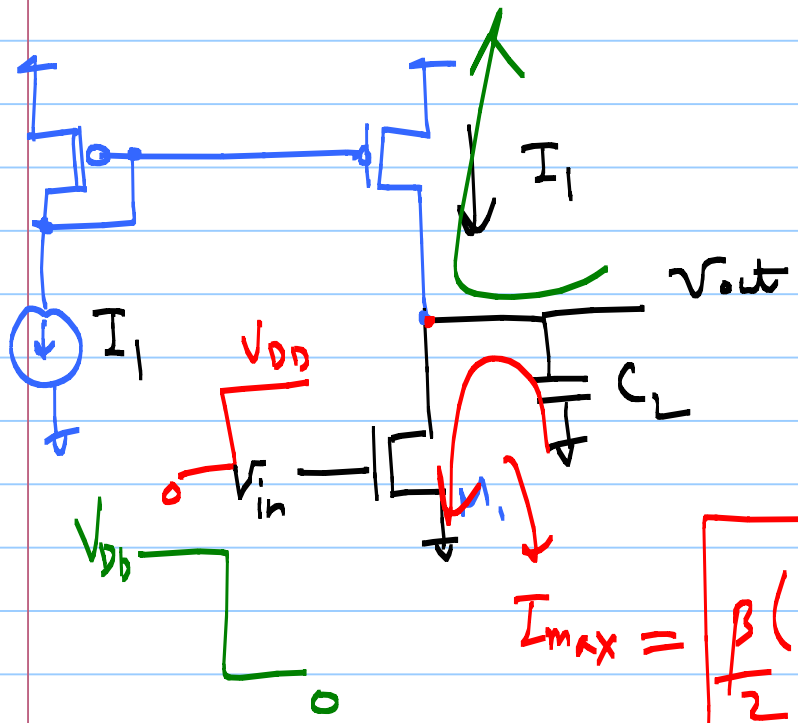
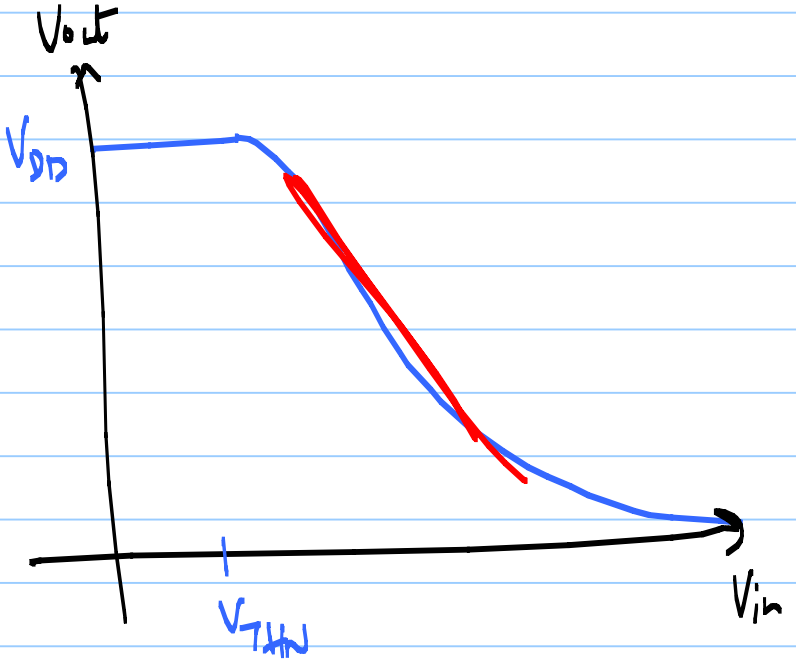
ECE 511 – Lecture 17

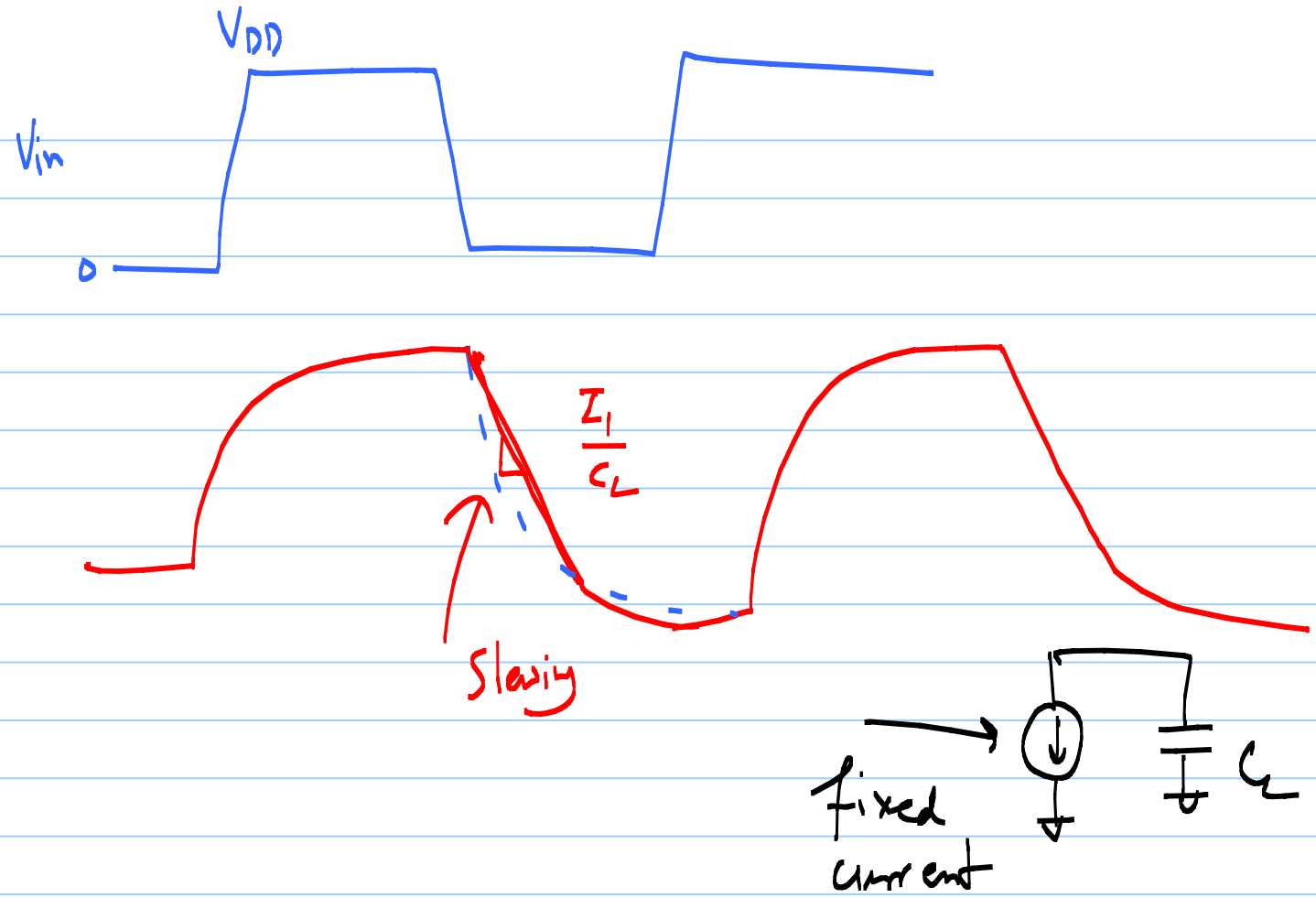
Note Title 4/2/2012

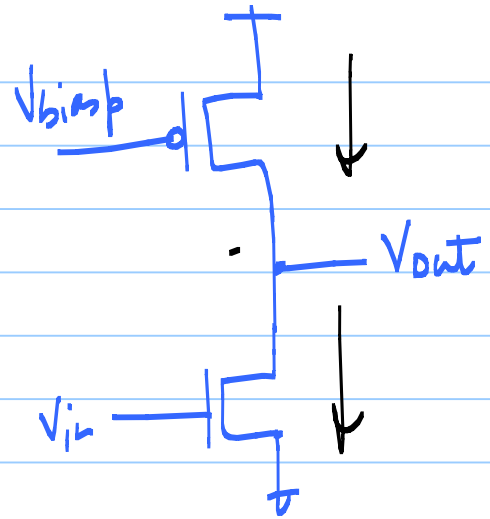
CS amplifier:





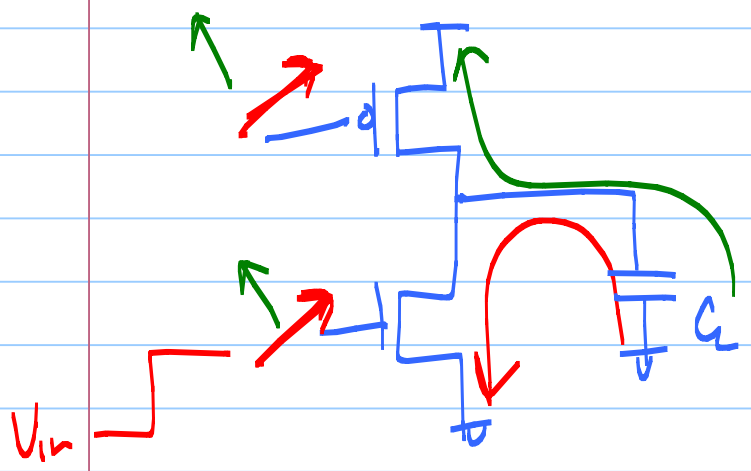
$$I_{max} = \frac{\beta}{2}(V_{DD} - V_{THN})^2$$


V_{DD}
V_{in}
0
$\frac{I_1}{C_L}$
Slewing
fixed
current
C_L



Class-A stage

* both conduct at the same time



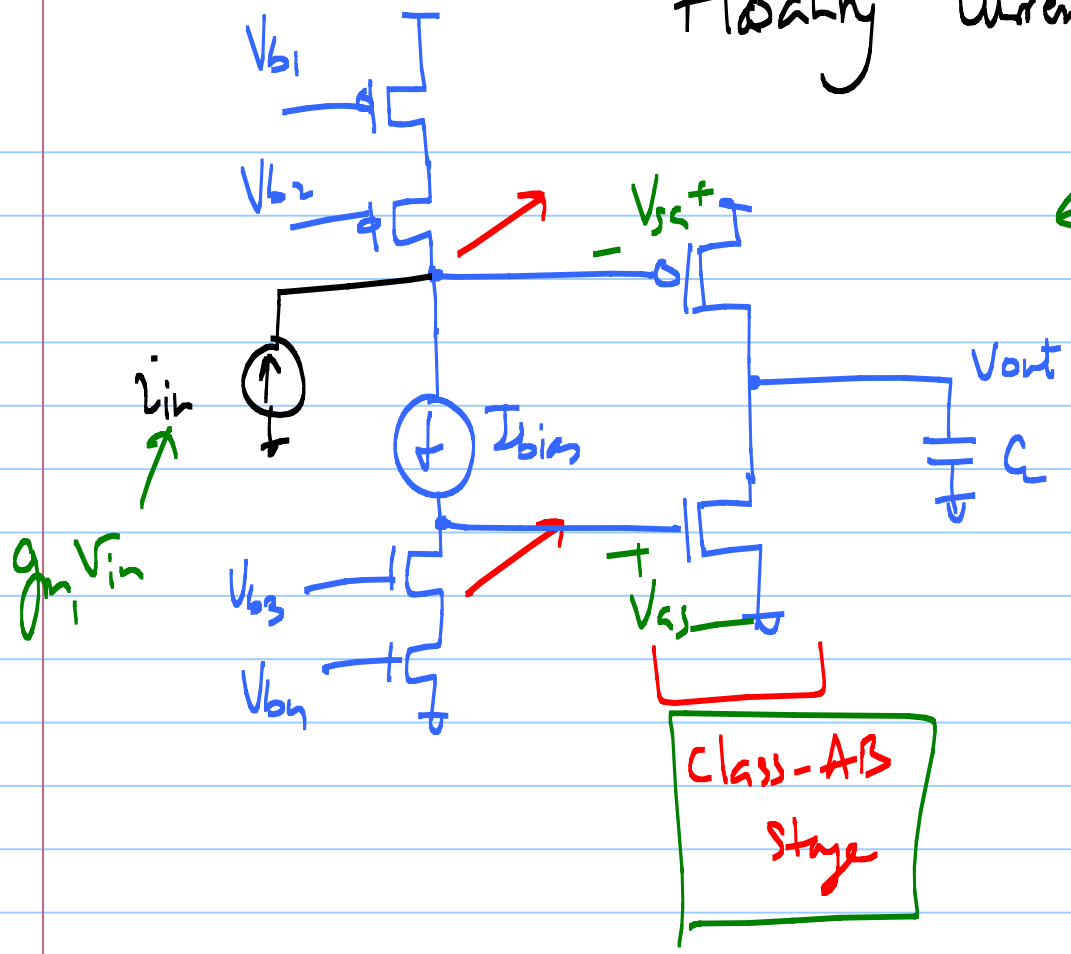
Class AB stage

Smooth transition from one device to another

↳ output stage of an amplifier

* In class B → only one device is on at a time

floating Current Mirror

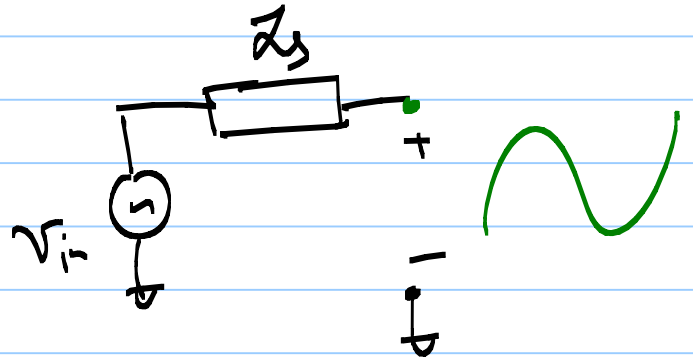


← Chapter 20.

← o/p Stage for an op amp.

Chapter 22 – Differential Amplifiers

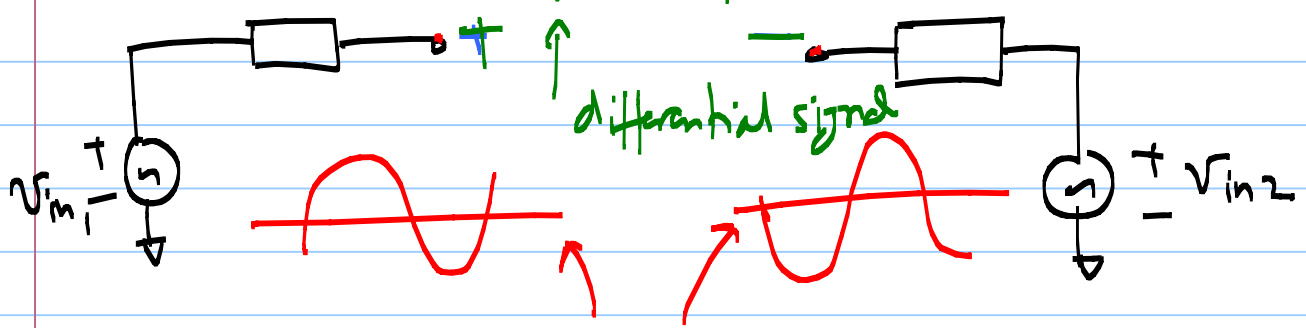
* Single-ended signal



one wire wrt the ground.

* Differential signal → measured b/w 2 nodes, which have equal and opposite signal excursions around a fixed potential

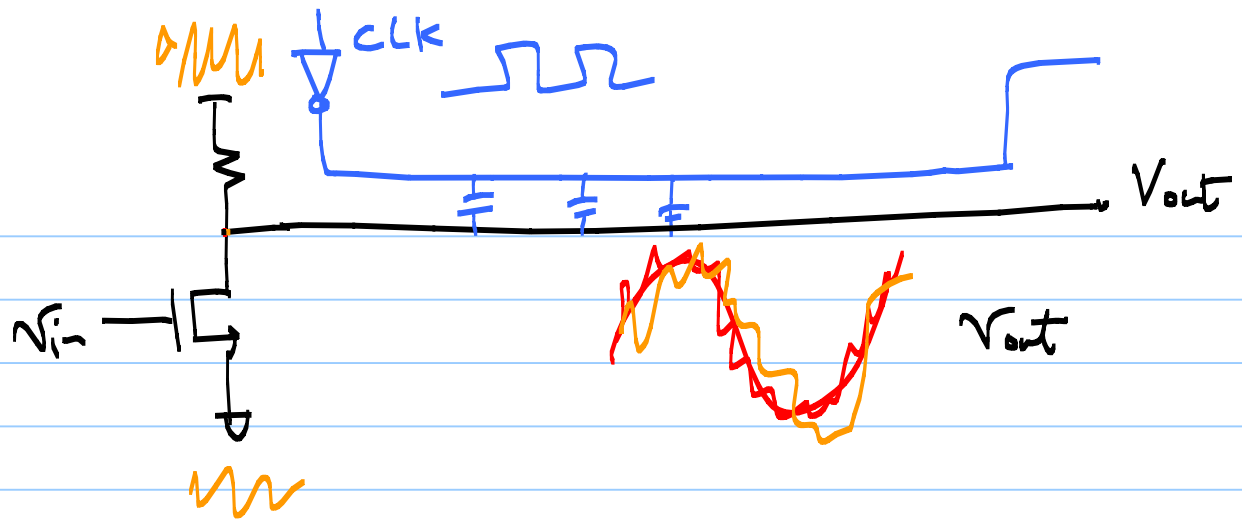
$V_d = V_{in_1} - V_{in_2}$

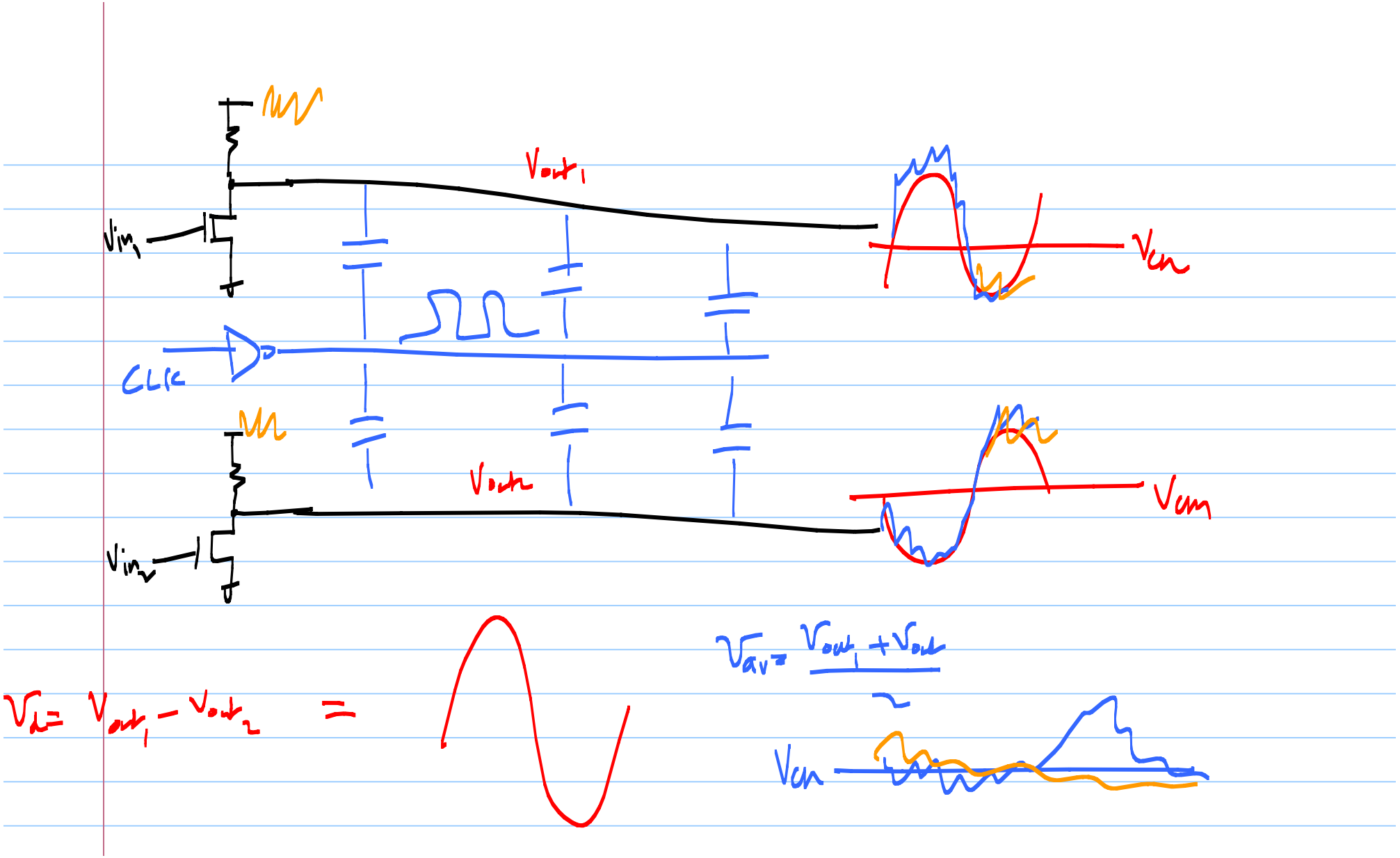


V_{CM} ← common-mode voltage

$V_d = V_{in_1} - V_{in_2}$ ← DM signal

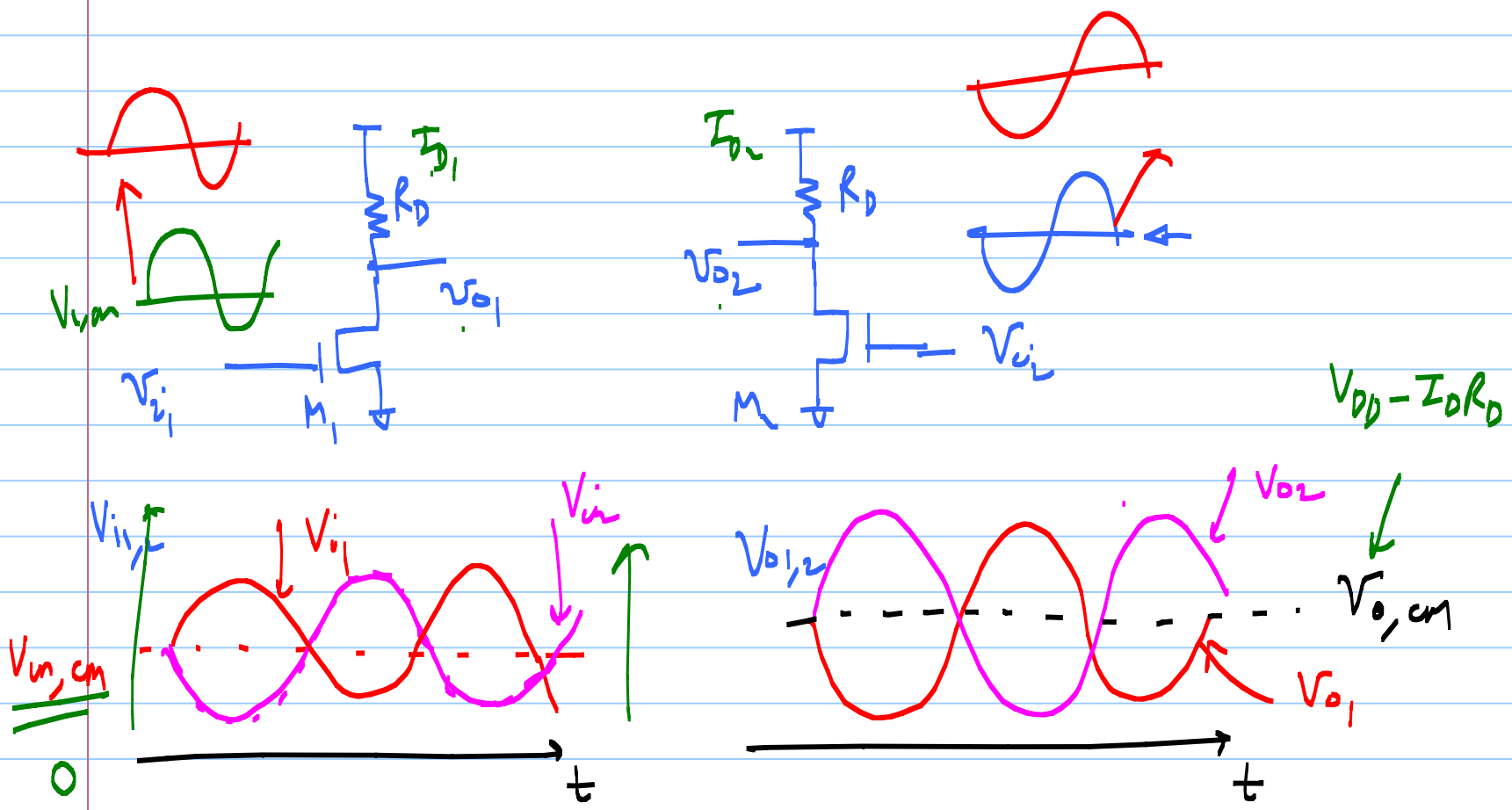
$V_{cm} = \frac{V_{in_1} + V_{in_2}}{2}$ ← CM signal


CLK
V_{out}
V_{in}
V_{out}


V_{out_1}
V_{in_1}
CLK
V_{out_2}
V_{in_2}
V_{cm}
V_{cm}
$V_d = V_{out_1} - V_{out_2} =$
$V_{av} = \frac{V_{out_1} + V_{out_2}}{2}$
V_{cm}

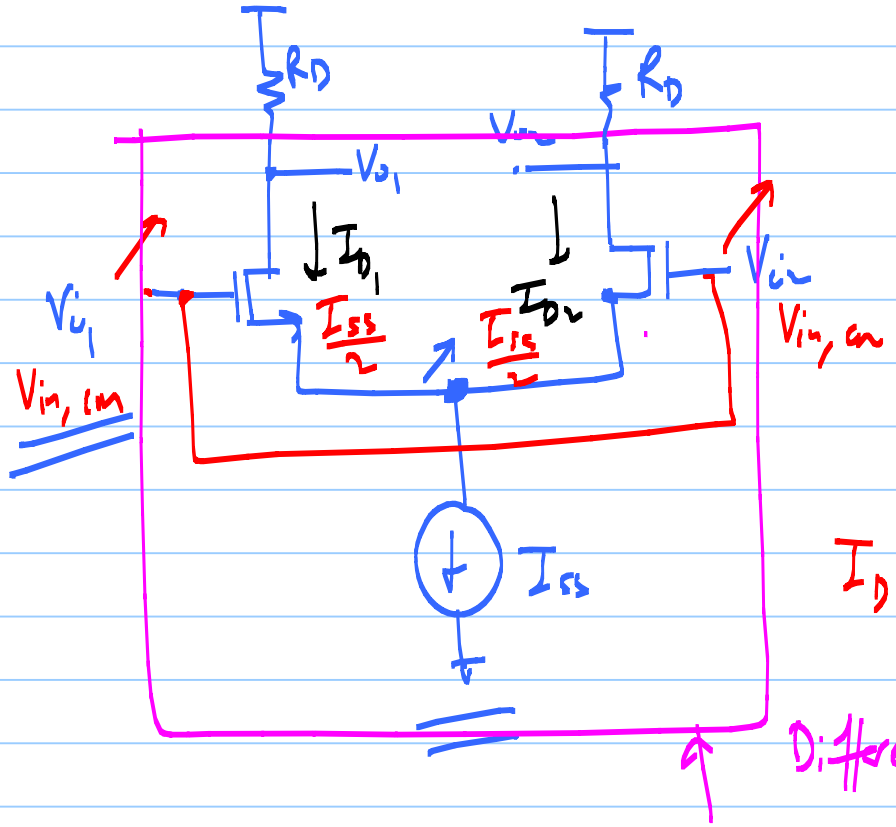
Differential signals/ circuits

↳ reject CM disturbances.


I_{D1}
R_D
V_{o1}
$V_{i,cm}$
V_{i1}
M_1
I_{D2}
R_D
V_{D2}
V_{i2}
M_2
$V_{DD} - I_D R_D$
$V_{i1,2}$
V_{i1}
V_{i2}
$V_{in,cm}$
0
t
$V_{o1,2}$
V_{o2}
$V_{o,cm}$
V_{o1}
t

* Bias currents I_{D1}, I_{D2} depend upon the input cm voltage

* Somehow make I_{D1} & I_{D2} independent of $V_{in,cm}$ voltage



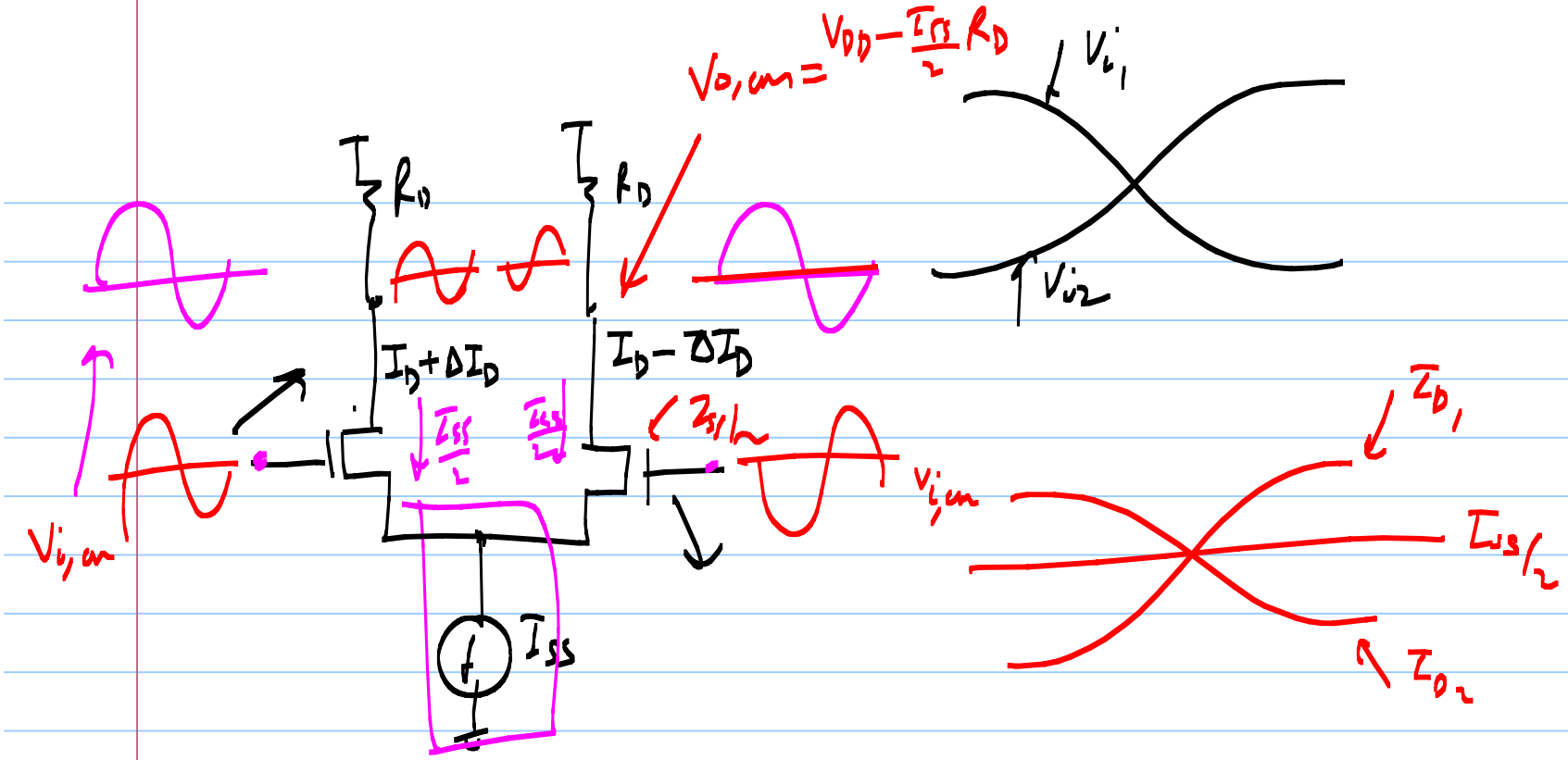
$$I_{D_1} + I_{D_2} = I_{SS}$$

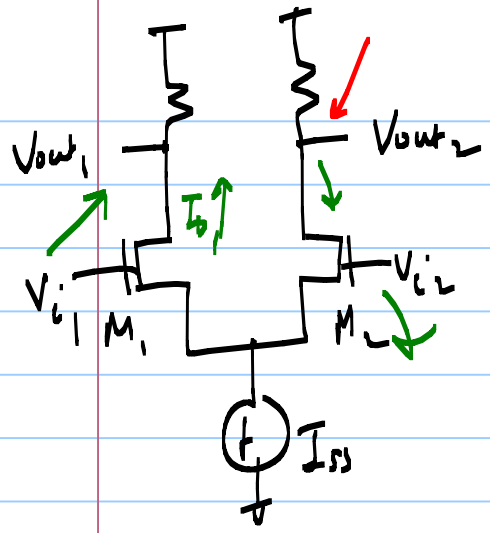
↑ independent of $V_{in,cm}$

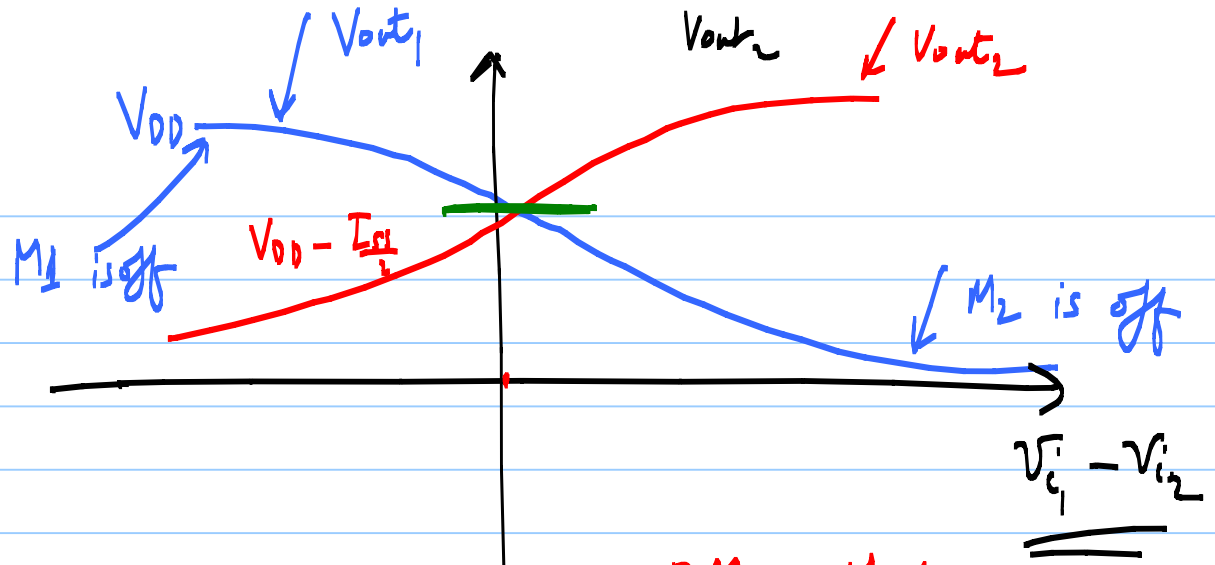
$$I_{D_1} = I_{D_2} = \frac{I_{SS}}{2}$$

Differential pair

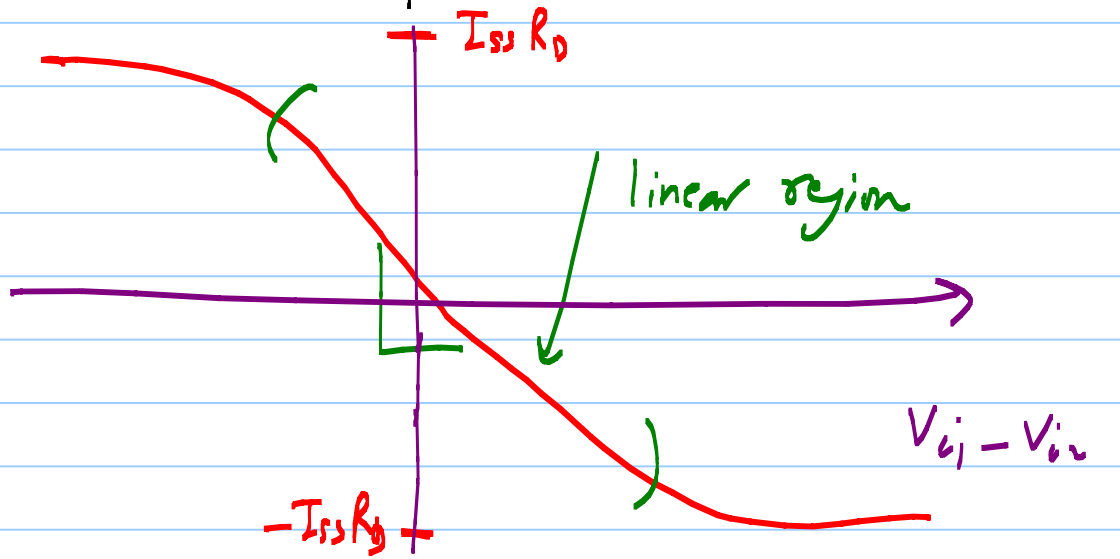
$$I_{D_1} + I_{D_2} = I_{SS}$$

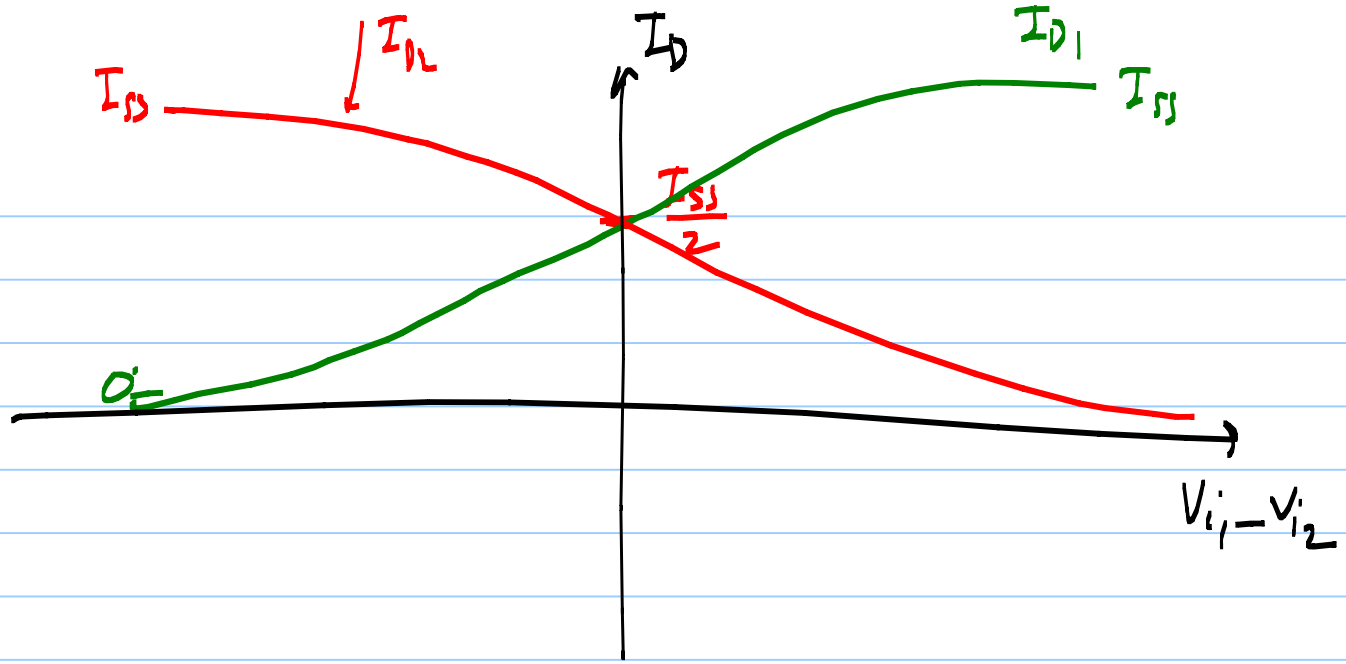

$V_{o,cm} = V_{DD} - \frac{I_{SS}}{2} R_D$
R_D
R_D
V_{i1}
V_{i2}
$I_D + \Delta I_D$
$I_D - \Delta I_D$
$\frac{I_{SS}}{2}$
$\frac{I_{SS}}{2}$
$2 g_m$
$V_{i,cm}$
$V_{i,cm}$
I_{SS}
I_{D1}
$\frac{I_{SS}}{2}$
I_{D2}

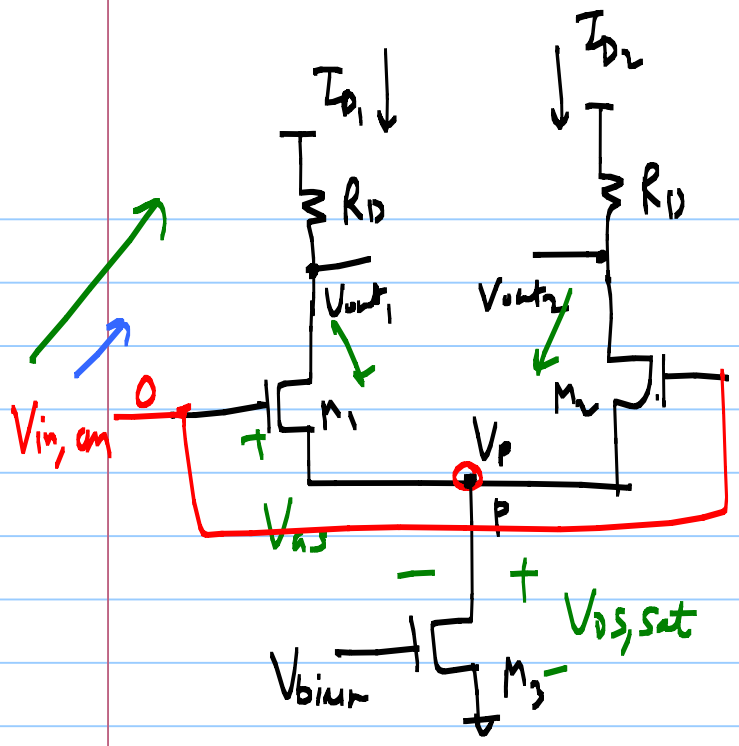


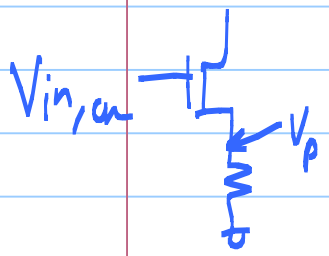


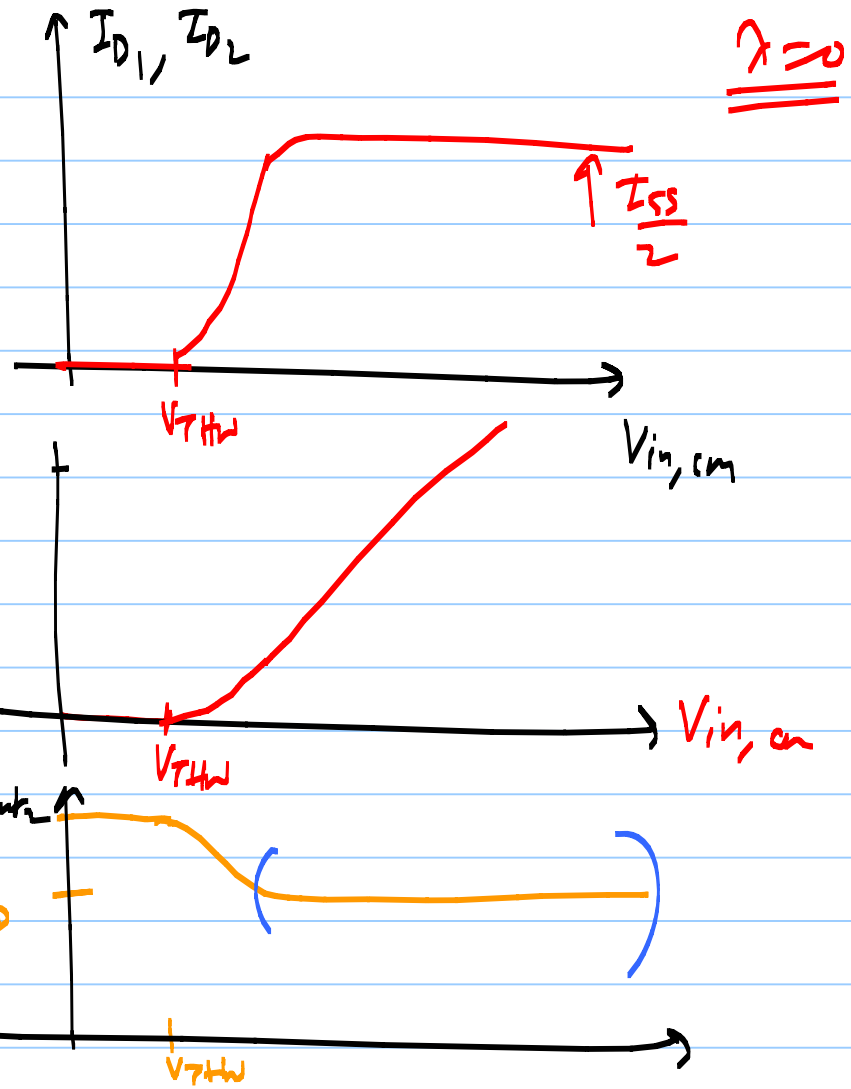
$V_{out} = V_{out_1} - V_{out_2}$ ← DM output




I_{D2}
I_D
I_{D1}
I_{SS}
I_{SS}
$\frac{I_{SS}}{2}$
0
$V_{i1}-V_{i2}$


I_{D1}
I_{D2}
R_D
R_D
V_{out1}
V_{out2}
$V_{in,cm}$
0
M_1
M_2
V_P
P
V_{GS}
$V_{DS,sat}$
V_{bias}
M_3


$V_{in,cm}$
V_P


I_{D1}, I_{D2}
$\lambda = 0$
I_{SS}
2
V_{THN}
$V_{in,cm}$
V_P
V_{THN}
$V_{in,cm}$
V_{out1}, V_{out2}
$V_{DD} - I_{SS} R_D$
2
V_{THN}

$V_{in,cm} \geq V_{DS,sat_3} + V_{GS_{1,2}}$ ⟺ $M_{1,2,3}$ are all in SAT

M_1 & M_2 enter Triode

$$V_{in,cm} > V_{out_1} + V_{THN}$$

$$V_{DS_1} < V_{GS_1} - V_{THN}$$

$$(V_{incm} - V_p) < (V_{out_{1,2}} - V_p) - V_{THN}$$

$$V_{in,cm} > V_{out,cm} + V_{THN}$$

$$V_{in,cm} > V_{DD} - \frac{I_{SS}}{2} R_D + V_{THN}$$

$$V_{GS_1} + V_{DS,sat_3} < V_{in,cm} < V_{DD} - \frac{I_{SS}}{2} R_D + V_{THN}$$

↑ Allowed input Common-mode range

Input CMR