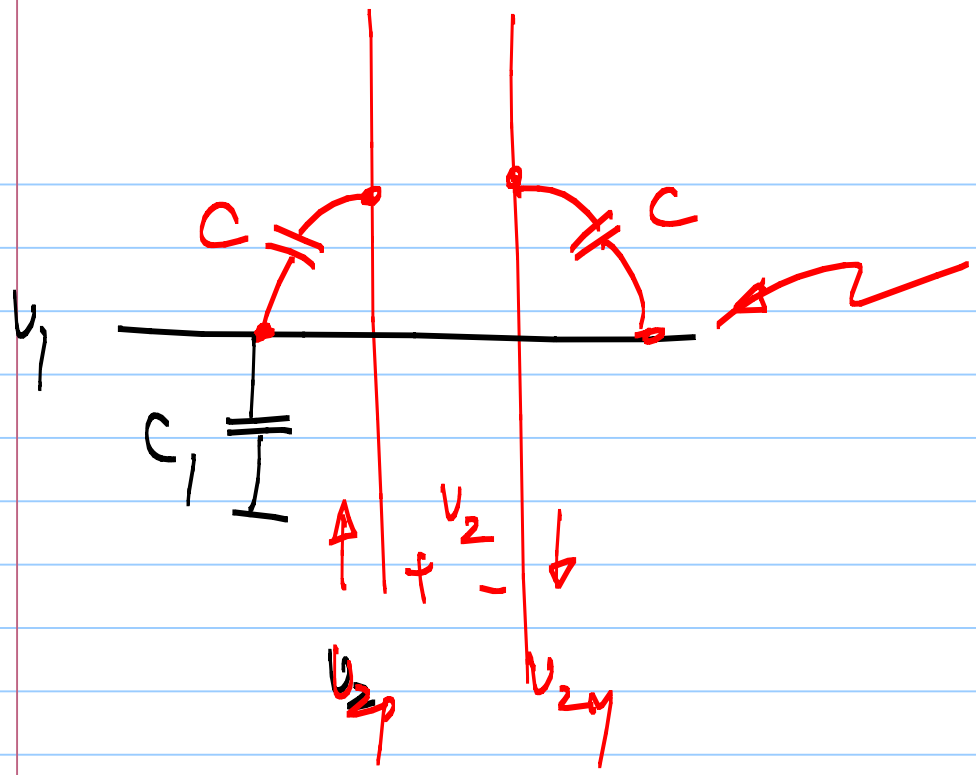
Differential signalling


v_i
A_1
A_2
A_3
v_{o1}
v_{o2}
v_{o3}
V_{DD}
V_{o1p}
V_{o1m}


Substrate


C
C_2
v_1
C_1
v_2
$v_1 \cdot \frac{C}{C+C_2}$


C2
C2
C
C
v1
1
+ v2 −
C1 / (C + C2) . v1
C / (C + C2) . v1
Cancelled out
in the difference



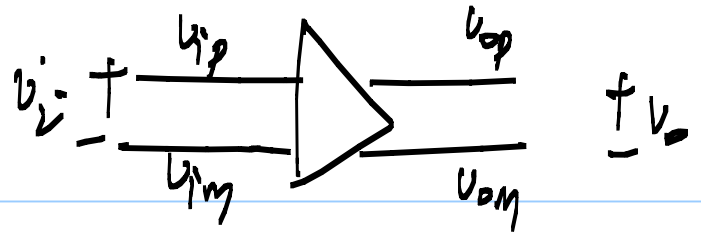
$$v_{2p} \cdot \frac{C}{C+C_1} + v_{2m} \cdot \frac{C}{C+C_1}$$

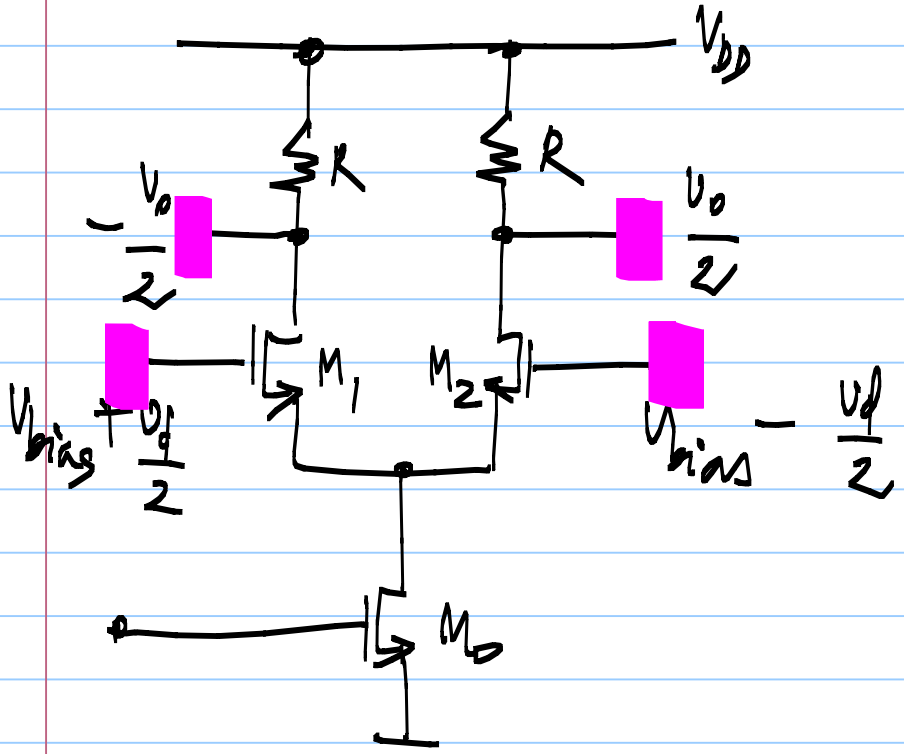
$$v_{2p} = -v_{2m} = \frac{v_2}{2}$$

Fully differential signalling:

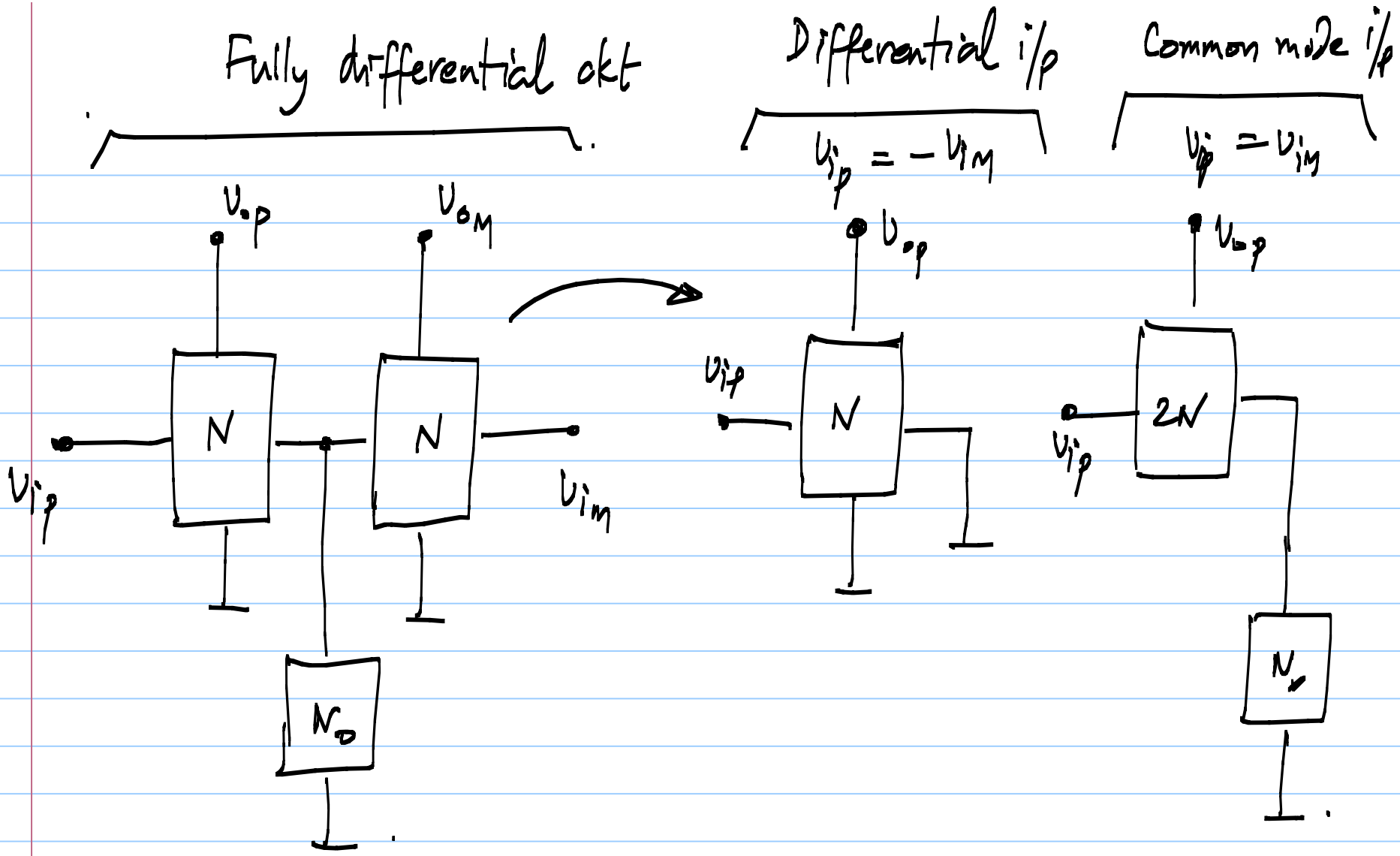
* A pair of wires carry any given signal
* Each wire has a voltage $\frac{v}{2}, -\frac{v}{2}$ wrt common ground in the ckt.
  * Less interference due to common voltage drops in supply & ground lines
  * Less interference from other sources
  * Lesser generation of interference.

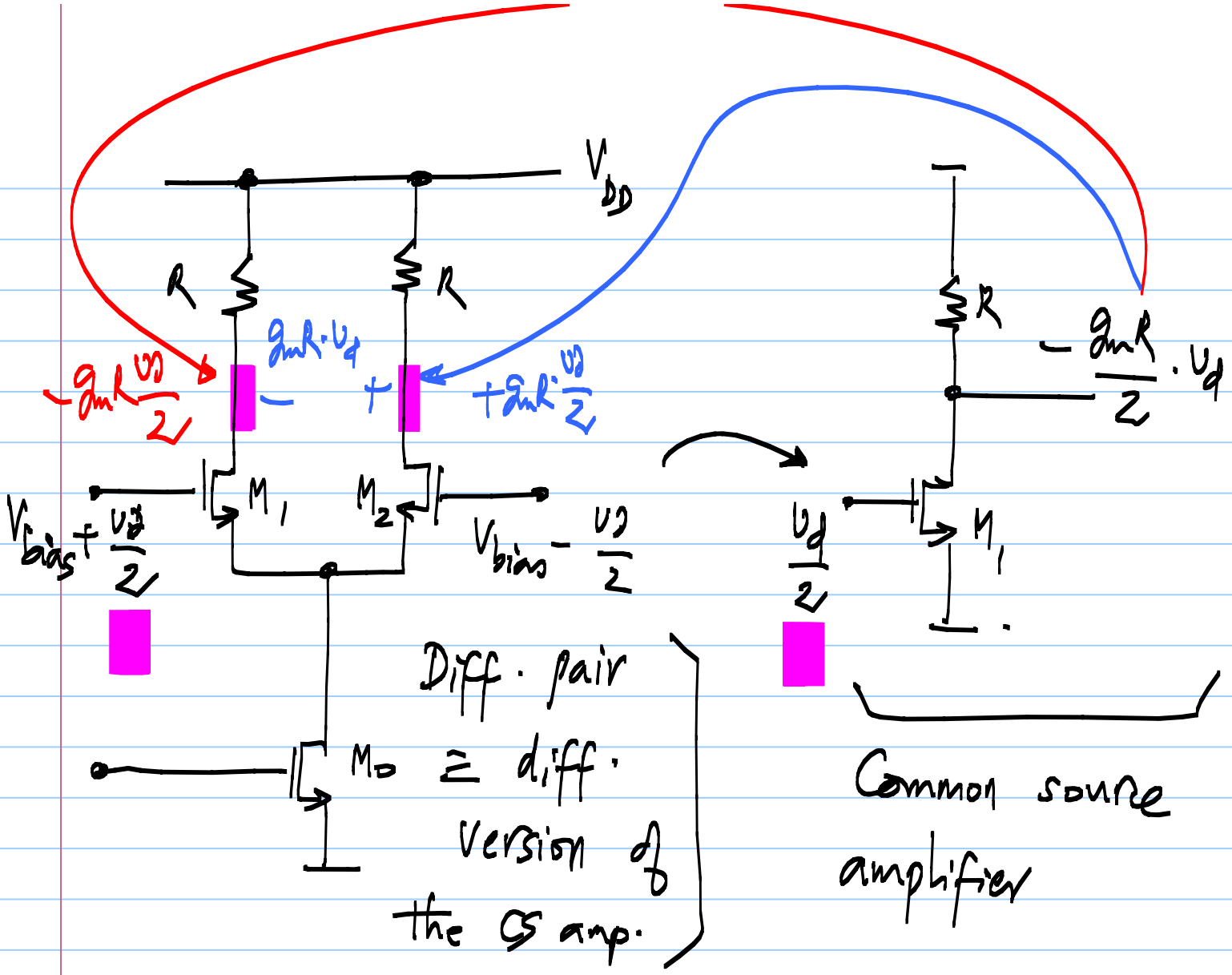
Differential pair:



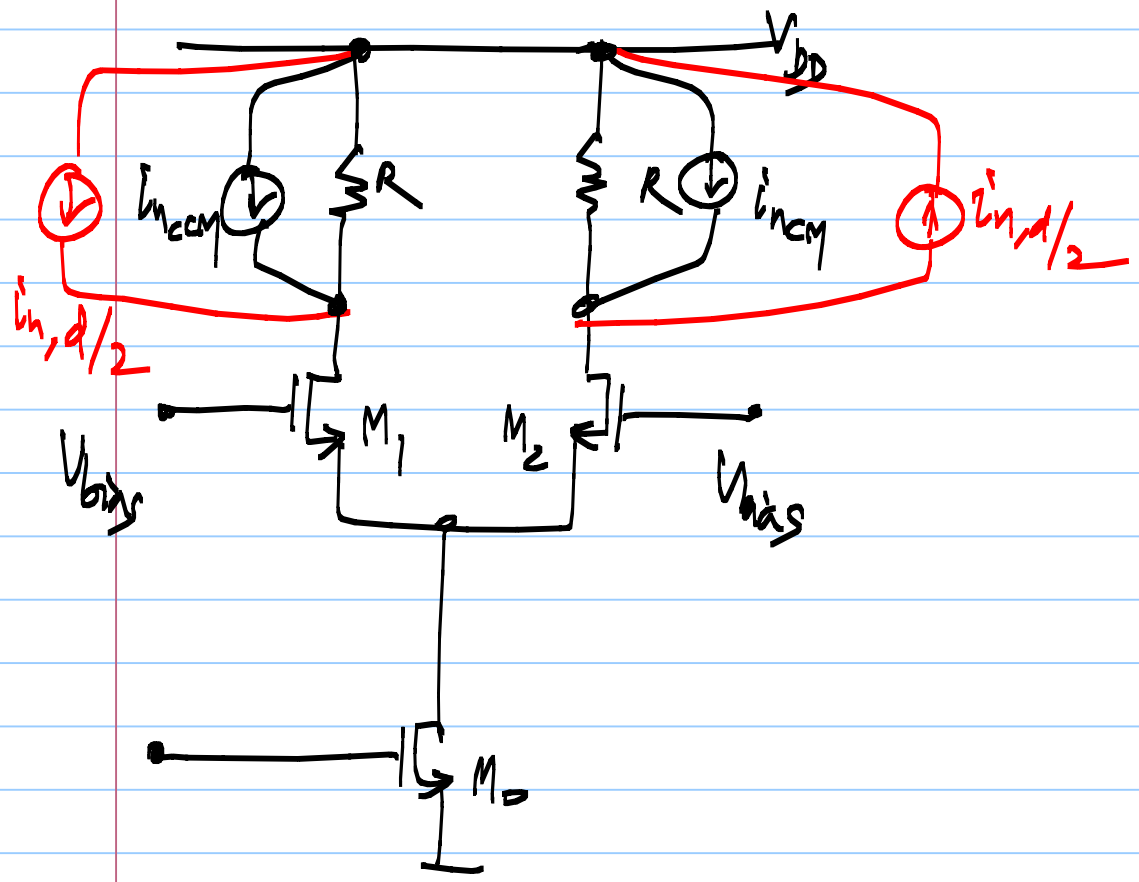


Fully differential signals are handled by fully differential circuits


Fully differential ckt
Differential i/p
$v_{ip} = -v_{iM}$
Common mode i/p
$v_{ip} = v_{iM}$
v_{oP}
v_{oM}
N
N
N_D
v_{ip}
v_{iM}
v_{cp}
2N
N_c


V_{DD}
R
R
$-g_mR\frac{v_d}{2}$
$g_mR \cdot v_d$
$+g_mR\frac{v_d}{2}$
M_1
M_2
$V_{bias}+\frac{v_d}{2}$
$V_{bias}-\frac{v_d}{2}$
M_0 ≡ diff. version of the CS amp.
Diff. pair
R
$-\frac{g_mR}{2}\cdot v_d$
$\frac{v_d}{2}$
M_1
Common source amplifier

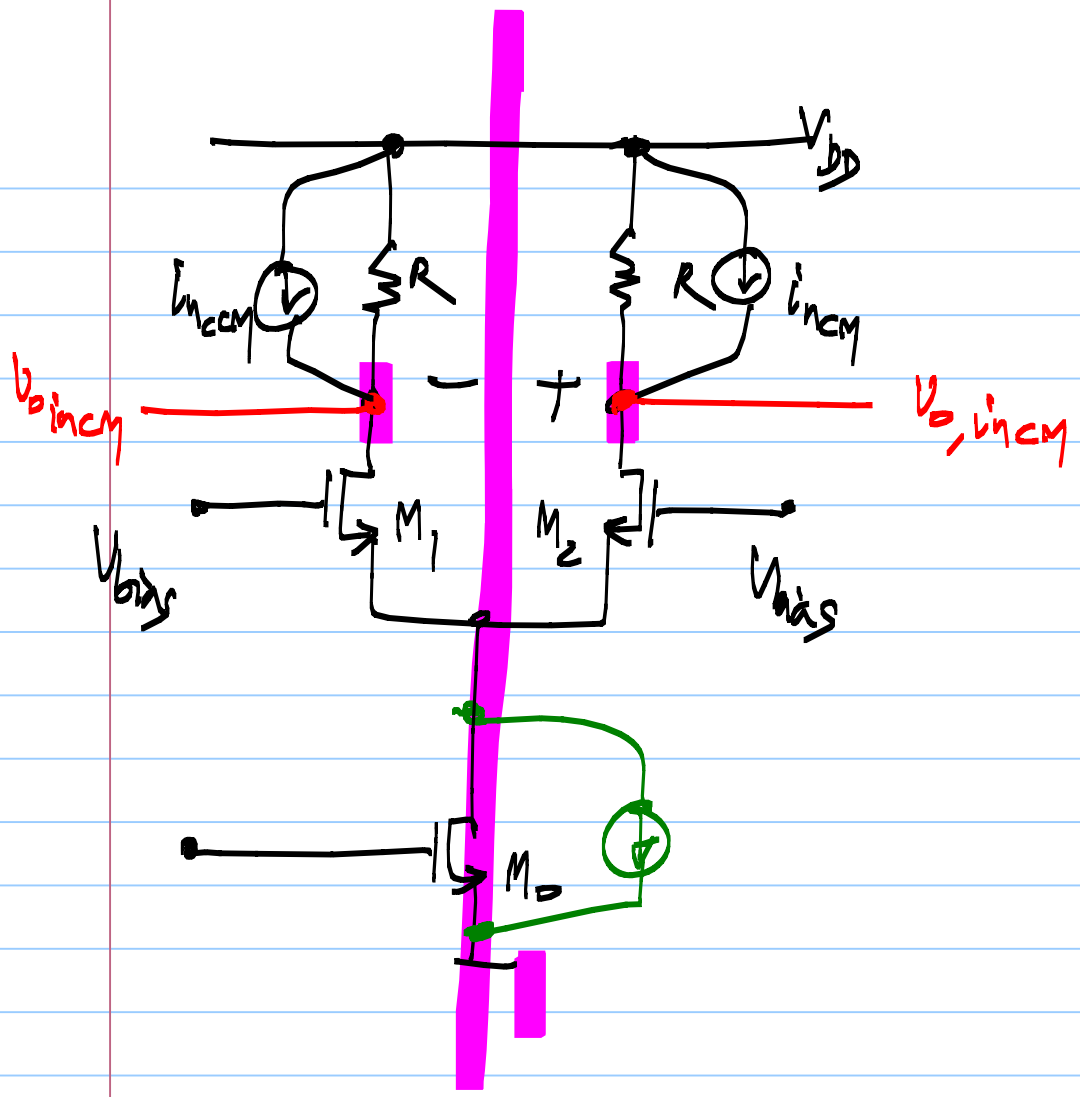
Fully differential circuits: noise



$$i_{n_1} = \frac{i_{n_1} + i_{n_2}}{2} + \frac{i_{n_1} - i_{n_2}}{2}$$

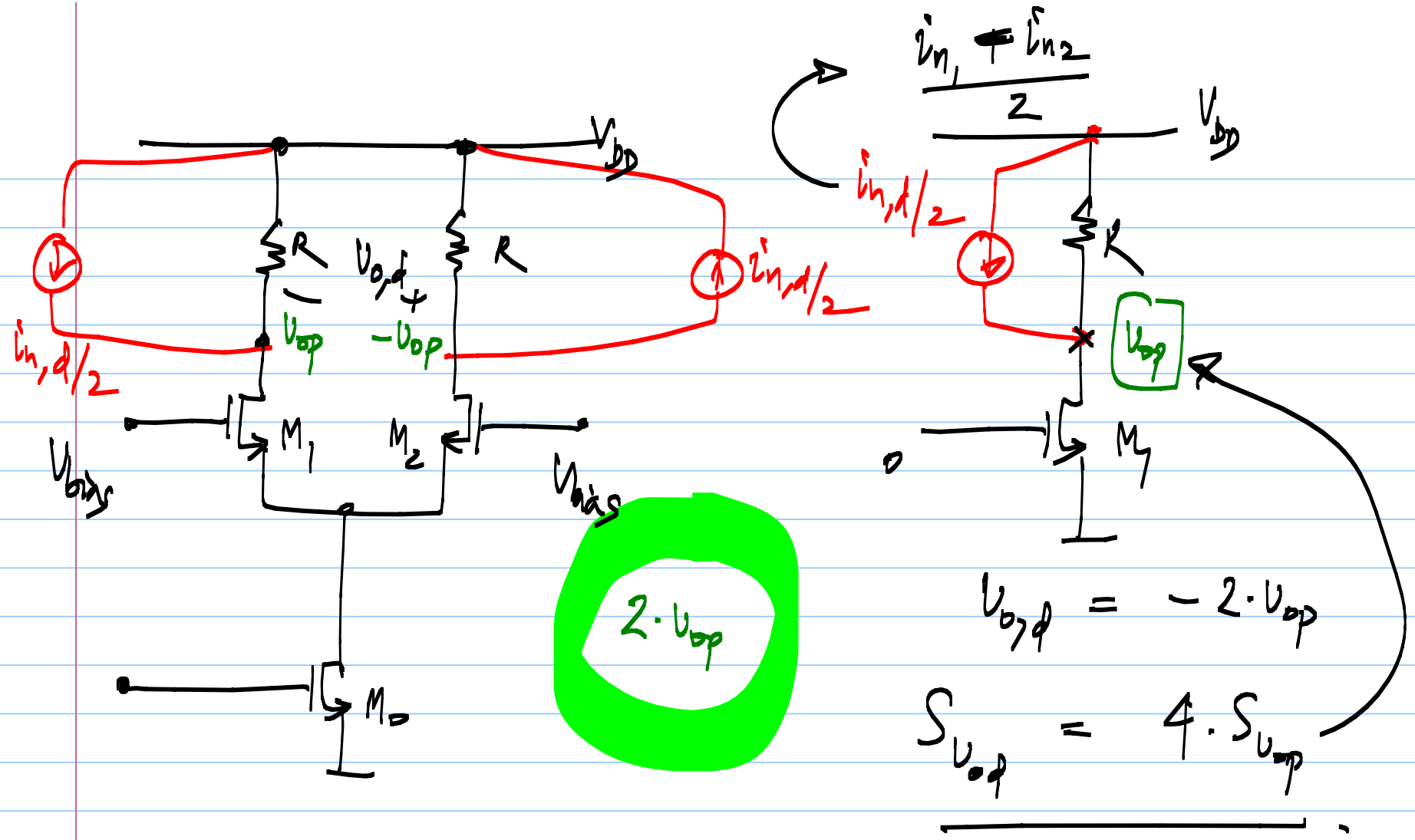
$$i_{n_2} = \frac{i_{n_1} + i_{n_2}}{2} - \frac{i_{n_1} - i_{n_2}}{2}$$

$$i_{n_{1,2}} = i_{n,cm} + \frac{i_{n,d}}{2}$$



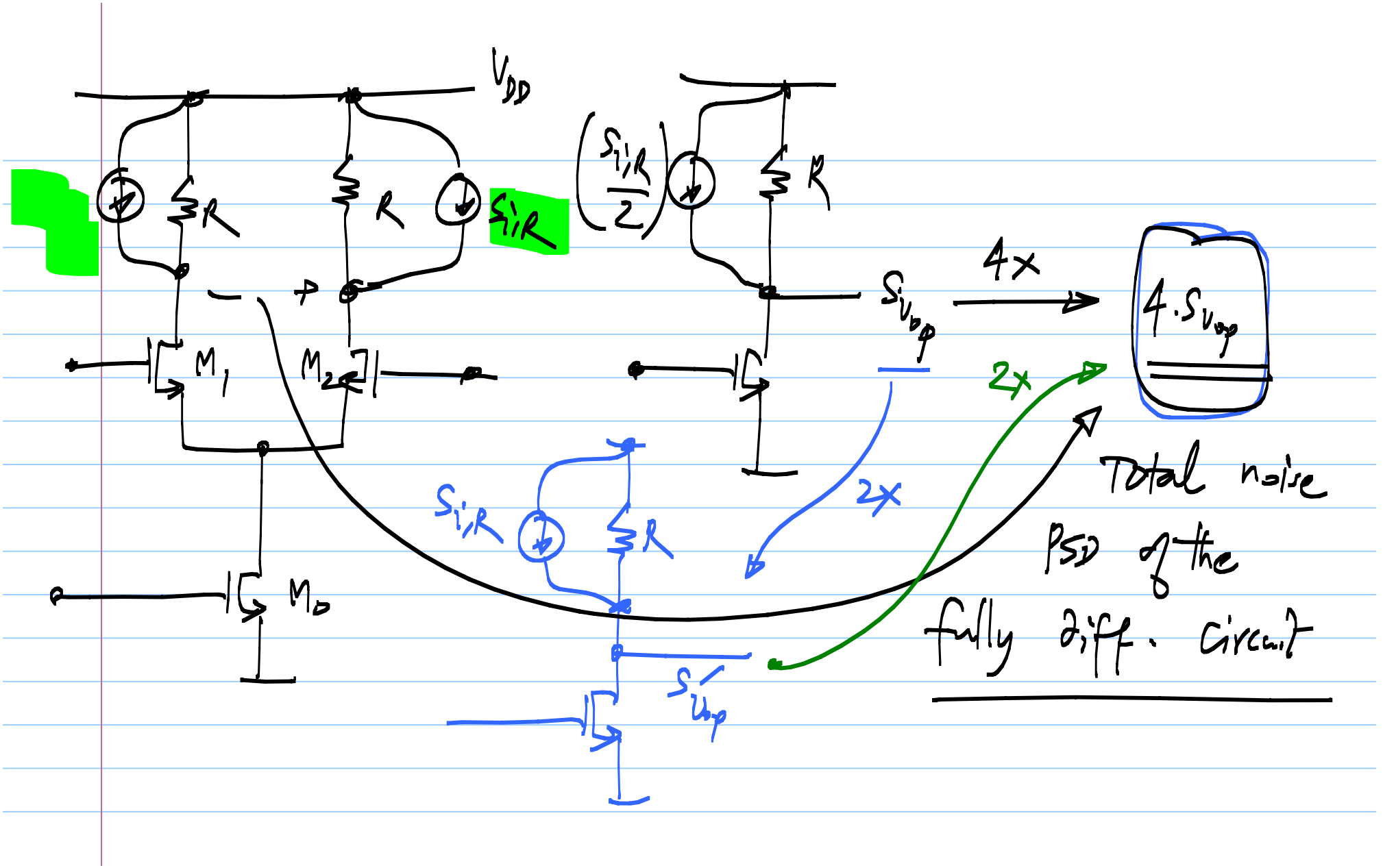
Effect of $i_{n,cm}$ on the diff. o/p = 0

Effect of noise from Common Components = 0


V_{DD}
R
R
V_{out}
+
V_{op}
$-V_{op}$
$i_{in,d}/2$
$i_{in,d}/2$
M_1
M_2
V_{bias}
V_{bias}
M_0
$2 \cdot V_{op}$
$\frac{i_{in1} + i_{in2}}{2}$
V_{DD}
$i_{in,d}/2$
R
V_{op}
M_3
$V_{out} = -2 \cdot V_{op}$
$S_{out} = 4 \cdot S_{op}$

$$\left(\frac{i_{n,d}}{2}\right) = \frac{i_{n_1} - i_{n_2}}{2} = S_{i,R}$$

$$= \frac{S_{i,R} + S_{i,R}}{4} = \left(\frac{S_{i,R}}{2}\right)$$


V_{DD}
R
R
$S_{i/R}$
$\left(\frac{S_{i/R}}{2}\right)$
R
$S_{v_{op}}$
4x
$4.S_{v_{op}}$
M_1
M_2
M_D
$S_{i/R}$
R
2x
2x
$S_{v_{op}}$
Total noise PSD of the fully diff. circuit

Fully differential circuit: noise analysis

* Analyze the noise of the half circuit

* Multiply the o/p noise PSD by 2x to obtain the noise in the fully diff. output