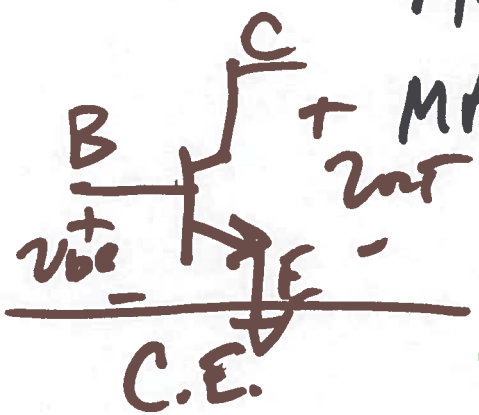
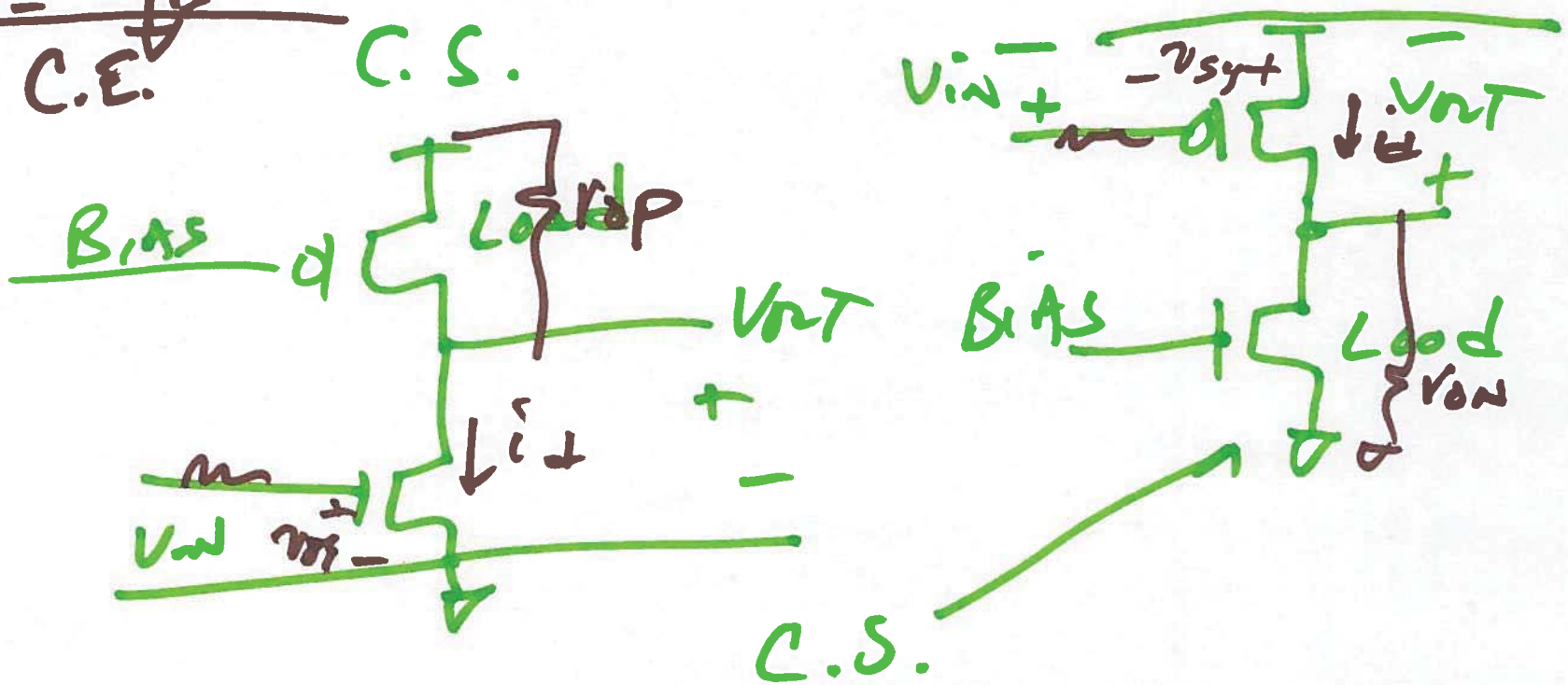
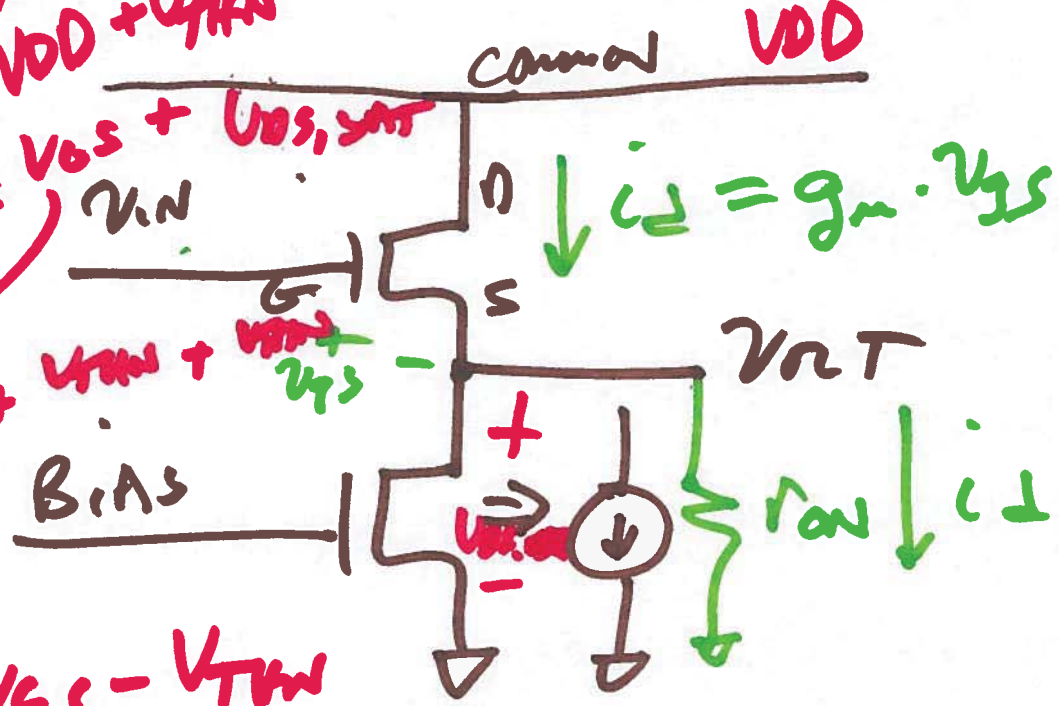
EE 420/ELG 620
Analog IC Design
March 27, 2019
Lecture 15





COMMON-DRAIN (CD) (source-follower)



$V_{INMAX} = V_{DD} + V_{THN}$

$V_{IN,MIN} = V_{DS} + V_{DS,SAT}$

$V_{DS} \geq V_{GS} - V_{THN}$

$V_D - V_S \geq V_G - V_S - V_{THN}$

$V_D \geq V_{INMAX} - V_{THN}$

$V_{INMAX} \leq V_{DD} + V_{THN}$

$v_{IN} = v_{gs} + v_{rT}$

$= i_d\left(\frac{1}{g_m} + r_{ON}\right)$

$\frac{v_{rT}}{v_{IN}} = \frac{i_d \cdot r_{ON}}{i_d\left(\frac{1}{g_m} + r_{ON}\right)} = \frac{1}{1 + \frac{1}{g_m r_O}}$

$\frac{v_{rT}}{v_{IN}} \simeq 1$

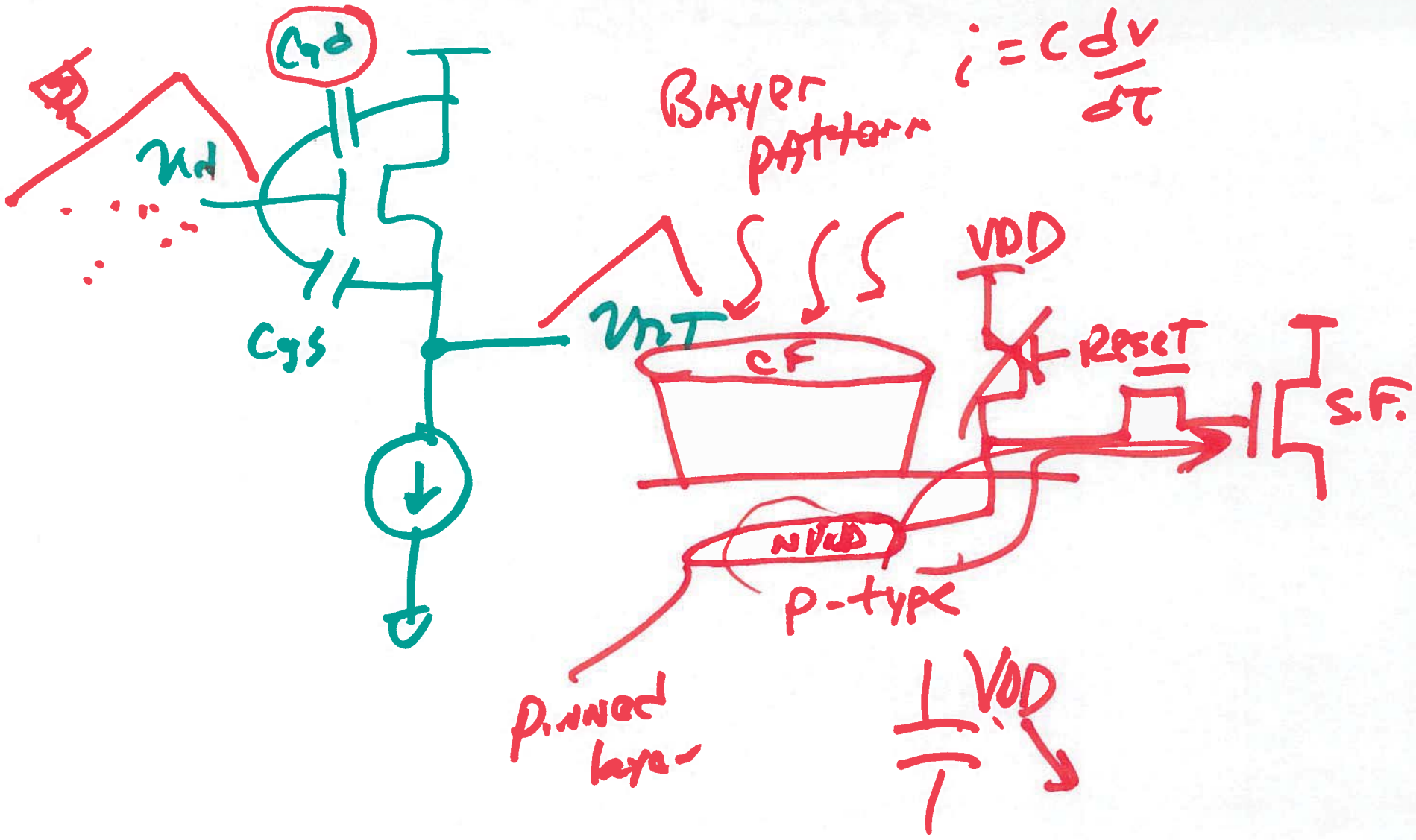
$V_{DD} - V_{DD,SAT} - V_{SG}$

$V_{SD} \geq V_{SG} - V_{THP}$

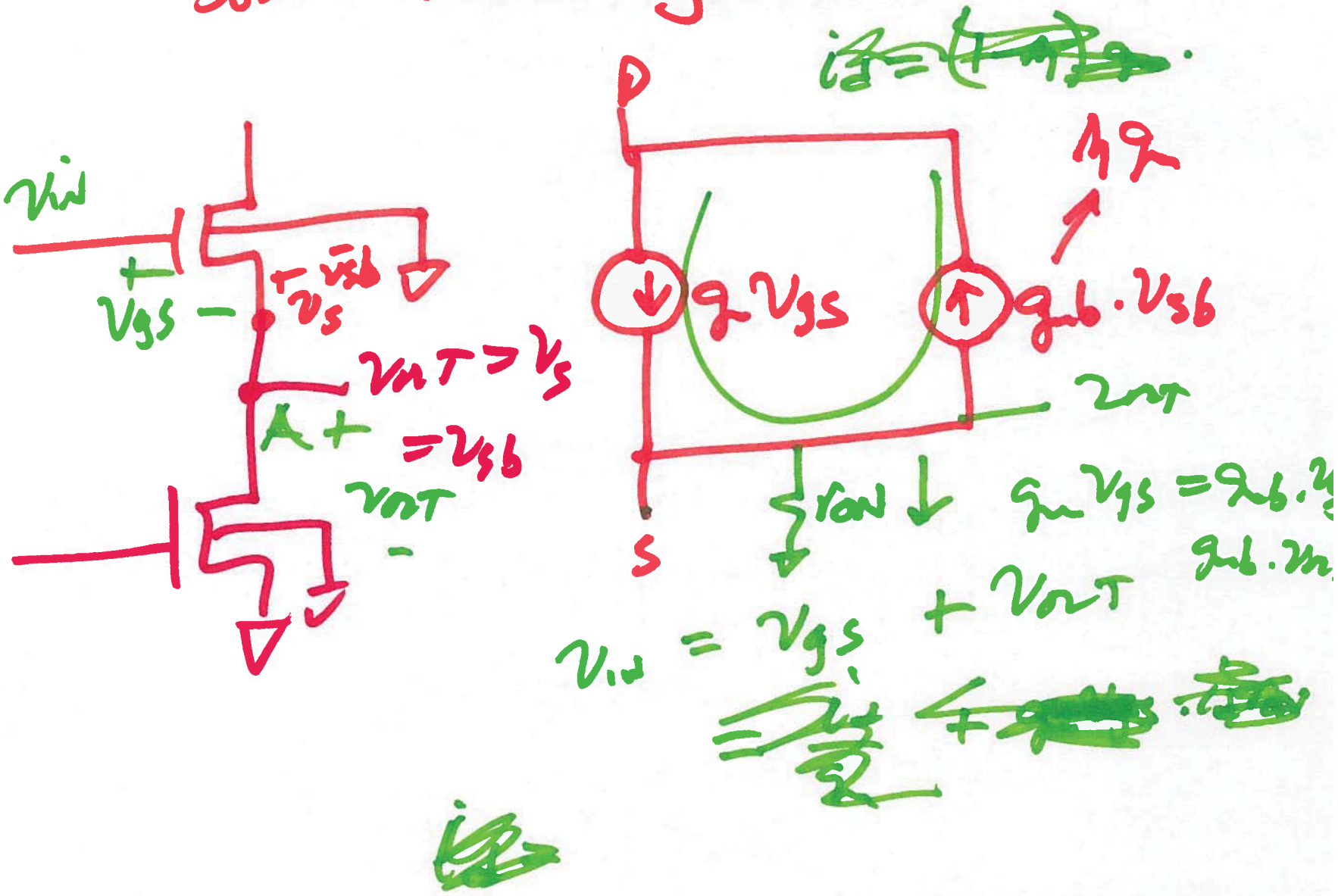
$V_D \leq V_G + V_{THP}$

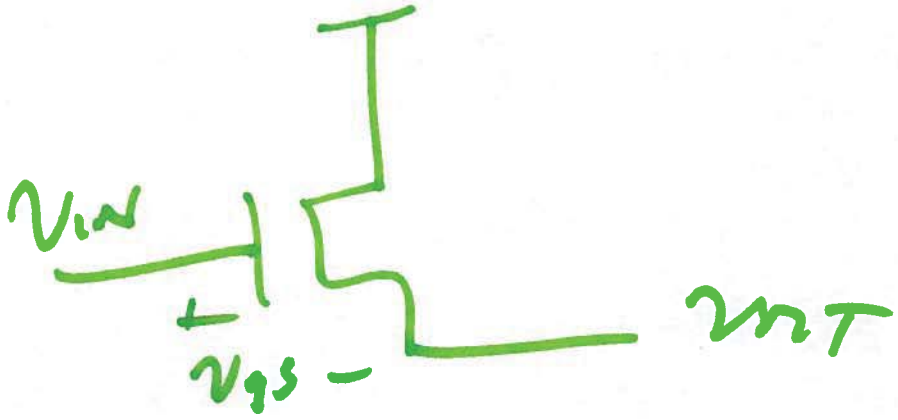
$0 \leq V_{INMIN} + V_{THP}$

$V_{INMIN} = -V_{THP}$


C_{gd}
V_d
C_{gs}
V_{RT}
Bayer pattern
$i = C\frac{dv}{dt}$
VDD
CF
Reset
S.F.
nVDD
p-type
Pinned layer
VDD
T

Source follower gain revisited





$$v_{in} = v_{gs} + v_{mT}$$

$$\eta v_{gs} = \eta v_{in} \cdot v_{mT}$$

$$v_{gs} = \eta v_{in} v_{mT}$$

$$v_{in} = \eta v_{in} v_{mT} + v_{mT}$$

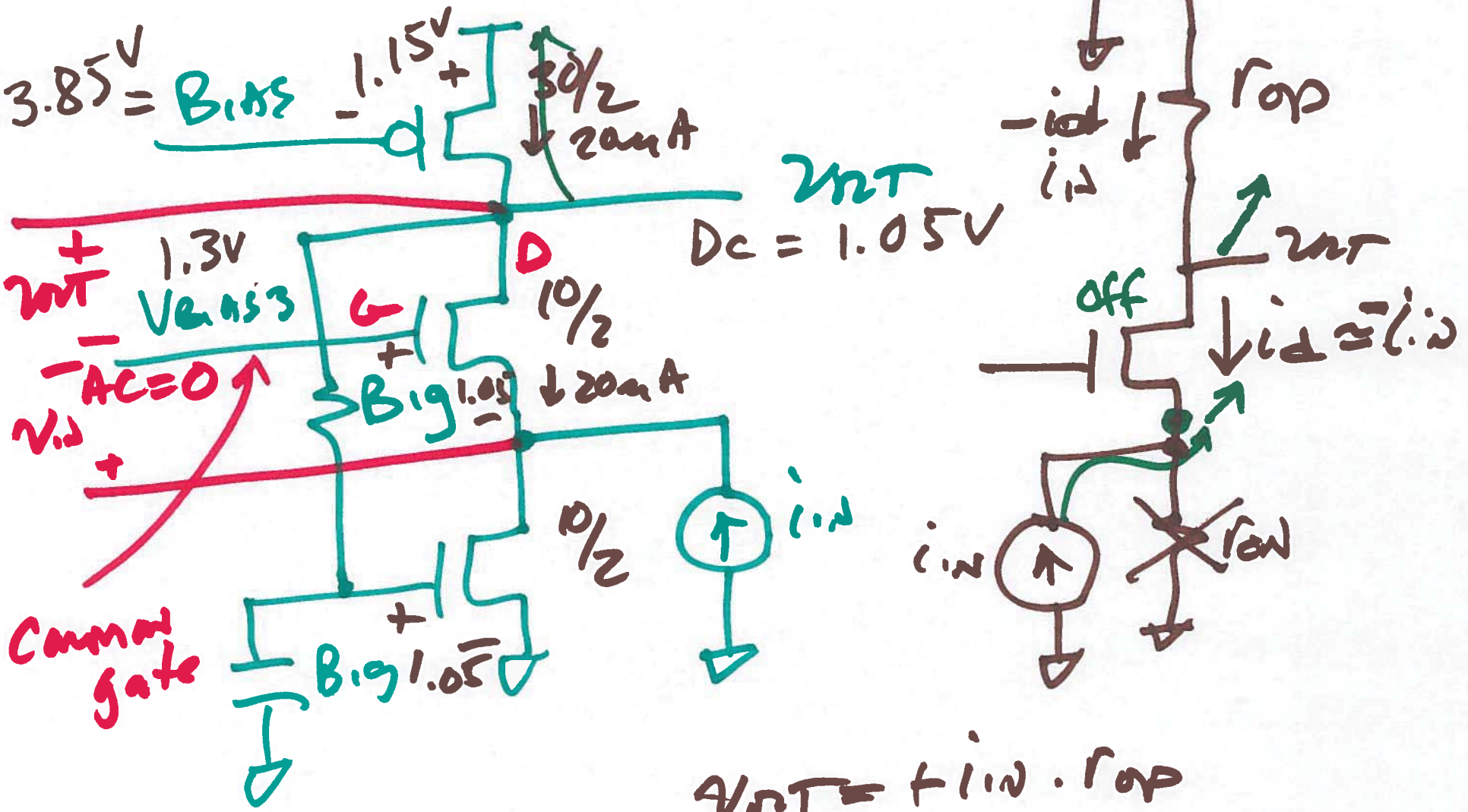
$$= v_{mT}(1 + \eta)$$

$$\frac{v_{mT}}{v_{in}} = \frac{v_{mT}}{v_{mT}(1+\eta)}$$

$$0 < \eta < .3$$

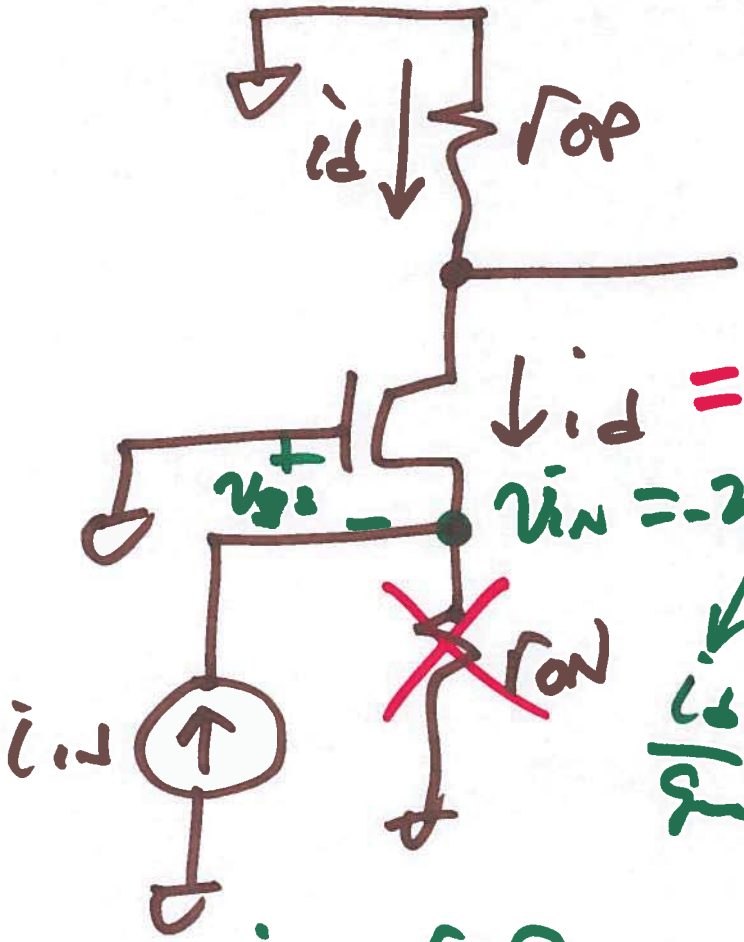
$$\boxed{\frac{v_{mT}}{v_{in}} = \frac{1}{1+\eta}}$$

COMMON-GATE (CG)



$$V_{out} = +i_{in} \cdot r_{op}$$

$$\frac{V_{out}}{i_{in}} = \frac{+i_{in} \cdot r_{op}}{i_{in}} = +r_{op}$$



$v_{out} = -i_d \cdot r_{op}$

$= i_{in} \cdot r_{op}$

$i_d = -i_{in}$

$v_{in} = -v_{gs}$

$\frac{v_{out}}{i_{in}} = \frac{i_{in} \cdot r_{op}}{i_{in}}$

i_{in}

$\frac{i_d}{g_m} = \frac{-i_{in}}{g_m}$

$\frac{v_{out}}{i_{in}} = r_{op}$

$\frac{v_{out}}{v_{in}} = \frac{i_{in} \cdot r_{op}}{-v_{gs}}$

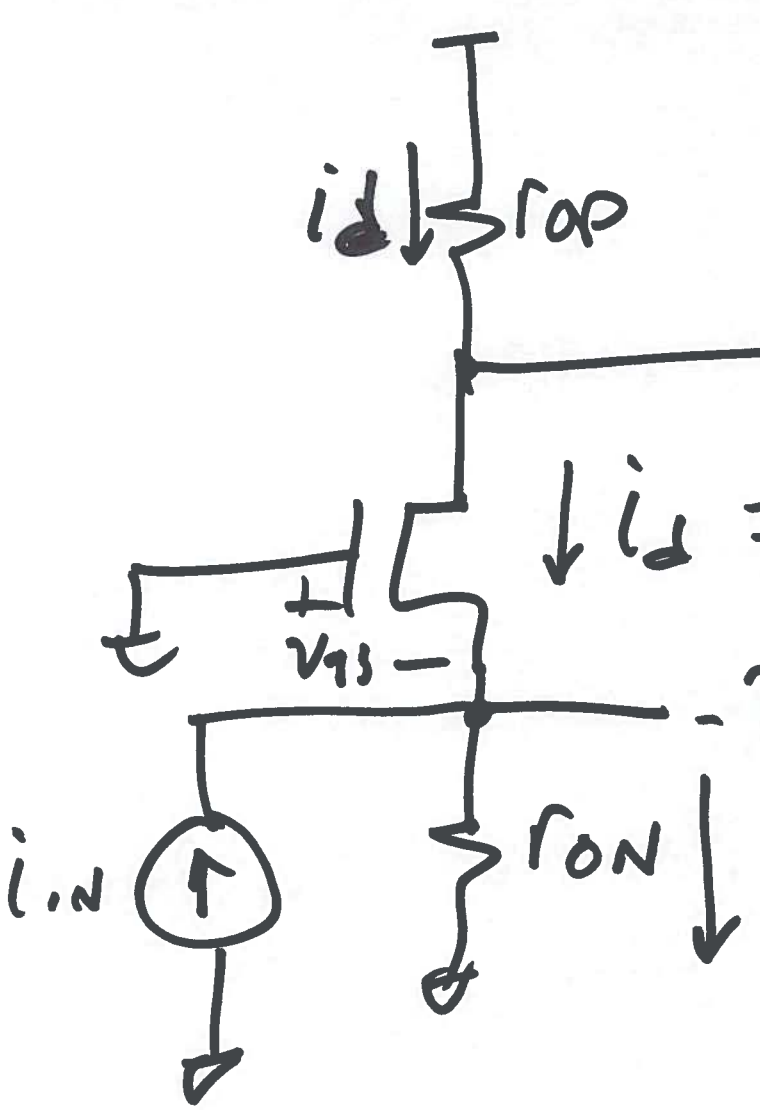
$= \frac{i_{in} \cdot r_{op}}{+\left(+\frac{i_{in}}{g_m}\right)}$

transimpedance, $\frac{V}{A}$ (Ω)

resistance

$\frac{v_{out}}{v_{in}} = g_m r_{op}$

7)



$$v_{RT} = -i_d \cdot r_{OP}$$

$$\downarrow i_d = g_m v_{GS} = -i_{IN} + \frac{-v_{GS}}{r_{ON}}$$

$$v_{OUT} = -i_d \cdot r_{OP}$$

$$v_{OUT} = \left(i_{IN} + \frac{v_{GS}}{r_{ON}}\right) r_{OP}$$

$$v_{RT} = \left(i_{IN} + \frac{i_d/g_m}{r_{ON}}\right) r_{OP}$$

$$= i_{IN} r_{OP} + i_d \cdot \frac{r_{OP}}{r_{ON}} \cdot \frac{1}{g_m}$$

$$\frac{v_{OUT}}{i_{IN}} \approx r_{OP}$$